Book of Abstracts

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Theme

Irresistible India - a Global Engineering Powerhouse

Organised by

The Institution of Engineers (India)

8 Gokhale Road, Kolkata

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BOOK OF ABSTRACTS

39th Indian Engineering Congress

20-22 December 2024, Kolkata

theme

Irresistible India:
A Global Engineering Powerhouse

The Institution of Engineers (India)
8 Gokhale Road, Kolkata 700020

Book of Abstracts
39th Indian Engineering Congress, Kolkata
Irresistible India: A Global Engineering Powerhouse

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THEME

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Biomedical Science & Technology

AI/ML in Biomedical Research & Technology

81_IEC64426 ➲

FelAug, WaterAug: Superpixel-based Medical Image Augmentation Methods for Improving Accuracy and Reducing False Predictions in Dermatological Image Classifications

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Abstract: Identification of skin diseases of Indian patients using publicly available datasets fails due to the difference in skin tones and the nature of the disease. Training with clinically acquired datasets presents a big problem due to the reluctance of patients to be filmed, getting approval from the Human Ethics Committee, and the involvement of dermatologists for data labeling. Moreover, data from a single clinic is often very low as the maximum number of patients are revisited cases. Because of this, we have developed four superpixel-based augmentation methods to increase the dataset. Our research has shown that this augmentation method not only increases efficiency but also reduces false predictions which can be detrimental to patients' safety.

Keywords: FelAug; WaterAug; InceptionV3; MobileNetV2; Superpixel, Machine-learning

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206_IEC44754 ➲

Prediction of Post Operative Complications from Pre and Peri Operative Statistics using Artificial Neural Network

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Abstract: India being one of the most populated countries conducts more than 50 million surgeries annually. Thus, it becomes challenging for medical organizations to accurately predict the post-surgery risks of every individual patient. Accurate prediction of the risk of the same is important for patient selection prior to surgery and for guiding perioperative decision-making. Accurate assessment of post-surgery risk will make the patient as well as their medical escort to be more vigilant, as well as directing early interventions. Eventually, it will reduce the overuse of hospital resources as well as reduce morbidity and mortality in high-risk patients. In this study, an Artificial Neural Network model to accurately predict post-surgery complications using pre and perioperative parameters is developed. This model is implemented on a cohort of 7908 patients and observed post-surgery infection in 1128 of them. The data set was divided into training and testing sets to train the predictive model and assess generalization performance respectively. The Artificial Neural Network displayed potential performance in predicting the presence of postoperative complications. Further clinical studies are required to confirm its applicability in routine clinical practice.

Keywords: Artificial Neural Network (ANN); Cohort; Infections; Logistic Regression; Post Operative Complications (PoCs); Prediction

221_IEC56641 ➲

Machine Learning-Driven Scaffold Design: Advancing Tissue Engineering with Stem Cells

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Abstract: Machine Learning (ML) is transforming the field of tissue engineering by improving the design of scaffolds for stem cell applications. This study focuses on how deep learning, particularly Convolutional Neural Networks (CNNs), can optimize the 3D scaffold architecture to enhance human Mesenchymal Stem Cell (hMSC) differentiation and tissue growth. By integrating biological data into the scaffold design process, ML predicts scaffold structures that mimic natural tissue environments, significantly boosting cell attachment, proliferation and differentiation. The study shows that scaffolds by ML significantly enhance tissue formation compared to traditional designs and also offering more efficient and cost-effective solutions for regenerative medicine. This approach not only improves cell functionality but allows personalized treatments tailored to patient-specific needs. Our results highlight the transformative potential of AI-assisted scaffold design in tissue engineering, with a lot of scope for development of more advanced and personalized therapies.

Keywords: Scaffold Design; Tissue Engineering; Machine Learning, Stem Cells, Regenerative Medicine

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251_IEC22776 ➲

Lung Cancer Detection using Deep Learning

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Abstract: Lung cancer is the second leading cause of cancer-related deaths, is primarily caused by long-term tobacco consumption (85% of cases). Surprisingly, 10-15% of cases occur in non-smokers. In 2020, approximately 2 million people were affected globally, resulting in 1.5 million deaths. The survival rate, at around 20%, lags behind other cancers, partly due to late-stage symptom manifestation. Lung cancer, a prevalent and deadly disease, necessitates early and accurate detection for effective treatment. Performance metrics such as accuracy, precision, recall (sensitivity), and F1-score are calculated to provide a comparative study of each model's capabilities. By comparing these metrics, this study offers insights into the strengths and limitations of each approach, contributing to the advancement of lung cancer detection techniques. In this paper, different deep learning algorithms - InceptionV3, MobileNetV2, VGG16, and ResNet152 — are explored for their efficacy in classifying lung cancer cases. But our Proposed Model, which is a 16 hidden layers architecture based on CNN model has better accuracy. The proposed model for lung cancer detection using deep learning exhibits several key highlights that contribute to its novelty. Firstly, the model incorporates 2D Convolutional layers, enabling it to capture spatial and temporal dependencies in the input data. By integrating multiple layer types such as convolutional, pooling, flatten, dropout, fully connected and dense layers, the model leverages the strengths of each layer to enhance its predictive capabilities. Novelty of our proposed model is that its accuracy is increasing consistently with the increasing no of epochs. We have tested the model performance up to epoch no 30. Our proposed model also overcomes the overfitting problem.

Keywords: Lung Cancer; Deep Learning; CNN; 2D Convolutional Layer; Accuracy

284_IEC49976 ➲

Intelligent Lung Cancer Detection System

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Abstract: Lung cancer is a major global health concern that requires sophisticated detection methods to identify it early enough for effective care. In this paper, the authors present a CNN model-based Smart Lung Cancer Detection System using image processing techniques to classify various cancer types. The detected results are displayed on LCD with the help of IoT for the general public. Additionally, a web application has been created for uploading the dataset and showing its photographs using the Python Streamlit package. The proposed system combines state-of-the-art technologies to offer a complete solution for patients and healthcare providers.

Keywords: Lung Cancer; CNN; LCD; Detection; IoT; Image Processing

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292_IEC18634 ➲

Revolutionizing Healthcare: Unleashing AI and ML for Next-Gen Disease Detection

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Introduction: This review paper is on AI/ML intervention in Biomedical Research and Technology. Its primary focus is on the applications, constraints, and potential future uses of artificial intelligence (AI) and machine learning (ML) algorithms in cancer prediction.

Cancer represents a global health emergency, and while progress has been made in terms of diagnosis, prognosis, and treatment, it remains difficult to provide patients with tailored, data-driven care.

Artificial intelligence has the power of prediction and automation through risk assessment, diagnosis at an early stage, time estimation and therefore is improving the accuracy in biomedicine. ML can be regarded as a subset of AI enabling the computers to learn from a set of existing training data which is used to effectively predict various types of cancer(including breast, brain, lung, liver etc) with higher accuracy. The deep learning technology is useful for detecting a range of chronic diseases and supporting medical decision-making for physicians across several industries. A review states that the five types of cancer that the deep learning system was able to classify were lung adenocarcinoma (LUAD), kidney renal clear cell carcinoma (KIRC), breast invasive carcinoma, and prostate and colon adenocarcinoma.

AI and ML algorithms are designed in such a way that they intend to solve various challenging tasks of predicting the possibility of cancer-based on the patient's molecular, genetic and tumor-based features. By analyzing the various available resources such as the pathology profiles, and imaging studies the ML and other models can convert these into their corresponding "Mathematical Sequences". These are then further analyzed and developed to predict certain traits.

An artificial intelligence system built on the "Google DeepMind algorithm" was created in January 2020 by researchers, and it was able to outperform human "breast cancer" detection specialists.

The University of Pittsburgh created a machine learning method based on AI systems in July 2020 that has the best accuracy in prostate cancer diagnosis, with a 98% specificity and 98% sensitivity.

Keywords: Artificial Intelligence; Machine Learning; Diagnosis; Prevention; Techniques

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303_IEC7939 ➲

Medical Applications of Graph Convolutional Networks using Electronic Health Records: A Survey

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Introduction: Electronic Health Records (EHRs) are comprehensive digital systems that store a variety of patient data, including demographics, medical history, diagnoses, medications, and test results [1]. These systems serve as critical tools for healthcare decision-making, quality management, and outcomes reporting. Moreover, EHRs represent one of the most valuable resources for medical research, enabling the application of artificial intelligence (AI) and machine learning (ML) to uncover actionable insights. However, the heterogeneous nature of EHR data, comprising both structured and unstructured formats, poses significant challenges to traditional ML approaches[1].

Graph Neural Networks (GNNs), a novel class of deep learning models, have emerged as a promising solution for analyzing complex and interconnected data like EHRs. By representing EHR data as graph structures—where nodes represent entities such as patients or clinical events, and edges denote relationships—GNNs enable the modeling of intricate dependencies [2][3]. A specific type of GNN, Graph Convolutional Networks (GCNs), performs convolutional operations on graphs, aggregating information from neighboring nodes to generate node feature vectors [4]. This unique capability allows GCNs to better handle the complexity and interconnectedness of medical data compared to other methods [5].

This study explores the application of GCNs to datasets such as MIMIC-III, a large critical care database [19]. By leveraging GCNs, the goal is to enhance predictive healthcare models for outcomes such as hospital readmission rates and patient mortality. The study highlights how GCNs effectively utilize the structural properties of EHRs, offering new perspectives in medical analytics and decision-making [5].

Keywords: Graph Convolutional Networks; Electronic Health Records; Machine Learning; Medical Informatics; Hybrid Models

304_IEC88727 ➲

Investigation of Time-Frequency Features for the Detection of Epileptic Seizures through Machine Learning Approaches

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Abstract: Epilepsy is a long-term brain disorder that impacts many people across the globe. Effective identification is primarily employed to observe these conditions, enabling the diagnosis of the disorder. However, the perceptual analysis of electroencephogram (EEG) signals is a tedious and time-consuming process, leading to the development of various automated techniques. Many different studies have analysed the different features individually including time, frequency and time frequency techniques. In this study we extracted the five time-frequency discrete wavelet transform, Haar, Daubechies, Symlet, Coiflet and Biorthogonal wavelet coefficients and extracted the six statistical features from this coefficient. The extracted features with statistically significant one is tested with the random forest classifier model over the Bonn EEG dataset, demonstrating the model's efficiency and the significant features achieves a higher accuracy rate than contemporary pioneering approaches with an accuracy of 88% in 5 class dataset using 5-cross validation.

Keywords: EEG; Discrete Wavelet Transform; Machine Learning

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337_IEC5959 ➲

Mind Controlled Bionic Arm with Sense of Touch

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Introduction: This paper presents a novel design for a cost-effective bionic hand intended to restore hand function in individuals with hand amputations or partial paralysis. The proposed design leverages a gripper as the end effector, like commercially available options [1]. However, it distinguishes itself by incorporating a touch sensor within the gripper, aiming to provide a sense of touch comparable to a natural hand. This feature can significantly improve user safety and dexterity when grasping objects [2]. The hand is an intricate and vital component of the human body, responsible for a vast array of tasks essential for daily living [3]. Notably, the central nervous system dedicates a significant portion (approximately 30%) of its resources to controlling the hand, highlighting its critical role in sensory and motor function [3]. Traditionally, regaining hand function after amputation has been primarily limited to hand transplantation, a complex and resource-intensive surgical procedure first introduced in 1963 [4]. Bionic hands offer a more practical and accessible alternative for individuals with hand impairments.

The proposed bionic hand design prioritizes four key functionalities:

— Integrated Sensory Feedback: A distinctive feature of this design is the incorporation of a touch sensor within the gripper. This sensor aims to provide the user with a sense of touch, mimicking the functionality of a natural hand. This capability is crucial for safe object manipulation and preventing injuries [2].

- Mind-Control Potential: EMG sensors detect electrical signals generated by muscles, which can be translated into control signals for the bionic hand [5]. And EEG sensors detect the brain-wave signals generated by the person's brain.
- Signal Acquisition and Processing: The design proposes utilizing an EMG sensor to capture data on muscle activity. The Laplace transform, a mathematical tool employed to analyse signals in the frequency domain, will then be applied to process the acquired EMG signal [6]. Similarly, there would be a hand band type of thing which would be worn in by the patient to record the brain signals (EEG Signals), then it would be transferred to the machine to be decoded by the AI models.
- Control Mechanism: The processed EEG and EMG signal will be used to generate a pulse width modulation (PWM) signal. This PWM signal will subsequently control a servo motor, actuating the robotic arm and enabling movement of the bionic hand [7].

The design strives to replicate the anatomical structure of a natural hand, encompassing the wrist, palm, and fingers. The human hand possesses 27 bones and boasts a wide range of motion, including significant wrist rotation [8]. While the specific details of the bionic hand's structure are not explicitly provided, it is likely to incorporate mechanisms that replicate these features to the greatest extent possible. The paper acknowledges the critical role of nerves in hand function and provides a brief overview of the median, ulnar, radial, and digital nerves. These nerves are responsible for transmitting sensory information and controlling muscle movement within the hand. However, the proposed bionic hand design does not delve into the specifics of how it directly interfaces with the user's nervous system.

Keywords: Bionic Arm; Robotics; Biotechnology; Mind Control; Prosthetics

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338_IEC12385 ➲

Silent Speech Recognition using Cascaded Classifier with sEMG Measurements from Facial Muscles

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Abstract: Silent speech recognition (SSR) leverages non-audible cues to interpret speech, offering significant potential for aiding individuals with speech impairments and enhancing silent communication interfaces. In this study, an attempt is made to explore the use of surface electromyography (sEMG) for silent speech recognition (SSR), specifically targeting facial muscles such as the mentalis, buccinator, hyoid muscles, and the Infraorbital Region (IOR), which includes the zygomatic major. Six healthy participants were recruited to silently utter arithmetic-related words, with the resulting sEMG signals being recorded, pre-processed, and analysed for features including Simple Square Integral (SSI), Root Mean Square (RMS), Variance (VAR), and Shannon entropy. The classification of these features was performed using Random Forest (RF), Support Vector Machine (SVM), and cascaded classifiers where RF preceded SVM, and vice versa. The results demonstrated that the RF classifier achieved an accuracy of 77%, the SVM attained 74%, the RF+SVM cascade reached 75.32%, and the SVM+RF cascade achieved the highest accuracy at 79.22%. These findings highlight the potential of SSR using sEMG for reliable silent communication, especially in scenarios where traditional acoustic methods are infeasible. This research paves the way for developing more sophisticated SSR systems, with practical applications in assistive technology and human-computer interaction, offering a silent yet effective communication channel.

Keywords: Speech Recognition (SSR); Surface Electromyography (sEMG); IOR Region Muscles; Random Forest (RF); Support Vector Machine (SVM); Cascaded Classifiers

340_IEC12280 ➲

Structural Connectivity Analysis in ASD: A DTI-based Machine Learning Classification

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Abstract: Autism spectrum disorder (ASD) refers to a range of neurodevelopmental conditions characterized by challenges in social interaction, communication, and the presence of repetitive, stereotyped behaviors. In this study, we explored the potential of diffusion tensor imaging (DTI) analysis for distinguishing between ASD and typically developing (TD) brains by examining structural connectivity (SC) and applying machine learning algorithms. Initially, the DTI images available at Barrow Neurological Institute (BNI) and Institute Pasteur and Robert Debré Hospital sites of the Autism Brain Imaging Data Exchange (ABIDE-II) database were preprocessed using a standard pipeline. Further, the white matter diffusion metrics such as fractional anisotropy, radial diffusivity, axial diffusivity, and mean diffusivity were extracted for different regions using the Johns Hopkins University atlas. SC features were calculated using Euclidean distance and, significant features were extracted using recursive feature elimination with cross-validation to construct a diagnostic classification model with a logistic regression and support vector machine (SVM) classifier. The SVM classifier achieved the highest performance, reaching a peak accuracy of 84.69% for the BNI dataset using 40 features. The top three SC features are Posterior limb of internal capsule R to Fornix (cres) / Stria terminalis R, Corticospinal tract L to Inferior fronto-occipital fasciculus R and Pontine crossing tract (a part of middle cerebellar peduncle) to Body of corpus callosum contributing to diagnose ASD and TD.

Keywords: Autism Spectrum Disorder; Diffusion Tensor Imaging; Structural Connectivity; Feature Ranking; Machine Learning

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341_IEC50769 ➲

Identification of Optimal Features for EEG-based Authentication in Response to Emotional State

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Abstract: EEG-based authentication demonstrates strong potential in biometrics, but its performance is often hindered by the complexity of feature computation and its sensitivity to variations in emotional states. This study attempts to identify the features of EEG signals for biometric authentication, specifically focusing on the high arousal, high valence emotional state. Initially, the signals were preprocessed and 76 features from different domains were computed. These features were fed to the XGBoost to identify the significant features and to build a classification model. Our results found that the maximum value of the signal, Hjorth complexity, variance, kurtosis, and Higuchi's fractal dimensions are crucial for EEG-based authentication. Further, our model achieved the highest accuracy, sensitivity, precision, and F1 score of 81.22%, 82%, 83%, and 80% respectively. In conclusion, the proposed pipeline highlights their potential to enhance the efficiency of EEG-based biometric systems, through critical features.

Keywords: Biometric; Electroencephalography; Emotions; Optimal Features; Machine Learning

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360_IEC71472 ➲

Revolutionizing Cancer Drug Development with Artificial Intelligence: Navigating Patent and Licensing Challenges

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Introduction: Cancer is an international medical concern. Owing to its great heterogeneity, patients with the same tumour may respond differently to the same medications or surgical techniques, necessitating the development of more precise tumour treatment techniques and patient-specific personalised treatments. To design focused treatment options for patients, it is imperative to have a thorough understanding of the changes that tumours experience, including changes in their genes, proteins, and cancer cell morphologies. Precise therapy of tumours is fundamental.

The era of Artificial Intelligence (AI) is transforming cancer drug development through enhanced efficiency in drug discovery, target identification, and patient response prediction. AI algorithms are capable of analyzing huge datasets and thereby can predict drug efficacy and toxicity. This can improve the drug design process significantly [1,2].

However, the "black box" nature of the AI systems, challenges that are found would include data diversity, model interpretability, and regulatory compliance [3,5]. Moreover, it is very crucial to ensure that AI applications are ethically sound and they have been validated through clinical trials for their successful integration into different cancer research strategies [4,6].

AI enhances drug efficacy and toxicity prediction by leveraging machine learning (ML) algorithms to analyze extensive datasets, identifying patterns that traditional methods may overlook. These algorithms can integrate diverse data types, such as genetic profiles and chemical structures, leading to more accurate predictions of how individual patients will respond to treatments and the potential side effects [7,8]. For instance, deep learning models can predict drug activity based on historical data, while classifiers combining chemical and gene expression features improve the accuracy of toxicity predictions [9,10]. This integration fosters personalized medicine by tailoring therapies to individual patient profiles [11,12].

Keywords: Precision Medicine, Artificial Intelligence, Cancer Drugs, Patent, Legal Personality

Biomedical Science & Technology

Biomaterials, Tissue Engineering, and Regenerative Medicine

42_IEC32451 ➲

Study on Structure and Properties of Bioactive Bioceramic Biomaterial obtained from Marine Shell Species Magallana Cuttackensis

Subhasis Nath[1]✉, Rajib Gupta[2], Sampurna Mukherjee[3], Debdut Roy[3], Adnan Hossain[3], Soumya Mukherjee[4], Sourav Debnath[5], Sujan Krishna Samanta[3] & Akshay Kumar Pramanick[2]

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Abstract: Calcium is an important element in our body having multiple roles in bone building, Blood clotting pathways, muscular activities, nervous transmission, Hormonal regulation etc. This study reports on the preparation, characterisation and structural analysis of calcium rich Marine shell bioceramic biomaterial from a marine shell species Magallana Cuttackensis. The heat treated shells were converted to a bioactive bioceramic biomaterial by using a wet chemical precipitation synthesis technique Phase analysis from XRD data revealed the presence of hydroxyapatite phases Bonding analysis by FTIR shows the functional group for OH^{-}, $PO4^{2-}$, $CO3^{2-}$. Morphological features are noted from scanning electron microscopy (SEM) data that execute pore formation while the mechanical properties like hardness data of the developed pellets are observed to be similar to the reported research studies. Conventional antibacterial studies, bioresorption analysis hemocompatibility cell toxicity and Clotting Time (CT) proved that the developed material is biocompatible with potential utilization as a bone healing agent or as an accelerator for blood clotting.

Keywords: Marine Shell; HAP; Bioresorption; Bonegraft; Biocompatibility

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147_IEC29315 ➲

Wound Healing with the Controlled Degradation of Biomaterial

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Abstract: Importance of wound healing in context of scaffold degradation cannot be overstated, as timing and manner of scaffold degradation directly influence healing process. In present study, a bio-composite scaffold (Chitosan: Polyvinyl alcohol, polyvinyl alcohol: Centella Asiatica, Centella Asiatica: Chitosan, Silk Fibroin: Chitosan, silk fibroin: Centella Asiatica) and explicit scaffold were considered for different hemocompatibility, anticoagulant assay and characterization study. In addition to this for scaffold degradation, explicit scaffolds as well as poly electrolyte complex (chitosan: Gelatin and chitosan: Alginate) scaffolds were fabricated. In the current study, scaffold deterioration was evaluated in presence of perfused media. Study found that the maximum degradation of chitosan: alginate (20:80) PEC based scaffold occurred at flow rates of 2 ml/min and 0.5 ml/min. Alginate-based scaffolds degraded almost 80% from their original weight, with slower degradation at 2 ml/min. FTIR analysis reveals different functional groups amide I, amide II and amide III for silk fibroin. Likewise for Centella Asiatica extract are phenolic groups and alkyl halides. Silk-I (alpha form) and Silk II (beta form) found at diffraction peaks 20–21° and 28° respectively according to XRD analysis. PVA/silk fibroin has the highest swelling ratio (77.5%) and Silk fibroin /Centella Asiatica have shown maximum serum adsorption capacity.

Keywords: Anticoagulant; Bio-composite; Degradation; Hemocompatibility; Perfused Media

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311_IEC95743 ➲

Degradable Microcarriers and their Role in Stem Cell Expansion and Hard Tissue Organoid Development

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Abstract: Microcarriers are extremely small particles that have been thoroughly studied for usage as medication carriers and in cell production. Their diameters range from 50 to 400 μm[1]. The biomedical industry has shown a great deal of interest in microcarriers with flexible designs, materials, and sizes for wider use in tissue fabrication, 3D bioprinting, and in vitro disease modeling platforms[2]. The use of microcarriers to scale up cells for use in cell therapy applications is growing in popularity. More simplified scale-up, process robustness, cost-effectiveness, and regulatory compliance are needed as cell therapies are employed in clinics more often[2]. One of the most thoroughly studied cell-based medicinal products, mesenchymal stem cells (MSCs) have been shown to have significant applications in tissue regeneration, immune-mediated regulation, and repair[3]. Owing to the constrained quantity of adult stem cells that can be extracted from patients, it is imperative to produce substantial quantities of stem cells extracellularly in a cost- effective way. An environment optimal for the large-scale generation of adherent cells may be created by combining stirred-tank bioreactors with the well-established technology of microcarriers in the biopharmaceutical sector[2]. The fabrication of in vitro tissue engineering models for drug screening and organ-on-a-chip platforms, as well as in situ tissue regeneration as a "one-size-fits-all" platform for minimizing highly invasive surgical procedures, have both been documented as intriguing uses for microparticles[4]. Presently, scaffold-free spheroid cellular aggregates are produced by 3D cell culture techniques, which hold great promise for supplanting traditional 2D cell culture methods. While they can more accurately and geographically reproduce the milieu of physiological tissues, they nevertheless have some drawbacks that may be resolved by incorporating biomaterials—such as micrometric particles—into the cellular constructions[5]. The development of biodegradable implants for bone tissue engineering has been impeded by the lack of biocompatible materials[2]. Therefore, optimizing bioactivity by altering the composite's surface is crucial for bone regeneration. The ratio of surface area to volume of microcarriers is their most important characteristic because it allows for the development of huge cell populations in a relatively small culture vessel while using less growth media[6]. For cell development and harvesting, the matrix materials utilized in the creation of microcarriers are essential. For instance, polylysine, poly(N-vinylguanidine), and poly(N-isopropylacrylamide) (PNIPAAm) surface coatings on microcarriers may promote MSC cell attachment, bead-to-bead cell transfer, nutrient perfusion, and differentiation into a range of target mature cells[2][7].

Furthermore, one of the most innovative areas of tissue engineering and regenerative medicine is the fabrication of engineered tissues, which has been made possible by microcarriers' bottom-up assembly. The current developments of biopolymer-based microcarriers—particularly polysaccharides like chitosan, chitin, cellulose, hyaluronic acid, alginate, and laminarin—for 3D cell culture and the creation of engineered tissues based on them are thoroughly examined in this study[8].

Keywords: Microcarriers; Mesenchymal; 3-D Bioprinting; Fabrication; Tissue Engineering; Regenerative

358_IEC24648 ➲

Microstructural Characterization and Corrosion Analysis of HA/TiO_2 and HA/ZrO_2 Composite Coating on Ti-Alloy by Laser Cladding

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Introduction: Titanium alloys, particularly Ti-6Al-4V, are favored for orthopedic implants due to their strength, bio-inertness, and corrosion resistance. However, in physiological environments, Ti implants can release metallic ions, which may cause adverse effects. Hydroxyapatite (HA) coatings improve bioactivity but lack mechanical strength and adhesion. To address these issues, this study investigates laser cladding of HA/TiO_2 and HA/ZrO_2 composites on Ti-6Al-4V. Laser cladding provides precise microstructural control, resulting in a dense, well-bonded, corrosion-resistant coating with enhanced biocompatibility, which could better support bone integration than conventional plasma-sprayed coatings.

Keywords: Composite Cladding; Hydroxyapatite (HA); Titanium Dioxide (TiO_2); Zirconium Dioxide (ZrO_2); Corrosion Resistance

Biomedical Science & Technology

Biomedical Imaging-Sensing and Instrumentation

18_IEC82925➲

Cancer Detection by Integrated Optic Devices: A Digital Signal Processing Approach

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Abstract: Digital signal processing and optical communication have an important spin-off in the form of biosensor at improving human health by relaying real-time biometric data. Proposed label-free integrated optic single ring resonator (SRR) with high-Q is designed and analysed to exhibit high sensitivity and high selectivity against five different common cancer cells. The Q- factor in this study varies around 5600. Distinct resonant peaks for different affected blood samples with respect to normal blood sample give an insight on the affected cells. This integrated optic device can seamlessly be integrated with the CMOS ecosystem with distinct advantages in terms of size, weight, power consumption, and cost.

Keywords: Single Ring Resonator; Mason's Rule; Delay Line Signal Processing; Q-Factor; FWHM; Sensitivity

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19_IEC33118 ➲

A Web based Tool for Spinal Cord Tumor Classification from MRI

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Abstract: This paper presents a prototype developed to validate the concept of integrating machine learning into medical diagnostics without requiring prior machine learning knowledge from users. The prototype features an embedded machine learning model within a user-friendly interface, designed to facilitate ease of use by healthcare professionals. Inputs such as MRI scans and patient demographics are processed by the model, which employs advanced algorithms to classify spinal cord tumors based on patterns learned from historical data. The classification results are displayed to provide healthcare professionals with essential diagnostic insights. Moreover, the performance of the tool is compared with gold standard diagnoses to assess its effectiveness. Preliminary results indicate that our prototype has the potential to enhance diagnostic accuracies, thereby contributing significantly to the field of medical diagnostics.

Keywords: Spinal Cord Tumors; MRI; Convolutional Neural Networks; Machine Learning; Web-Based Tool; Gold Standard Comparison; Cohen's Kappa Statistics

173_IEC50993 ➲

Graphene FET Biochips on PCB for Exosome based Early Screening of Cancerous Cells

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Abstract: Tumor-derived exosomes (TEXs) are particularly significant in cancer, potentially serving as cancer prognostic markers. In recent years, several sensor technologies have been developed for exosome detection, including potentiometric sensors, electrochemical methods, capacitive sensors, fluorescence methods, and surface-enhanced Raman scattering. However, most of them lack the capability to detect at early stage. In this context, field effect transistor (FET) biosensor enables rapid, sensitive and label-free detection approaches. However, most of the FET based devices require sophisticated fabrication facilities which are often not economical. Herein, the work demonstrates a robust, custom-built scalable FET biosensor employing thermally reduced graphene oxide as sensing material designed on affordable PCB platform to achieve sensitive and reliable early detection of exosomes from lung cancer cells. The proposed device has the ability to detect 104 exosomes/ml which is comparable to the detection limit reported by other FET biosensors deploying cost intensive fabrication procedures. This unfolds the potential for effortless translation of graphene FET biochips on PCB platforms which additionally promises clinical translation capability as pre-screening device.

Keywords: Graphene FET; PCB Biochips; Exosomes; Thermally Reduced Graphene Oxide; Scalable

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177_IEC5681 ➲

A Comprehensive Review of Sensors in Medical Application

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Abstract: The healthcare industry is experiencing paradigm shift from conventional healthcare system to healthcare 5.0 standard to provide patent centric service. The healthcare 5.0 standard integrates various technologies such as IOT, Artificial intelligence, Machine learning and cloud computing. One of the requirements of such a healthcare system is reliable sensing solution to accurately measure and transmit the measured data by using IOT technology. The different types of sensors are available for measurement of healthcare parameters. The electronic sensors have proven their usefulness in biomedical applications, but they have limitations to support healthcare 5.0 standard. The electronic sensors are not suitable in radio frequency and electromagnetic based environment which affects the accuracy of measurement. Implanting the electronic sensors with radiating signals is not advisable for continuous monitoring of patients' healthcare parameters. In recent years, remarkable progress has been noticed in development of sensors for clinical diagnosis and treatment. The development of optical fiber sensors have proven the most promising solution for rapidly changing healthcare standard. The optical fiber sensors have compact size, immunity to electromagnetic interference and high sensitivity. The optical fiber sensors are also useful for wearable sensor technology due to its compact size and light weight. The optical fibre sensors have ability to support multiplexed and distributed sensing solution to meet the rapidly changing healthcare standard. This paper reviews the different types of sensors, their working principle, limitations and medical applications.

Keywords: Healthcare Parameters; Electronic Sensors; Optical Fiber Sensors; Wearable Sensors

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209_IEC3920 ➲

Microwave Imaging: Using Gradient Method and Biconjugate Gradient Methods for Breast Cancer Detection

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Abstract: The reconstruction problem for microwave imaging (using Tomographic method) is investigated in this work using gradient-based optimization and Biconjugate gradient-based optimization. For high-dimensional linear systems design, the incident fields can be resolved for each assessment of the cost function and its gradient, with a significant number of computations. Here we used Biconjugate gradient algorithm, with effective implementations unique to the microwave imaging context. To compare with the conventional gradient method, Biconjugate method computational time savings and get the better resolution, according to numerical experiments conducted on synthetic data set (collected from HFSS) observations. Breast models with cancerous area and without cancerous area (dielectric properties of tissues) are compared with Gradient method and Biconjugate gradient method, the results are quite similar but for Biconjugate methods the accuracy and resolution of images are high.

Keywords: Microwave Imaging; Gradient Method; Biconjugate Gradient Method; Microwave Tomography; Breast Cancer Detection

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229_IEC34826 ➲

An IoT-based Smart Health Monitoring Wheelchair System for Physically Challenged People

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Abstract: The research work presents a comprehensive study on an Internet of Things (IoT)-based smart wheelchair that offers complete mobility support in addition to real-time health monitoring, AI (Artificial Intelligence)-driven illness prediction, and a facial expression detection system. In contrast to traditional wheelchairs, our technology incorporates cutting-edge biomedical sensors to continuously track vital signs like blood pressure, oxygen saturation, heart rate, body temperature, and ECG (Electrocardiogram) monitoring. Furthermore, the wheelchair integrates fall detection capabilities and tracks the user's movement patterns to improve safety.

The wheelchair has Internet of Things (IoT) capability to enable seamless and smooth data transfer to a cloud-based platform, enabling caregivers and medical professionals to connect with their patients and also to monitor them remotely. It also enables them to create customized care plans, and have virtual consultations. Early diagnosis and predictive analysis are made possible by the AI-powered system used to gathered data to identify possible health problems. With the Internet of Things (IoT) technology installed in this cutting-edge wheelchair, users may have their entire health status tracked in real-time. The goal of this research is to develop assistive gadgets into all-encompassing health management systems rather than just basic mobility aids. This paper covers the creation, testing, and design of the smart wheelchair.

Keywords: IoT; Smart Wheelchair; Predictive Analytic; Assistive Technology; Biomedical Engineering; Preventive Healthcare

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322_IEC2424➲

Container Filling System for Radioactive Materials

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Abstract: The present paper relates to systems for filling containers with radioactive and/or other types of potentially hazardous materials. The systems include a shielding material that substantially defines a chamber that substantially blocks radioactivity, a conduit extending from outside to into the chamber, and a unit that is disposed in the chamber proximal to the conduit and is adapted to receive a capsule through the conduit.

The container filling system specifically comprises: a. a dispensing chamber that is made of a shielding material, and having:

(i) a first side opening;
(ii) a second side opening;
(iii) at least one rod inside the dispensing chamber that vertically extends outside and above the dispensing chamber for manipulating the position of a syringe that is located inside;
(iv) a chute manipulator extending vertically inside and outside the dispensing chamber for sliding a capsule inside the dispensing chamber;
(v) a capsule securing unit having at least one receptacle has a size adapted to tightly receive a capsule that has slid inside the dispensing chamber; and
(vi) (a) shielded window for allowing a user of the system to see the syringe and capsule securing unit;
  (b) a loading chamber that is made of a shielding material, and having a first side opening and second side opening, the second side opening is in communication with the first side opening of the dispensing chamber, the first side opening provides access to a user hand for introducing a material;
  (c) a sliding door for alternatively closing and opening the first side opening of the dispensing chamber and therefore closing communication with the loading chamber;
  (d) a door for alternatively closing and opening the second opening of the dispensing chamber;
  (e) a syringe controller for controlling the syringe;
  (f) a computer that activates the syringe controller; and
  (g) a waste container located at a level within the system that is lower than a level at which the dispensing chamber or the loading chamber are located within the system, wherein the waste container is made of or surrounded by a shielded material and comprises a first waste chute interconnecting the dispensing chamber or the loading chamber to the waste container and allowing waste material to slide into the waste container.

Keywords: Radiopharmaceuticals; Radiochemistry; Syringe; Shielded Cells; Diagnostic Equipment

346_IEC99079 ➲

Leveraging Force-Sensing Technology for Personalized LBP Care: A Scoping Review

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Abstract: Low back pain (LBP) remains a significant global health burden. This review explores the potential of non-invasive force-sensing technology to revolutionize LBP diagnosis and treatment. By accurately measuring abdominal wall tension (AWT) and intra-abdominal pressure (IAP), force sensors offer a promising avenue for personalized rehabilitation strategies. Existing studies demonstrate the feasibility and reliability of force-sensing techniques in assessing core muscle activity and spinal stability. However, further research is needed to validate their clinical utility in LBP patients, establish standardized protocols, and address ethical considerations. Future directions include integrating force-sensing with biomechanical modeling and patient-reported outcomes to optimize personalized LBP care. The adoption of non-invasive force-sensing technology holds the potential to transform LBP management by providing objective, real-time data for tailored interventions and improved patient outcomes.

Keywords: Abdominal Wall Tension (AWT); Intra-abdominal Pressure (IAP); Force Sensor; Core; LBP

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347_IEC85073 ➲

The use of Thermal Test, Electric Pulp Test and use of Modified Pulse Oximeter for Assessment of Pulpal Status of Permanenet Mature Teeth

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Introduction: The sensory fibers in dental pulp are primarily nociceptors classified into A-delta (A∂) and C fibers. While A∂ fibers have a low threshold and are responsible for conducting pain in reversible inflammation, C fibers, with a higher excitation threshold, indicate irreversible pulpal inflammation when activated[1]. Traditional pulpal sensibility tests, such as heat, cold, and electric pulp tests, evaluate neural responses to these stimuli but often fail to provide accurate readings regarding pulp vitality, especially in cases with an open apex, recently traumatized teeth, or geriatric patients. These tests are subjective, relying heavily on patient responses, which may result in false positives or negatives [2]. The use of Pulse oximeter to assess the vitality of teeth was first assessed by Schnettler[3]. Setzer[4] et al. concluded "pulse oximeter can be used as valid measurements for the assessment of different stages of clinically diagnosed pulpal inflammation and may be a valuable adjunctive tool for clinical diagnosis". Bargrizan et al.[5] concluded "the pulse oximetry was effective in assessing oxygen saturation because it confirmed the avascularity of the root filled tooth". The use of a pulse oximeter, a non-invasive device traditionally used to monitor blood oxygen saturation, has been proposed as an objective alternative to evaluate pulpal vitality.

This study aims to design a modified pulse oximeter probe suitable for use on permanent adult teeth and measure the pulp oxygenation rates (%SpO_2) in teeth diagnosed with various pulpal conditions — irreversible pulpitis, and pulpal necrosis—and to establish whether SpO_2values can be reliably used to assess the vitality of the pulp.

Keywords: Pulse Oximeter; Pulpal Inflammation; Pulpal Oxygen Saturation; Dental Vitality Testing; Pulpal Diagnosis

Biomedical Science & Technology

Genomics, Bioinformatics, and Synthetic Biology

87_IEC2144 ➲

Phase Response Synchronization using Fractional Kuramoto and Repressilator Models

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Abstract: Generating electrical oscillations through the synchronized activity of networks of neurons, is an intriguing feature of the brain, commonly termed as neuronal synchronization. Several researchers have employed the classical Kuramoto model with appropriate modifications to explain this phenomenon. However, the existing models have scope of improvements in terms of reducing the computational effort and making it more physics-based. In this paper, we first generalize the classical Kuramoto model by replacing the integer-order derivative by a derivative of fractional order. This is carried out to account for the deficiencies shown by integer-order models to explain the real physical systems. Simulation results show that the fractional dynamics can lead to the generation of chimera states for neurons, setting the coupling strength at a lower value than the critical coupling strength. Next, we make some revisions in the fractional Kuramoto model and study the effect of an external stimulus on phase response synchronization of a simple ten-oscillator system with time-varying coupling strength and time delay. Simulation results attached here with demonstrate the occurrence of chimera states for various combinations of stimulus intensity, stimulus frequency, and coupling schemes. Also, we show that for higher stimulus frequency, the oscillators get synchronized in both the cases of weak and strong coupling. However, the stimulus intensity has very little effect in case of strong coupling. A popular concept in Synthetic Biology deals with the generation of limit cycles in protein concentration using repressilator model. We have translated a new application of the repressilator model by synchronizing nine repressilator rings to study the synchronization characteristics. Generally, these models are used for emulating the protein synthesis system, wherein the output of three oscillators are synchronized through a Hill Function based model. By modifying the system output in terms of phase stabilization, we have shown interesting potential of the model for the synchronization of the oscillators. We have included the results of simulation of a three pairs of triplet oscillators and shown their convergence with time. Furthermore, this work opens a direction of research whereby studies might offer more insight into the phenomenon of neural synchronization by integration of fractional derivatives and repressilator models.

Keywords: Electrical Oscillations; Neural Synchronization; Fractional Kuramoto Model; Chimera States; Phase Response Synchronization

376_xxxxxxx➲

Farming the Future: Revolutionizing Agriculture with Gene Editing to Tackle Food Insecurity

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Introduction: The path to secure a country's future is through grains, not guns. This emphasizes the importance of addressing food security[1]. Currently, there are about 840 million people with constant starvation and 3 billion individuals facing nutritional deficiencies mostly seen in developing countries. To address this concern, strategists must focus on increasing agricultural productivity using various gene editing techniques to enhance crop tolerance to combat various challenges[2].

By combining traditional plant breeding methods with the modern plant breeding techniques is crucial for enhancing agricultural productivity and crop resistance[3]. Gene editing is a term that encompasses various molecular techniques[4]. Some of the techniques of gene editing are- CRISPR-CAS9, TALENS, ZFNS, etc., of which CRISPR-CAS9 is the most versatile and known technique for crop production and protection[3]. This technique allows researchers to modify gene function in plants and animals without using the foreign DNA. By introducing genetic variation within the crops, it increases productivity, disease resistance, and tolerance to various environmental stresses. By increasing crop resilience and productivity, CRISPR-CAS9 has been playing a vital role in addressing barriers like food security and supporting sustainable agricultural growth [5]. This article focuses on the application of gene editing technology for crop enhancement through CRISPR-CAS9 techniques.

Keywords: Gene Editing; Crop Production; Food Insecurity; CRISPR-CAS9; Disease Resistance; Biofortification; Agriculture

Biomedical Science & Technology

Interdisciplinary Biomedical Research

160_IEC59332 ➲

Potential Mechanisms of Selected Intracellular Metabolites on HEWL Aggregation: Insights from Endpoint Assays, Aggregation Kinetics and Computational Studies

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Introduction: Protein misfolding diseases cause Neuropathic and non-neuropathic pathological conditions in humans, mainly due to protein misfolding and the subsequent formation of amyloid or aggregates. Amyloid plaque, characteristic of various neurodegenerative conditions, is an ordered structure, mostly fibrous [1]. The acceleration in the rate of amyloid deposition is supposedly a primary event in the pathogenesis of Alzheimer's disease (AD). A wide array of endogenous factors could affect the rate of amyloid formation in vitro and play a role in the pathogenesis of AD [2]. Cellular systems have their quality control mechanism, which maintains a balance between protein production and degradation. Deregulating these systems could prove vital for being a causative factor in various diseases, primarily neurological disorders and systemic amyloidosis [3-5]. Nucleotide balance is an essential factor in both dividing and quiescent cells. The emphasis is more on neural tissues as there is a high rate of metabolism and, hence, a high requirement of ATP [6] for proper functioning. One exciting aspect of protein misfolding diseases that has come into being is the existence of intermediates during the formation of amyloid fibrils or complete protein unfolding. These oligomeric intermediates are potentially more cytotoxic and have also increased the scope of further research [7].

The current study aims to elucidate the effect of selected nitrogenous bases viz—cytosine, guanine, thymine and uracil, and nucleosides viz. adenosine and guanosine on amyloid formation using HEWL amyloids as a model. Further investigations have also been made for the possible formation of intermediate states and monitoring of structural changes, morphology and shape of the possible oligomers and amyloid fibrils using extensive spectroscopic and imaging analysis. Another aspect investigated includes the effects of these molecules on modulating the oligomeric state towards a more fibrillar state, which is potentially less toxic. The study employs extensive use of spectroscopic and microscopic techniques and complementary Thioflavin T aggregation kinetics to gain valuable insights into establishing a potential mechanism that the ligands exhibit depending mainly on the dynamic behaviour of proteins based on pH. Lastly, extensive computational methods have also been utilised, like molecular simulation studies based on previous molecular docking studies, to gain more insights into the possible mechanism of the effect of metabolites on the model protein.

The data suggest the anti-amyloidogenic nature of these metabolites. Primary results indicate that the metabolites can drive the hen egg-white lysozyme towards forming aggregates over 120 hours in near physiological pH. Further, when added to soluble aggregates/oligomers at near physiological pH, the results indicate these ligands convert them towards more matured fibrils as measured by Thioflavin T (ThT) binding and atomic force microscopy. Detailed investigation of ThT binding kinetics showed that these ligands at physiological pH modify key microscopic protein aggregation processes depending on the step of aggregation they are introduced in. The study has also shown a significant decrease in the aggregation index of the protein solutions incubated with various selected metabolites. Surprisingly, turbidity and UV scattering intensity of the preformed oligomers at physiological pH decrease, which may be due to an overall decrease in scattering due to the presence of large aggregates in the solution. Moreover, the molecular simulation studies also indicate that these metabolites have stable binding at amyloidogenic sites of HEWL and possibly prevent amyloid by inhibiting intermolecular interactions. The study provides aspects for investigations of these metabolites as protein aggregation modifiers and potential therapeutics in neurodegenerative diseases.

Keywords: Lysozyme; Protein Aggregation; Neurodegenerative Diseases; Intracellular Metabolites; Aggregation Kinetics

239_IEC96327➲

Facial EMG based Approach for Investigating the Activation of Zygomaticus Major during the Articulation of Malayalam Phonemes

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Abstract: The coordinated action of various facial and vocal muscles facilitates speech. Facial muscles show distinct levels of activation depending on the words being pronounced. Investigating muscle activation while articulating different words may contribute to developing speech-assistive devices. In this work, the activation of Zygomaticus major muscle during the articulation of fifteen Malayalam syllables is studied using surface electromyography (sEMG) signals. Signals are recorded from twenty-one healthy female subjects using standard protocols. Features namely root mean square (RMS) and mean frequency (MNF) are extracted from the recorded signals, and the syllables related to the minimum, and maximum activation of the Zygomaticus major are identified. Results indicates that the highest mean values of RMS equals to 1.1E-02 obtained for the phoneme അം (am), indicating the maximum activation of the muscle during the articulation of this phoneme. The minimum activation is noticed while articulating the phoneme ആ (aa). However, MNF exhibited a maximum value of 83.22 Hz for the phoneme ഊ (uu). In addition, the syllables ഒ (o), ഓ (oo), and ഔ (au) exhibited similar level of activation. Thus, the extracted sEMG features are found capable of reflecting the distinct activation of Zygomaticus major muscle for various Malayalam syllables. The proposed study may be used to identify the other facial muscles involved in the pronunciation of various syllables that contributes to human machine interfacing and developing speech aids for people suffering from speech disorders.

Keywords: Facial sEMG; Malayalam Language; Silent Speech Recognition; Swaraksharas; Zygomaticus Major

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305_IEC44147 ➲

Bidirectional Gated Recurrent Unit based Recurrent Neural Network for the Real-Time Prediction of Epileptic Seizure Stroke

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Abstract: Epilepsy, a prevalent chronic neural disorder, affects millions worldwide, emphasizing the critical need for timely detection and treatment. This research explores the development and performance evaluation of four distinct model architectures for epileptic seizure detection cases using EEG signals. The dataset is strategically preprocessed, focusing on the detection of epileptic seizures. The proposed models, namely Recurrent Neural Network (RNN), Modified Recurrent Neural Network (Modified-RNN), Gated Recurrent Unit based RNN (GRU), and Bidirectional GRU-based RNN (Bi-GRU), are evaluated over the various metrics. Results demonstrate a notable progression in model performance, demonstrating significant advancements in accuracy, precision, and sensitivity. The bidirectional

GRU-based model emerges as the most effective architecture, providing a promising solution for accurate epileptic seizure detection with more than 99% accuracy for all binary data clusters and almost more than 95.5% for all trinary data clusters. This was then used to deploy a web-based application that predicts epileptic activity in a patient's brain. These findings underscore the potential of advanced neural network architectures for enhancing diagnostic capabilities and improving patient outcomes in epilepsy management.

Keyword: Epileptic Seizure Detection, Electroencephalogram, Deep Learning, Recurrent Neural Network (RNN), Gated Recurrent Unit (GRU)

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317_IEC70450 ➲

A Numerical Investigation of Thermal Transport for Magnetic Fluid Hyperthermia in Breast Tissue with Lobular Carcinoma

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Abstract: Conventional treatment methods for malignancy often face efficacy challenges specifically for advanced stage cancers or after prolonged treatment exposures. Magnetic Fluid Hyperthermia (MFH) treatment is found to offer promising outcomes in unison with the existing treatment methods like chemotherapy, surgery, radiotherapy, immunotherapy, etc. Rapid advancement in nano-science has led to the synthesis of super-paramagnetic nanoparticles (SPNs) which has gained confidence in MFH as a promising novel treatment therapy. The present numerical study explores the thermal transport phenomena due to infused surface modified super-paramagnetic iron oxide nanoparticles (SPIONs) of volume concentration 0.003, infused into a spherical tissue-tumour geometry of breast tissue and exposing to an alternative magnetic field of tolerable ranges with field strength (H0) of 5518 A/m and frequency (f) of 300 kHz which is within the Atkinson–Brezovich limit. The results presented includes the trajectory of spatial temperature distribution across the geometry, temperature contour representing temperature rise at the centre of the tumour and tissue tumour periphery when the treatment is carried out for 500 sec. Considerable damage at the tumour region with negligible baneful effect to the adjoining healthy tissue can be concluded. However further regulation of temperature to restrict the rise to hyperthermic levels of around 42-45ºC may be a future scope from this study.

Keywords: Magnetic Fluid Hyperthermia; Super Paramagnetic Iron Oxide Nano Particles; Alternating Magnetic Field; Cancer; Breast; Lobular-Carcinoma

326_IEC32863 ➲

Interaction Dynamics of Pristine and Pt-decorated ZnO Nanosheet during Cytosine Adsorption: A Robust Electro-Chemical Analysis of Biosensor

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Abstract: The performance of pristine and platinum (Pt) decorated ZnO nanosheets in detecting cytosine (C) nucleobase was compared in the current study, using a first principle computational study with Gaussian 09W and Gauss View 6.0 package. Cytosine, a pyrimidine nitrogenous base, was selected as the adsorbed biomolecule for both nanosheets. Two systems were involved: cytosine-adsorbed pristine ZnO nanosheet (case-A) and cytosine-adsorbed Pt-doped ZnO nanosheet (case-B). The interaction between the sensed molecule and the sensing material was analyzed using various electronic parameters such as molecular electrostatic potential, the total density of states, the lowest unoccupied molecular orbital (LUMO), the highest occupied molecular orbital (HOMO), and Mulliken charge analysis. It was inferred that the Pt-doped ZnO nanosheet was a better sensing material, exhibiting strong adsorption energy (-1.421 eV) and a decreased binding distance (2.215 Å) compared to the pristine ZnO nanosheet, which had an adsorption energy of -0.377 eV and a binding distance of 2.707 Å. The importance of accurate detection and sensing of cytosine in our body was elucidated, helping in coding for proteins and regulating gene expression.

Keywords: Cytosine; Pt-ZnO Nanosheet; Density of State (DOS); Mulliken Charge; Molecular Electrostatic Potential (MEP)

<u>Biomedical Science & Technology</u>

Microbiology, Virology, and Evidence-based Medicine

202_IEC34121 ➲

Evaluation of Lactic Acid Bacteria from Chilli and Capsicum Stalks (Calyx) as a Starter Culture for Curd (Dahi) Preparation

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Introduction: Chilli stalks (calyx) are a known source of lactic acid bacteria, namely Lactobacillus acidophilus and Streptococcus thermophilus. Recently the potential of chilli stalks as a starter culture for fermented milk products has gained attention owing to the mass media. However, use of chilli calyx to induce fermentation in milk is not a new practice; the root of the tradition lies in ancient South Indian and Mexican cuisines. Freeze-dried started cultures are reportedly expensive and unavailable in most market-places. Store-bought and packaged products often contain additives that make them unsuitable to be used as a starter culture. Another issue is the decrease in production potential of active starter cultures over time due to various environmental reasons. Hence, this practice of repurposing food waste promotes sustainability and accessibility of affordable food products. Although, a few studies have evaluated the quality of curd produced by chilli calyx, the microbial nature of the starter culture and the chemical aspect of the production have still been largely unexplored. In one study, capsaicin, the major chemical compound present in chilli, has been reported to increase the production of lactic acid in lactic acid bacteria. The role of capsaicin in curd production, however, has not been studied yet. In this study, lactic acid bacteria were isolated from green chilli, capsicum, and bell peppers and evaluated on their ability as a starter culture. The whole calyx as well as the isolated bacteria from the said calyx were evaluated based on their potential of fermentation mainly focusing on the followings: total time required for initiation of curdling, change in pH, titrable acidity (lactic acid), sugar (lactose) content, and syneresis of end product. The obtained data then were compared with the same from conventional method.

Keywords: Chilli; Capsicum; Starter Culture; Curd; Lactic Acid Bacteria; Capsaicin

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315_IEC95247 ➲

Wastewater Testing for Surveillance of Covid-19 Outbreaks at a Ward Level: Emerging Insights from Bangalore City in India

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Introduction: After the outbreak of COVID-19 all over the world, responses like lockdown, testing, tracing, and vaccination were executed commonly. However, when faced with limited resources, the efficient distribution of the available resources has proved to be a problem in the control of the pandemic in some places. Wastewater monitoring

services can proactively find novel solutions, therefore, they can be used for timely detection of the hotspots and most importantly for the right resource distribution.

The first COVID-19 case was detected in India on January 30, 2020, and by the middle of May 2021, more than 25 million cases had been added during the second wave[1]. Limited testing and tracing resources[3,4] force the adoption of alternate pathways such as wastewater monitoring to act as the first signal. Along with the other coronaviruses, SARS-CoV-2 also excretes RNA through the feces[5], and by the sewage scrutiny, the viral RNA was traced out 4-10 days earlier than the actual clinical cases ever were[6,7,8], leading us to believe wastewater study a cost-effective mechanism for monitoring purposes[9].

Although there is a relationship between the levels of the sewage's RNA and the number of cases in a community[13,14], the problems including the existence and survival of the virus in wastewater, natural elements such as temperature, or how the different RNA readings are parallel to the thwarting the infectivity in a community have to be still figured out. These defects make it necessary that further research be made into this topic.

Keywords: Wastewater Based Epidemiology; Wastewater Surveillance; Sewage Monitoring; SARS CoV2 Covid-19 Surveillance; Pandemic Prediction

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356_IEC9568➲

Analysis of Viral Proteins from Common Viruses of West Bengal using Bioinformatics Tools

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Introduction: The analysis of viral proteins for potential drug targets plays a pivotal role in modern infectious disease research, especially for regions with recurring outbreaks. In West Bengal, several notable viruses, including Dengue, SARS-CoV-2, and Japanese encephalitis, continue to pose significant public health challenges. By leveraging bioinformatics tools, researchers can dissect the molecular makeup of these viral proteins, unveiling their structure, function, and interactions with host proteins[1].

Bioinformatics tools allow for sequence alignment, structural modelling, enabling researchers to predict the unique amino acid sequences present in viral proteins of different strains that are essential for viral replication and pathogenicity of that specific virus strain. The computational analysis further aids in understanding viral evolution[2]. Thus, the combination of bioinformatics and virology offers a strategic framework for understanding viral infections endemic to West Bengal, contributing to global efforts in controlling viral diseases.

Keywords: Virus; NCBI; PDB; West Bengal; Protein; Drug Target

365_IEC93161 ➲

Natural Synergy: Neem and Honey as a Biocompatible Oral Irrigant for Enhanced Dental Care

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Abstract: This study evaluates the potential of a natural oral irrigant combining Neem (Azadirachta indica) and honey as an alternative to sodium hypochlorite, a conventional endodontic disinfectant known for its potent antimicrobial properties but also for drawbacks such as cytotoxicity, strong taste, and patient intolerance. Neem, with its broad-spectrum antibacterial, antifungal, and anti-inflammatory properties, offers a more biocompatible option, though its bitterness reduces patient acceptability. Honey, known for its antibacterial and wound-healing benefits, complements Neem's effects while making it more palatable. This research analyzed the antimicrobial effectiveness of Neem-honey extracts on bacterial cultures from infected root canal samples and compared them to sodium hypochlorite. The findings revealed that a 1:5 Neem-honey dilution demonstrated superior antibacterial efficacy without the harsh side effects associated with sodium hypochlorite, suggesting it as a viable alternative for endodontic irrigation.

Keywords: Oral Irrigant; Neem, Honey; Sodium Hypochlorite; Biocompatible

Biomedical Science & Technology

Neural and Rehabilitation Engineering / Technology

179_IEC54384 ➲

Need for Wearables in Generating EHRs for Physical Rehabilitation Sector, Pheezee® — A Case Study

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Abstract: In the era of digital health, electronic health records (EHRs) are becoming the norm for storing and analyzing patient data. Data not only aids in clinical decision-making but also has the potential to help in achieving better clinical outcomes during patient recovery. Recently, wearables are seen to play a crucial role in creating EHRs, especially in a home-based care setting where traditional bulky machines cannot be deployed for continuous monitoring of patients. Pheezee®, an USFDA-listed [510(k) exempt] novel prognostic app-based wearable device for the rehab sector, has established itself to have huge potential in generating patient-specific ailment records in a scientific manner, thereby establishing the concept of EHRs in a clinical rehab setting. It consists of range of motion (ROM) sensors and a surface electromyography (sEMG) bio-amplifier that can be used for assessment, monitoring, and tracking of the recovery of patients via shareable scientific reports. The objective is to integrate the multi-sensory information from the device into an EHR system through remote monitoring. Pheezee® acquires the movement and muscle contraction information in real-time and pushes the data to the cloud for postprocessing, thereby establishing a novel approach to introducing EHR in physiotherapy. The data is encrypted, stored in a secured format, and maintained through an effective database management system. This clinical data helps the healthcare providers track the patient's rehabilitation and propose patient-specific, tailor-made treatment protocols. In the future, this EHR data combined with AI/ML algorithms has the potential to be used not only for assessments but even for exact diagnoses. The AI/ML models can also open preventive and predictive clinical models for value-based insurance claims.

Keywords: Rehabilitation; Wearable Sensor; Electronic Health Record; Evidence Based Practice; Patient Adherence; Recovery Tracking

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302_IEC81438 ➲

Determining the Efficacy of using EEG Signals in Post-Stroke Rehabilitation Engineering Applications through a Pilot Study

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Abstract: Stroke is one of the major cause of disability globally. Monitoring recovery after stroke is crucial for assessing rehabilitation progress. Electroencephalography (EEG) plays a key role in stroke diagnosis and helps track patient's recovery. To facilitate restoration of lost motor function, post-stroke patients are instructed in a range of physical activities designed for Activities of Daily Living (ADL). This study assesses the EEG data collected from patients in rehabilitation from Day 1 to Day 30, focusing on pre and post exercise EEG data. Parameters such as Mean, standard deviation, and Power spectral density (PSD) were extracted as features from healthy and stroke subjects as a pilot study. A positive mean and change of PSD was seen as the rehabilitation progress, which signifies changes in brain activity. The finding shows that monitoring neural changes through EEG data can provide valuable insights into post-stroke recovery.

Keywords: Electroencephalography; Power Spectral Density; Stroke Rehabilitation

<u>Chemicals & Hydrocarbons</u>

Application of AI and ML

289_IEC20674 ➲

Digital Twin Implementation in RFCCU

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Abstract: Digital twin is a replica/virtual representation of the existing plant and using real-time data, the entire plant has been simulated using First Principles based process model to predict the output which enables decision making for plant optimisation. The RFCCU reactor model was developed and the same was further tuned for meeting actual plant conditions. Interfacing of the tuned reactor model with DCS was then carried out for getting real time model output at DCS panel. Digital twin is helping operators Product Yield prediction through processing various types and enables quick decision making for plant optimization.

Keywords: Digital Twin; Optimization; Simulated Model

<u>Chemicals & Hydrocarbons</u>

Gas Processing

236_IEC44090 ➲

Achieving Flowability for Enhancing Crude Oil Recovery using PIPESIM Software

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Abstract: This study outlines an effort to design and optimize a gas lift system utilizing Pipe SIM software. After depletion of primary pressure energy in an oil well, it is often installed the gas lift system to help extend oil recovery. The PIPESIM model analysis in this work considered gas lift design based on well completion data, reservoir fluid characteristics, and reservoir data. The temperature and pressure profile of the well system were taken into account for this analysis. The downhole condition of the well was replicated with an allotment of actual tubing and casing inside diameter, thicknesses, perforation details, and downhole completion information. Gas lift valve details, installation depths, and respective opening pressures were also incorporated into the model analysis. Finally, the work took into account sensitivity analysis, considering varying conditions to the gas lift system.

Keywords: PIPESIM; Gas Lift; Optimum Gas Injection Rate; Well Data, Pressure-Temperature, Reservoir Pressure

<u>Chemicals & Hydrocarbons</u>

Hydrogen Economy and Circular Economy

290_IEC23561 ➲

Green Hydrogen: Engineering and Safety Challenges

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Abstract: In recent years, hydrogen has gained much attention as an energy carrier in the pursuit of sustainable and clean energy. Its ability to decarbonise various sectors, from transportation to industry, has increased the interest in the production and storage of hydrogen. But as the hydrogen economy continues to grow, concerns have been raised about the safety of green hydrogen. Green hydrogen production is at the forefront of the transition to a sustainable energy landscape. Green hydrogen refers to hydrogen produced using renewable energy sources such as wind, solar power, or hydropower, and is considered one of the cleanest forms of energy. One of the main advantages of green hydrogen production is the possibility of storing surplus renewable energy: during periods of low energy demand, surplus electricity can be used to electrolyze water, splitting it into hydrogen and oxygen. This hydrogen can be stored for later use in a variety of applications, such as fuel cells and industrial processes, and can effectively act as an energy carrier and grid balancing tool. This article provides a review of hydrogen safety, and highlights the safety challenges in the electrolytic production, storage and transportation of green hydrogen.

Keywords: Climate Change; Renewable Energy; Hydrogen; Green Hydrogen

Chemicals & Hydrocarbons

Net Zero, Sustainability

162_IEC83477 ➲

Droplet Dynamics: A New Frontier in Energy Harvesting

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Abstract: Piezoelectric nanogenerators (PENGs) are a great option for developing renewable energy sources because of their adaptability, flexibility, and scalability. The kinetics of energy transmission and its implications for energy harvesting using piezoelectric mechanisms are emphasized in this research, which looks into the mechanics of droplet impact on a flexible cantilever-like surface. Surface wettability, droplet height, and impact speed are some of the characteristics that we simulate to find out how they influence surface deflection, force generation, and piezoelectric output. In order to better understand the intricate relationships between fluid dynamics and structural reactions, our research makes use of COMSOL Multiphysics. To optimize PENGs and make the most efficient use of the mechanical energy transferred by droplet collisions, it is essential to have a firm grasp of these interactions. Both the basic knowledge of energy harvesting systems and the creation of novel, environmentally friendly energy solutions with broad applicability are enhanced by this research.

Keywords: Nanogenerators; Piezoelectricity; Energy Harvesting; COMSOL; Energy Materials; Fluid-Structure Interaction

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195_IEC75237 ➲

Amine Functionalized Activated Carbon Sourced from Wood Dust for CO_2 Capture

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Abstract: This study focuses on the production of wood dust-derived amine functionalized activated carbon for CO_2 capture applications. Wood dust has been employed as the carbon precursor. A quick and scalable one-step procedure is used to attach long-chain amine groups, (3-Aminopropyl) triethoxysilane (APTES) & tetraethylenepentamine (TEPA), to the surface of activated carbon (AC) obtained from the carbonization of wood dust to functionalize it. An in-house adsorption set-up has been utilized to test the CO_2 capture capability of the synthesized adsorbents. Under ambient conditions, the adsorbents have demonstrated adequate adsorption performance (~0.8 mmol/g at 32°C and 1 bar). Characterizations carried out on the samples indicate reversible physisorption of CO_2 on the adsorbents. The interaction of the long-chain amines and the naturally sourced reducing agent L-ascorbic acid has been observed to be a key factor in determining the CO_2 capture potential of the prepared capture materials. These adsorbents may be considered as a sustainable alternative for the capture of CO_2.

Keywords: Activated Carbon; Wood Dust; CO_2 Capture; Sustainable; Adsorption

Chemicals & Hydrocarbons

Polymer and Nano Materials

333_IEC54788 ➲

Integration of Advanced Multi-material Fibres in Electronic and Smart Textiles

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Introduction: Traditionally known for producing garments, home furnishings, and industrial fabrics, the textile industry has undergone a paradigm shift by introducing advanced materials and technologies. As the world approaches sustainable energy solutions, there is increasing demand for flexible, wearable, and lightweight energy storage devices that seamlessly integrate with everyday objects. One emerging field is textile-based energy storage applications, where fibres with enhanced functionalities are incorporated into textiles to store and manage energy. Among the most exciting developments is the creation and application of multi-material fibres [1]. These fibres are composed of two or more materials engineered to exhibit enhanced or novel properties. By integrating multiple materials into a single fibre structure, researchers are opening up possibilities for textiles beyond basic functionality, paving the way for intelligent, interactive, and multifunctional fabrics.

Multi-material fibres can incorporate different polymers, metals, ceramics, and even biological materials, allowing for a wide range of physical, chemical, and mechanical properties. This versatility makes them suitable for various applications in sectors such as healthcare, energy storage, environmental monitoring, and wearable electronics. Integrating such fibres into textiles holds the potential to redefine what fabrics can do, extending their use beyond conventional applications and into the realm of intelligent textiles.

Traditionally, the textile industry relied on single-material fibres like cotton, wool, synthetic polymers such as polyester and nylon, or their blends. While these materials have served well in various applications, they offer limited scope for achieving advanced functionalities. The advent of multi-material fibres addresses these limitations by combining materials with complementary properties. For instance, a fibre might be composed of a conductive polymer for electrical conductivity, a thermoplastic material for flexibility, and a ceramic component for thermal resistance. This opens up new possibilities for creating textiles that can conduct electricity, regulate temperature, or even respond to external stimuli such as light, temperature, or pressure.

One key development in this area is the fabrication of core-sheath fibres, where one material forms the core and the other forms the outer layer [2]. These fibres allow for functional separation within a single fibre structure, such as a core made of a conductive material for electrical functionality, surrounded by a protective polymer sheath for mechanical durability and wear resistance. Coaxial extrusion, electrospinning, and thermal drawing techniques have been particularly useful in producing these multi-material fibres.

One of the primary advantages of multi-material fibres is their ability to offer multi-functionality in a compact and efficient form. Instead of using separate components to achieve different functions, such as sensors or energy storage devices sewn onto fabrics, multi-material fibres allow these functions to be integrated directly into the fabric's structure. This leads to a more seamless and durable solution, making the final textile more comfortable, lightweight, and adaptable. For instance, multi-material fibres can incorporate sensing and energy harvesting capabilities, making them ideal for wearable technology. Fibres embedded with conductive materials and piezoelectric elements can harvest energy from movement or environmental stimuli.

In contrast, fibres containing sensors can monitor physiological parameters like heart rate, temperature, and blood pressure. This opens up a wide range of applications in medical textiles, where fabrics not only cover the body but also monitor health in real-time. Another advantage is the customisability of multi-material fibres. By carefully selecting the materials and their arrangement within the fibre, specific properties such as strength, flexibility, conductivity, and thermal resistance can be precisely tailored to meet the requirements of different applications. This makes multi-material fibres particularly attractive for industries like aerospace, where high-performance textiles are required to withstand extreme environments.

Energy storage is another field where multi-material fibres are making significant strides. By incorporating electrodes, electrolytes, and current collectors into the fibre structure, textiles can serve as flexible, lightweight energy storage devices. Such textiles could be used in portable electronics, allowing users to charge their devices on the go simply by wearing their clothes. In the future, smart textiles could harvest and store energy from the environment, making them ideal for applications in remote areas or during outdoor activities.

Energy storage is a key challenge in developing portable and wearable electronics, particularly in applications requiring flexibility and conformability such as smart textiles. Conventional batteries, though effective in terms of capacity and output, suffer from inherent limitations when integrated into textiles, such as weight, rigidity, and limited flexibility. Additionally, wearable devices often demand multifunctionality, such as the ability to stretch, bend, and flex without compromising energy storage capabilities. This is where multi-material fibres come into play. Their ability to integrate diverse functionalities in a single fibre structure makes them ideal candidates for the development of flexible, textile-based energy storage devices.

Keywords: Energy Storage Devices; Functional; Multi-Material Fibres; Smart Textiles

Chemicals & Hydrocarbons

Speciality Chemicals

94_IEC30297 ➲

Turning Art into Design: Creating a Surface with a Discharging Effect

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Introduction: Surface ornamentation on textiles has become essential to improve functional qualities and visual appeal. Manipulating texture is one of the most inventive ways to approach surface design. It helps designers play with the tactile and visual aspects of materials, adding dimension and depth that can turn an ordinary cloth into a unique piece of art. Discharge printing provides an additional adaptable technique for surface design in addition to texture; it allows for the development of complex patterns by eliminating colours from ground colour, particularly on dark backgrounds. This technique increases the possibilities for artistic expression in textiles.

In recent years, there has been a significant shift towards integrating more creative and unconventional printing techniques.

This study explores the use of innovative printing techniques that transform artistic concepts into functional designs by removing the dye from the ground colour, creating intricate patterns and unique effects. This technique pushes boundaries in fabric design, turning artistic visions into wearable art. The study assesses the impact of discharge printing on product versatility and marketability, providing designers with a competitive edge. Reactive dyes are widely used in the textile industry for several advantages, making them a preferred choice for dyeing cellulosic fibres like cotton, linen, and viscose. One of the primary reasons for their popularity is their ability to produce vibrant and diverse shades. It offers a broad colour palette, ranging from soft pastels to deep, intense hues, allowing designers to achieve precise colour matching and rich, eye-catching designs.

The effects of the colour discharge style of printing on cotton fabric using various sulphur, acid, natural, and pigment, focusing on reactive dyes as the ground colour have been reported in the literature[1] (Das et al., 2017). The controlled fading of soluble sulphur-dyed cotton fabric using oxidising agents has been reported in the literature[2] (Alam et al., 2018).A new eco-friendly reduction system has also been reported instead of the hazardous commercial chemicals used popularly in textiles[3] (Karthikeyan & Dhurai, 2011).

Keywords: Art; Colourfastness; Design; Discharge; Textile

Chemicals & Hydrocarbons

Waste Management & Pollution Abatement

143_IEC753 ➲

Comparative Study on Dye Removal using Luffa Cylindrica Extracted Cellulose using 4 and 10% NaOH

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Abstract: Cellulose is a great source of biofuel and other value-added products. Luffa cylindrica being an agricultural waste, is used to extract cellulose using different concentrations of sodium hydroxide (NaOH) that is 4% and 10% NaOH. The cellulose, extracted from the Luffa cylindrica is characterized using g Fourier transformed infrared (FTIR), scanning electron microscopy (SEM), X-ray diffraction (XRD), particle size distribution, zeta potential, thermogravimetric analysis (TGA). Further the cellulose is used for dye removal study. The cellulose is used for removal of Eosin yellow (EY) at different conditions and parameters. The parameters that are optimized in the adsorption study are contact time, dosage of adsorbent, pH of the dye, incubation temperature and dosage of pollutant(dye). The cellulose extracted from 4% NaOH shows 73% removal while cellulose extracted with 10% NaOH exhibits 83% of eosin yellow removal at 24 h contact time. pH 3 is the optimum pH for the removal of eosin yellow in both the cases, the cellulose extracted using 4% NaOH and 10% NaOH shows 59.45% and 81.26% of removal respectively. Similarly at temperature 25℃ the cellulose shows the maximum removal in both the cases. This study shows the comparative analysis of dye removal the cellulose samples extracted using different concentration of sodium hydroxide and cost-effective production of cellulose from an agricultural waste, which has biodegradability rate.

Keywords: Cellulose; Luffa Cylindrica; Eosin Yellow; Adsorption; Extraction; Biodegradability

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172_IEC77699 ➲

Preparation of Activated Carbon-Alginate Beads for Adsorption of Methylene Blue

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Abstract: This study presents the development of activated carbon-embedded alginate beads for the efficient removal of Methylene blue (MB) dye from wastewater. The adsorbent was prepared by incorporating activated carbon into a sodium alginate matrix, followed by coating with calcium chloride. The effects of pH, adsorbent loading, and dye concentration on MB adsorption were investigated. The results demonstrated that the prepared beads exhibited optimal MB removal efficiency of ~66% at pH 4, an adsorbent loading of 1 g/L, and 100 ppm of dye concentration. The adsorption mechanism was influenced by the cationic nature of MB and the surface properties of the adsorbent. Overall, the developed activated carbon-embedded alginate beads offer a promising and sustainable solution for the treatment of dye-contaminated wastewater.

Keywords: Activated Carbon; Alginate Beads; Dye Removal; Adsorption; Wastewater Treatment

192_IEC48857 ➲

Effectiveness Study of Banana Peel Biochar (BPB) towards Adsorption of Fluoride Present in the Solution

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Abstract: Excessive Fluoride (> 1.5 mg/Lit) in drinking water is a smouldering problem worldwide. Fluorosis is a common health hazard caused by consuming fluoride contaminated water for long time. In india more than 20 states are effected by fluorosis pandemic. Weathering of rocks, geochemical reaction and waste effluents from industries are the main reason of ground water fluoride contamination. Different techniques like precipitation, ion exchange, electro coagulation, and adsorption have been successfully used to eliminate fluoride from water. In this work banana peel biochar (BPB) has been prepared for study the effectiveness of fluoride removal from solution. The BPB was characterized by using FESEM, FTIR and EDX. Point zero charge of the material was also examined. The effects of parameter were analysed for optimization. The experiment result shows that BPB has fluoride adsorption efficiency of 92 % in optimizing condition. In the batch study maximum fluoride adsorption was achieved at pH 4.0. This study shows that in room temperature at pH of 4, adsorbent dose of 2 gm/lit, contact time of 60 min and initial fluoride concentration of 10 mg/lit in the solution can be removed with efficiency of 92% by using BPB. The result shows good correlation with corresponding experimental data and well fitted with Langmuir isotherm. The results suggest that banana peel biochar (BPB) could be a commercial, eco-friendly adsorbent for removal of fluoride from aqueous solution.

Keywords: Fluoride; Banana Peel; Adsorption; Batch Study; Optimization

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198_IEC9777 ➲

A Critical Review on Biological Remediation of Per- and Polyfluoroalkyl Substances

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Abstract: Water pollution is a critical threat to the environment nowadays. Several pollutants are responsible for water pollution, out of which one emerging pollutant is per- and poly-fluoroalkyl substances (PFAS), a group of synthetic fluorinated organic compounds that have been used in the production of several consumer products like shampoo, nail polish, paints, nonstick cookware, etc. PFAS has been designated as an emerging pollutant of concern since 2000, with potential health risks such as cancer, liver damage, chronic kidney disorder, preeclampsia, etc. The Environmental Pollution Agency (EPA) has released multiple guidelines regarding the safe limit concentrations for PFAS. PFAS consists of a C-F bond, a stable covalent bond that is resistant to degradation, making PFAS persistent in the environment. Efficient methods for remediation are in high demand and this critical review highlights mitigation strategies for PFAS in detail, focusing on the advantages of bioremediation methods over conventional expensive, energy-intensive strategies like sonolysis, and independent and assisted photocatalysis. This review explores the alternative, sustainable, and feasible degradation strategies for PFAS, with an emphasis on bioremediation methods.

Keywords: Water Pollution; Per- And Polyfluoroalkyl Substances (PFAS); Forever Chemicals; Environmental Pollution Agency (EPA); Biological Remediation

204_IEC72985 ➲

Facile Low Temperature Fabrication of B-TiO_2 using Sol-gel Method

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Abstract: Wastewater contamination, particularly by synthetic dyes, poses significant environmental and health risks. Traditional remediation methods are often ineffective for these non-biodegradable pollutants. Photocatalysis has emerged as a sustainable approach to degrade such pollutants, with titanium dioxide (TiO_2) being a preferred photocatalyst due to its stability and non-toxicity. However, TiO_2's wide band gap restricts its photocatalytic activity to UV light. This study explores defect engineering of TiO_2, including the synthesis of b-TiO_2. We synthesized TiO_2 via a low-temperature route using $NaBH_4$ and polyethylene glycol (PEG) 4000 to promote oxygen vacancy formation and improve charge carrier separation.

Keywords: Black Titania; Titanium Dioxide; Doping; Wastewater Treatment; Organic Dyes; Band Gap Reduction

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207_IEC64320 ➲

Preparation of Activated Biochar Doped Polyvinyl Alcohol (PVA) Aerogel and its Application in Wastewater Treatment

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Abstract: As pollution is gaining more attention with every passing day, different studies are being conducted to develop more suitable technologies to treat wastewater. This study puts a spotlight on the development of activated biochar doped PVA aerogel and its application in Phenol removal from wastewater. Aerogel is a new form of solid material with a high application potential. In this study activated carbon doped PVA aerogel was developed, and it was found that by using this material as an adsorbent a significant 80.27% removal can be achieved for Phenol from water solution after 180 min. Different parameters, viz., Phenol concentration (1-10 mg/L), aerogel dose (0.5-1.5 g/L), pH (2-10), and temperature (25°C- 40°C) varied during the batch study. From the FTIR analysis, the presence of functional groups, viz., C=O, C-H, and C-O was observed. From the XRD analysis, a characteristic peak of PVA at 19.3o was observed. The SEM and light microscopy study revealed the uneven and cavity-containing surface morphology of aerogel. From the observation, it can be stated that these characteristics of aerogel contribute significantly to the adsorption efficiency of prepared aerogel.

Keywords: Biochar; Aerogel; Phenol; Adsorption; Wastewater Treatment

210_IEC35362 ➲

Sustainable Solutions: Efficacy of Catalyst-Induced Co-Pyrolyzed Jute-PET Char in Congo Red Dye Removal from Wastewater

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Abstract: This study investigates the efficacy of catalyst-induced co-pyrolyzed Jute-PET char for the removal of Congo Red dye from wastewater, with Gypsum as the catalyst, addressing a critical environmental challenge posed by textile effluents. Congo Red, a carcinogenic azo dye, is notoriously resistant to degradation, necessitating effective removal techniques. The research emphasizes a sustainable approach by utilizing co-pyrolyzed char derived from jute and PET waste, which not only enhances adsorption capacity but also contributes to waste valorization. The pyrolysis process was optimized to maximize surface area and functional groups on the char, facilitating improved dye adsorption. Characterization techniques, including ATR-FTIR, SEM, XRD, CHNS analysis, confirmed the structural integrity and porosity of the char. Batch adsorption experiments were conducted to evaluate the influence of parameters such as contact time, initial dye concentration, pH, and temperature on removal efficiency. Results indicated a significant adsorption capacity, with kinetics fitting well to pseudo-second-order models. This innovative method presents a dual benefit: it provides an effective solution for wastewater treatment while promoting circular economy principles through the recycling of industrial waste materials. The findings underscore the potential of co-pyrolyzed Jute-PET char as a viable adsorbent for mitigating the environmental impact of dye pollutants in water bodies.

Keywords: Adsorption; Wastewater Treatment; Co-Pyrolysis; Jute-PET Char; Waste-to-wealth

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211_IEC57058 ➲

Extraction of Silica from Sugarcane Bagasse and its Application in PVA Aerogel Preparation for Dye Removal from Water Solution

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Abstract: Wastewater treatment is one of the rising global issues and different studies are being conducted to study to understand the treatment process using suitable and cost-effective methods. Aerogel materials possess a wide variety of exceptional properties; hence a striking number of applications have been developed for them. Here, in this paper, we report an eco-friendly use of aerogel which is doped with silica that is extracted from sugarcane bagasse, and its application in the removal of organic soluble dye, Congo Red. In the study, it was observed 87.68% removal of the dye was observed after 180 minutes. Different parameters, viz., Congo Red dye concentration (10-50 mg/L), aerogel dose (0.5-1.5 g/L), pH (2-10), and temperature (25°C- 40°C) varied during the batch study. From the XRD analysis, a characteristic peak of PVA at 19.3°C was observed. From the FTIR analysis, the presence of functional groups, viz., C=O, C-H, and C-O was observed and SEM and light microscopy studies revealed the uneven and cavity-containing surface morphology of aerogel. From the observation, it can be understood that the mentioned characteristics of aerogel contribute significantly to the adsorption efficiency of prepared aerogel.

Keywords: Silica; Aerogel; Wastewater Treatment; Congo Red; Adsorption

216_IEC61578 ➲

Waste Leaf Biomass to Activated Carbon: A Sustainable Strategy for the Removal of Cationic Dye from Wastewater

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Abstract: Removal of toxic pollutants from the water bodies needs to be dealt with great concern as these pollutants have harmful effects on living beings. Among many removal strategies, adsorption is a very effective process as it is sustainable, low-cost, and easy to handle with great final results. Various waste biomass is now used widely to develop sustainable adsorbents for removing pollutants from wastewater. In this study, the waste leaf biomass of Polyalthialongifoliais used for preparing biochar at different temperatures for removal of Methylene Blue dye. The most efficient biochar at 485°C was selected for synthesizing activated carbon by chemical method. The adsorption experiments were demonstrated at varying parameters by a batch study. The highest removal efficiency for the activated carbon was obtained as 99.957% when the conditions were 1g/L adsorbent dose, 20 mg/L initial dye concentration, 40°C temperature, and 130 agitation speed. The results thus indicated the production of activated carbon from Polyalthialongifolia leaves is a well-sustainable strategy for dye adsorption.

Keywords: Polyalthialongifolia; Waste Biomass; Adsorption; Methylene Blue; Biochar; Activated Carbon

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312_IEC35627 ➲

Simulation of Direct Air CO_2 Capture & Conversion to Chemicals using ASPEN

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Abstract: A standard CO_2 capture process is implemented in Aspen HYSYS, simulated, and evaluated based on available data from Fortum's waste burning facility at Klemetsrud in Norway. A simplified carbon-capture unit with a 10.4 m absorber packing height, 98% CO_2 removal efficiency, and a minimum approach temperature for the lean/rich amine heat exchanger (ΔT min) of 3°C was considered in this simulation model. Acid gas-chemical solvent fluid package was used in this study along with 29.48 wt% monoethanolamine (MEA) as a solvent. CO_2 capture rate was 55.34 ton/h with 83.63% purity. Conversion of CO_2 captured to methanol was carried out using plug flow reactor with a copper oxide-based catalyst (CuO, ZnO, or Al_2O_3). Operating the reactor beds with suitable conditions, 5.801 ton/h methanol was produced with conversion of 23.04 %. Total capital cost estimated in the entire process i.e. from CO_2 capture to methanol synthesis was 79.7 million USD. Desorber or Stripper column was used to regenerate rich MEA solvent. Thermal energy consumed by reboiler is about 3.08 GJ/ton CO_2.

Keywords: Aspen HYSYS; Absorber; CO_2 Capture; MEA; Heat Exchanger

Environment & Sustainability

Air Pollution and Control

320_IEC49345

Phytoremediation Technique for Reducing Air Pollution in Indoor Environments

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Abstract: Phytoremediation is a promising, sustainable strategy to reduce indoor air pollution by utilizing houseplants to absorb, break down, or sequester airborne pollutants. Plants such as Sansevieria trifasciata (snake plant), Tulsi(the holy basil), Chlorophytum comosum (spider plant), and Epipremnum aureum (money plant) have been studied for their ability to remove harmful volatile organic compounds (VOCs) like formaldehyde, benzene, and xylene. These plants absorb pollutants through their leaves and roots, while microorganisms in the soil contribute to the breakdown of these compounds. However, the efficiency of phytoremediation varies based on the number of plants, species used, and environmental factors. The present research aims to bring forth a cost effective and natural mechanism to curtail the harmful effects of air pollutants in indoor environments like offices, households etc. The study was carried out for a period of one month duration with different plant varieties. The results show an average of 70-80% reduction in total pollutants.

Keywords: Phytoremediation; Volatile Organic Compounds (VOC); Air Pollutants; Air Purification; Indoor Plants; Particulate Matter (PM)

<u>Environment & Sustainability</u>

Climate Change – Mitigation and Adaptation

189_IEC89545 ➲

Impact of Metrological Parameters on Tea Yield in Assam (India)

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Abstract: India, specifically the northeastern part, is one of the top contributors to the growth and supply of tea across the world. To achieve a high yield of good quality tea in the tea gardens controlling various auxiliary parameters are of utmost significance. A model of how crops react to weather is necessary to predict the potential impacts of climate change on crop output. Utilizing different models techniques that have been trained on past yields and some standardized meteorological parameters, such as maximum and minimum temperature, rainfall, mean wind speed, sunshine hour, mean Evaporation etc. In order to achieve above-mentioned goal various parameters from the year 2010 to 2021 has been collected from (Borshilla, Borkatonee, Koombar and Tezpur) and analyzed in this paper using statistical & schematic modeling. It seemed that climate conditions had a significant impact on tea production. The four Assamese tea-growing regions' total rainfall, sunshine duration, maximum temperature, minimum temperatures have a major impact on tea produced. Among the statistical models, Time series Analysis and MLR models produced the best fits for monthly yields, probably indicates that the multivariate time series models may be better suited for expressing the short-term variations and long-term variations in the time series.

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374_xxxxxxxxx➲

Dam Safety Act-2021 — Dam Rehabilitation & Improvement Project (DRIP of Govt. of India): Practical Issues Related to Implementation

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Abstract: This article deals with the activities of human beings towards harnessing the huge water resources as well as saving them from devastating floods. Saving the peoples & properties from devastating floods definitively comes under a major activity of Disaster Management and all major dams play a very important role in mitigation through moderation of huge inflows. Construction of dams across a river started in the world from the ancient ages and with the result the world has created about 57000 major dams where India stands in 3rd position in the World with about 6000 or more major dams. Dams are assets of our country, and some are very old and serving the nation for last 50-60 years to a great extent. Many steps were earlier taken by the Govt of India in ensuring the safety & maintenance aspects of dams. But in the recent years, with the initiative of Ministry of Jal shakti (Central water Commission), enactment of Dam Safety Act-2021 has been possible and the whole scenario has been changed and it has now become mandatory by all dam owners (generally States) to ensure the safety & proper maintenance of dams being operated by them. Further with the start of Dam Rehabilitation & Improvement Project (DRIP) in association with World Bank, funds have been arranged by Govt. of India for a large scale maintenance & ensuring all safety aspects of some of the major dams of our country.

So, in this article most of the aspects of Dam safety act and DRIP project in phases (Phase-I completed in 2021) has been highlighted. Presently, under DRIP-II & III projects (duration 10 years), about 19 states and 3 Central agencies are participating (considered 736 dams). This article also highlighted some of the important issues or ground realities being faced by dam Owners in implementation of the DRIP scheme as per the guidelines of Central water Commission & World Bank.

It is really a very welcome approach of Ministry of Jal Shakti & Ministry of Water Resources & Ganga Rejuvenation, Government of India for realising the necessity of such activities with not only the enactment of Dam Safety Act, but taken up a large scale project DRIP for its implementation.

Keywords: Dam Safety Act; DRIP; CPMU; SPMU; NHP; RTDAS; RTDSS

Environment & Sustainability

Emerging Pollutants

226_IEC45073 ➲

Emerging Pollutants in Soil and Water: Detection, Assessment, and Remediation Techniques

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Introduction: Emerging pollutants (EPs), such as medicines, personal care items, insecticides, and industrial chemicals, have lately received attention due to their permanent persistence in soil and water. Unlike traditional pollutants, EPs are frequently derived from domestic waste, agricultural runoff, and industrial activities, and many are not currently controlled. Their ability to alter ecosystems and endanger human health has made detection, evaluation, and remediation a key field of research in environmental sciences. Recent research indicates a wide range of new contaminants, including endocrine disruptors and microplastics, that have received insufficient attention in terms of their long-term consequences on soil and water systems. Synthetic or naturally occurring compounds that are not usually monitored in the environment but have been found in a variety of habitats, particularly in soil and water bodies, are referred to as emerging pollutants (EPs). Numerous substances, including medications, personal care items, industrial chemicals, insecticides, and microplastics, are among these contaminants. Unlike conventional pollutants, EPs are frequently produced in small levels; nonetheless, in recent years, worries have been raised about their persistence in the environment and possible harm to both people and wildlife. The increasing amount of EPs in the environment can be attributed to the increased manufacturing and use of these compounds as well as ineffective removal procedures in wastewater treatment facilities. The swift introduction of novel chemicals has outpaced the implementation of traditional environmental monitoring and regulatory systems, resulting in several environmentally harmful substances (EPs) being uncontrolled and neglected. As a result, sophisticated detection techniques and a thorough evaluation of their ecological hazards are now required. The complicated chemical makeup of EPs and their many routes into the environment define them. For example, herbicides frequently leak into water bodies from agricultural areas, and medications infiltrate water systems through human waste and inappropriate disposal. Manufacturing facilities can release industrial chemicals into the land and water, which can lead to long-term pollution. Because soil and water are essential resources for agriculture, human consumption, and biodiversity, the pollution of these ecosystems by EPs poses a major threat to the environment and public health. Because their impacts are not usually apparent right away and because they may build up over time to produce major ecological disturbances such microbial resistance, loss of biodiversity, and endocrine disruption in aquatic creatures, emerging pollutants provide a special challenge. There is an immediate need for innovative remediation techniques due to the shortcomings of traditional treatment methods in eliminating these contaminants.

With the development of detection methods like mass spectrometry and chromatography, it is now possible to identify EPs with greater precision even at low quantities. In a same vein, novel approaches to remediation—such as advanced oxidation processes (AOPs), phytoremediation, and bioremediation—are being developed to deal with the expanding issue of EP pollution. To effectively mitigate the consequences of emerging contaminants and inform policy frameworks, it is imperative to comprehend their behaviour, distribution, and effects in soil and water ecosystems. This work seeks to fill a vacuum in existing research by offering a complete framework for identifying these contaminants, analysing their impact, and adopting novel remediation methods. The primary outcomes of this study include the creation of EP detection instruments, a risk assessment model for contaminated locations, and a comparative examination of remediation approaches appropriate for various soil and water conditions.

Keywords: Emerging Pollutants; Soil Contamination; Water Quality; Remediation Techniques; Environmental Monitoring

Environment & Sustainability

Environmental Pollution and Management

45_IEC51255➲

Novel Approaches: Shipborne Oil Slick Detection and Mitigation

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Abstract: Marine ecosystems and coastal communities face catastrophic consequences from oil spills caused by ship collisions, grounding, and rig leaks. Effective prevention and detection strategies are crucial to reduce the risk of oil spills. Various treatment strategies such as booms, skimmers, in situ burning, adsorbents, dispersants, and bioremediation are used. The chosen treatment approach depends on factors like oil type, spill volume, location, weather, and sea conditions, in addition to technique efficacy. Detection methods involve satellite imaging and sensor technologies. The primary goal is to protect marine life, prevent shoreline contamination, and facilitate oil degradation.

Keywords: Oil Slick; Biocides; Skimming; Optical Sensors; Sorbents

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56_IEC19323 ➲

Decarbonizing the Maritime Industry: The Way Ahead

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Abstract: Shipping accounts for 11% carbon dioxide emissions in the transportation sector and is likely to surge by 50% by 2050 if proactive measures are not taken, mainly due to the increase in global trade and the demand for maritime carriage of goods. Maritime decarbonization is the process of reducing greenhouse gas (GHG) emissions from the global maritime sector, with an overall goal of placing the sector on a pathway that limits global temperature rise to 1.5^{o}C. Shipping is hard to decarbonize due to the wide spectrum in vessel types and sizes, the large amounts of energy they use, and the inherently global nature of maritime transport that necessitates working across geographies. The maritime transportation sector primarily relies on fossil fuels like marine gas oil and heavy fuel oil (HFO) and the combustion of HFO releases harmful gases including carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), all of which contribute to the problem of climate change. Scaling up investment in new ships (hull form, engines, onboard technologies, crew skills), energy supply and bunkering infrastructure (i.e., alternative fuels availability and supply through dedicated and adequate production, bunkering facilities, and storage) is crucial.

Keywords: Decarbonization; Greenhouse Gas; CO_2; Heavy Fuel Oil; Alternative Fuels

72_IEC69472➲

Iron Removal from Aqueous Solution using Copra Cake Biochar as Adsorbent

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Abstract: Access to clean and safe drinking water is essential for public health and well-being. However, the presence of iron in groundwater and other water sources poses significant challenges. Excessive iron levels in drinking water can lead to aesthetic issues, such as discoloration and unpleasant taste, and may also cause health problems, including gastrointestinal distress. Traditional methods for iron removal, such as chemical precipitation and ion exchange, can be costly and may have environmental drawbacks. Consequently, there is a growing interest in developing costeffective and environmentally friendly alternatives for water treatment. Water bodies receive iron either through geogenic sources or via the dumping of domestic waste and industrial effluents. The sources of iron in water are mainly pollution from iron and steel industries, mining, and metal corrosion. Apart from surface water, iron is also present in groundwater. The major reason behind the presence of iron in groundwater is due to leaching from iron bearing rocks and minerals present in different types of soil.

Keywords: Iron in Drinking Water; Copra Cake; Biochar; Adsorption

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93_IEC96796 ➲

Exploration and Optimisation of Eco-Friendly Dyeing with Natural Indigo

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Introduction: Textiles have long been a major consumer product, with a rich history spanning centuries. However, a troubling aspect of this history is the textile industry's significant contribution to pollution, dating back to the Industrial Revolution in the late eighteenth century. Denim made from cotton fibre are biodegradable, but their production remains far from eco-friendly behaviour. During the dyeing process, indigo is converted into a water-soluble form known as leuco indigo by adding a reducing agent in alkaline conditions (pH~10-12). Sodium hydrosulphite is the most commonly used reducing agent due to its cost-effectiveness but has significant drawbacks. It oxidises quickly in air, is flammable during storage, and can corrode wastewater pipelines. During wastewater treatment, sodium hydrosulphite can disrupt aerobic processes and produce toxic hydrogen sulphide from sulphate under anaerobic conditions [1]. Sodium hydroxide is often used alongside sodium hydrosulphite, but it is also harmful to the environment, can corrode concrete waste lines, and adds to the wastewater burden. A typical denim manufacturing plant can generate over 400,000 tons of wastewater annually during dyeing[2]. This wastewater contains high levels of salt, 20–30% of the original indigo dye, and traces of metals. The wastewater is problematic because of its high chemical oxygen demand (COD) and elevated pH, making it unsuitable for reuse or safe disposal[3]. The increasing environmental concerns and the global push towards sustainability have necessitated exploring eco-friendly dyeing techniques.

Keywords: Indigo; Madder; Reduction; Sustainable; Vat Dye

130_IEC73909 ➲

Sound Absorbing Textiles – A Review of Accomplishing Quiet Comfort

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Introduction: Acoustics derives from the Greek word „akoustikos", which means „to hear". In Latin, „acoustic" also acts as a synonym for the word „sonic". „Acoustics" as a scientific term is the science of sound that constitutes the generation, transmission, and biological or psychological effects of sound waves when the emission occurs in a specific area and its surroundings [1]. The acoustic materials are thus comprised of materials that are involved not only with the principles of generation, emission, transmission, and conversion of sound waves but also help with determining, analysing, and understanding the characteristics, behaviour and effect of a sound wave on the environment.

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201_IEC29747➲

An Investigation on Quantity of Domestic Wastes Generated from Packed Utilities

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Abstract: The quantity of domestic dry waste generated from all kind of packed food materials as packing covers, usage of medicines, costumes and other commodities contributes a large to the total amount of solid waste generated in a town or city. The disposal of solid waste by the city municipal authorities become a task and cause environmental degradation, flooding and health hazards. So, this study has focused on investigating the total quantity of domestic dry waste generated under Indian urban living conditions and finding ways to recycle the same. The methodology adopted was collecting dry domestic wastes from four different size residences for four months and weighing daily. Accordingly the daily average and monthly average quantity of waste was determined as 16.49 g and 494.78 g respectively per residence. So the quantity of waste to be generated in cities with population of various ranges was also forecasted. Hence it is concluded that there is no waste at our home and all such dry covers, containers, bottles can be recycled through proper storing procedures at our premises without dumping or throwing away to attain the goals of sustainable development.

Keywords: Quantity of Household Waste; Food Waste; Kitchen waste; Packing Waste; Costumes Waste

272_IEC48090➲

Utilization of a Biochar Synthesized from Rice Straw and Modified by a Hummer‟s Method for the Purpose of Removing Carbamazepine from its Aqueous Solution: Batch Study and Fixed Bed Study

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Introduction: In recent times pharmaceutical compounds are becoming one of the most rapidly emerging pollutants. Carbamazepine (CBZ) is one of the most widely utilized pharmaceutical compounds in the world with more than one thousand tons of annual consumption (Naghdi et al., 2019). As with all other emerging contaminants, the conventional waste water treatment systems are unable to effectively remove this type of pollutants from (Baghdadi et al., 2016; Naghdi et al., 2019; Nielsen et al., 2015). Therefore non-conventional methods of waste water treatment needs to be utilized for the purpose of removing these trace pollutants from water (Baghdadi et al., 2016). For this particular study, rice straw which is an abundantly available agricultural by product was utilized for synthesizing a biochar. The biochar was then activated by a modified Hummer‟s method. Then final product which was termed Activated Rice Straw Biochar (ARSB) was utilized for removing CBZ from its aqueous solution by adsorption. A set of batch studies were performed to find the effect of different experimental conditions on the removal of CBZ by ARSB. The data from the batch study was utilized for calculating the adsorption isotherm, adsorption kinetics and adsorption thermodynamics. The effect of the operating parameters on the removal of CBZ by ARSB was further optimized by Response Surface Methodology (RSM). The removal of CBZ under a dynamic flowing condition was evaluated by conducting a continuous column study. The main objective of this particular study was to synthesize a cost effective adsorbent followed by testing of its efficacy for the purpose of removing a recalcitrant pollutant CBZ from water.

Keywords: Carbamazepine; Activated Rice Straw Biochar; Adsorption; Batch Study; Column Study

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282_IEC98328 ➲

Ship Operation for Net Zero Emission

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Abstract: Industrial Revolution in Europe is the tipping point at which greenhouse gas (GHG) emissions released into the atmosphere began to skyrocket. With the growth of Cargo transportation across the world the demand and production of energy increased. Energy demand was satisfied mainly through burning fossil fuels, which has been easily available across the World. Excessive burning of Fossil Fuel resulted in the global increase in temperature of approximately 1.07°C since the pre-industrial period. This rise is proportional to the global cumulative emissions over the period. Global cumulative emissions determine the global temperature that will be reached. To limit the increase in global temperature, the cumulative emissions must stay within a Global Carbon Budget. The Amount of Carbon Budget left is 500 $GtCO_2$ for limiting temperature rise to 1.5 degrees and 1350 $GtCO_2$ for 2 degrees.

Globally the shipping industry emits about 3% of the world's CO_2 emissions. India's efforts to cut its carbon footprint will also help in meeting the International Maritime Organization's target to reduce overall greenhouse gas emissions from ships by 50% of 2008 levels by 2050. International Maritime Organisation has introduced Mandatory reporting of fuel consumption data by ships above 5000 MT.

As per IMO"s New Data Collection System, almost 29000 ships reported on the consumption of fuel consumed by them. This number shows that about 800 ships more than 2021 data has reported on fuel consumption. These ships reported the use of 213 million tonnes of fuel, which is just slightly higher than in 2021 (212 million tonnes in 2021).

Key words: Global Warming; Energy Efficiency; Net-Zero; Renewable Energy; Decarbonisation

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329_IEC74956➲

Effluent Discharge from Metal & Metallurgical Industries — Environmental Impact and Control

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Introduction: Industrialization has become the ultimate driving force to the development of a country"s economy, through the establishment of plants and factories. Specifically, the metal and metallurgical industries have significant impact on the country"s economy. However, these metal industries have also hugely impacted on the environment status of these countries. The waste or by-products discharged from them consisting of various kind of contaminant are severely disastrous to the environment which contaminate the surface water, ground water and soil.

This article deals with various effluents discharged from various metal and metallurgical industries, their characteristics, and effects on environment and human health.

Keywords: Industrialization; Contaminant; Effluent; Zero Liquid Discharge

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351_IEC53107➲

The Recycling Gap: Assessing India's E-Waste Management Infrastructure

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Abstract: This study focuses on the Indian e-waste generation, formal processing and recycling of e-waste and number of authorized recyclers with its capacity and investigating past and future trends using Auto ARIMA, LGBM Regressor, XGB Regressor, and Random Forest Regressor, Time GPT models, commonly used in time series analysis and forecasting the e-waste generation up to financial year 2031-2032. In this study it is observed that for all the cases the values of error matrices (such as MAE, MAPE, RMSE etc) of XGB Regressor is lowest among all the models. So, we choose this model for forecasting the e-waste generation. The study predicts that the E-waste generation in India will rise up to 7.269 MT at 2032 as per GEM report and 4.14 MT at 2031-32 financial year as per CPCB annual report. The prediction also shows that the e-waste will be formally recycled is 2.25 MT which is about 54.34% of e-waste generation and the capacity of recycler will be increased up to 5.06 MT with the 1442 number of authorised recyclers at 2031-32 financial year.

Keywords: E-Waste; Forecasting; Machine Learning Modeling; Recycling

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377_IEC318➲

Wreck Removal of MV Green Opal

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Abstract: Kolkata Port Trust (Shyamprassad Mukherjee Port Trust at present) is situated 123 nautical miles from Sandheads where the Hoogly River falls in the Bay of Bengal. River Hoogly is considered as one of the most difficult waterways for navigation in the world. River Hoogly is called "A Navigator‟s Nightmare and a river scientist‟s delight".

In short the problems of navigation in river Hoogly can be described by 3B‟S.

Bars Bends and Bores

The River Hoogly meandering down the deltaic region of Bengal is notoriously famous for its bars, bends and bores. It is tidal from the sandheads to Tribeni around 29 Nautical miles upstream of Kolkata with Semi-diurnal tides; two high tides and two low tides in a span of around 24 Hours 30 Minutes.

Bars:

Bars in the river are those shallow stretches lurking below the waters formed by siltation because of scouring of the banks, shifting of sands or at places where owing to the flow of the river the incoming flood tides and the outgoing ebb tides do not run fair. There are 15 numbers of bars which a ship has to cross to reach sandheads from Kolkata.

Bends:

The upper reaches of river extending 25 nm downstream of Kolkata up to Diamond harbour are tortuous with numerous turns that restrict the length and beam of the ships that can ply to Kolkata.

Bores:

The upper reaches of the river are frequented by the „bore tides‟, a phenomenon that occurs during the spring tides when the predicted tidal range at Garden Reach exceeds 4.0 mtrs. As an example when the range is in 5.0 mtrs i.e. low waters is 1.2 mtrs and succeeding high water 6.2 mtrs, the ingress flood tide shortly after low water, surges it to „fill‟, the sand chocked stretches of the river. The first surge of a bore can attain a speed of 7-8 knots. A steep wall of water 3-4 feet high could be seen sweeping along the shallower side banks, fast and furious. Small crafts get swamped, ships riding at anchor if caught the wrong way fear snapping of anchor chain.

In this respect I would like to mention about „Farakka barrage" which was commissioned in 1975. This barrage is always criticised as if it has not served its desired objectives. But I would like to point out that due to this barrage need for dredging of five of the bars in upper reaches of the river is eliminated and number of bore-days had been reduced considerably, easing shipping operation in the port.

In spite of superb skill of Hoogly River pilots, running aground of ships in the river because of above mentioned problems cannot be avoided. Sinkage of ships in Kolkata port is very rare. But unfortunately when I took charge as Director Marine Department, within a few months of that a vessel M.V Green Opal sank due to unavoidable circumstances.

Singapore bound ship MV Green Opal flying Panama flag sunk in the river Hoogly on June 19 , 1997 after colliding with a lash barge in a Titanic - type encounter. The 106 meter long, 16.31 meter broad ship had sunk within half an hour at Birlapur with cargo of 5806 tons of wire coils and steel bars .All the Officers and Crew were rescued by Port vessels immediately.

Then the real problem started. Half of the narrow channel was occupied by the sunken vessel. Kolkata port Pilots as usual displayed superb skill in guiding ships to Calcutta Dock System through one half of the channel. This was obviously a dangerous proposition. KoPT started negotiating with the concerned UK P&I Club for the removal of the wreck . Due to court cases and other formalities the actual salvage operation started in December 1997. The P&I Club awarded the job to a Greek salvage company Travliris Russ.

The salvage company was successful in removing all the Cargo, oil etc. from the ship by March. By this time the ship had broken her back and the salvors had cut the ship into two halves. The Company tried to lift the halves by three sea-camels and 30 air lift bags. Sea-camels are steel cisterns and air lift bags are heavy duty balloons.

The balloons were blown with the hope that the ship parts will be lifted by the buoyancy, but the operation proved unsuccessful.

After a painful wait, Port authorities requested UK P&I Club to change the Salvage company. After a lot of negotiations the P&I Club appointed a new salvage company, the Singapore based Smit International.

The company brought one 1000T Crane Vessel and a Heavy duty Tug . This Company placed a heavy chain under the ship and started moving the chain up and down like a saw by alternately slackening and pulling the chain from the crane and the tug. In the process, the salvors cut the vessel in six parts and with the help of the crane vessel put the parts one by one ashore. We checked the river bottom by our own survey vessels as well as by Indian Navy vessels. It was seen that no part of the ship or cargo was lying on the river bed.

Thus with the help of UK P&I Club and the Salvage Companies Kolkata Port had overcome one of the biggest hazards in the history of the port.

<u>**Environment & Sustainability**</u>

Natural Disaster Mitigation

73_IEC10554➲

Rain Water Harvesting is the Key to Mitigate Floods

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Abstract: As the insatiable needs of our society keep on increasing along with the advancement of science & technology, the entire world has faced abusive & unfair use of natural resources. As a result, today we are creating a time which we very fondly refer to as "Climate Change". In reality, our society has become more & more selfish and is leading to the destruction of natural resources just to full fill their endless desires. It"s not that the world is unaware that Mother Nature has not given us any warning signs, despite that we have been ignoring this for decades. Now when water has reached above our heads, everyone is becoming restless. All leads to various national & international seminars & conferences on this topic of climate change. Herein experts often discuss & share the various problems, solutions, policies & regulations.

Of all the deadly natural disasters such as Earthquakes, Floods, Droughts & Cyclones, floods are certainly the most unfortunate & pitiful for humankind. With the advancement of science, we now get very early warnings of floods, despite that the floods never fail to show their wrath. Floods lead to millions of dollars of losses to land, farms, buildings & industries. Mankind is left with no other option but to just helplessly be a witness to this disaster. Floods are not just a natural disaster, but in reality the response to all the atrocities that man has done to Mother Nature. Be it a developing, under developed or a developed nation, the deadly impact of floods are seen everywhere. The key reasons behind these are deforestation, obstructing the natural flow of rivers, illegal construction on river banks, pollution of river water, plastic waste discharge in rivers, poor drainage systems and most importantly our reluctance in harvesting the gift of nature rain water, lack of efforts & lack of will power.

If we look towards major challenges management of floods all over the world, we will found, lack of coordination, un proportionate planning in disaster risk management, lack of awareness among people, communication issues, change in flood prone areas, lack of regularly survey & monitor flood prone areas, emphasizing on widening of rivers & removal of encroachments on the river banks at any cost, interstate water disputes etc. Political will-power can play a pivotal role in minimizing any disaster. India witnessed the divesting floods in Kedarnath in the year-2013 and many metro cities in recent years.

The leading causes of floods in India are incessant monsoon rainfall, reduced river channel carrying capacity for high flows, riverbank erosion and the siltation of channel beds, poor natural drainage in flood-prone areas, cloud bursts and several other meteorological factors. Rapid urbanization and changes in the land use pattern have given rise to urban floods. In the recent time during this monsoon India witnessed the heavy to very heavy floods all over the country. All these makes flood management a tedious process.Despite massive investments and continuous flood-control efforts, the socio-economic damages and death toll continue to remain high. The process of flood management becomes very complex due to several socio-hydrological-climate factors along with socio-economic dynamics.

Keywords: Flash Floods; Cloud Burst; Climate Change; Encroachments; Political Will Power

104_IEC99914➲

Fractal Dimension and Earthquake Frequency Magnitude Distribution in West Patna Fault, Bihar

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Abstract: The state of Bihar is situated within foredeep plain bordering foothills of Himalaya, and is almost entirely occupied by Indo Gangetic Alluvium Belt. In terms seismogenic sources, the earthquake prone history of Bihar has a twofold character: (1) On the north, there are the E-W trending seismogenic thrusts of the Himalayan fold-thrust belt, and (2) there are several NE-SW to NW-SE trending transverse faults. Several major earthquakes had caused widespread damages and loss of life in Bihar in the historical past, namely Nepal earthquake of 1833 and Bihar-Nepal earthquakes of 1934 and 1988. They originate in the basement rocks beneath Indo Gangetic Alluvium Belt and continue into the tectonically active Himalayan fold-thrust belt. The West Patna Fault (WPF) is one of the notable transverse faults (Fig.1). The 2015 Nepal earthquake initiated enhanced seismicity rate of micro earthquakes recorded in temporary station network in and around West Patna fault in Bihar. The frequency magnitude distribution (FMD); Gutenberg and Richter and fractal dimension (Dc) have been adopted as effective approaches for understanding the local seismotectonic activities in the study area (latitude: 24° - 29°; longitude: 84° - 86°). The b values and fractal dimensions estimated from epicenter clusters of two different depth constraints, 0-50 km and 50-100 km, show a positive correlation among them through regression analysis by least square (LS) method. Moreover, a positive correlation between b-value and Dc for spatiotemporal evaluation of the resulting seismicity is due to progressive alignment of epicenters along incipient fault plane towards the deeper part of the crust and is also well reflected in the hypocentral depth section. The modified Griffith's criterion also predicts an increase of potential energy release rate in presence of an interaction potential.

In above study, frequency magnitude distribution of earthquakes, b-values and fractal values, Dc attribute that there is a change in geological heterogeneity as well as rheological characteristic of rock material within the depth level 40-50 km. secondly, the fracture density in the upper part, ≤ 50 km is comparatively more homogeneously distributed epicenters which probably follow a linear fault system (Wyss et al., 2004). The result also shows that there is a tendency of coalescence of unstable due to more concentrated appearance of epicenter clusters in the lower part than the upper part which may give rise to mechanical weakening effect within the fault region of WPF. Moreover, a sharp change of b value (Fig.2a, Fig.2b) manifests a sharp change of heterogeneity within 40-50 km depth which also suggest improper stress balance within the small focal zone of WPF.

171_IEC68944

Remote Sensing based Disaster Management

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Abstract: Disasters are becoming more and more frequent. The new technological evolution can help rescue missions in an area where disasters have been hit hard. This paper explores the problem of less visibility during disaster using satellite platform based active sensing modalities to generate visualization which can be understood by human and rapid orient, decide and act of OODA (observe, Orient, Decide and Act) framework can be facilitated. The proposed method uses Synthetic Aperture Radar (SAR) modality data which can penetrate through translucent layers which normal passive sensing Electro Optical (EO) modalities like Hyperspectral, Multispectral or RGB fail. The Generative AI based approach is used to fuse EO and SAR data to train a model. During inference time SAR data is given as input and EO modality image as output is expected from the model.

Keywords: Remote Sensing; Disaster Management; SAR; Image translation; Generative AI

Environment & Sustainability

River Rejuvenation

22_IEC55345➲

Fundamentals of River Rejuvenation and Application in Industrial Site Selection

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Introduction: Rivers and streams are very important landforms which have been associated with the development of human civilization right from the initial days. The developmental processes have affected the rivers' physical and chemical characteristics and have caused deterioration of the overall health of the rivers. Rivers which are important features on the surface of the earth are primarily the results of the exogenetic processes on the surface of the earth. The formation and actions of the rivers are governed and guided by the mechanics of slope formation, action of snow and water, and formation of drainage basins and large-scale landscape development.

Due to increased population growth, urbanization, industrial development and infrastructural development the global water demand is increasing over the years. In India surface water, and ground water are the major sources of water used for residential, agricultural, commercial, industrial and various other purposes. Among surface water the role of rivers and other water bodies such as lakes, ponds, springs and nalas are of importance.

Rivers are the most important source of fresh water and water is the most important ingredient for both existence of human beings and all developmental activities undertaken by human beings. With extensive urban and industrial development and improvement of standard of living the demand and extraction of water has increased. Further with large-scale modification of landforms the basin characteristics which are primarily dependent on virgin topography suffer extensively. All these cause physical damage to the river bodies and river basins. India being g a monsoon-fed country gets floods and droughts alternatively and both these natural events cause physical damage to river bodies. River rejuvenation is a process by which a river adjusts to a new base level and at the same time restores its natural flow and health. The lowered base level induces energy and renews the river’s capacity for vertical erosion.

The flowing water in river channels has another important characteristics that is biodegradation of the pollutants in waste water produced by human beings. For a long time this has been utilized by human beings to dump the domestic and even industrial water and effluents to be dumped in rivers. Initially the rivers absorbed these polluting materials but with fast development, the river water quality deteriorated significantly and many rivers became unusable. This problem can be tackled by providing appropriate waste water treatment in both domestic and industrial units and by adopting zero discharge technology in all domestic and industrial units.

Over the years the growing pressure of water demand on rivers and dumping of pollutants in the rivers have resulted in deterioration of river water quality particularly the river Ganges. Climate change is expected to impose additional impact on the river basins and river channels. Considering the urgency of the situation the government of India established National Mission for Clean Ganga project (NMCG) to implement the Namami Ganga Mission launched in 2015. Along with Ganga Action plan Yamuna Action Plan, Gomti Action Plan and Damodar Action Plan are also undertaken. The Ministry of Environment, Forests and Climate Change has proposed the rejuvenation of 13 major rivers namely Jhelum, Chenab, Ravi, Beas, Sutlej, Yamuna, Brahmaputra, Luni, Narmada, Godavari, Mahanadi, Krishna, and Cauvery, Yale et al (2020) in a book on Riverv Rejuvenetion model of the Kumudvati river basin in Karnataka presented the concept and methodology of rejuvenation of degenerated rivers as successfully implemented .The book emphasized the fact that a river is not an entity by itself but is intimately connected to rainfall, topography, soil, forestry, infiltration, runoff, evaporation and groundwater. River flows recharge groundwater in monsoon which in turn sustain the flows in lean months ...Groundwater plays a vital role in sustaining perennial river flows.

Restoration of overexploited ground water is crucial part of river rejuvenation programme. Artificial recharge and rainwater harvesting are the two important means to augment ground water.

In International scenario the most important basins undertaken for rejuvenation are the Rhine, San Antonio, Marray – Darling, Thames, Mekong and Danube. The important parameters undertaken for study are Ecology, Water Quality, Flood, Low Water, Water for Environment, Ground Water, Pollutants, Changes in Water Flow &Water levels, Basin wide features, and Acquatic Ecosystem.

For urban units the diversion of rivers and nalas should be kept at minimum. For opencast mining units nala diversion should be designed taking care of future precipitation values considering climate change, modification of topography and accurate values of hydrologic variables like infiltration, evapotranspiration and ground slope.

Parihar, D.S. (2021) presented a treatise on need of river rejuvenation in India. The river ecosystem is a complex platform of interaction of human and interrelationship of biotic (Flora & Fauna) and abiotic (hydro-meteorological, hydrogeological, hydrogeomorphological) components in dynamic equilibrium. The ecological function of a river is linked to the hydrological and hydrogeological variations in the river flow. The most ancient source of water even before the human race came into being was the rivers. A process based understanding of the river basin ecosystem is expected to facilitate sustainable exploitation of water resources. Jain, S.K et al (2014) presented a treaties on Environmental Flow in India towards sustainable water management. To achieve Ecosuatainabiolity in water regime this environmental flow in rivers have to be maintained. Sekhar, S et al (2009) studied the groundwater comditions in the Yamuna Flood Plain of Delhi India and enumerated the management options regarding utilization of groundwater during a critucal period. Shasank Sekhar (2016) analysed the requirement of Environmental Flows as a factor of River Rejuvenation and arrived at three important criteria : 1) over-exploitation of River Resources and Poor Flow in the River, 2) Contamination of River by Domestic and Industrial liquid waste and 3) Encroachment on River Space, Obstruction of Water ways, Excessive Sand Mining and Deforestation. Soni et al (2014) arrived at a conclusion on environmental flow for the Yamuna River in Delhi as an example of monsoon rivers in India. The authors concluded that the maximum sustainable water use from a river required to maintain ecological integrity is 50-60 % of flow in all seasons.

One important aspect of River Rejuvenetion is the study of stability of landscape. In this study the river network analysis using thermodynamic concepts plays an important role. Bandopadhyay Sujay et al (2014) made an entropy based study to decipher the behavior of streams and landscape stability in Kunnur River Basin ,West Bengal , India. This entrpy based analysis demonstrated that the lithological control, grainsize and channel morphology influence the gradient in short term and climate induced hydrological changes control the long term stability of the total landscape. Instream Green Corridor has a vital influence on River Rejuvenetion. By enhancing the bio-physical features of the fluvial system. Nandi, Ketan Kumar et al (2021) studied the entropy based morphological variability and dynamics of vegetation cover over 240 km braided reach of the Brahmaputra river and concluded that entropy based bio-morphological studies can be integrated into River Rejuvenetion programme to provide nature based solutions to the dynamic river system.

Keywords: Ecology; Environmental Flow; Encroachment of River Space; Sustainable Water Management

80_IEC8422➲

Water Quality Index and Sediment Analysis in the Lower Basin of the River Hooghly

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Abstract: The River Ganges, often referred to the Ganga plays a central role in Indian civilization and nourishes the cultural, economical, spiritual and social development of India. The lower basin of the River Ganga named as the River Hooghly flows through West Bengal. The twin city of Howrah and Kolkata on the bank of the River Hooghly are the major sources of water pollution. The present work examines the water quality of the River Hooghly before the river enters in the city of Howrah and Kolkata. The samples collected from five stations are examined and the results analyzed for sediment loading, seasonal variation of water quality for different physicochemical parameters (turbidity, pH, alkalinity, dissolved oxygen, total dissolved solids, BOD etc.) and other flow parameters which are important for river rejuvenation. The results of this work can be used for the maintenance of required water quality of the River Hooghly that in return will nourish the mankind in the lower basins of the River Hooghly.

Keywords: Water Quality Index (WQI); Physicochemical Parameters of Water; Sediment Loading; River Rejuvenation

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280_IEC99195➲

Antibiotic Detection in River Water by Electric Field Enhanced Graphene Electrochemical Sensor

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Abstract: In this paper, a novel graphene electrochemical sensor for detection of antibiotic Ciprofloxacin (Cfx) in river water is developed. The device was fabricated using a coplanar configuration of electrodes fabricated on printed circuit boards that enhance the sensitivity due to dielectrophoretic capture techniques. Immobilization of the surface of thermally reduced graphene with anti-Cfx antibodies is essential for specific detection, and therefore assessment of sensor performance takes place. Results from sensor testing demonstrate its ability to detect Cfx at extremely low concentrations of 10 pM, thereby making it potentially useful in real-time monitoring of pharmaceutical residues in aquatic ecosystems. This research re

presents an extremely crucial need due to environmental risks brought by levels of antibiotic contaminants and increasing resistant bacteria. The findings contribute to efforts targeted toward developing sensitive devices that are simple and cost-effective at monitoring levels of pollutants in water sources, underlining consideration of pharmaceutical contaminants in the environment.

Keywords: Antibiotic Detection; River Water; Graphene; Electrochemical; Electric Field

Environment & Sustainability

Sustainable Development and Smart Cities

67_IEC76553➲

Soil Slope Stabilization using MSW Incineration Ash

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Abstract: Soil slope stabilization is crucial in infrastructure development, especially in erosion-prone areas. Traditional methods often rely on costly materials with environmental drawbacks. This study explores an innovative approach using municipal solid waste incineration ash (MSWIA) and fly ash as a partial replacement for conventional stabilizers. Flyash, a waste product of thermal power plants, is used as a soil stabilizer for embankment slopes. The study mixes soil with 5-25% fly ash by dry weight and conducts modified Proctor compaction and direct shear tests. Results show increased dry density and cohesion, but decreased angle of internal friction with higher fly ash content. Incorporating MSWIA enhances soil slope stability while addressing waste disposal challenges. Environmental impact assessments demonstrate the sustainability of this approach, offering a promising eco-friendly solution for soil stabilization. This innovative method reduces reliance on costly materials with negative environmental effects, making it suitable for infrastructure development in erosion-prone areas. The study's findings suggest a viable alternative for soil slope stabilization, promoting sustainable infrastructure development.

Keywords: Fly Ash; Slope; Stabilized Soil

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125_IEC53884➲

Structural Conservation Work of Rumi Gate, Lucknow — An Overview

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Abstract: This case study paper discusses the sustainability efforts for conservation of Rumi Gate (an iconic historical structure and centrally protected monument of Archaeological Survey of India) Lucknow, India. This structure situated on the right bank of river Gomati and suffers many major flood in past times like 1891, 1894, 1960 and more. Due to many flood, the foundation settlements suffered and whole structure bear a major vertical crack, from top of super structure to foundation. For structural strengthen and safety of the structure, many efforts taken place in past time, from British period to present. Since last few years, due to climatic changes in this region and pollution around this structure and due to heavy vehicle movement through the gate was one of the major causes for the development of the cracks in the edifice. Therefore, during the session 2022 and 2023, ASI Lucknow circle carried out the structural conservation work with the help of traditional lime mortar (mix of Lime, Sand and Surkhi) used in a specific ratio with natural adhesives like bel fruit gel, babbol gum, gur/malaises, urad dal pest, chicken egg gel within a desired manner and proportion. During the process of conservation the cracks were filled through proper grouting & stitching work also provided wherever required. After 2 year study, it found that no any weathering effect seems. So, it may be point out that carbonation effect may be reduced in lime mortar by addition of natural adhesives. This case study may be useful for other relevant structures for conservation with sustainability effort.

Keywords: Lime Mortar; Sustainability; Natural Adhesive; Climate Change; Pollution; Conservation

238_IEC9009➲

Pathways to Sustainability for Higher Education Institutions: NIRF induced SDGs

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Abstract: No collective effort from human beings have been closer to nature than sustainable development goals (SDGs). The societal benefits brought about by its impact are nothing less than revolutionary. More than bringing changes at the ground level it succeeds in planting the seeds of sustainability in the minds of our future generations. Technologies have helped the humans not just to survive and thrive in his environment, but also to drive the course of nature. Being a double-edged sword, technology is hurting the civilization more than ever now. Presence of micro-plastics inside human body should serve as the decisive reminder that should push any common man to adopt SDGs every living moment. Higher Educational Institutes (HEIs) are where manifestation of the best version of every student should happen. India utilises NIRF as a parameter, to set forth the guidelines for lucrative pathways, where SDGs have taken roots in the recently released NIRF-2024 rankings. Institutes are expected to explore and adopt these pathways to become a world class institution. In this paper, poignant perspectives through the watch glass of NIRF and SDGs are embarked to the benefit of the stakeholders of HEIs including the teachers, students, management, common public and employers.

Keywords: SDG; NIRF; HEI; Stakeholder; Societal Impact; Technology

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241_IEC29740➲

Circular Economy of Water: Production to Reuse for Sustainability

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Abstract: The circular economy promotes resource conservation through loops. Circulation efficiency depends on how much potable and non-potable water is returned to the supply system after usage. Circular economy quantifies a product's utilization by evaluating its whole life cycle. This covers direct and indirect water use and contaminated water. Water circularity depends on water supplied, lost, and reused. Water needs vary by human settlement, but one of them is enough clean water. Humans desire to use water efficiently, maintain water sources, and recycle to optimize water needs in an environmentally responsible way. This will reduce the stress on the water sources. One problem is creating long-term sustainable water sources without harming local biodiversity and ecosystems. Investments in water boost its value to society. The origin, post-use treatment, circularity, and sustainability of water are more important than throughput. The water footsteps estimations need to embrace circular economy ideas and lower production and water usage estimates.

Keywords: Circular Economy; Water Production; Water Recycle; Water Reuse; Sustainability

244_IEC1595➲

Smart Precision Irrigation System: Matrix-Driven Capacitive Sensing Optimization with Machine Learning

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Abstract: The smart precision irrigation system that includes current technologies for precision farming, aimed at optimizing water use and enhancing agricultural yield. Key components include capacitive soil moisture sensors that are arranged in a matrix structure in the plantation area for real-time moisture level tracking, an analog TDS (Total Dissolved Solids) sensor for assessing irrigation water quality, and a strategically placed water outlet network for precise irrigation. The system is augmented with a weather station that monitors local environmental conditions and alters watering schedules accordingly. Utilizing LoRA and ESP32 modules, it offers powerful connection and data processing, allowing farmers to administer the system remotely via a smartphone app. A machine learning system analyses historical and real-time data to change irrigation plans, boosting optimal water utilization while preventing waste. The system's versatility to varied soil types and weather patterns, together with its user-friendly design, gives farmers with actionable data and alerts. By applying predictive analytics, the smart irrigation system assists farmers to make intelligent decisions, eventually promoting sustainable agriculture and enhancing overall crop yield.

Keywords: Capacitive Soil Moisture Sensors; Matrix Structure; Machine Learning; Total Dissolved Solids (TDS); LoRA; ESP32

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269_IEC41020➲

Water Harvesting from Air Conditioners: A Green Approach

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Abstract: Water is essential to human survival and the lives on our planet. Owing to the massive increase in urbanisation, one of the most important issues in the fields of environmental sustainability and water resource conservation is the demand for water. To provide a sustainable solution to the water management system it is imperative to utilize the naturally available resources as much as possible to minimize the generation of greenhouse gas in order to reduce the carbon foot prints. It is possible to view a considerable amount of water in the form of moisture in the surrounding air as a potential source of water. The source has the capacity to generate clean water that is suitable for home, engineering and agricultural uses. Condensate water which can normally be extracted from air conditioners are disposed in sanitary drains has been identified as the possible source of clean water. This technique can be especially useful as an inventive approach to water management in crowded urban areas with limited space and resources in regions with high humidity, such as tropical and subtropical climates. At first the assessment of quality of condensate water has been done through Water Quality Index system proposed by Horton. The paper is an attempt to understand the quantity of water acquired from air conditioners for satisfying the need of the water requirement for different activities in a warm-humid tropical urban area.

Keywords: Water Demand; Water Quality Index; Condensate; Sustainability; BOD; Air-Conditioner

316_IEC67101➲

Transport Sustainability in Extreme Weather Conditions: An Indian Perspective

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Introduction: The built environment plays a critical role in shaping commuter preferences. In general, mass rapid transit systems are preferred over buses for longer trips[1]. However, extreme weather conditions can pose significant challenges for travellers, especially when they become difficult to tolerate. A study in Sweden using an extended national travel survey and comprehensive weather data across various regions and seasons found that in winter, individuals are more likely to choose walking and public transport while cycling declines. In contrast, summer increases the likelihood of cycling and reduces walking and public transport use[2]. In the Netherlands, during extremely low temperatures, individuals tend to transition from cycling to using cars and public transportation. However, as temperature rises, there is an increased preference for walking and cycling[3]. Mass rapid transit ridership data in Beijing indicates that weekend trips are more affected by weather conditions compared to weekdays. Monthly temperature fluctuations have a greater impact on ridership than daily variations. Specifically, a one-degree increase in effective temperature leads to a roughly 0.5 percent rise in ridership on weekends, while heavy rainfall causes an approximate 8 percent decline in ridership[4]. The results of a fairly recent study indicate that heavy rainfall generally disrupts passenger flow, exacerbating spatio-temporal imbalances[5].

To address this gap, the study aims to enhance our understanding of how weather-related factors, such as heat, humidity, and rain, affect commuters’ choice of transportation modes. Its primary objective is to create a platform that supports the development of adaptive strategies and policies, thereby improving the resilience and sustainability of transportation systems in response to climate change. The research approach is twofold: first, it examines commuter behaviour in selecting transportation modes, and second, it evaluates how such behaviour impacts near-road air quality. The field-based hypothesis in this context indicates that the share of air-conditioned buses and personalised public transport increases during peak hours in the summer but declines in demand during the monsoon season. Additionally, the usage of two-wheelers decreases significantly during heavy rainfall. By incorporating these elements, the study aims to equip transportation analysts with the insights necessary to manage weather-induced challenges effectively without compromising commuters’ transportation needs.

Keywords: Sustainable Transportation Systems; Transport Mode Choices; Weather Conditions; Socio-Economic Factors; Transport Footprint Measurement

Environment & Sustainability

Sustainable Industrial Processing and Green Technologies

23_IEC80660➲

Bio Treatment of Jute for Sustainable Scouring: An Alternative Approach

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Abstract: Jute is a lignocellulosic fibre and cultivated widely in eastern part of India particularly in West Bengal, Bihar, Assam Orissa etc. The fibre is long and strong and generally used as packaging material for food grains. Recently it is used in making diversified and value-added products like different types of bags, handicraft items and to some extent as ornamental fabric. So, chemical processing like scouring, bleaching, dying has become important unit operations now a days. In this experiment jute fibre has been treated with three commercial enzyme preparations as an alternative to chemical scouring and they were applied at three different pH levels. It was found from the experiment that there is a weight loss after enzymolysis and the fibre becomes softer, pliable, finer, and hygroscopic with a small loss of tensile property. The look, feel and performance are better than that produced by conventional scouring method in terms of water absorbance, wicking length and floating time on water surface. So, this bio treatment process has potential to replace the conventional scouring process. The analysis through FTIR and scanning electron microscopy is also showing the same outcome.

Keywords: Jute; Scouring; Enzymes; Tensile Strength; Soft Feel; Water Absorbency

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38_IEC4270➲

Fragrance Finishingon Textiles through Microencapsulation

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Introduction: A rise of environmental concerns and demands for eco-friendly processing of textiles has led to the development of many new cleaner and greener technologies viz. enzymatic finishing, plasma technology, finishing by natural products, microencapsulation etc. Microencapsulation is a technology for packaging particles of finely ground solids, droplets of liquids, or gaseous materials with the help of protective membranes. The material inside the microcapsule is called the core, whereas the wall is called a shell, coating, or membrane. Normally, microcapsules are produced in the range of 1-1000 µm, with those produced above 1000 µm are microcapsules and below 1 µm are called nanocapsules. Microcapsules with a wall thickness of less than 2 µm and a diameter in the 20-40 µm range are useful in textile applications. The release of the core components from the microcapsules depends on the type of material used in the shell, the number of layers present around the core and the thickness of the shell (Martel 2002). This encapsulation has allowed moisturisers, essential and therapeutic oils and insecticides to be incorporated into fabrics. Microencapsulation of anti-microbial agents is also gaining popularity in sportswear and medical textiles. Microencapsulation has a lot of potential for the advancement and development of compounds for the long-term conservation of naturally derived products which has low storage life.

Fragrances are used in an array of everyday products and the use of fragrance in textiles represents a fascinating conjunction of sensory experience and functional enhancement in textile technology. Essential oils, popular in aromatherapy are complex and multiple-component mixtures derived from plant metabolites. It is a preferred choice for those seeking alternative or complementary therapies for health and wellness[1]. These biologically active compounds have infinite potential for a healthy lifestyle by preventing microbial growth and due to different environmental factors, the bioactive properties of those oils differ, thus giving them various functionalities[2,3].

Essential oil is volatile and the most challenging task is to lengthen the emission of fragrance in textiles. The exposure problems of essential oils can be minimised by using the compounds in encapsulated form, which uses a masked shell, to restrict the loss of aroma during finishing application and storage. It can act as the core substance for fragrance-finished textiles through encapsulation and also helps control compound release at the time and site as required[1].

β-cyclodextrin is a cyclic oligosaccharide composed of seven glucose units linked by α-1,4 glycosidic bonds, forming a truncated cone-shaped structure with a hydrophobic cavity and hydrophilic outer surface. Appropriately sized guest molecule ranging from 100 and 400 g mol^{-1} is held within the cavity to form an inclusion complex. The β-cyclodextrin has no mutagenic effect and is also safe for the skin as it doesn't cause any skin sensitivity or irritation. The encapsulation with β-cyclodextrin can reduce the volatility of the compound encapsulated and also act as a barrier against oxidative damage, and degradation of the capsulated molecules against light and heat[4].

Keywords: Aromatic; Fragrance; Microencapsulation; Olfactometric; Textile

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48_IEC97495➲

Study of Compressive Strength of Concrete Modified with Pulverized Water Hyacinth

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Abstract: Water hyacinth, a fast-growing aquatic plant, imposes significant environmental challenges by clogging waterways and damaging aquatic ecosystems. To address these issues, researchers have been investigating the uses of water hyacinth fibers in different forms with concrete. In the same line present study investigates the effects of incorporating pulverized WH at varying levels—0%, 0.25%, 0.5%, and 0.75% as fine aggregate—on the compressive strength and durability of concrete. Firstly, the workability of test specimens is studied, and then concrete cubes are cast and tested after 7, 14, and 28 days of curing. All the tests and results are compared with that of the control mix results. Thereafter, some actual and practical conclusions are drawn based on current investigation. The authors have also pointed out field problems and the future scope of work after all these experimental works.

Keywords: Compressive Strength, Durability, Fine Aggregate, M25, Concrete, Pulverized, Water Hyacinth, Workability

69_IEC45750➲

The Promise of Syzygium Aromaticum (Clove Oil) in Developing Antimicrobial and Green Textiles

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Abstract: The research investigates the antibacterial efficacy of clove oil (Syzygium aromaticum) as a sustainable and environmentally acceptable substitute for synthetic agents in textile applications. Clove oil, mainly composed of eugenol, has prominent antibacterial, antioxidant, and therapeutic benefits. Modern extraction techniques, such as microwave assisted and ultrasonic assisted methods, enhance clove oil yield and quality while minimizing environmental impacts. This research highlights clove oil's superior antibacterial efficacy against Staphylococcus aureus and Escherichia coli on cellulosic substrates, achieving over 99% microbial reduction. Its phytochemical richness and bioactive compounds, including phenolic acids, position it as an effective, biodegradable, and renewable solution for antimicrobial finishes. Compared to other herbal extracts, clove oil demonstrates broad spectrum activity with promising applications in intimate apparel and moisture prone textiles. Future studies must concentrate on compatibility with various textile substrates, durability during wash cycles, and the engineering of patented formulations to enhance their potential in sustainable textile processing.

Keywords: Antimicrobial; Clove; Herbal; Pathogen; Sustainable

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95_IEC91468➲

Diversified use of Water Hyacinth

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Introduction: Water hyacinth, the 'Terror of Bengal' in India, is an invasive plant species with thick, rounded green leaves, lavender-blue flowers, and dark purple to black roots. It chokes streams, limiting activities like fishing and boating, impedes photosynthesis, lowers oxygen levels, and deteriorates water quality, affecting aquatic life, native plants, and animal communities [1]. Despite its negative impact on human health, the 'Terror of Bengal' has several benefits, making it a potential solution for a sustainable world. It has extraordinary properties, including producing biofuel, nitrocellulose, and paper and absorbing dye effluent. In different parts of India, various crafts are produced from water hyacinths. The present study helps partially clean the water bodies to save aquatic life by collecting raw materials. It aims to convert this weed into valuable products to add value to the waste and replace single-use synthetic material with a sustainable and biodegradable product.

Keywords: Air Permeability; Excel; Handicraft; Viscose, Water Hyacinth

110_IEC38742➲

The Functional Aspects of Natural Dyes used in Traditional Textiles

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Introduction: Historically, ancient textiles were dyed with natural sources derived from different parts of plants, minerals, fungi, insects, etc. Natural dyes, mainly used for textiles, are generally obtained from vegetable resources, i.e., barks, roots, flowers, fruits, leaves, seeds, etc. Dyeing and other surface embellishments with natural dyes on textile substrates were practised dating to the dawn of human civilisation to enhance the aesthetic appeal and cure specific diseases due to their proximity to the skin. This fabric, often called Ayurvastra, is used in apparel, floor mats, towels, and medicinal clothes [1,2]. The accidental discovery and gradual development of synthetic dyes in the mid-nineteenth century led to a sudden downfall in the demand and production of natural dyes and materials dyed from natural resources. Today, there is a market for the alternative options preferred by environmentally conscious consumers.

Natural dyes are biodegradable, eco-friendly, and not harmful to the environment if used judiciously. They are safe for skin, food, and children. Natural dyes also have functional properties, viz., antimicrobial, UV-protection, and mosquito repellent [3-5]. The waste materials after dye extraction can also be used as fertilisers (indigo, myrobalan, etc.). However, customer-driven massive industrial production is becoming a significant economic and cultural issue and potentially threatening some biodiversity. Despite these benefits, natural dyes have inherent drawbacks that are primarily to blame for the decline of this age-old, traditional craft [6]. One of the biggest obstacles to using natural dyes on textiles is standardising the recipe and ensuring that the shades are reproducible. It is expensive as it has comparatively low colour yields. The colour also may change when exposed to light, perspiration, air, etc. Some dye sources may have harmful effects on the environment. The dye bath containing various inorganic heavy metals may create a severe disposal problem [7, 8].

In the present study, dyeing and printing/painting textiles with natural colourants to achieve functional aspects of end products have been examined and reported. Today craftspeople are also opting for newer sources of dye materials. A detailed and comprehensive documentation of the traditional process of textile colourationsurely opened newer opportunities.

Keywords: Antibacterial; Functional; Natural Dye; Phytochemical; Traditional

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116_IEC79003➲

Exploration of Resist Technique with Natural Dyes

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Introduction: Batik is one of the most popular surface ornamentation techniques used in textiles to achieve value and aesthetic appeal. It is a method of creating patterns on the fabric surface using wax-resist techniques. Batik is derived from the Javanese word [1]. This age-old resist printing technique is prevalently practised in both Indonesia and India. The two countries have a different essence to their designs, which has deep cultural significance and unique stylized characters. Sophisticated intricate lines to bold motifs, the range is mesmerizing. Indian and Indonesian batik can be identified based on their fundamental pattern differences and colour choices.

The basic process of batik includes using a resisting agent, particularly beeswax and paraffin wax to achieve a cracked effect hence creating a pattern when the wax is removed from the dyed cloth. Naphthol colours are commonly used in batik work due to their known advantages i.e., producing vibrant shades and being dyed at room temperature in a very short time. However, present environmental legislation has stopped the use of naphthol colour in the export market due to adverse health and environmental hazards. Hence, sustainable and eco-friendly alternatives have become a matter of significant importance due to the increased environmental awareness among consumers. The present consumers are looking for a sustainable product in addition to its aesthetic appeal.

The present study aims at using natural dyes in batik work to achieve a more sustainable alternative to popularly used naphthol colour.

Keywords: Batik; Indigo; Natural Dye; Resist; Wax

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144_IEC51299➲

Comparative Analysis of Microwave Cavities for Biomedical Waste

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Abstract: A high-efficiency ridged coaxial cavity for biomedical waste disinfection via microwave heating is proposed. The cavity is designed to operate at a frequency of 2.45 GHz and has a transmission coefficient for TEM mode of more than -0.5 dB over the frequency band 2.3-2.7 GHz. The use of four ridged bars in the coaxial waveguide approximately doubles the operating frequency bandwidth of the cavity. The electric field pattern of the TEM mode in the proposed ridged cavity is more efficient than that of the TM01 mode in a cylindrical cavity, resulting in a more efficient transfer of energy to the biomedical waste. For the electric field pattern of TEM mode in proposed ridged cavity, the field strength at ridged surface is 50kV and at surface of outer cylinder is 27kV. Furthermore, comparison of E-field pattern of Ridged Coaxial Cavity regarding Likely TEM mode respectively shows that Ridged Coaxial Cavity is efficient in interaction with Biomedical waste.

Keywords: Ridged Coaxial Cavity; Microwave Cavity; Biomedical Waste; Microwave Heating; Coaxial Cavity

178_IEC87726 ➲

Improving Power Plant Efficiency through Carbon Capture and Utilization: CO_2 Capture in a Rotating Packed Bed Pilot Plant of One TPD Capacity.

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Abstract: Net-Zero targets for hard-to-abate industries such as thermal power plants can be achieved through effective Carbon Capture. These technologies can either remove the CO_2 from the exhaust stream or produce a concentrated CO_2 stream that can be utilized or stored safely. But, these CO_2 capture processes result in significant efficiency penalties when used in power plants. However, by utilizing the process intensification technique on Carbon Capture, the energy penalties can be reduced. This work involves the absorption of CO_2 in a process intensified Rotating Packed Bed (RPB) gas absorber using aqueous monoethanolamine (MEA) as a solvent for CO_2 capture. A one-tonne per day capacity RPB pilot plant has been installed at our department's R&D centre. The experimental results on the CO_2 absorption process in RPB encompass operating variables, such as rotating speed, solvent concentration, liquid and gas flow rate, temperature., etc. This RPB CO_2 capture process is more efficient concerning overall performance as compared to a conventional column-based absorption-regeneration system. Retrofitting this process in the pulverised coal power plants and other processes has also been discussed.

Keywords: Carbon Dioxide; Chemical Absorption; Rotating Packed Bed; CO_2 Capture

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208_IEC4195 ➲

Leveraging AI and Continuous Improvement for Zero Defects and Sustainability in the Automotive Industry: A Digital Transformation Study

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Abstract: For the automobile sector to achieve zero defects and maintain sustainable business processes, artificial intelligence and continuous improvement are essential. This study examines the gradual adoption of kaizen principles and the changeover from a manual inspection procedure to a fully digital, artificial intelligence-integrated. An analysis is conducted on the digital tracking and inspection system at a multivariant automobile production factory. By Utilizing electronic devices like tablets, barcode scanners, and integrated car monitoring systems, the business was able to successfully lower errors, boost productivity, reduce lead time and use less paper, supporting both environmental sustainability and operational excellence. The application of the use of PDCA (Plan-Do-Check-Act) and statistical quality tools, among other continuous improvement approaches, improved problem-solving and process optimization. This paper provides an information about how adopting AI-powered technology can promote manufacturing sustainability.

Keywords: AI-integrated Inspection; Digital Transformation; Continuous Improvement; Operational Excellence; Environmental Sustainability

278_IEC59702 ➲

The Selection of Optimal Biocomposite by Utilizing a Multi-Criteria Decision-Making Technique

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Abstract: This research focusses on selection of a suitable bio-composite sheet using a Multi-Criteria Decision-Making (MCDM) technique, specifically Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for its desirable applications. Nonwoven reinforcements consisting of Sunnhemp and Dhaincha fibres were used to create the bio-composite sheets, with polylactic acid (PLA) as a matrix material. Bio-composite density, flexural and tensile strength, and flexural and tensile modulus were used to assess the performance of bio-composites. Each characteristic was given a unique desirability weight. The PLA-300GSM Sunnhemp bio-composite was identified as a best material based on the highest TOPSIS score; it was followed by the PLA-300GSM Sunnhemp-Dhaincha biocomposite. This rating provides insightful information on the potential of environmentally friendly, sustainable materials for an array of industrial uses.

Keywords: Eco-friendly Composites; Sustainability; TOPSIS; Sustainable Materials; Polylactic Acid

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308_IEC11665➲

Standardization of Sustainable Surface Modification Protocol of Nonwoven Jute Fabric with Dry Heat Treatment for the Development of Biocomposite Products

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Abstract: Jute nonwoven fabric can be utilized for development of biocomposite with 18-21 percentage volume of reinforcement; however, it can be improved by prior suitable surface modification of jute fibre with reduction in the processing void. In this work, Jute nonwoven fabric was exposed to dry heat at 100°C, 110°C, 120°C, 130°C, 140°C, 150°C & 160°C for 2 h to modify its surface for improving its compatibility with unsaturated polyester resin (USP). Dry heat-treated jute fibre and fabrics (DHJF) were evaluated for their physical, chemical, mechanical and morphological properties and then used for the development of biocomposite with USP by conventional brush dabbing cum compression moulding method. Results inferred that dry heat treatment modified the physio-chemical, mechanical and morphological properties for the improvement of interfacial adhesion with USP resin. The enhancement of fibre properties is positively correlated with the dry heat temperature up to 140oC and then declined due to reduction in mechanical properties. Among biocomposites, DHJF (140°C): USP based bio-composites shown higher tensile, flexural and Interlaminar shear strength properties than other biocomposites. It is concluded that jute fibrous reinforcement can be modified with dry heat at 140°C for 2 hours for improvement its compatibility with the hydrophobic resin. It could also be a sustainable surface modification protocol for the benefit of natural fibre based composite industry by achieving SDG-06.

Keywords: Jute, Biocomposite; Sustainable Goal; Dry Heat; Surface Property; FTIR

371_IEC36154

Modeling and Simulation of Process Coupling in Sustainable Esterification by Pervaporation

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Abstract: Esterification, an essential reaction in both the chemical and pharmaceutical fields, often en-counters equilibrium constraints that limit the product yield. Pervaporation, a unique membrane separation process involving phase change, offers a successful remedy to these limitations by selectively eliminating either water which is an esterification byproduct or ester which is the main product of concern and shifting the chemical balance toward product production. This work investigates the integration of pervaporation with esterification, high-lighting the significance of precise pervaporation modeling in ensuring sustainable and efficient process coupling. Empirical models reported in literature were investigated for their im-pact on estimating final composition of the products. The effect of non ideality nature of components was also considered by incorporating activity coefficients into the model through UNIFAC method. By creating robust models that simulate this hybrid pervaporation coupled esterification process, it is feasible to anticipate membrane performance, optimize operational conditions, and analyze energy efficiency. Furthermore, pervaporation modeling improves reactor design by allowing for process intensification while minimizing energy consumption and waste creation. This combined approach not only increases yield, but also adheres to the principles of green chemistry and sustainable process design. The incorporation of pervaporation models into esterification processes thus has transformational potential, providing a path to eco-friendly production methods that are both economically and environmentally advantageous.

Keywords: Pervaporation; Esterification; Non-Ideal System; Modelling and Simulation; Kinetic Modelling; Sustainable Technology

<u>Environment & Sustainability</u>

Waste Management and Circular Economy

25_IEC55364➲

A Small-Scale Pilot Project on Vermicompost Enriched with STP Sludge: An Opportunity to Recycle the Organic Waste into Organic Fertilizer

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Abstract: The present paper addresses the opportunity of Wealth creation from Waste in Mejia Thermal Power Station, DVC. There are different types and substantial amounts of bio waste generated in thermal power stations and some of the sources are sludge of Sewage Treatment Plant (STP), dry leaves, dry grasses and dry branches of leaves etc. The study discovered two „waste" items, that is, STP Sludge and dry grass that are convertible manually into organic fertilizer for plant growth through Vermicomposting method. Result shows that a good quality vermicompost can be produced economically from the STP sludge, dry grass and cow dung with an optimum bed layer ratio as 5:1:1, respectively. Vermicompost is enriched with Nitrogen, Phosphorous and Potassium whose values are about 9076.92mg/kg, 3883.48 mg/kgand 1461.35 mg/kg, respectively which is helpful for effective plant growth. Cost-benefit analysis discloses that the production cost of vermicompost is about Rs. 22.57 /kg which comparatively lower than the market prevailing rate (Rs. 50 /kg). About 400kg of developed and tested vermicompost is distributed among the forestry department of DVC filed formations and successful plant growth is found.

Keywords: Dry Grass; Economic; Sewage Treatment Plant; Sludge; Vermicompost

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34_IEC46195➲

Just Transition of NTPC Badarpur Power Plant — a Leap towards Sustainable Future

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Abstract: Over the past two decades, as the urgency to build a low-carbon society has gained momentum, the question about the fate of the fossil fuel industry workers and the communities dependent on such industries have gained prominence.

Just transition highlights the need for social justice in the shift towards a zero-carbon world. It reinforces the fact that ending our dependence on fossil fuel should not be a trade-off between the environment and economy. It compels us to think and plan alternative economic and social systems that are sustainable and thriving.

For India, the question to move away from coal is complex given the country‟s coal dependency and the social fabric of fossil fuel supply chain ecosystem. But Just Transition can be "good economics and good politics", if a shift away from coal-economy is planned and managed well. A well-managed just transition will not only help to mitigate the impacts of climate change but also ensure a growth trajectory that is sustainable and equitable and is less vulnerable to social and economic disruptions. The advancements in renewable energy and other innovative technologies give us a perfect opportunity to transition to clean energy; we must seize it. At the same time, we must ensure that fossil fuel related industry workers and the local communities do not shoulder the burden of such energy transition. NTPC, through its engagement on climate change mitigation is working towards a just transition through a collective approach of fulfilling both environmental and social obligation.

At 705 MW Badarpur Thermal Power Station (BTPS) of NTPC Limited was fully decommissioned from operations in October 2018. The plant was successfully sold through e-auction for a sum of Rs. 266.75crore higher than its asset‟s book value. The challenges of resettlement of its employee and contract labor were met as per present industrial practices and laws. The plant had been fully dismantled and disposed-off following environmental guidelines of DPCC, CPCB, NGT & CAQM. The timelines could be maintained despite hurdles posed by COVID‟19 and countrywide lockdown, GRAP orders in various categories during Oct. to Feb. each year affecting construction & demolition works and vehicular movement in NCR. The development of Ecopark on the ash dyke also have challenges of matching technologies, product, designs suitable for harsh and corrosive nature of ash, creating conducive working conditions for labor and handling strict compliance of NGT and Forest department, continual liaison with state and central bodies e.g. DJB, UPID, MoP, DDA, Forest Department, NGT, DPCC, BRPL.

In the case of BTPS, the land had been leased to NTPC Limited by the central government for fifty years at an annual rental lease of 52 million. Land was handed over to MoHUA (Ministry of Housing and urban affairs) in June 2023. Challenge of huge amount of ash in dyke was coped up through intervention of central government who decided to redevelop the ash pond area into an EcoPark as the company was required to return the land fully levelled, remediated and „re-grassed‟.

BTPS and Ecopark are leading examples of Just transition of coal-based power plant for the country and globe at large imbibing adherence to all aspects of a coal plant‟s end-of-life, from retirement to decommissioning to remediation and redevelopment, adherence to legal and regulatory requirements.

Keywords: Just Transition; BTPS; NTPC-EcoPark; Decommissioning and Dismantling; Badarpur; Coal Plant; I-Forest

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89_IEC85694➲

Packaging Box for Transport of Fruits and Vegetables from Jute Stick Particle Board

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Abstract: A formal dehyde free board was developed from jute stick particles. The jute stick was chopped into particles of 6 mm size. About 24% polyvinyl alcohol of the weight of the dry jute stick was taken and mixed with the jute stick particles. The adhesive coated particle was subjected to a constant pressure of 100 kg/cm^2 in the hot press 20 min at 140°C and. After pressing, the particle boards were taken out, cooled and kept at 65 ± 5% humidity and 25 ± 2 °C for seven days to stabilize the particleboards before their evaluation of properties. The modulus of rupture was

15 MPa which satisfies the minimum criterion for the MOR in the Japanese Industrial standard (8 MPa) for particle boards. The two hour water absorption ranged between 30-40%. The weight of the box varies between 1-2 kg and has the capacity to hold about 5 kg fruits like mango or apple. Each box cost around Rs 200-250 and is a reusable, environmental friendly alternative to plastic crate popularly used for transport of fruits and vegetables. The box comply by IS 9590: 1980 (non-returnable wooden boxes for horticultural produce — Type 1 — non-returnable wooden box with corner posts, of nailed or stitched construction The box has high compression strength (3967 kgf) (determined as per IS 7028-1987 (Part 6) RA 2013). The box has bending strength of 30.15 kgf/60 mm (as per guidelines of IS:6219:1989 RA 2014). Can withstand incline impact at a speed of 4 km/h (as per guidelines of IS 7028-1987 (Part 3) RA 2017). Can with stand vibration of 200 cycles and 2.54 cm amplitude for 1 h (as per guidelines of IS 7028-1987 (Part 4) RA 2018).

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102_IEC26914➲

Eco-Friendly Handmade Paper from Jute

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Introduction: Jute, the golden fibre and one of the most important cash crops is a natural lignocellulosic bast fibre. It is a strong, shiny, long, rough fibre that can be spun into fine or coarse yarn. Jute is composed of primarily cellulose (64.4%), hemicellulose (12%), lignin (11.8%), pectin (0.2%), water-soluble matter (1.1%), wax (0.5%), and water (10%)[1]. Jute is widely used in the packaging industry due to its eco-friendly, biodegradable nature, offering a sustainable alternative to plastic. Jute plants clean the air by consuming large quantities of CO_2 gas, and it is reported that one hectored of jute plants can consume about 15 tonnes of CO_2 from the atmosphere and release about 11 tons of oxygen in the 100 days of the jute growing season.

It is cost-effective, strong, and durable, making it ideal for packaging heavy goods like agricultural products. Jute"s breathability helps preserve perishable food items, while its recyclability and aesthetic appeal enhance its suitability for both industrial and premium packaging. The eco-friendly and biodegradable nature of jute has created a new domain in applying non-traditional diversified products. Different researchers have reported the diversified use of jute by modifying its mechanical and chemical properties. The product innovation of making green bags made of jute has been reported in the literature[2]. Some other researchers tried to incorporate the used jute sacks into recycled polyethylene to make composites, which may be used as alternative materials for low-strength conventional composites[3]. The Central Pulp and Paper Research Institute reported that plants with good cellulose content can produce paper[4].

Keywords: Antifungal; Corn husk; Eco-friendly; Jute; Handmade; Paper

133_IEC70372 ➲

Sustainable Textiles through Natural Dyes — a Shift from Fast to Slow

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Introduction: Human activities adversely impact the environment in various ways; textile production, processes, and disposal are some of the key contributors to this phenomenon. The environmental impacts of textiles can be categorised at every stage, including raw material collection and production, transportation, fabric manufacturing, dyeing, finishing, use, and disposal. From the extraction of fibres to the final product, it consumes significant energy, water, and chemicals. Moreover, processes including dyeing and finishing release toxic effluents to water bodies, affecting the ecosystem. In addition, the disposal of textiles, especially synthetic textiles (non-biodegradable materials like polyester), plays a significant role in polluting the environment by accumulating in landfills for ages[1]. Fast fashion trends further fuel overconsumption, which leads to excessive production of cheap polyester clothes and waste generation. At this juncture, it is essential to slow down and think about the environment by introducing and adopting green and resource-efficient products and processes. Slow fashion as a business model emphasises ethical production and sustainable practices[1]. It reduces overproduction, encourages conscious consumerism, durable clothing, and fair labour practices, and minimises environmental degradation. This study promotes a slow fashion model by exploring natural dye on natural fibres alongside different printing applications to broaden consumer acceptance. The natural dye application extends beyond traditional colouring; it also improves functional properties such as UV protection and antimicrobial properties of the fabric. Natural dyes require mordants that fix them to the fibres and enhance their fastness properties. Metal mordants are widely used, but some of them generate toxic effluents. Researchers are trying to replace these heavy metals with eco-friendly, bio-inspired mordants.

Keywords: Fashion; Fast; Mud-Resist; Slow; Textile

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205_IEC55108➲

Cradle-to-Gate Life Cycle Assessment of Perlite Based Composite Plaster Developed with Upcycled Material

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Abstract: This study examines the environmental performance via cradle-to-gate life cycle assessment (LCA) of perlite based composite plaster developed with upcycled flue gas desulfurization (FGD) gypsum as replacements for cement in plaster production. A novel laboratory-scale assessment is performed using openLCA software and ecoinvent database. Three distinct formulations are developed and subjected to physical, chemical, mechanical and environmental assessments. Present analyses confirmed the advantageous effects of using FGD gypsum and perlite by significantly reducing the dry bulk density of the developed composite plaster, notably achieving 687kg/m^3. To enable broader applications of developed composite plaster, LCA is performed on five categories; climate change, energy resources, water use, human health and ecosystem quality. GPP3 mix presents a promising environmentally sustainable lightweight composite plaster. In the composite plaster production, the minimum contribution and maximum benefit is from the non-renewable energy resource consumption (-24.916MJ) along with -1.897CO_2-Eq climate change impact. Gypsum plaster production creates the highest impact of ecosystem quality as 0.212PDF m^2yr. Present study upcycles the by-product FGD gypsum from coal fired power plants for development of lightweight interior single coat plaster. This work will solve the problem of industrial waste disposal and help in reducing the environmental impacts of construction sector.

Keywords: Perlite; FGD Gypsum; Composite Plaster; Life Cycle Assessment

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297_IEC77354➲

Waste Management and Circular Economy

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Abstract: The conception of waste has changed into the new area of raw materials used for the next process to convert in the form of Circular Economy to help the mankind in various ways. The wastages are of different in in nature i.e. Organic, solid waste, liquid waste, recyclable and hazardous . Today‟s idea of refuse, reduce, reuse, repurpose, repair is very common among the domestic and industrial Circle. The whole concept of those 5 R is to save energy , environment, to generate energy, and to be economical. However, the hazardous wastes, in general, are non- recyclable . More and more wastages are generated from the Industries, households, eateries, hospitals, prisons, school & colleges are controlled by local municipalities and most of them are being recycled to create biogas, electricity, and composed for using fertilizers. There are limitations in waste management system because of the lack in knowledge , equipment, and skilled manpower in the municipal bodies. The Circular economy is to create energy from all types of wastages through suitable designs and Technology. It is now-a-days started by various organizations, all over the world to produce electricity, biogas and Gobar gas.

Keywords: Recycle; Energy; Environments; Control of Waste; Technology

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318_IEC429➲

Smart Waste Management: A Community-Driven Revenue Generation Model for Small Townships

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Abstract: The increase in population has surge the demand of all essential services. The increasing demand and supply, change in lifestyle and march towards a cosmos life has led to and poor management in various sectors. Among these, waste management stands out as one of society's most pressing challenges. Traditional methods of waste disposal are increasing the burden on land and contributing to land pollution, hampering the environment. Due to Change in life style the change in waste generation has also changed. It has given a rise to an urgent need to develop sustainable and effective waste management strategies. The existing literature highlights the problems encountered in pre and post waste managing services. In response, to manage the waste at the source and to encourage the people"s participation a revenue generation model is proposed and applied to a small residential area, colony. This model is designed is to generate revenue through awareness and implement “3 R"s” (Reduce, Reuse, Recycle), making the residential colonies self-sufficient. A comprehensive study on revenue generation and its management is presented, demonstrating the effectiveness of this approach.

Keywords: Revenue Generation; Smart Waste Management; Reduce; Recycle; Reuse; Community Engagement

Information & Communication Technology

5G/6G Communication

152_IEC74748➲

Design and Analysis of Compact Antenna for 5G Advanced mm Wave Bands for V2X Wireless Telemetry Applications

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Abstract: This paper presents a compact, wideband antenna designed for modern mm-wave communication systems, particularly 5G applications. The antenna employs a combination of meander line and ring-loaded structures to enhance current density and performance across multiple frequency bands designed on a Roger substrate measuring 28 mm by 42 mm, with a height of 1.6 mm, and the antenna achieves a peak gain of 8.4 dBi with 20dB front to back ratio and –2.4dB isotropic sensitivity and features wide band capabilities, with notches around 34.9 GHz and a minimum reflection coefficient of -35.4 dB. Covering frequencies from 34.4-38.8 GHz, it supports 5G bands n259, n260, V2X wireless telemetry, and ground-based navigation systems, making it ideal for advanced 5G applications.

Keywords: Wireless Telemetry; Fractals; Microstrip Patch Antenna; Wireless Communication

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188_IEC36941➲

Selection of a Suitable Filter to Reduce ISI and Improve BER for 5G Links

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Abstract: The interference between the two consecutive symbols, received in two successive clock periods in a data communication receiver is a very common phenomenon. It happens mainly due to the fact that the waveforms generated corresponding to a symbol takes certain time to die down. This slow decay again has a role to play in the stability of the system. It is known from theory that filters can help to reduce this problem. However, theory also states that the effectiveness of different types of filters varies quite a lot. In this work, we have experimented with three types of filters- Butterworth, Chebyshev-I and Raised Root Cosine (RRC) filters. We have generated the comparisons in two formats –

i) constellation diagrams to explain the ISI performance and
ii) BER graphs. The objective is to show quantitatively the differences among the three filters in respect of their efficacy to reduce the effect of Inter Symbol Interference (ISI).

The definite way to compare the results is with the help of Bit-Error-Rate (BER) in all the three cases. We have derived results to prove that RRC type is the most efficient to reduce ISI.

Keywords: BER; Butterworth Filter; Chebyshev Filter; ISI; RRC Filter

217_IEC56673➲

Far Field Radiation Pattern Synthesis of Elliptical Antenna Array for 5G and 6G Communication Systems

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Abstract: This paper introduces a novel design strategy for a 12-element Time-Modulated Asymmetric Elliptical Antenna Array (ATMEAA) aimed at optimizing far-field radiation patterns for 5G and 6G communication systems. The design focuses on minimizing interference by reducing sidelobe levels (SLLs) and sideband levels (SBLs), both of which are critical for enhancing signal quality in high-frequency communication environments. To achieve ultra-low SLLs and SBLs, an optimal combination of switch-ON time sequences and progressive phase delays is employed. These parameters are fine-tuned using advanced metaheuristic optimization techniques, namely Grey Wolf Optimization (GWO) and Sail Fish Optimization (SFO) techniques. The practical implementation of ATMEAA is analyzed at a fundamental operating frequency of 2.4 GHz. Key performance metrics such as SLLs, SBLs, feed network efficiency, and directivity are evaluated using the GWO and SFO methods. The results demonstrate significant improvements in reducing unwanted radiation components and boosting antenna performance. This approach ensures the antenna array is well-suited for high-performance applications in next-generation 5G and 6G wireless communication networks, where minimizing interference and maximizing efficiency are paramount for reliable and high-speed data transmission.

Keywords; Elliptical Antenna Arrays; Feed Network Efficiency; GWO; Sidelobe Level; Sideband Level; SFO

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291_IEC91281➲

Empowering Bharat's Digital Future through 5G Ecosystem and Bharat 6G Alliance (B6GA) Initiative — A Collaborative Approach

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Introduction: The mobile telecommunications landscape is undergoing rapid transformation, driven by emerging technologies and shifting user behaviors. Key trends include the widespread adoption of 5G networks, enabling faster data rates, lower latency, and greater connectivity. The Internet of Things (IoT) is expanding, with 5G-powered devices and applications proliferating across industries. Artificial intelligence (AI) and machine learning (ML) are optimizing network operations, enhancing customer experience, and improving security. Edge computing is gaining traction, reducing latency and enabling real-time processing. Furthermore, the convergence of 5G, AI, and cloud computing is driving the development of immersive technologies like augmented and virtual reality (AR/VR). As 6G research begins, focus areas include terahertz frequencies, quantum computing, and holographic communications. These advancements promise to revolutionize mobile telecommunications, transforming industries, and enriching user experiences.

India's mobile communications market is growing rapidly, driven by increasing smartphone penetration, expanding internet usage, and rising data consumption (TRAI, 2020).

Keywords: 5G Ecosystem; Bharat 6G Alliance; Indigenous Technology; Digital Transformation; Collaboration

Information & Communication Technology

Computer Architecture

228_IEC55293

Bridging Technology and Tradition: Mobile Apps in the Preservation of the Irular Language

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Abstract: This study addresses the revitalisation of the endangered Irular language spoken by the indigenous Irula people in southern India through a novel Mobile-Assisted Language Learning (MALL) approach. This innovative methodology, aimed at preserving language and enhancing the socioeconomic conditions of the community, demonstrates significant potential. This research delineates the development of a mobile application that incorporates participatory observation with 50 native speakers from Tamil Nadu and iterative feedback mechanisms to create a culturally sensitive and effective learning platform. Preliminary findings from pilot testing indicated improved language retention and engagement, particularly among younger users, facilitated by adaptive learning technologies and gamification. However, the study is subject to limitations such as a minor participant pool and the absence of a standardised script, which may impede broader application. This research contributes to the field of language revitalisation by elucidating the potential of mobile technologies to support endangered languages and empower indigenous populations.

Keywords: Irular Language; Mobile-Assisted Language Learning (MALL); Language Revitalisation; Indigenous Communities; Mobile Technology; Adaptive Learning; Gamification

Information & Communication Technology

Cyber Security

129_IEC43639➲

Enhancing Healthcare Security and Efficiency through Blockchain and Fully Homomorphic Encryption

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Abstract: Blockchain technology presents significant opportunities to enhance security, efficiency, and data privacy in healthcare. This research integrates blockchain with Zama's Fully Homomorphic Encryption Virtual Machine (FHEVM) to improve data security during medical emergencies. By enabling computations on encrypted patient data without decryption, this approach maintains confidentiality throughout data processing. Hospitals utilize two datasets—'currentSet' for real-time updates and 'existingSet' for static data—while blockchain-based smart contracts enforce patient-defined access policies for Personal Health Records (PHRs), ensuring secure and transparent data transactions. Our findings indicate that FHE improves encryption speeds, achieving processing times of 9.25 to 13.975 milliseconds for 2 to 10 attributes. Throughput analysis shows efficient deployment times, such as 4 seconds for 15 attributes and 10 seconds for 180 attributes. By integrating blockchain with FHEVM, we enhance data security and confidentiality in PHR management, while also reducing processing times for Medical Users (MUs) and Medical Service Providers (MSPs), thereby increasing overall reliability and data integrity in healthcare systems.

Keywords: Blockchain Technology; Fully Homomorphic Encryption (FHE); Healthcare Management Systems; Data Security; Smart Contracts; Personal Health Records (PHRs)

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180_IEC333➲

Advancements in Deep Fake Detection: Strengthening Trust and Security for Global Societal Growth and Sustainability

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Abstract: Deepfake technology has the potential to disrupt societal trust by enabling the creation of highly realistic, yet falsified, media content. As this technology advances, so too must the methods for detecting and mitigating its harmful effects. This paper explores cutting-edge advancements in deepfake detection techniques, focusing on AI-powered systems, forensic analysis, and blockchain verification. These enhancements aim to protect individuals and institutions from the growing threat of media manipulation, thereby fostering societal security and trust. By implementing advanced detection mechanisms, we can mitigate the misuse of deepfakes and promote the responsible use of digital technologies for societal growth.

Keywords: Deepfake Detection; AI; Forensic Analysis; Blockchain; Media Manipulation; Societal Trust

265_IEC2721 ➲

Phishing Detection using Machine Learning Algorithm

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Abstract: This study deals with the employment of artificial intelligence algorithms to catch the phishing websites and the spam emails, thus, it focuses on cyber security. Mainly it focuses on challenges to mobility, classifying such as Decision Trees, Random Forest, Support Vector Machines (SVM), Naive Bayes, K-Nearest Neighbours (K-NN), and then designing methods like, Bagging and Boosting on a range of datasets in order to get the right model were prescribed to the algorithms; this was done through the use of feature extraction which mainly focused on the URL and contents of the email. Users showed that the combination of Genetic Algorithms (GAs) and WHOIS protocol analysis greatly boost credibility and speedup detection. Further, Random Forest and AdaBoost were found to display stable and improved the performance by reaching the rates of99.87%. This work provides experimental evidence for the important role of algorithm effectiveness in real-time phishing and spam detection.

Keywords: Phishing Detection; Spam Email Detection; Machine Learning; Random Forest; Support Vector Machine (SVM); Naïve Bayes; K-Nearest Neighbors (KNN); Ensemble Methods, Bagging; Boosting; Genetic Algorithms (GAs); WHOIS Protocol; URL Feature Extraction; Real-Time Detection

<u>Information & Communication Technology</u>

Digital Transformation (AI/ML, Bigdata, IoT, IIoT, Analytics, Cloud Computing, Digital Twin, Robotics, Industry 4.0/5.0)

12_IEC00012A➲

Role of Machine Learning Analytics to Secure Financial Fraud Operations

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Abstract: Machine learning (ML) analytics is widely recognized for tapping unidentified frauds, particularly in addressing the challenges of financial fraud and data-driven operations. Emerging patterns of financial transactions and new ways of fraud hybrid with different industry segments online and offline pose significant challenges to operations. The current study augments these challenges and assesses the role of varying ML analytics such as logistic regression (simple, interpretable, and applicable for binary classification; support vector machines (addresses outliers and is effective in high-dimensional spaces); decision trees (identifies non-linear patterns); and random forest (combines multiple decision trees) to compare with each other against traditional rule-based systems for tapping financial frauds with improved accuracy and reduce overfitting.

In the current study, due to the confidential nature of online payments transactional data considered here of an IT-based firm, a synthetic and labeled dataset of digital transactions (based on aggregated metrics and with intentional malicious entries) generated from Kaggle (a simulator-PaySim), is used for the data analysis. Transaction type, the monetary value of each transaction, customer identification number, recipient's existing and post-transaction account balance-related transactions, time step for each transaction, and fraudulent transaction binary indicator are considered variables to ML-based model building. Firstly, the ML extensive feature reduction and statistical analysis are carried out to understand the dataset's characteristics and class imbalance and identify key predictors of fraud. Secondly, the comprehensive data analysis provides outcomes and effectiveness- performance assessment of each ML analytics based on cross-validation and confusion-based performance metrics such as accuracy, precision, recall, and the rate of false positives.

By leveraging such advanced analytics and addressing the nuances of fraudulent patterns, the current research observed that the random forest-based ML approach is the best-performing algorithm, which can increase an appropriate level of accuracy and model fit in detecting fraudulent transactions to a scalable fraud detection system. The study shows implications for scalability, deployment, data security, and legal compliance. It suggests for future research that the appropriate ML models can be used further in real-time monitoring systems to design reliable fraud detection systems and enhance the security of scaled-up financial transactions. The current study is built on digital transaction data, which may not be universalized to other types of financial fraud and pattern recognition. Future research can be extended fraud in credit card segments. The study used a pre-labeled dataset, which may be restricted to the real-world situation of the financial sector. Future work may also be focused on unsupervised or semi-supervised learning -ML models/ analytics to reduce this dependency. Limitations of the study are also acknowledged in terms of the financial sector seeking support from ML techniques to combat the growing threat of online payment fraud.

Keywords: Machine Learning Analytics, Financial Frauds, Digital, Data Pattern

50_IEC65760 ➲

Optimizing Indian Agriculture with AI and IOT Selecting Mutation for Crop Optimization

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Abstract: The rural area of India is at its critical position, with the growing population interests and development are affecting the current environmental change. The historical methods which are ground rooted techniques in the country's where unable to meet the current day demand with price, supply, sustainability, and efficiency. This paper primarily focuses on the transformation of these methods by using Artificial Intelligence (AI) and the Internet of Things (IOT) which enhance the genetic optimization of the crops to meet the demand of the current Indian agricultural landscape. By careful monitoring the field was able to analyse that information to ensure high accuracy with better decisions that impact both yield and supply. combining AI driven predictive analytics with IOT enabled precision farming we can unlock new levels of crop yield, quality, and resilience which further leads to more enhanced techniques which initiate Algorithms ensure real-time monitoring techniques. This paper investigates usage of the Indian home needs, commercial needs displaying the better usage of the advanced techniques, and features the potential for scaling up the demand and production with the whole nation. The discoveries are recommending that Artificial Based Intelligence and IOT not just increase the path but provide additional support and profit in cultivating yet in addition hold the commitment of changing Indian agriculture by continuous supply of food and upgrading everyone's livelihoods.

Even with developing populace requests and the difficulties presented by environmental change, the rural area in India is at a basic crossroads. Customary cultivating techniques, while well established in the nation's set of experiences, are progressively lacking to meet current necessities for proficiency, maintainability, and efficiency. This paper investigates the ground breaking capability of Man-made brainpower (man-made intelligence) and the Web of Things (IOT) in the hereditary improvement of harvests inside the Indian horticultural scene. By incorporating man-made intelligence driven prescient investigation with IOT empowered accuracy cultivating, we can open new degrees of harvest yield, quality, and versatility. Simulated intelligence calculations, joined with IOT sensors, empower constant checking and data driven navigation, enhancing water system preparation, and bug control. Besides, this approach works with the improvement of hereditarily advanced crops that are more qualified to neighbourhood climatic circumstances and impervious to sicknesses. This paper examines contextual investigations from Indian homesteads, displaying the effective execution of these advancements, and features the potential for scaling these developments the nation over. The discoveries recommend that computer based intelligence and IOT not just proposition a pathway to additional supportable and proficient cultivating rehearses yet in addition hold the commitment of changing Indian horticulture by guaranteeing food security and upgrading the livelihoods of ranchers.

Keywords: Artificial Intelligence; Internet of Things; Man-Made Brainpower; Simulated Intelligence Calculations

55_IEC60336 ➲

Application of Convolution Neural Network to Classify Thermal Tomographic Images for Heating Assessment

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Abstract: Classification of thermal images has been extensively used for its significant usefulness in various applications in security, medical, and industrial domains. This work proposes a Convolutional Neural Network (CNN) based architecture, to excerpt features from thermal tomographic images and thereby their classification towards evaluation of heating pattern in a closed chamber. Accurate and efficient classification of thermal tomographic images poses a significant challenge in the assessment of heating qualities like they are uniform or non-uniform due to the complex image content and the scarcity of annotated datasets. The temperature and air-flow data are collected using sensors over a circular boundary inside the chamber. These data are fed to COMSOL Multiphysics software running on a PC, which forms the thermal tomographic images under different heating and airflow velocity conditions over the space bounded by a circular contour. Thermal tomographic image database is formed following experimentation from which 40 thermal images of each class for three different classes indicating three different heating qualities. Random 35 thermal images from each class are used for training with the proposed CNN based classifier. Rest images are selected arbitrarily for testing. The result obtained from CNN based classifier is quite satisfactory with accuracy levels of 100% for class 1, 80% for class 2, and 100% for class 3.

Keywords: Tomographic Image; Image Processing; Convolution Neural Network; COMSOL

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58_IEC22427 ➲

Business Growth with AI/ML

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Introduction: This paper looks in to the various ways in which AI/ML can be used to drive the growth of businesses and their potential area of application.

The information technology and services sector in India is getting into an exciting phase with huge growth and opportunities across diverse segments. Since the last couple of decades, India's technology service industry is at the forefront and driving technology-enabled business transformations across the world. With initiatives like Aadhar, Aatma Nirbhar Bharat and Digital India along with technologies like Data Analytics and AI, India is not just transforming but leading the global market in digital transformations.

AI & ML is one of the emerging technologies in digital transformation that help businesses deliver unforgettable digital customer experiences. They enable the emergence of new business innovations.

The use of data and AI is the central point for organizations and management, driving their digital transformation journey. Digital transformation coupled with AI & Machine Learning can deliver best results and help in transforming core areas like BFSI, healthcare, citizen services, MSME, agriculture and manufacturing, with speed and scale.

Organizations can build predictive models to bring a great deal of efficacy in digital optimization and automation and it can help scale processes much faster, allowing results to be delivered in seconds as compared to months

AI (Artificial Intelligence) and Machine Learning (ML) is projected to achieve a CAGR of 52% by 2025, indicating its rapid adoption by worldwide businesses.

Collectively, they augment growth prospects for businesses focused on customers and striving to leverage the extended possibilities of digital transformation fully. The integration of AI is currently permeating and being put into action across diverse industries, including but not limited to national security, healthcare, logistics, and education.

Keywords: Data Analytics; Automation; Cyber Security

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74_IEC74268 ➲

Exploration of Relative Permittivity as a Marker for Moisture Content in Bamboo Samples

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Abstract: In present times, ethanol is used as an alternative to fossil fuels globally. Bamboo is an important source of producing ethanol. The moisture present in the bamboo determines the efficiency of ethanol production. Hence, accurate moisture measurement in bamboo is important. Gravimetric measurement is gold standard for determination of moisture content in any solid fuel (i.e. coal, biomass etc.). However, this method is time consuming and not suitable for onsite or field testing. On the other hand, other available methods for onsite moisture measurement are primarily applied to woods. Bamboo being one of the tallest grass shows significant different characteristics than woods. Here, as an initial exploration, we attempt to measure moisture content in Bamboo through capacitance sensing, which is simple, compact and thus field deployable. Our work shows promising result where relative permittivity of bamboo sample, when measured through capacitance sensor, well correlates with its moisture content.

Keywords: Ethanol, Capacitive Sensor, Bamboo Moisture Measurement, Relative Permittivity

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88_IEC89694 ➲

Quantum Speedup of Machine Learning Algorithms

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Abstract: Quantum machine learning is a burgeoning field that leverages the unique properties of quantum computing to accelerate traditional machine learning algorithms. By exploiting quantum parallelism and interference,

quantum computers have the potential to dramatically outperform classical computers on certain machine learning tasks. This research investigates the quantum speedup achievable for several fundamental machine learning algorithms. We observe significant improvements in the computational efficiency of:

- k-means clustering: A popular unsupervised learning algorithm used for data segmentation.
- Support vector machines (SVMs): A supervised learning algorithm widely used for classification and regression.
- Principal component analysis (PCA): A dimensionality reduction technique used to extract the most important features from data.

The findings reveal that quantum algorithms can offer exponential speedups compared to their classical counterparts for these tasks. This is due to the ability of quantum computers to explore a vast number of possible solutions simultaneously and to exploit quantum interference to amplify the probability of finding optimal solutions. These results highlight the promise of quantum computing for revolutionizing machine learning and enabling the analysis of larger and more complex datasets than is currently possible with classical approaches. As quantum hardware continues to advance, it is anticipated that quantum machine learning will play a crucial role in addressing a wide range of challenges in fields such as artificial intelligence, drug discovery, and materials science.

Keywords: Quantum Machine Learning; Quantum Speedup; Machine Learning Algorithms; Quantum Computing; Computational Complexity

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103_IEC43935 ➲

Revolutionizing Healthcare: A Comprehensive Survey on Large Language Models

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Abstract: Large language models (LLMs) are enabling a revolution in artificial intelligence, particularly in the healthcare industry. These models enable a more customized approach to healthcare analytics, which raises the relevance and accuracy of results when they are customized to specific disorders. Specialized LLMs improve their ability to respond to inquiries unique to their area of expertise by building on basic models and being trained on extensive datasets spanning a wide range of subjects. The increasing prevalence of tailoring LLMs for medical applications is exemplified by applications such as MedAlign, MedLM, and MediPalm, which are instances of generative AI solutions created with the healthcare sector in mind. The countless opportunities that LLMs have to improve the working conditions of healthcare personnel and, consequently, the caliber of patient care, are evidenced by the continuous advancement of novel approaches and applications in this domain. This research attempts to showcase the most recent developments in cutting-edge LLMs in the medical field, with an emphasis on personalized models that address particular medical requirements.

Keywords: Large Language Model; Artificial Intelligence; Generative AI; Healthcare

113_IEC96381 ➲

A Systematic Review and Experimental Analysis of AR based Simulator used for Maritime Training

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Abstract: This is a systematic literature review and experimental study on the integration of Augmented Reality (AR) based Training methodology within maritime training. The study focuses on systematic optimization the usability and evaluating the training effectiveness. AR Technology presents a promising AI tool bridging between the conventional training simulators and final proficiency acquisition by making the seafarers training environment a virtually real space. This preview analyses an abundance of data gathered from more than a hundred pre reviewed studies offering a clear understanding of how immersive technology can be effectively utilised to evaluate the training and watch keeping requirements (STCW).

The experimental study, involves application of AR based tailored training simulators to a group of aspiring maritime professionals allowing an immersive, hands-on practice with increased student engagement, and evaluation of competency, knowledge retention and skills without an associated risk.

To assess the impact of AR on skill acquisition, a series of experiments were conducted, wherein 80 students specializing in maritime engineering participated in a series of tests designed to evaluate the effect of augmented reality on skill learning. Two groups of participants were formed; one group trained conventionally, and the other group trained using

an augmented reality simulator. The purpose of the experiment was to assess how augmented reality (AR) impacted student practical skills, comprehension of marine operations, user engagement, flexibility, and overall training satisfaction. Comparing the students who trained with the AR simulator to those who received traditional training, the results showed that the former had significantly improved their ability to acquire new skills. In particular, the AR group performed better trouble shooting tests involving managing equipment, spatial awareness, and taking corrective action decisions.

Despite of these encouraging results, the study also pointed out certain challenges. A portion of students reported feeling uneasy or confused when utilizing the augmented reality simulator, suggesting that additional improvements to the technology are necessary to guarantee user comfort. Furthermore, the AR equipment's initial setup and maintenance required a significant amount of time and money commitment, which would prevent some organizations from adopting it. Finally, by providing an efficient, interesting, and adaptable learning tool, augmented reality (AR) has the potential to transform certain areas of maritime engineering education, as demonstrated by the experimental study and systematic literature review. The benefits of augmented reality (AR) in improving proficiency skill acquisition and offering a safer, more affordable training environment are evident, notwithstanding several obstacles to its broad adoption. Future research on addressing the technical and logistical barriers to AR adoption, as well as exploring long-term outcomes of AR-based training in maritime engineering will ease in its adoption as an effective tool.

This study intends to analyse and increase and constantly improve the application of augmented reality (AR) in maritime education, with a special focus on engineering equipment maintenance. The purpose of the study is to determine how well AR-based training may improve the practical skills, knowledge retention, and competency of maritime engineers.

Keywords: Augmented Reality; Immersive Technology; Maritime Training; Education, Training Effectiveness; Simulators; Marine Engineering; Proficiency; STCW, MET

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124_IEC35197➲

Development of an IoT Based Simplex Wireless Communication Protocol for Smart Lighting Control

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Abstract: Due to the advancements in the field of electronics, the economical availability of varieties of sensors, microcontrollers and microprocessors have become a reality for the users. Recent trend of manufactured products include wireless transmission modules as well as microcontrollers with an integrated Wireless Fidelity (Wi-Fi) chip, the availability of which has prompted a surge in research and developmental studies in the field of wireless communication, wireless data monitoring and wireless controlling of electrical or mechanical appliances. Due to the availability of Wi-Fi, Internet of Things (IoT) sensor data transmission and wireless controlling has been steadily increasing. In the current paper a simplex wireless communication procedure has been presented, which has been developed and applied to an IoT based Pulse Width Modulated (PWM) lighting control of Light Emitting Diode (LED) luminaires. The working principle of the aforementioned developed system along with the performance evaluation of the LED luminaire has been presented. The performance evaluation includes both the electrical as well as illumination parameters. The LED luminaire chosen in the present work is a high voltage street luminaire.

Keywords: Internet of Things (IoT); Light Emitting Diode (LED); Pulse Width Modulation (PWM)

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135_IEC29928➲

Comprehensive Survey on Blockchain-Based Identity and Access Management Systems in Mobile Networks

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Abstract: This paper provides a comprehensive survey of blockchain-based identity and access management (IAM) systems in mobile networks. Blockchain technology, due to its decentralized, secure, and transparent nature, has been a promising solution for addressing the limitations of traditional centralized IAM systems. This paper examines the key concepts, challenges, and future directions of blockchain-based IAM in mobile networks. It explores self-sovereign identity, zero-knowledge proofs, and smart contracts to bring security, privacy, and scalability. Lastly, it talks about integration with blockchain and IoT/next-generation mobile networks. By highlighting the challenges along with harnessing the strength of blockchain, we would be able to build stronger, efficient, and more user-centric mobile network ecosystems.

Keywords: Identity and Access Management (IAM); Mobile Networks; Blockchain Technology; Self-Sovereign Identity (SSI); Decentralized Identity Management; Next-Generation Mobile Networks (5G)

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151_IEC54034➲

Wireless IoT-Based Soil Health Monitoring System by using Soil NPK Sensor for Crop Yield Optimization

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Abstract: Farming is important to our economic growth of a country. Crop productivity is mainly governed by soil fertility. Fertilizers are usually suggested based on the soil's nutrient content. To suggest an appropriate fertiliser amount, a soil nutrient analysis must be performed, which is normally done using laboratory procedures. Manual soil nutrient testing methods are time consuming. To implement precision Farming, a needle sensors based system has been proposed. A needle-based sensor has been developed to measure and identify the presence of Nitrogen (N), Phosphorus (P), and Potassium (K) in the soil. Such a sensor is used to estimate how much extra content of these nutrients should be given to the soil in order to boost soil fertility. The system collects data using an AVR micro-controller, so the sensor's output is converted to a digital display showing. The needle-based readings on many soil samples have been found to be capable of calculating the quantity of NPK content in the soil in mg/kg. This information is sent to the Amazon Web Services (AWS) cloud, and the resulting values are presented on a mobile app. The suggested Internet of things (IoT)-based application server has the knowledge to recommend the appropriate amount of Nitrogen (N), Phosphorus (P) and Potassium (K) fertilizer to improve the soil's integrity and assure the crop's optimal growth. All device are mounted into a Single PCB board.

Keywords: Soil Sensor (NPK); Arduino IDE; RS485(TTL); NodeMcu ESP8266; OLED Dispaly; Battery

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153_IEC69➲

Leveraging AI and Digital Twin Technology to Shape the Future of 6G Wireless Communication Networks

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Abstract: The advent of 6G wireless technology heralds a new era of communication, with research focusing on emerging technologies to shape its landscape. Artificial intelligence (AI) and machine learning (ML) are poised to revolutionize 6G networks by optimizing processes, enhancing efficiency, and improving resource allocation. A key innovation is digital twin technology, enabling real-time simulations to refine designs. 6G promises higher data rates, greater spectrum efficiency, and improved performance metrics, including reduced latency and energy consumption. However, achieving these goals requires advancements in semiconductor technologies and AI-driven simulations. The integration of AI/ML will drive new approaches in semantic communications and resource management, crucial for future wireless systems.

Keywords: 6G Technology; Artificial Intelligence (AI); Machine Learning (ML); Digital Twin Technology; Wireless Communication

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155_IEC62341➲

Electricity Power Defense Mechanism

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Abstract: Electricity theft emerged as a critical issue in modern smart grids, leading to substantial financial losses and jeopardizing grid stability. Traditional detection methods, such as manual inspections, audits, and rule-based algorithms, are increasingly ineffective in addressing the sophisticated techniques employed by modern electricity thieves. Though electricity consumption can be measured using a smart meter, a deviation exists between the actual and the current outcome that has not been identified properly. To address this challenge, we propose a deep learning-based data analytical model that can analyze the dynamic nature of cyber-attacks and detect a zero-day attack. Hence, it acts as a power defense mechanism.

Keywords: Convolutional Neural Network; Deep Reinforcement Learning; Zero-Day attack; Cyber-Attack;

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164_IEC44093➲

Robust Deep Learning Model for Plant Disease Identification and Management with Crop-Specific Precision

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Abstract: Effective and quick identification of plant diseases contributes significantly to farm production level as well as to the proper preservation of land and its resources. In case of overfitting in the previous models, they often misstated the crops, e.g., mistaking an apple leaf for a tomato leaf, or incorrectly identifying diseases etc. In this work, we propose a new system that deals with this problem by training and deploying different models for different crops resulting in an increase in accuracy and robustness. The model uses ResNet50 for image processing and disease detection, while a Nonet, a custom Nine-layered dense neural network is used for plant disease prediction. For training these models, an extensive dataset was used, which was gathered from various sources such as National Institutes of Health (NIH), Kaggle, and Research Gate, consisting of over 200,000 images per disease. The system is equipped with all functionalities to provide a seamless experience to the farmers with regards to management, a Flask-based backend and HTML/CSS based frontend. Machine learning elements employed include Tensor Flow, Keras, NumPy and Scikit-learn while the app is envisioned to be built with Buildozer. The objective of this system is to assist the farmers in the early detection of diseases and the subsequent management of the crops as per the given recommendations.

Keywords: ResNet50; Transfer learning; Overfitting Mitigation; Buldozer; Precision Agriculture

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169_xxxxxxxx➲

Investigating the FSO Communication Way using Articulate Optical Sources in Visible Wavelength under Simulated Rainy Condition

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Abstract: Rain, fog, dust, snow, and other atmospheric dangers can impair the optical wireless communication channel established in free air in a free space optical communication system. Precipitation has a noteworthy effect on the Free Space Optical (FSO) communication system. Higher rainfall rates may have an unwieldy influence scheduled the system, particularly in the sultry and moderate regions. This article examines the investigational findings of different rain tariff that were manufactured artificially and how they affected the FSO communication channel. Using an artificial rain chamber with visible wavelength laser communication channels at 532 and 638 nm over a 20-meter connection range, the bit error rate (BER) and their attenuation levels have been determined for varying rainfall tariff.

Keywords: FSO; BER; Optical Power Attenuation; Visible Wavelength; Rain

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174_IEC73247➲

Gen AI-Powered Distributed Asset Health Monitoring, Data Ops & Chat Interface by Presenter

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Abstract: In the modern industrial landscape, organizations are facing an unprecedented influx of real-time data from sensors, machines, and Industrial Internet of Things (IIoT) devices. This data deluge poses significant challenges for traditional asset management approaches that rely heavily on human expertise and manual processes (Biggio & Kastanis, 2020). As industries strive for greater efficiency, reduced downtime, and improved decision-making, the limitations of these traditional methods have become increasingly apparent. Enter Generative AI, particularly Large Language Models (LLMs), which have emerged as powerful tools for transforming asset health monitoring and maintenance. By processing vast amounts of industrial data, LLMs can identify patterns, detect anomalies, and provide predictive insights that allow organizations to transition from reactive to proactive asset management. A critical component of this transformation is the Data Verse, a comprehensive data repository that serves as the foundation for AI-based analysis. The Data Verse can be deployed on 'cloud infrastructure' or 'on-premises', providing organizations with the flexibility to manage their data according to security and operational needs. This abstract outlines the transformative potential of generative AI-powered asset health monitoring systems and explores how LLMs, integrated with robust data pipelines, can reshape industrial maintenance strategies.

Keywords: Predictive Maintenance; Industrial DataOps; Gen AI; IIoT; Distributed AI; D2P2; Data Lake; ETL; Cloud Computing; AIML; Industry 4.0/5.0; Digital Twin

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181_IEC36267➲

Facial-recognition based Secured Cloud Voting System using Transfer Learning

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Abstract: The smooth and effective administration in a country requires the unbiased representation of people’s mandate obtained through the Voting system. The traditional voting approach is prone to manipulation by non-state actors, thereby increasing the risk of proxy voting. To mitigate this issue, the conventional voting approach may be upgraded with the aid of advanced technologies of Cloud Computing to formulate an electronic, integrated, and unified citizen-centric voting mechanism. In this paper, a Cloud Voting System (CVS) based on a smart card namely, Multipurpose Electronic Card (MEC) has been proposed. This MEC provides multi-variate electronic services to citizens through the public cloud. Authentication of voters is one of the important aspects of the Cloud Voting System. One-shot learning-based facial recognition is a classification task that performs classification given one or a few instances of each class. The authors have addressed the One-shot Learning Facial recognition using the transfer learning technique of Deep Learning. Transfer learning works by applying a pre-trained model to a new problem. The input facial image could be verified successfully with that of the facial images stored in the repository dataset using ResNet and Xception pre-trained models. The accuracy obtained using the Xception model is 87.916%.

Keywords: Cloud Voting; Facial Recognition; One-shot Learning

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182_IEC96545➲

Machine Learning and Artificial Intelligence in Object Detection: Applications, and Future Emerging Trends in Technologies

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Abstract: Object detection has become integral to numerous applications, including autonomous vehicles, surveillance, and medical imaging. With advancements in AI and ML, significant improvements have been made inaccuracy, speed, and efficiency. This research examines state-of-the-art models such as CNNs, YOLO, Faster R-

CNN, and SSD, conducting a comparative analysis of their CPU usage, memory optimization, and system performance on benchmark datasets like COCO and Image Net. Key metrics such as precision, recall, and computational efficiency are evaluated to assess the balance between speed and accuracy across different hardware environments. Additionally, the challenges of real-time deployment, including latency, processing speed, and energy consumption, are discussed. This paper offers a comprehensive review of current methodologies and highlights future research directions for improving AI-driven object detection technologies.

Keywords: Convolutional Neural Network; YOLO; Latency; Artificial Intelligence; Single Shot Multibox Detection

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196_IEC44417➲

A Comprehensive Approach for Enhancing Mental Well-Being through the Application of Restorative Frequencies

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Abstract: The research aims to elucidate the distinct patterns of neural activation across different brain lobes. Through meticulous statistical analysis of EEG signals, the underlying mechanisms governing brain activity before and after listening healing sounds using EMOTIVE. The study employs advanced signal processing techniques and AI analysis to discern temporal and spatial dynamics in neural responses. The research uses EEG data from 20 subjects, both male and female, to analyze brain function by applying these conditions, highlighting the challenge of mapping and integrating the data into a device. It optimizes therapeutic auditory experiences to each person's unique brainwave patterns using EEG data and accurate frequency analysis, encouraging mental endurance and emotional well-being. This approach optimizes the therapeutic power of sound and enhances mental health outcomes by designing personalized sound environments.

Keywords: Electroencephalography (EEG); Brain Activity; Emotion Recognition; Linear Regression Classification; Mental Health Monitoring

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213_IEC97075➲

Enhancing Data Integrity and Privacy in Remote Patient Monitoring: A Blockchain-IoT Integrated Framework

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Abstract: Remote Patient Monitoring (RPM) systems have revolutionized healthcare by enabling real-time monitoring of patients' health outside traditional clinical settings. However, these systems face significant challenges related to data integrity, security, and privacy, which are critical in ensuring reliable and confidential patient care. This paper proposes a novel framework that integrates Blockchain and Internet of Things (IoT) technologies to enhance the integrity and privacy of data within RPM systems. The decentralized, immutable, and cryptographic properties of blockchain provide a robust solution to safeguard sensitive patient data, while IoT devices facilitate seamless, real-time data collection. The proposed architecture employs smart contracts for automated access control and leverages encryption techniques to protect data both in transit and at rest. Additionally, a consensus mechanism ensures the validation and security of transactions, mitigating vulnerabilities typically found in centralized systems. Through theoretical analyses and comparisons with traditional systems, this research demonstrates the potential of Blockchain-IoT integration in addressing the existing security and privacy concerns in RPM, paving the way for more secure and trustworthy healthcare solutions.

Keywords: Blockchain, Internet of Things (IoT); Remote Patient Monitoring (RPM); Edge Computing; Data Security

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214_IEC77249➲

Effects of Frequency and Mass Variations on QCM Response by eco-Friendly Green Synthesis of Silver Nanoparticles Derived from Murraya Koenigii Leaf Extract

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Introduction: A gas sensor is developed using a 10 MHz Quartz Crystal Microbalance (QCM) to detect the significant aroma of Indian cumin for quality detection. The sensor was made by drop-coating over the quartz crystal after finding silver nanoparticles (SNP) produced through the reduction of silver ions (Ag+) in the presence of leaf extract from Murraya Koenigii (MK) with the help of the solvated electron method. As silver nanoparticles with murraya koenigii leaf extract have been deposited over the surface of QCM as suspended particulate matter, a wide experimentation was carried out to assess the effect of mass deposition over the QCM surface unless and until the pre-set loading frequency has been achieved for the aroma detection. The initial frequency of the QCM was observed as 9993702 Hz. It has been observed that a minimum of 10 shots through the drop-coating method are required to achieve the expected loading frequency of 3470 Hz and after that, no significant frequency deviation was observed. The effect of frequency deviation due to mass deposition over the surface of QCM was observed through a Chronogram, where significant deposition of particle matter was observed[1]. In this work, a straightforward and low-cost sensor development method was used and easily available materials were used to sense the aroma of cumin.

Keywords: Quartz Crystal Microbalance (QCM); Mass Deposition; Frequency Deviation; Chronogram

215_IEC44546

Estimation of Chilli Growth Parameters: Monitoring Length and Width in Field Conditions with Low-Cost, Portable IoT-based Device

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Introduction: Chilli peppers (Capsicum annuum) are widely used globally for their color and flavor in various cuisines and beverages. India, particularly West Bengal, is a significant producer and exporter of chilies, with over 400 varieties cultivated worldwide and 12 popular types in India alone[1,2]. In 2020-21, India produced 2,049,213 tons of chilies across 702,047 hectares of land[3]. Assessing chili quality, especially regarding color and pungency, is crucial but challenging due to the large-scale production. Modern technologies like image processing offer a more accurate and efficient method for measuring parameters such as length and width, replacing traditional manual interventions.

In this study, we conducted an investigation into the growth patterns of locally available chilli peppers. Given the substantial scale of chilli production, there's a critical need for an automated system that can accurately estimate the quality of harvested chillies. To address this, we employed a straightforward setup involving an IoT-based camera capture device for continuous image acquisition. These images were then automatically stored in the cloud for further analysis, as depicted in Figure 1. Subsequently, we implemented an image processing-based algorithm, illustrated in the flowchart in Figure 2, to extract dimensional parameters such as the length and width of the chillies. These dimensions are significant indicators of chilli growth. For capturing the image, ESP camera module has been used. The ESP camera module refers to a camera module that is compatible with ESP32 or ESP8266 microcontrollers. These camera modules are designed to work seamlessly with ESP development boards, allowing developers to integrate camera functionality into their IoT (Internet of Things) projects. ESP camera modules typically include features such as image capture, video streaming, and sometimes onboard image processing capabilities. They are often used in applications such as surveillance systems, smart home devices, and other IoT projects that require visual data processing[4].

To assess the accuracy of our growth parameter measurements, we applied machine learning techniques including Logistic Regression, Random Forest Classifier, and Partial Least Square Regression (PLSR) using a training-testing methodology. Among these, the PLSR model proved particularly effective in generating highly accurate predictive linear relationships between the measured and estimated values of the length and width of chillies. This comprehensive approach not only enables automated and precise quality estimation but also demonstrates the potential of machine learning in enhancing agricultural practices and productivity.

Keywords: Image Processing; OpenCV; RGB; ESP32 Cam; Machine Learning; Logistic Regression; Random Forest Classifier; Partial Least Square Regression (PLSR)

219_IEC66194➲

Enhancing Human Behavior Analysis in Digital Systems through Domain Adaptation in Facial Emotion Recognition

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Abstract: This work presents a method for human behaviour analysis using a facial emotion recognition system. Implementing this system requires the digital transformation of facial images captured in an unconstrained imaging environment. The overall systems' implementation has three segments: image preprocessing, feature representation followed by classification, and transformation of techniques in the cross-sectional domain for real-time applications. The image processing step extracts the facial region from an input image that undergoes feature extraction using deep learning techniques. Then, the computed features undergo a classifier to build the recognition system. Domain adaptation techniques have been employed to enhance the recognition system's performance for real-time applications. The performance of the proposed system has been tested with two standard benchmark databases, KDEF and FER2013, and the performance with state-of-the-art methods shows the superiority of the proposed system.

Keywords: Human Behaviour Analysis; Facial Expressions; Domain Adaptation; Deep Learning; Digital Transformation

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223_IEC98532➲

A Compact and Non-Invasive Photoacoustic Sensor with AI for Volume Solids Measurement of Paints

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Abstract: A non-invasive and compact photoacoustic (PA) sensing method with AI model is proposed in this study to measure the Volume Solids of paint. Conventionally, Volume Solids is measured by the laboratory based time consuming methods. A time domain photoacoustic signal obtained from the paint can predict the Volume Solids values in near real time (within 3-5 seconds). The temporal shift of a time domain PA signal is used as a feature to predict the Volume Solids. A linear regression model is trained with the 75% of the total data sets and remaining 25% are used for testing purpose. A total of 16 samples with distinct Volume Solids are used in this study. The accuracy of the model to predict Volume Solids is found to be approximately 88%. Although the limited number of samples are involved in this study, the residual plot confirms that there is no overfitting in the model.

Keywords: Volume Solids; Paint Rheology; Photoacoustic Sensing

224_IEC62614➲

Computerized Verification Analysis for Digitally Printed Receipts

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Abstract: Digital print-document forgery is a growing problem for both the public and private organizations. So, document image tampering is a relevant problem in terms of negative economic impact for every country or society. Document forensic science has a crucial and imperative role for this forgery detection. Though, such forensics research is quite a sensitive topic, and also work is not progressing or seen so much, as very limited and restricted datasets are available. In this scenario, it is important to resort to forensic techniques to seek and analyze inconsistencies in the document image analysis. In this study, we present a classification-based approach for forgery detection by using a conventional neural network (CNN) with a unique branch mark real dataset. Results using CNN for character based classification show that computational systems are able to detect forgeries in digitally printed documents like pay slips, pay receipts, bills, etc. Our proposed computational model got more than an 88% average accuracy rate for character level fraud detection.

Keywords: Document Forensic Science; Conventional Neural Network (CNN); Optical Character Reorganization (OCR); Image Processing

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225_IEC13728➲

Blockchain, IIoT, and Neural Networks for Transparent and Predictive Agricultural Supply Chains

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Introduction: Blockchain technology is transforming agricultural supply chains by offering a decentralized, tamper-proof ledger that tracks the origin, quality, and transit of agricultural products from the farm to the consumer. This innovation reduces fraud, guarantees food safety, and improves transaction efficiency. Moreover, the integration of the Industrial Internet of Things (IIoT) and neural networks can enhance this system by enabling real-time data collection and predictive analytics. IIoT devices can monitor conditions such as temperature and humidity during transportation, while neural networks can analyze this data to foresee potential risks or inefficiencies in the supply chain, thereby bolstering security. Additionally, smart contracts driven by blockchain can execute and secure transactions based on this real-time data.

Keywords: Blockchain; IIoT; Neural Networks; Supply Chain Transparency; Smart Contracts; Food Safety; Predictive Analytics; Traceability; Agriculture

243_IEC27886➲

Development of Smart Helmet for Safety of Underground Mine Workers

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Abstract: Miners' safety is currently a key concern. Workers health and lifestyles are affected by a number of serious difficulties, including not just the working environment, but also its consequences. Mining processes emit hazardous and toxic fumes, putting the lives of the workers involved in the process in danger. The mining sector is under a lot of strain as a result of this. An innovative technique is essential to boost mining output and lower costs while also keeping worker safety into account. The health of miners is affected by the hazardous gases that are frequently discharged in underground mines. Human eyes are unable to recognize these gases easily. The presence of harmful gases in vital places, as well as their consequences on miners, will be investigated. A smart helmet for environmental monitoring and early warning system for mines and industrial worker safety is designed using wireless network with many sensors. This device keeps track of humidity, temperature as well as several hazardous toxins in the surrounding environment. This device additionally offers an early voice alarm warning, that will assist all employees within the underground mine in saving their lives before any fatalities happen. All Sensing devices (HTU2X, MICS CO, N02, NH3, NDIR Methne (CH4), Audio Alarm and Battery) were integrated into a single Smart Helmet.

Keywords: Mining and Safety; Arduino; Hazardous Gases; Voice Alarm; Battery

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248_IEC27842➲

Meijering Filter based Approach for the Identification of Papaya Seed Adulterants in Black Pepper

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Abstract: The food industry has seen a rise in fraudulent practices, necessitating the development of detection methods to reduce substantial health risks. Black pepper, widely recognized for its culinary and medicinal properties, is often subject to adulteration due to its high economic value. Unscrupulous merchants frequently add substances such as dried papaya seeds to increase their margins. This study aims to employ image processing techniques to differentiate between black pepper and papaya seeds, offering a swift, cost effective, and portable solution for the detection of adulteration in whole black pepper.

Keywords: Black Pepper Adulteration, Image Ridge Detection; Hessian Transform; Meijering Filter

252_IEC80967 ➲

Current Trends and Technological Features of E-Textile, Smart Garments and Intelligent Apparels: An Overview

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Abstract: The rapid growth, evolution and expansion of the electronics, data science, artificial intelligence (AI), machine learning (ML) and augmented reality (AR) etc., It is obvious that such technological excellence and applications are integral part of our daily life. From morning to night, till we fall asleep, a number of electronic gadgets are inseparable components of our daily activities. And even, when we are in sleeping state, we are dependent on some electronic devices for monitoring of our different physical parameters, as and when required. Also, in the outset of the AI, Deep Learning etc, we are entering in the age, where we can trust some non-living devices to take some decisions or pattern identification on our behalf. On the other hand, the textile and clothing are one of the three basic needs of civilised human society. Apparels are integral parts of our life since the inception of the ancient human civilization, thousands and thousands of years ago. And here comes the possibility and need of the optimum unification and amalgamation of textiles and electronics and AI. It is the most desired situation where textile goods and apparels can be equipped with electronics and AI, so that consumers don't need any separate electronic device or wearables to carry with, other than his or her very own and very handy fashionable garments. In other words, the apparel which serves the purpose of covering and protecting the body, can also act as an electronic device, for performing different needs relevant to different domains like health-monitoring, measuring crucial physical parameters during sports , defence and military purpose , remote and wireless communication for security , decision makings regarding climate , temperature , toxicity etc , fashion and lifestyle requirements, and what not. Therefore, continuous improvement, cost reduction, diversification and consumerisation of E-garments, E-Textile, Smart Fabrics, AI enabled Apparels are one of the most popular and promising thrust areas of research for the past one decade or more. The objective of this review paper is to present an exhaustive overview and critical review of the current research and development along with salient technological details in this field.

Keywords: E-Textile; Smart Garments; Artificial Intelligence; Conductive Textile; Intelligent Apparel; Smart Fabrics

258_IEC72068 ➲

A Novel Lightweight Cryptographic Protocol for Smart Home IoT Security using CoAP

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Abstract: A smart environment seeks to improve human existence by boosting efficiency and simplicity. These days, most computer networks have IoT tools, and the IoT paradigm has developed into a critical technology for building smart. However, IoT devices are vulnerable to cyber-attacks during this transition. Consequently, security and privacy are major concerns in real-world smart home applications. This manuscript aims to propose the Broken-Stick Regressive Lightweight Speck Ephemeral Cryptography-based Constrained Application Protocol (BRLSC-CoAP) to enhance data security in smart home environments while minimizing computational costs. IoT devices collect real-time data and transmit it to authorized users. To secure this process, BRLSC-CoAP incorporates registration, encryption, authentication, and decryption steps. A lightweight Speck ephemeral cryptography algorithm is used for encryption, and Forbes indexive Broken-stick regression ensures user authentication. The experimental results show that BRLSC-CoAP outperforms conventional methods by improving authentication accuracy, precision, and confidentiality, while reducing computational cost, delay, and overhead.

Keywords: Smart Home; Constrained Application Protocol (CoAP); Data Security; Lightweight Speck Ephemeral Cryptography; Authentication; Forbes Indexive Broken-Stick Regression

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262_IEC61857 ➲

Enhancing Security in User Authentication: A Hybrid Approach using Biometric and Behavioral Analysis

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Abstract: A cyber threats continue to evolve. The traditional password-based and two-factor authentication (2FA) are becoming more apparent. This paper presents a hybrid authentication framework that integrates the Convolutional Neural Networks(CNN) for biometric verification with Long Short-Term Memory(LSTM) networks for behavioral analysis. The system is designed to function effectively with or without 2FA, providing flexible and adaptive security for a variety of applications such as social media, online banking etc. The CNN handles biometric inputs such as facial recognition and fingerprint scans etc, while the LSTM analyses user behavior-such as typing speed and mouse movements etc- to detect anomalies. If an anomaly is identified, the system can block the potential attacker or request further verification. The framework ensures that legitimate users can access their accounts through an additional biometric check, even if traditional security methods fail. This paper outlines the architecture, potential applications and future research directions for implementing this hybrid model in real-world scenarios.

Keywords: Hybrid Authentication; Biometric Security; Behavioral Analysis; Convolutional Neural Networks (CNN); Long Short Term Memory (LSTM); Anomaly Detection

264_IEC45716➲

Machine Learning — Child Exploitation and Abuse

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Abstract: This research reviews the implementation of machine learning, deep learning, and natural language processing for detecting child sexual abuse materials (CSAM) and fighting against online child exploitation. It presents various techniques, such as file name categorization using convolutional neural networks (CNNs), Support Vector Machines (SVM) for dark web CSAM detection, and the application of network security tools like Bloom filters. Among the deep learning models, the Soft Stagewise Regression Network (SSR-Net) and BERT-based transformers are included. The SSR-Net is known for tasks such as age estimation in child exploitation material, and the other task is the automation of child abuse reports. The paper uses performance metrics, such as the accuracy of up to 97%, recall, precision, and latency to assess the efficiency of the systems. Therefore, due to these factors, the results obtained in real-time forensic investigations have been quite impressive. This paper introduces problems like obscured images, datasets with great unfairness, databases with less response time, counter-narratives, the need for low latency, and offers enhancement methods that not only bring accuracy to digital forensics but also enhance the efficiency of law enforcement. This project helps to establish a crime-fighting tool that extends the law enforcement effectiveness, thereby, minimizing the latency for recognizing the dark web perpetrator and eventually securing the well-being of children by reducing internet safety concerns.

Keywords: Machine Learning; Deep Learning; Natural Language Processing; CSAM Detection; Digital Forensics; Child Exploitation Prevention

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270_IEC85725➲

Towards Sustainable Aquaculture: Real-Time Detection of Freshwater Fish Species in the Indian Subcontinent

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Abstract: The growing demand for efficient fish identification in aquaculture has led to the creation of computer vision-based detection systems, improving fish population management, reducing errors, and boosting operational efficiency. This paper introduces an edge-AI solution optimized for Android devices, enabling real-time fish detection. It evaluates three deep learning models—Single-Shot Detector (SSD), Faster R-CNN, and CenterNet—on a dataset of six fresh water fish species found in the Indian sub-continent. Each model strikes a balance between speed and accuracy: Faster R-CNN excels in precision but is slower, SSD offers faster performance with slightly lower accuracy, and CenterNet provides a good balance of both. In terms of accuracy, Faster R-CNN achieves 96.2%, CenterNet 95.1%, and SSD 94.5%. For mean average precision (mAP), Faster R-CNN leads with 83.2% at IoU=0.5, and 74.5% at IoU=0.5-0.95.However after optimization of the models to implement in an android device the accuracies are as Faster R-CNN achieves 92.5%, CenterNet 92.9%, and SSD 91.9%.The accuracies were compromised with a smaller scale but resource utilization reduced to a larger scale enabling the complex models to run easily on an android device. These AI-driven advancements revolutionize fish farming by enhancing real-time monitoring and fish sorting processes.

Keywords: Aquaculture; Computer Vision; Faster R-CNN, Single Shot Detector (SSD); CenterNet

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274_IEC15719➲

Plasmonic Metamaterial Sensor for Nanoplastic Detection

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Abstract: Nanoplastic contamination in food or water is a burning issue in today’s time. As consumed with food or drinks, the tiny plastic particles enter human body, invade through the tissues and cells, and accumulate over time causing a potential long term health hazard. Due to the tiny size of the plastic particles (< 100 nm), it is not straightforward to detect the presence of nanoplastics is any contaminated sample. In this paper, a nanophotonic plasmonic metamaterial-based sensor is being proposed that can detect the changes in the optical signature due to the presence of nanoplastics in water. The metamaterial has been designed based on a combination of metal (silver), dielectric (refractive index 1.75) and metal (silver) layers. The metamaterial has been functionalized through an optical window of 600-1200nm. The sensor has demonstrated its ability to detect the shifts in the refractive index between 1.0-1.4RIU by a resolution of 0.1RIU. Further investigations have been conducted to optimize the sensor sensitivity through a range of periodicities 150-310 nm, and an optimized sensitivity of 259 nm/RIU has been achieved.

Keywords: Plasmonics; Nanophotonics; Sensitivity; Nanoplastic; Refractive Index

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295_IEC27843➲

Application of NLP in Job Search in Social Media (Analysis, Comparison, and Prediction of Job Search in LinkedIn & Indeed site)

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Abstract: Getting a good job is a dream for every fresher and unemployed person. The search for a job market is nowadays different compared last few years. Now everything is digitalized. So, students are confused about where they get full information about jobs according to their skills. students need to get full information about different places according to their skills. Students' have many skills but won't get a proper choice of a job according to learning skills because they do not know the reasons behind this. So, in this paper, we develop a platform where students get a piece of full information about job markets. We developed here a Python programming by ML and NLP techniques.

Keyword: Job Search Algorithm; Web Scraper; Machine Learning; Social Media; Data Visualisation

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298_IEC23490➲

Novel Data Imputation Technique for Mental Health Prediction

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Abstract: Artificial intelligence and machine learning developments have greatly enhanced mental wellness. providing insights into various mental disorders. This study uses the Relational Data Imputation (RDI) technique to identify susceptible mental disorders early, aiming to reduce disease severity.Algorithms for deep learning and machine learning are critical for early detection of mental diseases, improving social and general well-being. Here, we use different algorithms with the likes of Support Vector Machine (SVM), regression learning, natural language processing (NLP), and random forest classification (RFC). All mental disorders differ from one another; thus, understanding different datasets for different mental diseases is important. The dataset we used has some missing values that have a greater impact on the model and its accuracy. We are proposing a Relational Data Imputation (RDI) technique to replace missing values in health-h-related data. Using the RDI Imputation method, we consider all mental health diseases in a single platform and identify them, which have not been previously performed. By applying the suggested RDI method, we want to increase the effectiveness of the machine learning and deep learning models that are presently being utilized for the early identification and categorization of mental diseases.

Keywords: Alzheimer's Disease (AD); Dementia; Parkinson Disease's (PD); Bipolar Disease (BD); Schizophrenia Disease (SD); Mental Health

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323_IEC7296➲

XceptionNet: A Truly Exceptional Deep Learning Network for Brain Tumor Characterization

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Abstract: In recent years, brain tumors have emerged as a crucial health concern worldwide. Improving patient outcomes depends on the early and accurate diagnosis of brain tumors and guiding treatment decisions. In this paper, seven leading deep learning networks i.e. ResNet-152, VGG-16, LeNet-5, XceptionNet, Residual Attention Network, GoogleNet and MobileNetV2 have been examined to characterize brain tumor from MRI images as "No Tumor", "Glioma", "Meningioma" or "Pituitary". Based on training and evaluation on a publicly available popular dataset, XceptionNet is found to perform exceptionally well in comparison with other networks (100% classification accuracy). In future, further exploration may be done to locate the tumorous region and map with corresponding tumor category to foster computer assisted diagnosis of brain tumors.

Keywords: XceptionNet; Brain Tumor Classification; MRI Images; Computer Assisted Diagnosis; Deep Networks

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325_IEC17124➲

Applications of Textural Features and PCA on Facial Recognition after Medical Alterations

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Abstract: Numerous algorithms have encountered difficulties in identifying the face, which remains unaffected by plastic surgery due to variations in skin texture. Even though plastic surgery presents a difficult problem for face recognition, the issue needs to be reconsidered from both theoretical and experimental angles. This paper presents a new approach to face recognition by using textural image features like local ternary patterns (LTP) and binary patterns (LBP). The support vector machine (SVM) is trained using numerous principal component analysis (PCA) method versions, which reduce the feature dimensionality. In order to train a support vector machine (SVM) model to recognize medical alteration faces, this paper takes advantage of textural features, which are highly associated with changes in face recognition. Images retrieved from the database of plastic surgery are used to train the SVM classifier model. Following the conversion of the dataset into LBP, features were extracted from the LTP image using PCA and 2D-PCA. Using 452 plastic surgery faces, procedures such as blepharoplasty, brow lift, liposhaving, malar augmentation, mentoplasty, otoplasty, rhinoplasty, rhytidectomy, and skin peeling were attempted. Tests conducted on a plastic surgery database demonstrate the suggested approach's competitiveness in comparison to certain subspaces-based techniques currently in use.

Keywords: Plastic Surgery Face Recognition; Principle Component Analysis; LBP; LTP; SVM

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327_IEC74465➲

Hand Gesture Recognition for Deaf-Mute: Insights from RGB and RGB-D Driven Deep Networks

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Abstract: This paper presents a comprehensive comparative analysis of hand gesture recognition using two diverse datasets: the ASL Finger Spelling A dataset, which comprises both RGB and depth images, and the NUS Hand Posture dataset-II, containing only RGB images. The study evaluates the performance of state-of-the-art

Convolutional Neural Network (CNN) architectures, namely, VGG19, Inception V3, and MobileNetV2, in recognizing hand gestures across these datasets. By training and testing these CNN architectures on both datasets, we assess their accuracy and generalizability across varying input modalities (RGB versus RGB-D). Our results provide a detailed comparison of these CNN architectures, highlighting their strengths and limitations in addressing the challenges of hand gesture recognition. We achieved a highest accuracy of 99.98% on the ASL Finger Spelling A dataset using RGB samples and the VGG19 network.

Keywords: Hand Gesture Recognition; Convolutional Neural Networks; VGG19; Inception V3; MobileNetV2; RGB-D Images

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332_IEC78768➲

Cave Mapping using Unmanned Remote Controlled Vehicle

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Abstract: Cave mapping is crucial for understanding underground environments. Generally, these methods take a long time and may be hazardous to humans. This dissertation proposes an innovative approach that introduces remote-controlled vehicles equipped with sensors and SLAM (Simultaneous Localization and Mapping) algorithms for autonomous mapping in caves. The unmanned remote controlled vehicle system uses LiDAR, cameras, GPS, IMU, and ultrasonic sensors. The research directly contributes to the development of efficient, accurate, and safe cave mapping solutions useful in speleology, geology, and safety operations during search and rescue.

Keywords: Cave Mapping; Landscapes; 3D Maps; Remote Controlled Vehicle; Vegetation; Environment

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367_IEC21843➲

Generation of a Personal AI ChatBot using the Concepts of Natural Language Processing

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Abstract: The development of personal AI chatbots has gained significant traction, driven by advancements in Natural Language Processing (NLP). These chatbots enhance user interaction by providing personalized experiences and efficient communication. This paper outlines the fundamental concepts of NLP and the systematic approach to creating a personal AI chatbot. Key stages include defining the chatbot's purpose, selecting appropriate tools, designing conversation flows, and implementing NLP models. Additionally, the importance of continuous monitoring and updating post-deployment is emphasized to ensure optimal performance. By following these guidelines, developers can effectively create chatbots that meet user needs and enhance engagement.

Keywords: AI ChatBot; Natural Language Processing; Conversation Flow; Dialogue Management; Machine Learning; User Engagement

369_IEC31857➲

A Robust Deep Learning Framework for Validation of Reduplicated Multiword Expressions in Digital Bengali Texts

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Abstract: Reduplicated multiword expressions (RMWEs) are crucial linguistic constructs in Bengali, acting as unified entities that convey meanings beyond the sum of their domains. However, effectively validating these expressions is difficult due to a need for annotated datasets and pre-trained Bengali models. This study proposes a deep learning strategy for validating redundant RMWEs in digital Bengali text datasets. The proposed approach transcends the related work due to its impressive recall and well-calibrated accuracy. The proposed model detects all valid RMWEs with an outstanding recall score of 100%. The proposed strategy distinguishes valid and invalid RMWEs with 89.37% validation accuracy. Despite its lower precision of 46.91%, this method's flawless recall makes it notably beneficial in situations requiring thoroughness and inclusivity.

Keywords: Multiword Expressions; NLP; Text Processing; Reduplication; Deep Learning

Information & Communication Technology

Microwave, Millimeter Wave and THz Communication

85_IEC382➲

A Wideband MIMO Reconfigurable Antenna for RF Energy Harvesting

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Abstract: This article investigates a reconfigurable wideband MIMO antenna with dual band-notch features for RF energy harvesting. The optimized antenna, measuring 89×51.02×1.6 mm³, comprises two semi-circular monopole components sharing a ground plane. Split ring resonators on the ground plane enhance isolation between the components. Modified C-shaped slots in the radiating patch and rectangular split-ring resonators provide band-notch characteristics at 3.5 GHz (WiMAX) and 5.5 GHz (WLAN). Reconfiguring the band-notch function is possible through PIN diodes in the notch structures. The mutual coupling remains below -18 dB across 1.5-13 GHz, with an impedance bandwidth of 158.62%. The antenna shows significant efficiency and gain drops at notch frequencies, ensuring effective interference suppression. Performance metrics such as envelope correlation coefficient, port isolation, radiation patterns, efficiency, gain, and diversity gain indicate suitability for MIMO systems. Additionally, the antenna achieves a maximum harvested energy of 4.88 V, making it viable for wideband, band-notching, MIMO, and RF energy harvesting applications.

Keywords: Band Notch, MIMO Antenna, PIN Diodes, Reconfigurable, RF Energy Harvesting

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100_IEC59986 ➲

A Novel Design of Metasurface Flat Antenna Modules for Low-Profile VSAT Mobile Terminal Applications

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Abstract: In most of the current VSAT applications, high gain parabolic dish antennas are used extensively, e.g., at Ku-band (12 to 18 GHz). A typical demand for such antennas is to mount them on top of vehicles. Parabolic antennas are large and complex to install and maintain. On the other hand, a flat panel antenna can greatly simplify the manufacturing process in addition to its being amenable to be mounted on vehicles. Flat panel antennas are ultra-thin, low-profile, weatherproof high gain antennas used to electronically acquire, steer, and lock a beam to any satellite. Multiple research investigations are ongoing to design such antennas primarily using the concept of metasurface. In this work, a novel design methodology of building flat antenna modules for VSAT mobile terminals has been demonstrated, using a standard half-wavelength dipole as excitor antenna backed by High Impedance Surfaces (HIS), at an operating frequency of 12.6 GHz, with a high gain of approximately 7dBi. The design has been optimized for large impedance bandwidth, circular polarization and easy tuneability using capacitors. The design scales for different frequencies without change in functionality. This design principle is amenable to low-cost printing processes for mass production, e.g., printing of antenna using inkjet technique.

Keywords: 5G; Metasurface; Flat Panel Antenna; VSAT Mobile Terminal; Ku Band

106_IEC70946➲

Minkowski Fractal Shaped Reconfigurable Intelligent Surface Design with Bi-Directional Beam-Tilt Performance

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Abstract: With the advent of next-gen communication systems and evolution of sensing-dependent IoT-based solutions, goals to achieve real-time beamforming and seamless beam-steering capabilities have become the focal point of research. This calls for effective design of ancillary devices which may redirect or shape the radiated beams from the primary radiators towards specific objects as per requirement. This article presents a novel and uniquely designed Reconfigurable Intelligent Surface (RIS), which offers the ability to steer the beam in dual orthogonal directions, is fully controllable through electronic means and describes polarization sensitive performance, enhancing the robustness of operation under practical use. The reflective unit cell design is conceived as the shape of a first iteration Minkowski fractal patch, operating at 3.5GHz. Rigorous simulation-based characterization is done to achieve the necessary phase variation for dual-direction beam-tilt operation. After fabrication and initial measurements, the realized RIS structure described bi-directional beam-tilt performance along the horizontal and vertical directions with ±15 degrees of obtainable tilt, which agrees with the simulations, validating its suitability for commercial use.

Keywords: Reconfigurable Intelligent Surface (RIS); Real-Time Beam Tilt Operation; 5G Communication; IoT Devices; Minkowski Fractal Design

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199_IEC53942➲

Design and Characterization studies of Terahertz Antenna for Sustainable Health

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Abstract: In recent era, the developments in different technological fields are advancing to comply with the current aspects of the society. In the field of medical science also the researchers are finding way for the sustainable developments of the society. The requirements for better medical facilities are growing due to the sudden outbreak of nCovid-19 virus. According to WHO, 422 million people are affected with the diabetes across the globe. Also in addition to this, more than 972 million people are facing the issues caused by hypertension on earth. Death toll due to Covid-19 has crossed more than 6 million. The medical science needs the advancements in technological sector in terms of development of suitable imaging and detection system for early diagnosis. In this research work, the author tries to investigate on the design and characteristics studies of Terahertz antenna to be integrated with Terahertz source and system for application in Biomedical imaging unit that could be used for non-invasive imaging purposes. The study has been done through HFSS platform. The patch antennas show acceptable return loss, directivity, VSWR etc. Four designs are considered here and comparative studies of the four proposed patch antennas are plotted on the Matlab platform. To the best of author's knowledge, it is the first report on Terahertz antenna with considerably good directivity and return loss.

Keywords: Patch Antenna; Gain; Return Loss; VSWR; Terahertz Antenna

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237_IEC32225➲

Design of MIMO DRA with Isolation Strips and Metallic Rod for Enhanced Performance in Microwave Applications

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Abstract: In this work, a dual-port cylindrical dielectric resonator antenna (cDRA) with multiple-input multiple-output (MIMO) configuration is studied. Two cylindrical dielectric resonator antennas (cDRAs) are part of the antenna arrangement, and they are positioned above a FR4 substrate. Aperture coupling via a microstrip line excites each cDRA. The antenna elements have different polarizations as a result of the meticulous design of the feed systems. In order to increase the isolation between the antenna elements, copper striplines are attached to one side of the dielectric resonator walls. In order to further improve port isolation, a short metallic rod in the shape of a cylinder is placed between DR-1 and DR-2. This rod and stripline interact with some of the radiated power. As a result, the copper strips' and metallic rod's dimensions are carefully calibrated to reduce mutual coupling among the antenna's components, producing an astounding isolation of more than 25 dB between the ports. In addition, the antenna design covers the frequency range of 5.6 to 5.9 GHz with a bandwidth of 5.5%. The results demonstrate that the proposed novel MIMO antenna design is promising for various microwave applications.

Keywords: MIMO; DRA; Isolation; Metallic Strip; ECC

Information & Communication Technology

Optical Fiber Communication

149_IEC98331➲

Fiber Bragg Grating Sensor for Precise Monitoring of Healthcare Parameters

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Abstract: Optical Fibers are most promising for development of sensors required for modern healthcare systems. The Fiber Bragg Grating sensors plays vital role in such healthcare systems to transform healthcare globally for improved clinical diagnosis. The Fiber Bragg Grating sensors offers unique advantages over electronic sensors due to its small size, immunity to electromagnetic interference and precise measurement of healthcare parameters. Fiber Bragg Gratings function as distributed Bragg reflectors, reflecting desired wavelength while transmitting others. The reflected wavelength from the Fiber Bragg Grating depends on physical factors like temperature and strain which are useful for healthcare parameter monitoring. The performance of Fiber Bragg Grating sensor depends on certain parameters which includes sensor dimensions, grating period, grating length, modulation index and refractive index profile. These parameters affect reflectivity and bandwidth of sensor. The high reflectivity, narrow bandwidth and minimal side lobe levels are essential for sensing applications. The Fiber Bragg Grating sensor is simulated by OPTIGRATING simulation tool to show the effect of grating length and apodization profiles. The sensor parameters are optimized to obtain high reflectivity and minimum side lobe levels. The proposed design is useful for precise monitoring of healthcare parameters in modern healthcare systems.

Keywords: Fiber Bragg Grating Sensors; Grating Parameters; Reflectivity; Bandwidth; Side Lobe Levels

<u>Information & Communication Technology</u>

Quantum Computing- Quantum Sensing, Quantum Security, Quantum Communication

65_IEC48667➲

The Convergence of Quantum Computing and AI in Defense: Shaping the Future of Global Security

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Abstract: The rapid advancement of Artificial Intelligence (AI) and Quantum Computing has begun to reshape modern military strategies, introducing unprecedented capabilities and transforming global security dynamics. As these technologies converge, they offer the potential to revolutionize decision-making processes, enhance the speed and precision of military operations, and shift the balance of power on the global stage. However, the integration of these technologies into defense systems also presents significant risks, including ethical concerns, challenges in governance, and the potential for an arms race in AI and Quantum-based weaponry. This extended abstract explores the current state of AI and Quantum Computing integration in military applications, examines their influence on international security, and discusses the ethical and legal implications associated with their militarization. The paper also provides scenario-based foresight into the future of warfare, focusing on how these emerging technologies could shape global security in the coming decades. Key research questions addressed include the strategic integration of AI and Quantum Computing, their impact on power dynamics, the risks and challenges of militarization, and the broader societal implications of deploying these technologies in warfare [1,2].

Keywords: Quantum Computing; Artificial Intelligence; Modern Warfare; Ethical Implications; Military Strategy

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294_IEC8235➲

Quantum Algorithms and Computational Advantages for Fintech Safety

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Abstract: Financial technology (Fintech) has grown rapidly in recent years, incorporating advanced computational methods to enhance security, optimize transactions, and ensure regulatory compliance. However, with increasing complexity and cyber threats, traditional computational techniques are increasingly strained. Quantum computing, with its unique computational paradigms, offers potential for unprecedented advancements in cryptography, optimization, and risk management in the Fintech sector. This paper explores how quantum algorithms can be leveraged for Fintech safety and provides an analysis of the computational advantages they bring over classical methods.

Keywords: Quantum Computing; Fintech, Cryptography; Quantum Algorithms; Cybersecurity; Computational Advantage; Financial Security

Information & Communication Technology

VLSI

300_IEC68259

Comparative Analysis of Intercalation Doped MLGNR-based On-chip Inductor

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Abstract: This work presents the comparative study on analytically extracted effective inductance of an on-chip pristine and intercalation doped MLGNR-based inductor. The large relaxation time leading to higher mean free path (MFP), enhanced time and level of doping of carrier concentration are taken into consideration during the extraction of the on-chip inductance. Additionally, it has been demonstrated that intercalation-doped MLGNR increases the effective Fermi energy, subsequently, the conductivity, thereby enhancing high kinetic inductance. At the same time, a unique analytical approach has been adhered to determine the inductance by varying the width and thickness of the MLGNR. It has been observed that the kinetic inductance improves with intercalation doping with considerable carrier concentration and it becomes progressively dominant with alleviated width and thickness. The Br_2-doped MLGNR has been observed to exhibit superior performance as an on-chip inductor compared to Cu, Pristine MLGNR as well as AsF_5-, $FeCl_3$-doped MLGNR at lower widths and thicknesses in the micrometre regime.

Keywords: On-Chip Inductor; Graphene Nanoribbon; Mean Free Path; Intercalation Doping; Staging; Kinetic Inductance

<u>Infrastructure</u>

Application of AI & ML and Computational Techniques for Infrastructural Systems

52_IEC49542 ➲

BARF — A Web-based/Terminal Application for Multi-Objective Optimization of Pinned and Rigid Building Frames using Evolutionary Algorithms

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Abstract: Minimum weight design optimization of 2d and 3d trusses and minimum cost design optimization of reinforced concrete plane frames and beams using genetic algorithms and particle swarm optimization methods via a web/terminal based stand alone program (Bar Force Analyzer (BARF); hosted online and on github) written in Go is presented in this paper. A few standard problems in structural design optimization are modeled using the program and the results are compared with those in the references.

Keywords: Genetic Algorithm; Particle Swarm Optimization; Structural Optimization; Cost Optimization; Building Frames

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212_IEC32392➲

Automated Arc Welder's PPE Object Detection System using YOLOv8 Large Model

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Introduction: The arc welding process provides strong and durable joints and hence is primarily used in manufacturing, construction, automotive industries, shipbuilding, etc. The arc welding process can cause hazards to the welder if precautions are not taken. Personal Protective Equipment (PPE) protects welders from various dangers that were mentioned previously. Therefore, wearing PPE is necessary for workers' safety in industries and jobs requiring arc welding. The typical PPE used in arc welding includes welding helmets, welding gloves, fire-resistant clothing, safety glasses, welding boots, welding fume masks, hearing protection, and apron. The strategies followed by industries for workers' safety include forming clear safety policies and procedures, conducting training and awareness programs, supervision and enforcement, and regular audits and inspections. Therefore, traditionally, the industry manually ensures that workers follow safety guidelines and PPE. However, sometimes, due to discomfort and inconvenience, perception of low risk, lack of training knowledge, time pressure or productivity concerns, cultural or peer influence, resistance to change, or psychological factors, workers neglect to wear PPE and violate industry safety guidelines which may result in danger to the workers' physical safety. The remedy to ensure adherence to safety guidelines is automatically detecting the presence of PPE on workers' bodies via surveillance videos and giving feedback to comply with safety protocols if violated. Further, automatically detecting safety gears for arc welding jobs is relatively unexplored in literature and needs further attention.

Essentially, detecting an arc welder's PPE is an object recognition task. The state–of–the–art models for object detection are machine learning (ML) or deep learning (DL) models that detect the presence of safety gears using convolutional neural networks (CNN), recurrent neural networks (RNN), single-shot detection models, etc. [2]. These models require extensive resources and hardware for implementation. Therefore, doing real-time analysis using such models is time-consuming. Moreover, their deployment may become incompatible with edge or mobile devices.

Further, no object detection models for arc welders detect multiple PPE objects [5,7]. The literature study on YOLOv8 showed that it can detect multiple objects with fewer trainable parameters while retaining good accuracy[6,7,12]. Therefore, it is suitable for deployment on real-time mobile devices. The work presented in this study, which is inspired by [7], uses a YOLOv8 large model for detecting arc welder's safety gears.

The following is a summary of our key contributions.

- We have developed an automated arc welder's PPE object detection system using a lightweight YOLOv8 DL model. The model was deployed on Nvidia Jetson and tested for real-time performance, and the result was highly accurate.
- We created our own dataset from multiple sources to detect multiple objects simultaneously. The dataset contains images where more than one safety gear is on workers' bodies.
- Our system accurately detected four PPE objects, even when tested on average-quality images acquired from video streams.

Keywords: Arc Welding; Safety Gear; Deep Learning

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253_IEC67358➲

Higher Order Accurate Finite Difference Method for Solving Level Set Equation for Moving Interface Problems

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Abstract: In this work, we introduce a new scheme to solve the viscosity relation of the Hamilton-Jacobi equation (also known as the Level Set equation) in domains with discontinuities across time-dependent moving interfaces. This scheme is fourth-order accurate in time variables as well as in space variables. For the time variables, we use the fourth-order Runge-Kutta scheme, and for the space variable, we use the Higher-order Compact(HOC)[2] finite difference scheme. HOC scheme gives very accurate results in the convection-diffusion problem for the two-dimensional incompressible navier-stokes equation. The outcomes of the present scheme are very closed to the existing analytical and numerical results, as the compactness of the present discretization allows us for efficient computing, as it reduces the number of grid points to achieve high accuracy. Overall the scheme is found to be reliable, efficient, and accurate.

Keywords: HOC, WENO, Runge-Kutta, Level Set Equation, ENO

256_IEC84300 ➲

A Higher Order Compact Scheme for Heat and Mass Transfer of a Micropolar Fluid

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Abstract: In this study, we presents a higher-order compact finite difference scheme for solving the flow of micropolar fluids in a square cavity. The model accounts for the microstructural effects and rotational viscosity characteristic of micropolar fluids, offering a more accurate representation of the physical phenomena involved. By employing a compact scheme, we achieve higher accuracy with fewer grid points compared to traditional methods. The proposed method is validated through several benchmark problems, demonstrating its effectiveness in capturing the intricate dynamics of micropolar fluids and its potential application in engineering systems involving porous media. The stremlines pattern are plotted at Re = 400 for various values of vortex viscosity parameter K and it is observed that the strength of secondary vortex reduces as we increase the value of K.

Keywords: Micropolar Fluids; Microstructure; Vortex Viscosity Parameter; HOC Scheme

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257_IEC62315 ➲

Exploring Flow Patterns around Bluff Bodies using Physics-Informed Neural Networks

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Abstract: Partial Differential Equations (PDEs) play a fundamental role in Scientific Machine Learning and Applied Mathematics, particularly in the modeling of physical phenomena. Although deep learning has seen a wide range of applications, its recent use in solving PDEs has become a trending topic. Traditionally, meshbased numerical solvers such as the Finite Difference Method (FDM), Finite Volume Method (FVM), and Finite Element Method (FEM) have been employed to solve PDEs. However, these methods can face challenges with mesh generation, particularly for complex geometries, and are computationally expensive. In contrast, Physics-Informed Neural Networks (PINNs) offer a meshless alternative, providing flexibility and reduced computational costs for handling intricate domains. PINNs also take advantage of modern machine learning techniques, such as automatic differentiation, to ensure that solutions inherently satisfy governing physical laws without requiring labeled data. In this work, we create a PINN to solve the two-dimensional incompressible laminar flow, governed by the Navier-Stokes equations, with an emphasis on flow past bluff bodies such as squares and other shapes. The results demonstrate that PINNs not only provide a viable alternative to traditional numerical methods but also offer computational advantages in solving fluid flow problems with intricate geometries.

Keywords: Physics-Informed Neural Networks; Navier–Stokes Equations; Bluff Bodies; Deep Learning; Automatic Differentiation

Infrastructure

Disaster Resilient Infrastructural Systems

218_IEC57391 ➲

Unique Steel Concrete Composite for Most Demanding Civil Engineering Applications in Infrastructural System

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Introduction: The system combines two of the world's two widely used materials to make use of their strongest assets the tensile strength of steel with the compressive strength of concrete. The system opens up new opportunities to design and build infrastructure projects in ways that were once practically, structurally or financially impossible.

Safeguarding infrastructure facilities built for public, against the threats of terrorism has assumed significant importance . A steel concrete composite construction system has an inherent blast resistance characteristics and can provide unrivalled protection from explosions. The system excels where strength or speed of construction are of vital importance such as road tunnel sections, port roads, railway bridges/culverts and small bridges. The suggested system also finds applications in numerous other areas like bank vaults, lift cores in multistoried buildings where it can act as a shear wall. These composite system can resist high magnitude earthquake forces successfully.

The steel-concrete-steel (SCS) composite sandwich panel comprises two parallel steel plated fixed in their relative positions by an array of transverse bar (preferably reinforcing bar obtained as off cuts from construction sites or plain mild steel bars whichever is easily available) connectors that are welded at each end to the steel facing plates, these bars are closely spaced and arranged in a regular pattern (array). The individual panels may be bolted/welded together and can be fabricated in several sizes cither flat or curved. These individual panels may be prefabricated in a workshop and erected on site with relative case owing to their unfilled light weight, the space between the plates may be filled with concrete in-situ after erection has been completed. This composite action of the steel and concrete is responsible for the high strength of the arrangement.

The paper discusses the concept of this composite system, suggested manufacturing process and installation process along with the mechanism of the system proposed.

Keywords: Blast; Composite; Terrorism; Earthquake; Railway

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254_IEC20948 ➲

Performance of Cob Buildings during Devastating Tripura Flood August, 2024

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Abstract: Current study is an attempt to evaluate the performance of cob buildings during 2024 devastating Tripura flood water. Failure patterns of cob buildings were closely monitored after the flood water receded. Major drawbacks in cob buildings starting from initial construction to final completion have been analyzed based on engineering requirements such as compressive strength, shrinkage, wall strengthening scheme, durability, water absorption etc. Test results shows that addition of cement to the soil blocks increases the density and reduction in water absorption. Both compressive and tensile strength increases with the increase in cement content, by about 7 to 143% and 18 to 182%, respectively. Moisture content of various test samples during testing ranges from 3.48% to 3.92% with a

marginal variation of 0.44% between the samples, showing negligible effect on the strength and density of the given test samples. Un-stabilized samples failed to reach the suitable durability criteria. On the other hand, cement stabilized blocks satisfies the suitability range/criteria, as suggested by some previous researchers. Plain and fibre reinforced cob buildings are recommended in areas less prone to flooding. Protecting layers should be applied to the outer walls to prevent moisture ingress during heavy rain.

Keywords: Cob; Tripura Flood 2024; Shrinkage; Cracks; Strength

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266_IEC2817 ➲

Seismic Behaviour Assessment of Conventional and Hybrid Reinforced Concrete Buildings

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Abstract: Due to rapid urbanization, many cities have witnessed significant changes in building structures, including the emergence of hybrid structures, such as mixed concrete and steel frames. However, the current seismic code regulations provided by the Bureau of Indian Standards (BIS) do not offer specific guidelines for determining the appropriate design seismic forces and capacities for these hybrid multi-story buildings. Therefore, assessing their structural behaviour under seismic forces is critical to ensuring safe and effective designs. In this study, an attempt is made to evaluate the seismic behaviour of a hypothetical G+2 hybrid reinforced concrete (RC) building, compared to a conventional building, located in the Warangal district of Telangana state, which lies in a moderate seismic zone with a medium soil profile. The performance of these buildings is assessed based on base shear, horizontal displacement, inter-story drift ratio (IDR), and other key behavioural patterns. Furthermore, the study aims to analytically determine the design seismic forces required for earthquake-resistant hybrid buildings in urban environments, taking into account various structural configurations.

Keywords: Urbanization, Hybrid RC building, Seismic Performance, IDR, Horizontal displacement, Base shear.

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277_IEC43305 ➲

Removal of Chloride from Wastewater using Anion Exchange Resin: Fixed Bed Column Study

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Abstract: This study presents the evaluation of a fixed bed column for removing chloride ions from water using various adsorbents. Chloride contamination is a significant environmental issue, primarily caused by industrial effluents, agricultural runoff, and de-icing salts. High chloride concentrations can deteriorate water quality, harm aquatic ecosystems, and cause infrastructural corrosion. The fixed bed column was tested under various operational conditions to optimize its performance in removing chloride ions. Breakthrough curve analysis was performed to determine the system's efficiency, and different adsorption models were applied to understand the kinetics and dynamics of the process. Results show that the fixed bed column, when packed with suitable adsorbents, is an efficient method for chloride removal.

Keywords: Chloride Removal; Column Study; Break Through Curve; Resin; Infrastructure

Infrastructure

Health Monitoring and Retrofitting of Infrastructural Systems

32_IEC22319 ➲

Health and Performance Monitoring for Reducing Infrastructural Downtime: Intelligent & Predictive Maintenance with Retrofittable Onboard Diagnostic and Remote Monitoring Systems

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Abstract: THCM (Tata Hitachi Construction Machinery Private Limited) has been the market leader for Construction Equipment in India. The company manufactures equipment like Excavator, Wheel Loader, Backhoe loader etc. These equipments use various systems including engine, hydraulics and transmission. The overall operation of the machine is integrated by the electronic system. With the increasing customer demand and to maintain the leadership position in the market, there is a need to maintain the product quality and machine performance, to the highest standard. The performance & basic function of the machine was earlier monitored from the mechanical gauges on dashboard fitted inside the operator's cabin. The operator used to take corrective action based on the fault indication available on the dashboard. But with the increase in fleet size with a greater number of machineries, it has become essential to go for the latest on-board and remote monitoring of machine performance. This feature enhances machine diagnostics system with the help of faults & alarms. The cloud based remote tracking system can be retrofitted at the job site, which allows the fleet owners to automate their processes and shift from semi-autonomous systems to fully autonomous systems. This, not only enhances safety, but also is essential for proper running of the machines. The system enhances machine intelligence by increasing productivity and reduces the cost & downtime of operation.

Keywords: Predictive Maintenance; Real Time Data; Retrofittable; Onboard Diagnostic; Remote Monitoring

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120_IEC67763➲

Dynamic Behaviour and Numerical Analysis of a Supportive Transportation Infrastructure: A Case Study

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Abstract: The maintenance of infrastructure, especially bridges, is a global challenge, and India, with around 150,000 bridges, is no exception. Many of these are aging, making regular upkeep and monitoring crucial. Spatial Information Technology (SIT) has transformed bridge management by integrating sensor technologies for vibration data analysis. Historically, bridges have evolved from basic materials to modern designs built to endure environmental forces. Today, bridge health monitoring (BHM) systems use sensors to track temperature, humidity, wind, and traffic loads, with real-time data processing. Non-destructive evaluation (NDE) methods, such as acoustic analysis and vibration testing, are vital for assessing structural integrity. A study on two foot-over-bridges (FOBs) in

Hyderabad — Lingampally and HITEC City — demonstrates the efficacy of vibration analysis in ensuring safety. SIT enhances the prediction and prevention of structural deterioration, improving maintenance and helping prevent disasters.

Keywords: Spatial Information Technology; Numerical Modeling; Sensors; Vibration Analysis; Goodness of Fit

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176_IEC88585➲

Retrofitting of Structural Members with Post-Tensioned CFRP Strips

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Abstract: This research focuses on assessing the effectiveness of retrofitting structural members with post-tensioned Carbon Fiber Reinforced Polymer (CFRP) strips, employing both experimental and numerical approaches. Firstly, a comprehensive three-dimensional finite element model is developed in Abaqus to simulate post-tensioned CFRP beams. The validated model accurately captures the behaviour of the composite system, providing valuable insights into its applicability. Subsequently, experimental investigations are conducted in laboratory on beam samples, including a control Reinforced Concrete (RC) beam, a RC beam with CFRP wrap and a RC beam with post-tensioned CFRP strip. Through four-point bending tests, load was applied and deflections were measured using dial gauges. The experimental results revealed that there was a significant enhancement in flexural strength with post-tensioned CFRP strips compared to both control and CFRP wrapped samples. The study demonstrates the effectiveness of post-tensioned CFRP strips in retrofitting concrete structures, highlighting the improved properties of the CFRP strengthened beams as compared to CFRP wrap applications.

Keywords: Retrofitting; Post-tensioning; Carbon Fibre Reinforced Polymer (CFRP); Finite Element; Flexural Strength

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220_IEC39417➲

New Technique for Evaluating Concrete Strength through Non-Destructive Testing

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Abstract: Non Destructive testing (NDT) of concrete is one of the important methods to assess the strength of concrete without causing any damage to the concrete structure. Schmidt Rebound hammer is used to calculate concrete surface hardness which is a widely used non-destructive testing (NDT) method to predict strength of

concrete with the statistical correlation between strength of concrete and rebound index reading. Decades of practice and research in assessing strength using Schmidt Rebound hammer for an assessment of concrete strength remains a controversial issue as the test results are inconsistent by assuming the universal correlation model is correct.

The new Non Destructive testing approach is a pendulum based prototype designed to assess the concrete strength gain evaluation based on the principle of coefficient of restitution. The prototype tested on different types of materials used in the construction sector. Rebound angle calculated using prototype is different for different construction material and structural elements and there is increase in the rebound angle with increase in the days after casting of concrete from day 3 to 28 days. The increase in the rebound angle on concrete as the days of casting increases has a correlation with the strength gain of concrete.

Keywords: Schmidt Rebound Hammer; Coefficient of Restitution; Rebound Angle; Strength Estimation

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263_IEC90596 ➲

Inclinometer-based Health Monitoring and Digital Twin Development for Simply Supported Beam Subjected to Point Load

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Introduction: Structural Health Monitoring (SHM) is essential for ensuring the safety and integrity of structures by providing real-time data on their condition. It enables early detection of potential failures, optimizing maintenance efforts and reducing costs. SHM supports informed decision-making, ensures regulatory compliance, and enhances performance assessments. Additionally, it fosters public confidence in infrastructure safety, extends the lifespan of structures, and helps mitigate risks related to environmental changes, making it a critical component of modern engineering practices. IoT-based SHM can help improve structural safety by detecting damage early and enabling timely maintenance or repair [1]. Flexural members, such as beams and slabs, play a critical role in structural engineering by distributing loads, maintaining structural integrity, and controlling deflection. They enhance safety and efficiency while absorbing dynamic forces, making them essential for versatile and resilient designs in various construction applications. There is a need for reasonably reliable and easy-to-implement health monitoring schema for general beams and bridge structures.

This project has attempted doing real-time structural audit of simply supported steel beams loaded under moving point load by measuring rotation of beam at supports. Structural health monitoring of these flexural members requires decisions regarding appropriate types of sensors. Deflection measurement requires a fixed datum/ reference line, which is not practicable. Rotation measurement of the beam does not require an external reference line, and rotation measurements at the support of a simply supported beam are sufficient to map the position and magnitude of a point load. This was achieved by incorporating a real-time, IoT based embedded system to measure angle using ADXL345 accelerometers. Digital twin for deflection, shear force and bending moment diagrams are generated using support rotation values in real time. Digital twin is a concept that utilizes digital technologies to mirror the real-time states of physical assets and extract the hidden yet valuable information of physical assets for optimization, decision-making or scheduling [2]. The advent of digital twin technology, coupled with advances in sensing, data processing, and communication techniques, has presented new opportunities for enhancing SHM systems in civil structure [3].

Getting early warning regarding the real time integrity and serviceability of structures is crucial for manufacturers, maintenance teams, and operators [4].

This is a simple application of available sensor technology and cost effective microcontroller to demonstrate digital twin for simply supported beam under moving point load. Combined structural health monitoring with digital twin provides a comprehensive and easy to understand state of the structural component. This concept can be used in long term monitoring of numerous bridge structures, buildings and infrastructure.

Keywords: Structural Health Monitoring; IoT; Structural Audit; Digital Twin

Infrastructure

Planning and Design of Infrastructural Systems

51_IEC65812➲

Addressing Systemic Challenges in the Construction Industry: Pathways to Sustainable Improvement

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Abstract: Successful completion of various projects and schemes constitutes one of the most significant conditions for development. Effective coordination judiciously matched with regular monitoring thus becomes an important element in ensuring their successful completion with improved efficiency at greater speed and at reduced cost. However, seldom infrastructure projects are completed within the originally planned timelines or costs. Projects continue to be plagued with delays and cost overruns for several issues. The present paper intends to highlight the various challenges faced by infrastructure projects in India through a case study approach. The paper aims at the reforms required in the prevailing system/ areas, right from concept to commission for any infrastructure project by citing those areas that are affecting the project execution in time and cost. The paper aims to highlight the areas that need attention and measures that can be taken up by the project stakeholders that shall ensure the improvement in the efficiencies of project execution and the construction industry.

Keywords: Infrastructure; India; Challenges; Delays; Sustainability; Development

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60_IEC22309➲

Design of Transfer Beam for Torsion & it's Analysis in Different Seismic Zones

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Abstract: This research explores the design and analysis of transfer beams subjected to torsional forces across various seismic zones, adhering to the guidelines established by IS 1893:2016. The study's main aim is to ensure that transfer beams, essential for load redistribution in high-rise structures, can effectively withstand the combined effects of torsion and seismic activity. The research focuses on developing robust design methodologies in compliance with Indian standards, particularly IS 456:2000 and IS 13920:2016. The methodology employed in the study involves the use of structural analysis tools such as STAAD. Pro to simulate the behavior of transfer beams under different seismic conditions. The analysis concentrates on critical aspects like torsional stresses, shear forces, and bending moments, with an emphasis on optimizing reinforcement strategies. By evaluating the performance of beams across various seismic zones, the research identifies key design parameters that are crucial for maintaining structural integrity. The study's findings suggest that transfer beams located in higher seismic zones require increased reinforcement to adequately manage torsional stresses. It provides practical design recommendations aimed at enhancing the resilience and safety of buildings in earthquake-prone regions. These insights make a significant contribution to seismic design practices, helping to ensure the durability and reliability of transfer beams under complex loading conditions.

Keywords: Transfer Beam; Torsion; Seismic Zones; Vertical Irregularity

62_IEC95497

Design Concept, Optimisation Opportunities and Challenges of an Underground Station supporting a Flyover and Ramp

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Abstract: Urban transportation networks are acting nowadays like a lifeline of the city as well as main key drivers of sustainable development of any developing country like India. The underground constructions are gaining popularity by playing a key role in improving many more the urban space congestion problem. To provide multidimensional transportation system for busy road crossing at Radhakrishna Salai junction location of Chennai city, a highway flyover is planned above an underground metro corridor station. Design and construction of Radhakrishna Salai junction underground metro station from Chennai Metro Project Phase-II corridor 3 has been referred here for the present case study. 3D isometric view of Radhakrishnan Salai Junction Station with flyover running along the length of the station is shown Fig.1 The present paper describes the design concept, optimisation opportunities and challenges of this underground station supporting a flyover and ramp. The station comprises of three levels of slabs supported on two diaphragm walls on both sides. Diaphragm Walls are considered as external walls of the station with slabs forming a part of the internal framing. Entire underground station construction is planned with top-down sequence. Flyover and ramp parts have been planned to cast later once civil works of underground station be completed. As per plan, the flyover spans are supported on the station roof by means of 3 m (wide) × 2.4 m (deep) beams which in turn are supported on the 1000 mm thick diaphragm walls of the station. Besides this, the approach ramp of the flyover is also supported on the station roof. As a part of structural design of underground station and flyover, different types of stability analyses and construction stage analysis have been performed in finite-element-based software Plaxis 2D whereas service stage analysis has been done in STAAD Pro.

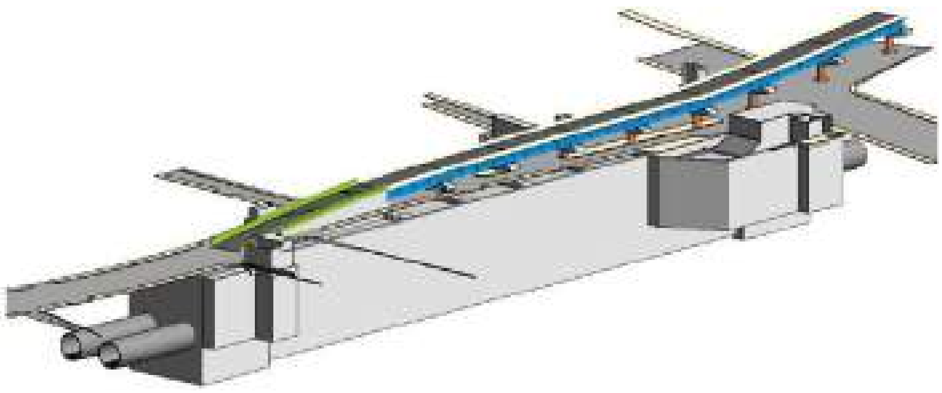

Fig.1 3D Isometric view of Radhakrishnan Salai Junction station with flyover running along the length of the station

Keywords: Urban Transportation; Underground Metro Station; Flyover above Unground Metro Station; Road Junction

105_IEC56565➲

Development of Infra-structure for Measurement of Needle butt-Cam Interactive Force inside Knitting Zone of Double Jersey Knitting Machine

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Introduction to Knitting and Needle butt-Cam Interacting Force: Knitting is the second most popular technique of fabric or garment formation by inter looping from one or one set of yarn and its share in fabric production is about 25 %. In knitting, continuous length of yarn is converted into vertically intermeshed loops for producing the fabric. The loop length (length of yarn in a loop) is the most important parameter which governs the ultimate quality of the knitted fabric. The primary element for loop formation is Needle, which moves either vertically up and down or horizontally to and fro under the control of cam system, for looping and subsequently interloping. According to the direction of movement of yarn during loop formation, there are two types of knitting – Weft & Warp knitting. Moreover, weft knitting machines may be flat and circular, at the same time, both of them may be single jersey and double jersey. Similarly warp knitting can be also of two types – Tricot and Raschel.

The nature of yarn tension is an important parameter for knitting. Some minimum tension in knitting is essential for smooth flow of yarn from the package to the needle as well as for loop formation. At very high tension, yarn may break along with other knitting elements. The input yarn tension in the first phase is generally uniform and easily measurable, however the resultant yarn tension developed during loop formation inside knitting zone fluctuates to a great extent due to needle butt-cam interaction, the magnitude of the same mainly depends on the type of the machine, cam profile, quality of the yarn and the requirement of the end product. The extent of robbing back phenomenon is also influenced by the yarn tension developed inside knitting zone, generally it is higher at higher tension.

Keywords: Knitting; Mechanics; Loop-Length; Cam-Force; Sensor

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108_IEC1133➲

Lift Irrigation – Re-Engineering of Irrigation Projects in the State of Telangana

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Abstract: Irrigation Engineering, primarily based on gravity storage (Dams) and gravity flows (contour canals) has remained stagnant for last one or two centuries due to no technological intervention on account of less revenue returns. Telangana State is a land-locked State located in the southern Indian peninsula on the Deccan Plateau. Though the region is drained by major rivers the Godavari and Krishna rivers, but these rivers flow at an average altitude of 100m above mean sea level whereas the habitations and lands are at about 500-600 m levels. The topography made providing irrigation difficult with conventional technologies which people of the region took as neglect. The aspirations of the people for irrigation and water forced the Central Government to carve out the region as a new State. The newly carved State had no option but to go for Lift Irrigations, made feasible with advancements in high capacity pumps to provide water and irrigation fulfilling the aspirations of the people. Lift irrigations broke the barrier of gravity and provided water and irrigation to much larger areas in the region giving opportunity for re-engineering of Irrigation projects. During the period 2014-15 to 2022-23, the Government has incurred an amount of Rs 1.61 lakh crore on irrigation projects in the State, which brought considerable prosperity to the State. The Paper describes re-engineering of a few Irrigation Projects made possible with lift irrigations. But Lift Irrigation has made irrigation waters very costly, and therefore, require high level of water use efficiency and restructuring of subsidy to make the water infrastructure sustainable.

Keywords: Telangana; Irrigation; Lift Irrigation; Water Use Efficiency

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112_IEC19999➲

Project Execution Marvel in Refinery, Petrochemical, Fertilizer, and Similar Chemical Plants – Leverage Modularization

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Abstract: Modularization is revolutionizing project execution in refinery, petrochemical, fertilizer, and similar chemical plants by offering a more efficient, cost-effective, and time-saving alternative to conventional stick-built construction methods. This paper explores the significant advantages of modularized construction—such as improved project timelines, cost reductions, and enhanced quality control — and presents a significant recent case study made in India that showcase its global adoption. Particular attention is given to the true partnership required among stakeholders and the logistical and engineering challenges that arise. The analysis highlights how modularization facilitates faster project commissioning and better return on investment while addressing the complexities of large-scale chemical plants, making it a critical growth driver in the industry.

Keywords: Project Cycle C2C (Concept to Commissioning); Chemical Plants; Stick-Built Construction; Modularized Construction; Engineering; Operationalization; Modularization

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123_IEC36790➲

A Comprehensive Exploration of Planning and Designing Effective Infrastructural Systems

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Introduction: Infrastructural systems are the backbone of modern civilization, playing a crucial role in economic growth, social well-being, and environmental sustainability. The effectiveness of these systems impacts everything

from urban development to energy distribution, water management, and transportation. In this paper, we explore the key aspects of planning and designing infrastructural systems, with a specific focus on India's evolving urban landscape. Recent literature highlights the growing demand for smart, sustainable, and resilient infrastructure to accommodate population growth and climate-related challenges. Projects like India's Smart Cities Mission emphasize the integration of sustainable practices with cutting-edge technologies to create future-ready cities. This paper reviews contemporary approaches to infrastructural planning, underscoring the challenges posed by economic, regulatory, and technological constraints.

Keywords: Infrastructural Systems; Sustainable Planning; User-Centered Design; Smart Cities; Environmental Sustainability

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128_IEC91263➲

Planning and Design of Infrastructural System

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Introduction: Infrastructure may be deemed to include facilities and processes in the following areas: Public utilities — power, telecommunications, piped water supply, sanitation and sewerage, solid waste collection and disposal, and piped gas. Public works - roads and major dam and canal works for irrigation and drainage.

Types of Infrastructure

Infrastructure is often categorized as hard or soft. Hard infrastructure is the tangible, physical assembly of structures such as roads, bridges, tunnels, and railways. Soft infrastructure is the services required to maintain the economic, health, and social needs of a population.

Hard infrastructure:

Hard infrastructure is the physical system needed to run a modern, industrialized nation. Examples include roads, highways, and bridges, as well as the assets required to make them operational such as vehicles, transit buses and oil refineries. Technical systems such as networking equipment and cabling are considered hard infrastructure and provide a critical function to support business operations.

Soft infrastructure:

Soft infrastructure represents human capital and institutions necessary to maintain an economy that delivers certain services to the population such as healthcare, financial institutions, government offices, law enforcement, and education.

–Infrastructure Planning is the process of integrating, design, construction, maintenance and rehabilitation to maximize the benefits to the users and it minimize the cost to the owners and users‖.

It is an interdisciplinary process. It involves the provision of physical facilities and the operations and its management.

Infrastructure is the backbone of a prospering city. The cities are because of living organisms and in order to keep them alive, healthy and prosperous atmosphere is required. Because of it only better society and economic growth of that region is possible.

Infrastructure design is a study involving comprehensive planning, development, and implementation of the core components that make the system work properly, for roads, bridges, hydraulics, subway lines, and the construction of roads, rail lines, water storage, and disposal systems. By using infrastructure design software, engineers can develop 3D smart models and mapping of environmental needs such as land, transportation, and services utilities.

Keywords: Infrastructure Planning; Infrastructure Design; Sustainability; Smart Infrastructure; Urban Planning

Infrastructure

Safety and Reliability of Infrastructural Systems

20_IEC50391 ➲

An Assessment of the High Mast Poles' Reliability with Corrosion Contemplated

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Abstract: Steel structures like high mast poles are often subjected to fatigue failures. The fatigue strength of these structures is impacted by degree of loading, type of loading – static, dynamic and the environment surrounding the structures. Maintenance of such structures becomes key in lengthening the life of overall system. Also considering the growing impact of prognosis, remaining useful life calculation of the product/ system becomes the key matrix especially for the high mast poles as they help create optimized schedule for the maintenance thereby minimizing the inspection and repair cost. This paper deals with introducing a remaining useful life (RUL) curve for the high mast pole based on physics-based approach which includes wind and thermal loads in initial calculations. Paper details how corrosion can be major factor and how it can impact the reliability. Incorporation of the corrosion as a separate factor in the RUL curve is studied in this paper. Application of this study is performed on the one of the high mast pole situated in the USA and detailed study was conducted. Finally, this study was concluded with the help of map charts for qualitative denouement.

Keywords: Reliability Analysis; Fatigue; High Mast Poles; Corrosion Damage; Remaining Useful Life

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24_IEC53203➲

Analytical Reliability Assessment of Soil Liquefaction Probability of Failure using Dynamic Penetration Test Data

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Abstract: Prediction of seismic liquefaction is much more complex due to the heterogeneous nature of soil and the large number of factors involved. Determination of site liquefaction can prevent major damages to infrastructure. Hence, reliability analyses are often used as an alternative to a deterministic approach. In this study, we have used 230 gravelly soil data obtained from various earthquake sites across the world and used the jointly distributed random variable (JDRV) method to evaluate liquefaction potential. The corrected DPT blow count (N’120), peak horizontal ground acceleration ratio (α) and magnitude of earthquake (Mw) has been considered as input parameters that are modeled using the probability density function. The results of JDRV method are compared to that of Monte Carlo Simulation (MCS) method for validating the robustness of this method. The results show faster calculation and effectiveness of the JDRV method in evaluating probability of liquefaction. This method can be used as an analytical tool in the reliability analysis of soil liquefaction.

Keywords: Liquefaction; Reliability; Jointly Distributed Random Variables Method; Dynamic Penetration Test

345_IEC34342

An IoT enabled Health Monitoring System for Construction workers

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Abstract: Ensuring the safety and well-being of construction workers is of paramount importance in hazardous work environments. These abstract outlines the development of a novel Wearable Safety Device designed to enhance the safety and protection of construction workers across various sectors. The Wearable Safety Device integrates advanced sensor technologies, real-time data analysis, and user-friendly design to provide comprehensive safety features and early warning systems. The Wearable Safety Device consists of several key components, including a ruggedized wearable module, a variety of environmental sensors (such as gas detectors, temperature sensors, and air quality monitors), motion and posture sensors, and wireless communication capabilities. These components work together to monitor the worker's immediate surroundings, physiological state, and movements. The real- time data gathered by the Wearable Safety Devices is transmitted to a central monitoring system, which employs machine learning algorithms to analyse the data and detect potential safety hazards. The system can identify factors such as toxic gas leaks, abnormal temperature fluctuations, dangerous posture or movement patterns, and signs of worker fatigue. The system can identify factors such as toxic gas leaks, abnormal temperature fluctuations, dangerous posture or movement patterns, and signs of worker fatigue. The Wearable Safety Device also collects valuable data over time, enabling employers to analyze trends and patterns in worker behavior and environmental conditions.

Keywords: Workers; Construction; IoT; Health; Monitoring

Infrastructure

Special Infrastructural System and New Technologies

36_IEC91205➲

Evaluating the Structural Integrity of Gabion Walls under Repeated Lateral Loads using Alternative Infill Materials

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Abstract: Gabion walls are wire mesh boxes filled with broken rocks of suitable size. These boxes are stacked together to form a wall of large self-weight which can resist lateral loads. Gabion walls are usually used in the form of retaining walls and they prove to be a quicker and economical solution compared to the traditional reinforced concrete retaining walls. The present study aims to evaluate the engineering behavior of gabion walls under lateral repeated loading with infill combination of broken rock with construction and demolition waste. Double twisted factory manufactured gabion boxes with different wire diameters and mesh opening sizes are used in the study. The gabion specimen is tested using a reaction retaining wall which houses the specimen as well as allowing for lateral testing. The gabion box was tested for its load carrying capacity and deflection resistance against lateral monotonic and repeated loading. The results showed that the gabion wall has high ductility but comparatively low elasticity. The structural behavior depends on the dead load of the gabion and the arrangement of infill inside it. Also, it was seen that partially replacing infill stone with construction and demolition waste did not alter the strength of the gabion to a large extent.

Keywords: Gabion Wall; Lateral Monotonic Loading; Lateral Repeated Loading; Deflection; Wire Mesh; Stone Infill

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86_IEC68132➲

Self-Healing Nano Additives for Augmenting the Durability and Sustainability of Cement Composites

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Abstract: Self-healing nano additives are nanomaterials that can improve the durability and sustainability of cement composites by repairs at the nano-level. Nano titania, also known as nano-TiO2, has a distinctive self-healing capacity whereby it not only increases the mechanical strength of cement composites and also concrete composites but also enhance the environmental remediation of cementitious systems by degrading organic pollutants thereby making it more durable & ultimately sustainable. Our paper reports the effect of adding hydrophobic 40 nm dia. nano-sized Titania (NT) particles by functionalizing them to hydrophilic via. surface modification or wrapping by new generation pH neutral polymeric admixtures & added them to cement: sand ratio of 1:3 with a water-cement ratio of 0.4. Mechanical strength results of the cementitious composites were taken at all terms up to 365 Days(D). The optimized quantity of NT as found in cement composites is then added to M-40 Grade concrete composites for compressive strength testing at both shorter & longer terms following Indian standard protocols. Results reveal that the application of NT in cementitious systems has an improved effect when compared with non-NT cementitious systems and also the former is more durable & sustainable. Photocatalytic NT is also time durable and the microstructural investigations disclose the crystallographic nature of NT, which is the main reason for their favourable mechanical impacts.

Keywords: Cements; Self-healing; Nano-TiO_2; Sustainable

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119_IEC61765➲

Autocross — an Automated Transit Shuttle System for Decoupling Pedestrians and Road Traffic

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Abstract: One of the prominent indicators of a country's growth is the consistency in infrastructural development and its engineering astuteness. Every country depends on its engineers to portray its capacity in building engaging solutions for the problems faced by its population. Advancement in technologies, world over, drives the engineers to work on enhancement over the existing solutions sometimes leading to path breaking outcomes. The success of an outcome of this nature is determined by the utility it provides to the users. Such a technology would primarily help overcome the problems faced by the existing solutions. As an unmistaken extension it would provide auxiliary benefits and set pathways for innovative solutions. In this paper, an automated technology to help pedestrians cross the roads involving heavy traffic is presented in detail to create awareness on the new technology. This paper is an extended arm of the Indian patent: 432636 granted on 23.06.2023[1]. The functionalities, salient features, advantages and auxiliary features are discussed in detail to spread the freshness and exquisite nature of such technologies.

Keywords: Technology; Automation; Robot arm; Pedestrian; Traffic; Autocross

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134_IEC55890➲

Manufacturing of Indigenous Tribal Bi-Component Fibres for Technical Textile Sector

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Abstract: Modern sportswear and activewear must incorporate both fashionable and functional elements. These are primarily meant for professional sports, where the pursuit of victory is paramount. [1–3]. Sports and activewear needs to have superior moisture transmission behaviour in order to be deemed comfortable. During an activity, sweat needs to evaporate quickly to keep the skin temperature stable. Improved moisture transmission properties of fabrics can be achieved by altering the cross-sectional shapes and morphologies of the fibres. The best way to address this is to modify the current fibre manufacturing process to produce fibres with different cross-sectional shapes and morphologies in order to achieve improved comfort and performance. The demand for more comfortable sports and activewear in India is driven by the country's youth and active population, and this demand is influenced by the country's climate. Trilobal cross-sectional fibres are superior to circular-shaped bicomponent fibres in terms of wicking or moisture transport, opacity, light weight, and specific surface area. By making modifications to a melt spinning machine and adding a spinneret and spin pack in the proper arrangement, these bicomponent fibres can be made. This article addresses the various forms of bicomponent fibres, their advantages and disadvantages, and applications. The construction of an indigenous melt spinning facility to create core-sheath trilobal bi-component fibres is also a topic of discussion.

Keywords: Bi-Component Fibre, Tri-Lobal, Technical Fibre, Core-Sheath, Wicking, Melt-Spinning

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231_IEC78856➲

Border Security Lighting: Comparison and Implementation of Different Types of Photometric Distribution

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Abstract : Border security lighting is a new age security lighting where object should be visible from 140M distance. To cover this high distance becomes very challenging. Earlier day’s combination of two optical distribution luminaires were used to achieve that criteria. But now a days, due to rapid growth of LED, any type of distribution can be done by using different structure of lens. Here in this paper, different types of lens photometric distribution is simulated based on the criteria of CPWD Border Fencing Security criteria and after that the combination satisfied the criteria is tested in practical field.

Keywords: Security Lighting; Border; Light Emitting Diode(LED); Vertical Illuminance; Uniformity

Infrastructure

Sustainable Material for Infrastructural Systems

46_IEC75597➲

Investigation on Behavior of Concrete Modified with Water Hyacinth Fiber

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Abstract: As we know concrete is brittle in nature, and have low strength against tension, so it has significant negative impact on the environment, human health, or both. The object of this study is development of environmental friendly concrete by incorporating natural water hyacinth fibers into the mix. The hyacinth fibers of lengths of 10 cm, 15 cm and 20 cm, added to the concrete in varying amounts of 0%, 0.3%, 0.4%, 0.5% and 0.6% of the concrete's volume. Cubes of 15 cm × 15 cm × 15 cm standard size are tested for compressive strength after 7 days, 14 days and 28 days curing. The specimens were cured by being fully submerged in a water tank at ambient temperature until the designated test age. Comparison of strength achievement of concrete based on percentage of water hyacinth fibers and curing period were done properly. After careful observation some important remarks have been drawn, which can be used for future research work.

Keywords: Fiber Reinforced Concrete; Geopolymer Concrete; Lignocellulosic Fibers; Natural Fiber; Sustainability; Water Hyacinth Fiber

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61_IEC14382➲

A Review Paper on Utilization of Bulk Industrial Waste Material for Developing Novel Aggregate

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Abstract: Industrial waste (Pet coke fly ash, Silico manganese slag, bed ash) is generated in large amounts worldwide. A hazardous, high-sulfur industrial waste material has been added to mortars in varying proportions as an alternative to burning. It is vital to treat or reuse industrial waste (such as bed ash, silica manganese slag, pet cokefly ash) since improper disposal can have detrimental effects on the environment, including the possibility of groundwater pollution from heavy metal leaching and/or particle emissions. Currently, there are various industries that use industrial wastes, including concrete and aggregate manufacture. Because the markets for industrial waste materials can only handle so much, new markets for the waste material that is left over must be created. This article presents the results of experimental research done on innovative aggregates, which are more affordable and environment friendly than conventional aggregates. The material properties will be ascertained by means of the following experiments: Fourier transform infrared spectroscopy, X-ray fluorescence, scanning electron microscopy, energy-dispersive X-ray, atomic absorption spectroscopy, X-ray diffraction, specific gravity, absorption, impact value, crushing value, and fineness modulus of three different proportions of waste aggregate in accordance with Indian standards. The results are compared with those of natural aggregates.

Keywords: Petroleum Coke Fly Ash; Silico-Manganese Slag; Bed Ash; Aggregate; Industrial Waste Material

71_IEC4160➲

Sustainable Materials in Construction: A Path to Green Building

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Abstract: Sustainable materials in construction are a critical factor in reducing the environmental impact of building and infrastructure projects. As urbanization accelerates globally, the construction industry is under increasing pressure to adopt materials and methods that reduce carbon emissions, minimize waste, and promote long-term environmental stewardship. This paper examines a wide range of sustainable materials, from recycled and renewable resources to innovative materials such as carbon-neutral cement and bio-based alternatives. It also explores the benefits, challenges, and technological advancements associated with these materials. Through case studies and real-world applications, this paper highlights the vital role of sustainable materials in creating greener, healthier, and more cost-effective construction practices.

Keywords: Sustainable Materials; Green Building; Eco-Friendly Construction; Energy Efficiency; Renewable Resources; Low-Carbon Footprint

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84_IEC8644➲

Measuring Bitumen Consistency: A Journey through Penetration, Viscosity and Performance Grades

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Background and Study Motives: The consistency of bitumen is primarily measured to differentiate among the various bitumen samples sourced from different crude origins. The grading system allows for the appropriate selection of bitumen for construction purposes based on its physical and rheological properties. Historically, before modern refining processes were developed, natural bitumen was widely used in construction, with notable sources such as Trinidad Lake bitumen. In the early 20th Century, methods like the chewing test were used by asphalt specialists to assess the consistency of bitumen. This was done by chewing the material to gauge the amount of pressure needed. Other basic methods, such as visually inspecting the bitumen sample and testing its solubility in carbon disulphide, were initially used for quality control. This was particularly important since natural bitumen often contained high levels of mineral impurities.

The binders were classified into grades based on measurable parameters correlated with field performance. The penetration grading system, developed in the early 1900s, utilized the penetration value at 25°C to specify parameters. However, this empirical method measured 'consistency' at a specific temperature without detailing the rheological behaviour of bitumen. To address these limitations, viscosity grading was introduced by ASTM D3381 in the early 1960s, grading bitumen based on viscosity at 60°C and 135°C to reflect maximum pavement temperature and mixing temperatures, respectively. This approach considers parameters such as softening point and ductility. Despite these advancements, variations in real-world pavement temperatures necessitated a grading system that ensures consistent performance across a range of temperatures, leading to the development of the performance grading system, grading bitumen based on rutting, fatigue, and low-temperature cracking parameters.

The primary objective of this study is to present a comprehensive review of the limitations in the current viscosity grading system, with a specific focus on the method outlined in IS 73:2013, as it applies to Indian roads. Given the specific climatic conditions and practical challenges in pavement performance, it is imperative to assess whether these grading systems adequately address the requirements for consistent performance under the varying temperature conditions as witnessed across the country. In this context, the current investigation offers a detailed analysis emphasizing the need for systematic collection of ambient and pavement temperature data over extended periods. This would help develop a comprehensive temperature database, guiding the conversion of air temperature to pavement temperature and enabling a more accurate selection of bitumen in accordance with the performance grading system.

Keywords: Bituminous Material; Road Pavement; Consistency Test; Temperature; Traffic Load

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90_IEC38416➲

Advancements in Sustainable Concrete Technologies and the Role of Graphene Oxide in Self-Compacting Concrete

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Introduction: In recent years, the construction industry has seen a growing interest in improving the performance of concrete, especially with the development of high-performance materials like self-compacting concrete (SCC). SCC is widely known for its ability to flow under its own weight and fill formwork without the need for mechanical compaction, making it ideal for complex structures. However, ensuring the balance between workability and mechanical properties in SCC remains a challenge, particularly in applications that require high strength and durability.

One of the emerging areas of research focuses on the incorporation of nanomaterials like Graphene Oxide (GO) to enhance the properties of traditional concrete. GO, due to its exceptional mechanical strength, high surface area, and hydrophilic nature, has been studied for its potential to improve concrete's mechanical properties, durability, and resistance to cracking. The use of GO in concrete has shown promising results in improving strength and durability while potentially addressing limitations associated with traditional concrete mixes.

This study investigates the effect of GO on the workability and mechanical properties of M40 grade self-compacting concrete (SCC). Specifically, it evaluates SCC mixes with and without the addition of 0.1% GO in terms of slump flow, compressive strength, and split tensile strength. A brief review of literature suggests that while GO can improve the strength and durability of concrete, its influence on workability due to its water absorption characteristics has not been fully explored.

The experimental results show that the addition of GO significantly impacts both the workability and mechanical performance of SCC. Although the inclusion of GO reduced the workability of the concrete due to its water-absorbing properties, it enhanced both compressive and tensile strengths. FESEM analysis further revealed that GO not only filled nano-scale pores but also regulated the growth of crystal structures, contributing to the improvement of mechanical properties. Notably, the compressive strength increased by 34.29% after 28 days, and the split tensile strength improved by 22.65%.

These findings underscore the potential of GO as an additive in high-strength SCC applications, providing improved mechanical properties at the cost of reduced workability. However, the reduction in workability highlights the need for the incorporation of superplasticizers to maintain proper flowability in concrete mixes.

Keywords: Self-Compacting Concrete (SCC); Graphene Oxide (GO); Workability; Compressive Strength; Split Tensile Strength; Field Emission Scanning Electron Microscopy (FESEM); Energy Dispersive Spectroscopy (EDS)

92_IEC64434➲

India’s Resilient Rock Heritage: A Treasure for Infrastructural Engineering

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Abstract: India’s rock deposits exhibit remarkable resilience, making them valuable resources for infrastructural engineering applications. India, a land of diverse landscapes and geological wonders, boasts an extensive array of rock deposits—over 300 varieties—scattered across its states. These rocks, with their inherent resilience, serve as invaluable resources for infrastructural engineering applications. This paper presents India’s distinction usage of rocks and stones and their products primarily depends upon the following factors such as geological diversity, resilience, and utlisation and their industrial and infrastructural engineering applications, challenges in conservations, and prospects.

Keywords: Rock Deposits; Resilient Rock Heritage; Industrial Infrastructural Applications; Conservations

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101_IEC82835➲

Review of Nanomaterials in the Civil Engineering Infrastructures

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Abstract: Nanocarbon tubes and nanomaterials are poised to revolutionize the civil engineering industry shortly by offering environmentally friendly and sustainable design options to minimize carbon emissions from coal burning in cement production. Their potential applications extend beyond civil engineering to include industries such as automotive, transmissions, solar energy, wind energy, lightweight armour for military tanks, shipbuilding, medicine, mechanical and electrical engineering, and more. Nanomaterials offer the added benefit of being lightweight, which can reduce foundation loads, bridge superstructure weight, cable diameter in cable-stayed bridges, ground improvement techniques, leak prevention, crack prevention, corrosion prevention in reinforced concrete elements, and materials for repairs and renovations. This paper compiles research and studies conducted worldwide on the sustainable and optimal use of nanomaterials, specifically nanocarbon tubes, nanocarbon powder, nanocarbon materials, nanofibers, nano silica, and titanium dioxide, which enhance concrete and cement paste strength while minimizing crack development and preventing rebar corrosion. It aims to provide future researchers with the most recent advancements in nanotechnology across the globe.

Keywords: Nanocarbon Tubes; Nanomaterials; Titanium Dioxide

117_IEC30711➲

Ground Improvement by Admixture using Banana Fiber: Experimental Study

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Abstract: Construction of a transport infrastructure such as highways and railways is often challenging when the natural soil subgrade is weak, with low strength and compressibility. In order to ensure long-term sustainability of the transport corridors, such weak soil needs to be sufficiently improved prior to commencement of construction. Several methods are available for ground improvement for transport infrastructure including dynamic compaction, preloading with consolidation and chemical stabilization. Among these techniques, using admixtures in virgin soil has been observed to enhance the strength, stiffness and penetration characteristics of soft ground. This paper presents an innovative technique of ground improvement by using natural banana fiber which is derived by splitting stems of banana trees and slicing them to desired shape and size. The primary advantage of this material is its wide availability, less expensive and eco-friendly. Soft soil is collected from a local site and banana fibers with desired specification and proportion is intimately mixed with it. The soil mixtures have been tested in laboratory to determine its compaction and penetration characteristics. It is observed that using this specific admixture enhance the soil properties significantly. From the entire study, a set of important conclusions are drawn.

Keywords: Optimum Moisture Content; Maximum Dry Density; California Bearing Ratio; Ground Improvement

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141_IEC47603➲

A Review on Seismic Performance of Smart Structures and Bridges with Shape Memory Alloy Reinforcements

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Abstract: Bridge columns are most vulnerable to earthquake forces and the damages can be of high intensity, leading to affect the safety and serviceability of the structure. Hence protecting them against damages due to severe earthquakes is at most priority. This paved the way for introducing smart infrastructure and smart materials for construction. Shape memory alloy (SMA) is one of the smart materials which has the potential to control damages due to seismic forces and reduce deformations. This alloy finds its application in structures in the form of bars, wires, dampers and many more. SMAs in the form of reinforcement bars along with conventional bars can be deployed in critical regions in bridge piers and beam columns for better performance and controlling deformations. To clearly understand the performance of shape memory alloys in seismic resistance of structures, various experimental and analytical studies were conducted by many researchers across the globe. A detailed review of literature is utmost necessary to understand the potential performance of various types of SMAs and efficacy of these unique smart material in the field of earthquake engineering. This paper critically reviews the application of shape memory alloys reinforcements in structures in mitigating the earthquake forces and performance of piers.

Keywords: Shape Memory Alloy; Bridge Piers; Seismic Resistance; Smart Alloys

190_IEC8931➲

Utilization of Construction and Demolition Waste for Sustainability

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Abstract: In the present age, the Construction industry is one of the biggest industries in almost all the countries in the world but it faces significant challenges concerning the environmental impact: two are at the forefront: 'more consumption of natural resources and energy than any other economic activity' [1] and a substantial volume of waste is generated, during construction of any structure, demolition/dismantling old buildings

The waste materials produced from these activities commonly contain Broken or unused concrete, bricks, leftover cement, sand, stone chips, and miscellaneous materials which are inert and thus devalued though in large volume. While some materials like metals and wooden doors can have scrap value, a large portion of C&D waste, such as broken concrete, bricks, and unused cement, sand lacks value in the linear economy and is very often dumped in unauthorized areas. It is established that this waste has great recycling and reusing potential so the researchers have the opportunity to focus on finding sustainable materials which involves reutilizing these abandoned debris and minimizing the natural resources. This paper also explores the potential for integrating a circular economy within the construction sector to address these challenges effectively. It aims to highlight innovative solutions for reutilizing C&D waste, and sustainability.

Keywords: Construction and Demolition (C&D) Waste; Recycling and Utilising C&D Waste; Sustainable Material

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307_IEC43265➲

Overview of using Construction & Demolition Waste in Hot Mix Asphalt

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Abstract: The escalating production of Construction and Demolition waste (C&DW) resulting from fast urbanization has prompted apprehensions about its disposal and environmental repercussions. Additionally, overexploitation of virgin aggregate to meet the requirements of roadway construction creates resource depletion and promotes the use of alternate materials in a sustainable way. This review paper discusses the utilization of C&DW as an alternative to virgin aggregate in Hot Mix Asphalt (HMA). The paper also tries to describe different characterizations of recycled aggregate (RA) and their benefits and drawbacks on the performance of RA-modified HMA mixes in terms of Strength, moisture durability, stiffness of asphalt mixes, and rutting and fatigue resistance. Based on the available literature the C&DW offers sustainable, eco-friendly, and cost-effective advantages over natural resources, since it reduces waste to landfills, conserves virgin resources, and reduces emissions. However, it is quite challenging to establish a strong correlation between the performances of HMA mixes with RA content.

Keywords: C&DW; Recycled Aggregate; Hot Mix Asphalt; Marshall Stability; TSR

<u>Infrastructure</u>

Transportation Infrastructure

41_IEC6554➲

Traffic Signal Optimization and Synchronization using PTV Vissim

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Abstract: Traffic congestion is one of the major problems in the metropolitan city. The rise in traffic is mainly due to increase in population and vehicle volume day by day, it leads to increase in queue lengths and delay time during peak hours. There are two methods to counteract this problem; the first one is by modifying the geometry of the road like widening of the roads and the second one is by optimizing the various facilities which are available on the roads. Nowadays due to the advancement of technology, it is easy to simulate the traffic simulation at various junctions which are available on the roads with a simulation tool. One such a simulation tool is Vissim. PTV Vissim is a micro simulation software which has been widely used to evaluate different traffic management scenarios to choose the best alternative and optimization measures before implementation of traffic. The aim of optimizing of the traffic signal is to provide smooth flow of traffic along streets and highways to reduce travel time, stops and delay. The output values obtained in Vissim were compared to the corresponding values before coordination.

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49_IEC71570 ➲

The Scenario of Advanced Aviation Manufacturing and Maintenance in India for Deployment throughout the subcontinent: Opportunities, Threats and Strategic Outlook

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Abstract: The extremely opportune geological position of India, its favorable demographics, its technological superiority and its diplomatic allegiance with neighboring countries ensures a thriving market for small and medium range aircrafts for servicing civil as well as freight aviation channels in and around the subcontinent. Given her unchallenged superiority in space exploration and an enthusiastic but small domestic aeronautics production capabilities, the next two decades of growth and rise in demand shall produce unprecedented prospects in the aviation services sector. The impetus provided by the Make-in-India movement shall help usher in a new era of advancements in production practices by the infusion of investments both from within and abroad. The following article provides a speculative analysis of the benefits and challenges involved in such a venture while providing special care to building strategic ties with important global partners. Finally, a case is presented for the incorporation of advanced sustainable materials and zero-carbon product life-cycle techniques that will cement India‟s position as a tactical global leader in the aviation sector.

Keywords: Aviation; Infrastructure; Manufacture; Maintenance; Civil; Military

96_IEC25991

Can Indigenous Driving Simulators Surpass the Limits of Automated Simulation Trials?

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Introduction: Alarming life losses caused by road traffic injuries [1] has led global and local organisations to make conscious efforts to curb road traffic crashes. Research has shown that the likelihood of traffic accidents is greatly influenced by the interactions between drivers, their vehicles, and the roadway; over 90% of accidents are caused by driver-related factors [2, 3]. To enhance road safety, a full comprehension of these relationships is necessary. Driving requires drivers to navigate while engaging with other road users since it requires them to perceive distances and integrate visual inputs from the surroundings [4]. Around 90% of information pertaining to driving is visual [5]; therefore, processing complex visual sceneries requires the brain's processing speed, which can occasionally cause confusion and contribute to risky driving [6]. Adverse weather conditions like rain, fog, dim lighting, etc., make driving strenuous and raise the possibility of accidents [7]. These elements emphasize how crucial it is to comprehend how visual perception affects driving behaviour and traffic safety. Drivers' visual abilities affect the sequential phases of detecting the road environment, which includes sensing, processing, and application [8].

Experiences shed light on the fact that conducting behavioural studies of drivers in a real-world scenario is crucial [9, 10]. Earlier investigations also highlighted traffic sign occlusions increase driver perplexity [11]. The dynamic and unpredictable nature of road environments makes it hard to control for variables such as traffic density, weather conditions, and driver intent, all of which can significantly influence driving behaviours. Data collection in real-time, fast-moving situations also requires sophisticated equipment and precise synchronization between vehicles, which can be logistically challenging and costly. Additionally, researchers must address ethical concerns related to privacy, as capturing data on public roads might inadvertently involve individuals who have not consented to participate in the study. Furthermore, the presence of an observer may lead to reactivity, where drivers alter their behaviours simply because they know they are being watched [12], which can skew the data. The investigations require that similar studies be repeated in various geographic or cultural contexts. Because field trials are unable to capture all potential impacts and implications in the real world [13], conducting controlled tests with a simulator in a virtual reality (VR) platform is preferable. These VR platforms, like driving simulators, range in fidelity from low to high, and the choice of one would rely on the goals and designs of the experiments. A simulator with high realism may not always imply high validity since the relationship between fidelity and validity of simulators is not simple [14]. Using a low-fidelity simulator with a systematic experimental strategy offers a cost-effective way to ensure high validity in testing safety performance.

The primary objective of this study is to examine drivers' perception reaction time (PRT), a critical factor influencing road safety and driving performance. To achieve this goal, the research employs a series of experimental trials designed to investigate how PRT varies under different environmental conditions. Specifically, the trials were conducted in three distinct weather scenarios: (a) clear weather to assess baseline perception reaction times under optimal driving conditions (b) rainy conditions to evaluate how precipitation affects drivers' ability to perceive and react to stimuli and (c) foggy weather to investigate the impact of reduced visibility on reaction times. Also, these trials were made during various times of day, which include daylight to understand reaction times during fully visible scenarios, twilight to analyse the transitional period when visibility decreases, and night-time to examine the effects of darkness on drivers' perception and response. While performing experiments, the study developed roadside environments using out-of-the-box elements. These environments are designed to simulate real-world conditions and include built-in analytic tools for precise measurement.

Keywords: Road Safety; Vehicle Simulation; Experimental Trial Performance

138_IEC31743➲

Erection of Two Stage Cantilever Concourse and Platform Pier Arm for Elevated Metro Stations

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Abstract: Increasing traffic volumes and a deteriorating transportation infrastructure have stimulated the development of new systems and methods to accelerate the construction. Precast & prestress pier arms components offer a potential alternative to conventional reinforced, cast-in-place concrete components. The use of precast components has the potential to minimize traffic disruptions, improve work zone safety, reduce environmental impacts, improve constructability, increase quality, and lower life-cycle costs. As per above introduction to the topic "Erection of Two Stage Cantilever Concourse and Platform Pier Arm for Metro Stations". The technical presentation put up for discussion, is a structure at station piers location, which is to support the station girders and slabs. The structure is completed and handed over to Station Civil Contractors to finally establish station buildings. The structure casted in stages with accuracy and with zero tolerance of errors in design, methodology and sequence of casting. The structure is a precast structure and executed in 2 levels with 3+6 complex stages.

Keywords: Pier Arms; Concourse Level; Track Level; Platform Level; Match Casting; Precast Concrete; Rapid Construction; Segment; Formwork

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175_IEC1445➲

Evaluation of Dowel Joints using Ground Penetrating Rader — A Case Study on a Highway Stretch

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Abstract: This study investigates the use of Ground Penetrating Radar (GPR) for evaluating the condition of dowel joints in a specific stretch of a national highway. Dowel joints are essential for load transfer between concrete slabs in highway pavements, and their proper functioning is critical for long-term pavement performance. Issues like dowel misalignment, corrosion, or voids can lead to early deterioration and costly repairs. The present research utilizes GPR, a non-destructive testing method, to identify subsurface anomalies in dowel joint placement and surrounding concrete. GPR's ability to generate high-resolution images of the pavement subsurface makes it ideal for detecting defects such as improper dowel positioning, misalignment, and voids that could compromise pavement integrity. The study focuses on a case stretch of a national highway, where GPR scans were conducted to assess the dowel joints' condition. The findings demonstrate GPR‟s efficiency in detecting dowel positions, providing a quick and accurate alternative to more invasive testing techniques.

Keywords: Nondestructive Tests; Ground Penetrating Rader; Concrete Pavement; Dowel Joints

314_IEC1506➲

Evaluating the Performance of Cell-Filled Concrete Pavement using Non-Destructive Testing Techniques

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Introduction: The development of cell-filled concrete pavement (CFCP) technology has gained momentum in the international arena over the past few decades [1-4]. This innovative pavement structure is composed of polyethenecells, which come in various thicknesses ranging from 50 -150 mm. These cells are filled with concrete and compacted, resting on a granular sub-base or a stabilized layer above the subgrade. When cast using plastic cell formwork, these concrete blocks exhibit an elastic modulus equivalent to that of traditional concrete [1]. This characteristic makes cell-filled pavements particularly suitable for low-volume roads, where they can provide effective support and durability while optimizing material use [3].

Experiments have demonstrated that CFCP functions similarly to a flexible layer [2]. In one study, researchers constructed a test section to investigate the behaviour of cell-filled pavement under load. They observed that after 1,500 repetitions of 141 kN loaded trucks, the rut depth remained less than 2 mm [4]. These results indicate that CFCP can effectively withstand repeated loading without showing any signs of distress or failure.Furthermore, the authors of the study highlighted that CFCP is a cost-effective alternative when compared to traditional flexible and rigid pavements. Another investigation focused on evaluating the structural integrity of cell-filled pavements through a finite element model. This analysis assessed critical structural performance metrics, including surface deflections and vertical subgrade strains [4].

A comprehensive study was conducted on CFCP specifically for low-volume rural roads. This research encompassed a series of tests aimed at evaluating both pavement distress and economic viability through the establishment of a dedicated test section [5]. Furthermore, another investigation assessed the performance of CFCP and established that distress evaluation can be effectively performed using the Pavement Condition Index (PCI). The results indicated favourable ratings consistent with PCI assessment criteria [6]. Additionally, a recent study explored in-situ concrete block pavements by measuring the vertical stresses induced by mobile and impact loads across two test sections. This research investigated various load levels to analyze their effects on the underlying granular base [7].

The aim of the current study is to evaluate the performance of CFCP using non-destructive testing techniques. This evaluation is conducted through a field study on roads with CFCP sections in the state of West Bengal. The paper is organized into three main sections: methodology, result analysis, and conclusion. The methodology section provides insights into the test procedures, specific locations, and relevant characteristics of the test sites. Following this, a comprehensive analysis is conducted to interpret the results and draw meaningful conclusions.

Keywords: Cell-Filled Concrete Pavement; Performance; Non-Destructive Testing

349_IEC98772 ➲

Construction of Whitetopping and its Performance in Early Years — a Case Study in India

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Abstract: India predominantly employs bituminous pavements for road construction due to their ease-of-construction and lower initial cost. However, these pavements often exhibit distresses, e.g., rutting and cracking, leading to frequent maintenance and reduced service life. While rehabilitating these pavements with bituminous overlays is common, it does not address the persistent issue of recurring maintenance. Despite their widespread use, there is a notable research gap in exploring durable and more efficient alternatives tailored for Indian climatic and traffic conditions. The present study attempts to bridge-up this gap by investigating Whitetopping also commonly known as Concrete Overlay as a potential solution, emphasizing its construction and performance reported from a pilot project in Eastern India. The results of pavement‟s performance at its initial years in terms of surface condition, surface roughness and quality of concrete overlay using non-destructive testing techniques revealed the promise of Whitetopping as a sustainable measure to revolutionize road rehabilitation practices in India.

Keywords: Whitetopping; Bituminous Pavement; Rehabilitation; Construction; Performance Evaluation

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362_IEC63043➲

Autonomous Vehicle in India: Navigating Technological Potential and Regulatory Hurdles

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Introduction: Recent years have witnessed revolutionary advancements in AI, leading to the introduction of Autonomous Vehicle (AV) in the transport sector. Through the advancement in the technological ecosystem involving machine learning algorithms, high-tech sensors, and robotic control, the technology of AV has established surreal capabilities of perceiving and interpreting the surroundings including, independent driving decisions without direct human intervention.[1] As per the 2024 report of the AV Industry Association, over 90% of motor vehicle crashes are caused by human errors. AV lacks basic human trails that contribute to such errors, establishing the possibility of AV offering safer mode of transportation. [2] Moreover, AV increases mobility access for those unable to drive, primarily children, elderly people and individuals with a disability. In an emergency also, when no human driver is available, AV will be of great assistance. AV will be devoid of rash driving or over speeding, leading to a safer social system[3].

Although, the idea of driverless vehicles have been around for decades, the development and deployment of AV has become a reality today in some parts of the world. The primary challenges however apart from technological aspects, include the absence of a strategic regulatory framework that will facilitate the introduction of AV, improving the scope of structured testing and implementing AV, in India. Without a clear regulatory framework, AV deployment in India‟s complex road system poses significant challenges. AV navigation requires complex, dynamic, and efficient system with advance prediction ability. Critical challenges around liability, data privacy, and decision making in critical situation also raise ethical and regulatory questions that need to be addressed. Other factors such as addressing infrastructure limitations, heterogenous population, road condition and traffic congestion can significantly contribute in combating the delay in the development and deployment of AV in India. [4]

Amidst a plethora of changes, the laws shall require a considerable role to play. A promising approach to evolve the landscape of transportation can be by redefining the definition of „driver‟ in the Motor Vehicle Act, 1988 and taking into account the possibility of including AV to start with. This will benefit in having a clear perspective over the liability, insurance and operational standard while establishing a regulatory framework.[5] The cybersecurity regulation also needs to be reevaluated due to the reliance of AV on V2X communication system which allows them to avail information regarding traffic conditions, obstacle and other important information. The dependence on V2X makes AV more vulnerable to cyberattacks, as hackers could potentially manipulate the data that is crucial for AV regulation. [6]

Keywords: Autonomous Vehicle; Artificial Intelligence; Transportation; Machine Learning Algorithms; Legal Framework

Metals & Minerals

Automation in Mining Operation

357_IEC16056➲

Evaluation of Social Hazard, Psychological Conditions, and Innovation in Automated Mining Operations

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Abstract: Automation's quick adoption in mining activities has changed environmental impact, safety and production. These developments pose difficult social and psychological problems for employees, causing worries about psychological issue, social risks that could impair productivity and employee well-being. The social risks associated with automated mining are examined in this essay, including role ambiguity, job displacement, the changing dynamic between automated systems and workers. Pressure, job insecurity, and low job satisfaction are examples of psychological variables that are evaluated for their effects on employees' mental health and productivity. We quantify the psychological effects on workers using qualitative as well as quantitative methods, and we use an organized structure to assess social hazards in automated environments. To find treatment strategies that can reduce social hazards and promote a positive work environment by looking into these factors. We investigate cutting edge technologies that can lessen psychological stress and enhance human-machine cooperation, such as adaptive training programs and real-time monitoring systems. In order to ensure an equal dedication to security, effectiveness, and workers happiness in the mining industry, the findings add to a thorough understanding of how modern technology as well as beneficial workplace systems can enhance mental wellness and productivity gains in automated mining.

Keywords: Environmental Impact; Safety-Production; Social Risks; Cutting-Edge Technologies

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359_IEC96838➲

Social Hazard, Psychological Condition & Innovation in Automation Minning Operation

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<u>Metals & Minerals</u>

Decarbonisation and Material Recycling

232_IEC19342➲

Study on Part Replacement of Coke Breeze in Iron or Sintering Process with Heat Altered Coal and Effects thereafter

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Abstract: In an iron ore sintering bed, combustion of solid fuel supplies heat needed for incipient fusion of fine particles and hence determines the quality of the sintered ores and the productivity of the process. Around 80% of the heat required in sintering is supplied by the combustion of solid fuel. The solid fuels used in sintering are primarily coke and, in some cases, anthracite, with each having different thermal effects depending on the chemistry (carbon content) and the combustion efficiency. The main combustible constituent of coke, used as a solid fuel in sintering, is carbon.

Jhama coal is characteristically a heat altered coal due to magmatic intrusion. The kind of coal alteration depends on the temperature of the intrusion, the duration of magmatic heating and the distance of coal from direct contact with the igneous rock. However, its high VM content restricts its application in Blast Furnace irons making. Jhama coal is available in plenty in Damodar basin, near Raniganj, West Bengal.

Its volatile matter varies from 4.0 to 7.7%, ash varied from 33.1 to 25.0%, fixed carbon varies from 61.4 to 68.9%. It has been found that volatile matter and total hydrogen decrease towards the contact zone, while ash, total carbon and vitrinite reflectance all steadily increase.

Jhama coal has been used in sintering process, as part replacement of conventional coke breeze. Highest specific productivity is achieved at 20% Jhama replacement. With 5% increment in Jhama replacement ratio, specific productivity increases up to 20% replacement, afterwards the curve starts decreasing. Up to 20% Jhama replacement, the VSS almost stays constant, after which it decreases. Flame front moves faster in 20% replacement ratio, as Jhama having higher VM ignites earlier and at lower temperature than coke breeze. With increased replacement of Jhama, yield is increased steadily till the critical point of 20% replacement. Afterwards, yield drops steeply.

Semi-metallurgical coal i.e. Jhama coal finds greater usage potential in sinter plant across whole of India, which can replace costly coke breeze and impart significant techno-economic benefits. Technologically, Jhama coal can only partially replace coke breeze for sinter making. Jhama coal (up to 20%) can be used as part replacement of coke breeze in iron ore sintering process with significant advantages in productivity and quality.

Keywords: Heat Altered Coal; VSS; Productivity

Metals & Minerals

High Performance Structural Materials for Mobility Applications

35_IEC14509➲

An Efficient Method to Enhance the Life of "Sprocket (Ground Engaging Tools)" in Hydraulic Excavators by Adding "Boron" as a Micro-alloying Element

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Abstract: Excavators are being used for various industrial, mining, agricultural and material handling applications. The market has been segmented by type, end-use industry, and geography. Based on the application, the global Excavator's market is segmented into construction, forestry, and agriculture, mining, and others. Now a day due to demand of low cost & high efficiency production rates in field of building construction, road construction, agricultural application, mineral excavation, ship & ports management, military applications, industrial applications, etc excavators are treated as first line of machinery. In spite of wide use of Excavators in Mining, Construction, irrigation, roads & other segments, the major challenge in at present is "Wear & Tear "of abrasion parts like Ground engaging tools & Track parts. The present invention generally relates to hydraulic excavators. This invention relates to enhancement of Wear & Tear life of 20T Class Sprocket which is one of the most selling excavators of THCM. We had field complain regarding less life of Sprocket in 20T Class domestic machines from customers.

Keywords: THCM; Ground Engaging Tools; Boron Steel; Induction Hardening; Hardness; Microstructure; Tensile; Case Depth; Wear Tear

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68_IEC82798➲

Mitigating Failures in 309S Stainless Steel Furnace Component: Causes and Solutions

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Abstract: The failure mechanisms and the prevention methods for 309S stainless steel inner covers used in Batch Annealing Furnace in Cold Rolling Mill are presented in this paper. In this work, the studies included characterization of material and microstructures analysis with Optical Microscope and Scanning Electron Microscope (SEM) coupled with Energy Dispersive Spectrometer (EDS). Microstructures examination and EDS analysis indicate the formation of carbide and precipitations of sigma phase in the matrix. Formation of carbides and sigma phases associated with depletion of alloying elements from the matrix deteriorates the mechanical properties and sensitizes the steel to corrosion attack because of reduction of chromium from the matrix of the inner cover material making it prone to bulging and cracking. To mitigate these issues, a mechanized cleaning system was developed and implemented to periodically clean the inner covers. It was also recommended to adjust the alloy composition and reduce the exposure time to high temperatures of the inner covers, where the formation of sigma phase can help minimize its presence. The introduction of this cleaning system significantly decreased the downtime associated with these failures, effectively enhancing operational efficiency.

Keywords: Inner Cover; Batch Annealing Furnace; Sigma Phases; Cracking & Bulging

82_IEC19165➲

Mechanical Testing and Structural Analysis of Banana Fiber Reinforced Composite Material

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Abstract: There has been a notable shift of industries, including automotive, construction, and packaging, towards the adoption of sustainable materials. One promising option in this regard is Natural Fibre Reinforced Composite Materials. These composites utilize natural fibres as reinforcement and are combined with a resin matrix. This study investigates a specific composite made from banana fibre and resin, supplemented with filler material to enhance mechanical properties. The research examines three different combinations with ratios of 80:20, 70:30, and 60:40, assessing their critical mechanical properties accordingly with ASTM standards to evaluate their structural and industrial applicability. The 70:30 ratio along with 10% of Alumina filler demonstrated superior performance compared to the other two ratios. Furthermore, this paper provides a detailed understanding of fabricated material's properties using stress strain diagram and analyses the material's static structural behaviour in automobile application through Finite Element Analysis (FEA), thereby assessing its feasibility alongside the stress-strain characteristics of the material.

Keywords: Natural Fiber Reinforced Composite; Banana Fiber Reinforced Composite; Stress Strain Diagram; Finite Element Analysis

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281_IEC69270➲

Modeling and Simulation Studies on TIG Welding of Gas Turbine Combustion Liner Sub-Assemblies

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Introduction: In aero gas turbines engines, combustor liner is one of the major components. The combustor liner is shown in Figure 1 (d) consists of 3 major sub-assemblies the front part Figure 1(a), inner part Figure 1(b) and the rear part Figure 1(c). The assembly is to be realized through TIG welding of cooling rings with a weld joint thickness of 1.2 mm. The present study explores a methodology to minimize the distortion of assembly combustor liner by numerical welding simulation of combustion liner subassemblies. Simulation of TIG welding is associated with thermal, metallurgical, and mechanical analysis. It involves the nonuniform heating and cooling of the material, which leads to changes in phases and material properties with variations in temperatures [1]. The non-uniform heating and cooling also causes uneven thermal expansion and contraction around the weld zone, which results in the formation of transient stresses and plastic deformation. As a result, the residual stresses and weld distortions are produced in the welded part. In this study, a sequentially coupled thermo-mechanical analysis was performed to calculate the weld thermal profile and deformation. The weld sequence and fixturing conditions was optimized by developing the temperature dependent material database of nickel based C263 alloy which was the input data for the numerical welding simulation. The simulation was implemented in Finite Element Analysis (FEA) software, Sysweld 17.0[2]. Two different welding techniques such as progressive and segmental methods were used in the welding of combustion liner sub-assemblies to minimize the distortion. The total length of the weld was divided into 8 quadrants (45° each). In the progressive method, continuous welding is carried out throughout the first two quadrants of the cooling rings, followed by welding on the next two quadrants. However, in the segmental method, the welding is carried out initially in one of the diagonal quadrants of the rings then it is carried out in the next diagonal quadrant. By varying the weld sequence and clamping conditions, the optimal weld parameters for minimum distortion of the assembly were determined.

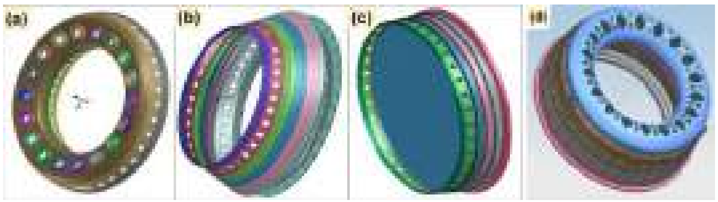

Figure 1 3D model of the liner sub-assemblies (a) Front part; (b) Inner part; (c) Rear part; (d) Liner Assembly

Keywords: Combustor Liner; Modelling and Simulation; TIG Welding; Distortion

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299_IEC82979➲

Case Study of FEM Analysis of Spreader Beam (Lifting of Beam)

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Abstract: Spreader beam is used in various industries such as Steel plant, power plant, construction, shipping, or manufacturing for lifitng heavy equipment, spreader beams are essential tools used for distributing the load evenly across lifting points. This reduces the risk of damage to the load and increases safety during the lifting process. Let’s break down the impact and benefits of using a spreader beam for lifting heavy beams: The lifting of heavy beams, particularly using a spreader beam, presents complex engineering challenges that necessitate a detailed understanding of load distribution, structural stability, and equipment interaction. This study employs Finite Element Method (FEM) analysis to evaluate the performance of a spreader beam system in lifting operations. The objective is to assess the structural integrity and dynamic behavior of the spreader beam under various loading conditions and to optimize its design for enhanced safety and efficiency

In this study, a Finite Element Method (FEM) analysis was conducted on a spreader beam used for lifting heavy beams in industrial applications. The primary objective was to evaluate the structural integrity, load distribution, and performance of the spreader beam under various loading conditions. The spreader beam, which plays a crucial role in distributing load evenly across multiple lifting points, was analyzed for its ability to minimize bending moments, shear forces, and stress concentrations that typically arise in heavy lifting scenarios.

The FEM analysis simulated different loading configurations, including uniform and eccentric loads, to determine the optimal design parameters of the spreader beam. Key parameters such as material selection, beam dimensions, and sling angles were incorporated into the model to assess their impact on stress distribution and deformation. The results of the analysis were validated against standard safety factors and industry regulations to ensure the reliability of the spreader beam under real-world conditions.

Findings from the FEM analysis revealed that the spreader beam significantly reduces stress concentration on the lifted load, thus enhancing overall lifting safety and reducing the risk of beam failure. The results also identified critical stress points on the spreader beam, guiding future design optimizations. This case study provides insights into the use of FEM in optimizing lifting equipment design and highlights the importance of precision in load distribution for safer lifting operations in the construction and heavy manufacturing industries.

Keywords: Finite Element Method (FEM); Industrial Design; Spreader Beam; Load Distribution; Heavy Lifting; Structural Integrity; Stress Analysis

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344_IEC23010

Effect of Ageing on Microstructure and Mechanical Properties of Mg-10%Sn Alloys

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Abstract: The objective of this study is to correlate between microstructure and mechanical properties of Mg-10%Sn alloy subjected to ageing for different times. The alloy was subjected to ageing at 200°C for 100 h and 500 h. Even after ageing, the intermetallic phase of Mg_2Sn remained at grain boundary as it was present in as cast alloy; however the area fraction increases. Microstructural Characterization was conducted to relate the variation of mechanical properties of an alloy to the alteration of its microstructure. The hardness of the alloy was increased by ageing due to increase the amount of Mg_2Sn intermetallic phase. During ageing, the ultimate tensile strength and ductility first increases and then decreases.

Keywords: Mg-alloys; Ageing; Intermetallic; Hardness; Tensile Strength

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372_IEC81891

Prediction of Lankford Constant from the Composition and Processing Parameters of High-Strength DP Steel using Machine Learning

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Introduction: Enhancing fuel efficiency in automotive applications involves minimizing vehicle weight by integrating lightweight metal alloys such as dual-phase (DP) steel. The unique microstructure of DP steel characterized by martensitic regions dispersed within a ferritic matrix imparts a favourable strength-to-weight ratio, a low yield-to-tensile strength ratio, substantial work hardening capacity, and superior formability[1][2]. A critical parameter influencing formability is the Lankford coefficient, or r-value, which quantifies plastic anisotropy[3]. It is the ratio of the plastic strain in the width direction to that in the thickness direction. Accurate r-value determination is, therefore, essential for formability assessments in engineering applications.

Traditionally, the r-value was determined through uniaxial tensile testing. However, this experimental approach is resource intensive, requiring a large volume of samples and considerable time investment. The advent of Digital Image Correlation (DIC) technology has revolutionized strain field measurement, enabling precise strain mapping via sophisticated image processing techniques[4]. Concurrently, advances in computational modelling, such as Hill's 1948 yield criterion within finite element analysis frameworks, have bolstered predictive capabilities[5]. However, these finite element models demand high computational resources[6].

Machine learning (ML) offers a solution to these constraints by leveraging experimental data to establish predictive relationships between compositional and process variables and mechanical outcomes. This approach mitigates the reliance on extensive experimental and computational resources[7]. While ML models have been successfully applied to predict traditional mechanical properties of DP steel such as ultimate tensile strength (UTS), yield strength (YS), and elongation percentage[8], predicting the Lankford coefficient remains underexplored. Addressing this gap represents an opportunity to extend ML applications to encompass plastic anisotropy predictions.

This study aims to employ supervised ML models to predict the Lankford constant for DP steel, utilizing compositional attributes and annealing temperature as primary inputs.

Keywords: Lankford Constant; Carbon Equivalent; Gradient Boosting Regressor; Metric Scores

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373_IEC45597

Structure-Property Correlation of a Novel Quenched and Partitioned (Q&P) Steel

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Abstract: The weight reduction of automobiles and improvement of safety have recently garnered interest for the development of advanced high-strength Q&P steels, comprising martensite (M) and retained austenite (RA). In this research, two high carbon Nb microalloyed hot rolled steel plates were processed, one in as rolled condition (HRAC) and the other subjected to one-step Q&P treatment at 200°C for 30 min, were selected to correlate the microstructure and mechanical properties. The characterisations were carried out by optical microscopy, SEM, EBSD, hardness and tensile testing. The UTS and TEL% for the HRAC and Q&P samples were 2010 MPa, 12% and 1897 MPa, 19%, respectively. Image Quality maps revealed the area (%) of RA is more in the Q&P sample (2.10%) than in HRAC (1.51%). From the orientation distribution function (ODF) it was found that higher volume % of the rotated cube ({001}<110>) component in the HRAC sample (14.52) than the Q&P sample (7.54) leads to higher UTS.

Keywords: High Carbon Steel; Quenching and Partitioning; Microstructure; Texture; Mechanical Properties

Metals & Minerals

Integrated Computational Materials Engineering (ICME)

363_IEC27948

Molecular Dynamics Study on Bending Creep Characteristics of $BaPd_2$ Crystal using Developed Embedded-Atom Method Potential of Palladium-Barium Alloy

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Abstract: Molecular dynamics (MD) simulation has been performed to study the bending creep characteristics of $BaPd_2$ crystal (C15 laves phase compound) using our developed embedded-atom method (EAM) potential for Palladium-Barium alloy. The force-matching method has been implemented to develop the EAM potential first, and then optimization to converged density-functional theory (DFT) data sets has been done to generate the accurate and reliable potential for the Pd-Ba alloy system. Density, elastic properties, and thermal expansion coefficient have been calculated using MD simulation and validated these properties with the help of DFT analysis to examine the performance of the potential. Then, using a force of around 2 pN applied in the Y direction with both ends held stationary, bending creep simulations have been carried out on $BaPd_2$ crystal at 100 K, 490 K, 600 K, and 900 K. Tertiary region has been observed above 490 K. Creep rate increases with increase in temperature.

Keywords: Embedded-Atom Method; Bending Creep; Density-Functional Theory; Pd-Ba Alloy

<u>Metals & Minerals</u>

Materials for Energy, Sensors and other Electronics Applications

17_IEC14477➲

Synthesis and Characterization of Delafossite $CuAlO_2$ by Sol-Gel Process

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Abstract: Delafossite copper aluminate ($CuAlO_2$) was synthesized by sol-gel process using Analytical Research (AR) grade precursors. Precursors were used in required molar ratio along with citric acid in deionized water after proper mixing. Jellification was obtained after drying the net resultant solution followed by annealing at about 1200°C for 4 hours. Phase analysis after annealing was carried by XRD followed by crystallite size estimated to be about 35.5 nm. Bonding analysis was carried by FTIR spectroscopy to observe M-O co-ordinations followed by morphological feature studies by SEM. SEM analysis reveals agglomeration tendency while individual particulates to be polygonal in shape with few interconnected porosity. EDX analysis reveals presence of required elements only responsible for formation of $CuAlO_2$ delafossite. Luminscence of the sample is obtained after having excitation at 280 nm wavelength leading to high intensity emission centred at about 557 nm. XRD, FTIR and EDX results were noted to be in close relation with each other.

Keywords: Delafossite; Phase Analysis; Bonding Analysis; Microstructure; PL Analysis

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150_IEC57684➲

Phase Analysis, Dielectric, PL and Microhardness of $CuAlO_2$ by Ball Milling Process

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Abstract: In the present article a ball milling assisted solid state process was undergone to synthesize delafossite having composition based on Cu-Al-O. Mecahnochemical activation by Ball milling was carried in air atmosphere keeping ball:sample ratio fixed at 10:1 having 370 rpm for 100 hours duration in acetone medium followed by air drying for 24 hours to recover the activated powder sample. Based on thermal analysis, annealing was carried at 1200°C for 6 hours duration for phase development. Crystallite was estimated using both Scherrer's formula and William-Son Hall equation along with micro-strain. Dielectric property was evaluated using LCR meter while mechanical integrity of the sample was done using microhardness and noted to be about 2.84 Gpa. Luminescene behaviour of the sample was noted in the lower visible spectrum (violet-blue) with maxima peak centred at about 433 nm wavelength.

Keywords: Delafossite; Phase Analysis; Ball Milling; Microhardness; PL Analysis

301_IEC81560

Design and Development of Computerised Instrument for Testing Bending Behaviour of Semi-rigid Fabrics

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Abstract: The extension under load along the fabric axis is our main concern for long time. The application of vertical force on the surface of fabric has practical importance also. It builts up a torque on the fabric resulting in bending deformation. Bending is defined as stiffness or rigidity which is basically the resistance to bend. Bending of fabric influences the drape and handle properties whereas recovery from bending influences the creasing of fabric. Various technical textiles, namely, insulating gloves, insulating jackets, geo-textiles, curtain, sports textiles, electronic textiles, waterproof fabrics etc are the technical areas where bending behaviour plays a great role. But, most of the existing systems have some limitations. Therefore, it was felt that a simple and low cost computerised instrument is required to evaluate complete bending behaviour of technical textiles.

Weighted ring loop is a known principle to measure bending behaviour of yarn. The developed instrument is working on modified ring loop principle to evaluate fabric bending behaviour in dynamic mode. In the modified principle, a rectangular fabric strip is initially clamped in the upper position of a vertical loop keeping both the ends face to face. The lower end of the loop is also clamped. When the upper clamp moves up and down up to a predetermined limit of deflection (well before stretching of fabric), the load on the lower clamp will be changed depending on rigidity of the fabric. This load will be measured by load cell. The deflection of upper jaw will be measured by deflection counter. Deflection counter contains a photo-sensor and a wheel, perforated along its circumference, mounted on the rotatable & reversible lead screw which is responsible for up and down movement of the clamp. The sensor measures the number of change of perforations due to rotation, which will be converted to length/deflection using the value of lead-screw pitch. The change of load (loading and unloading) is plotted against deflection. Other parameters will be calculated by software. The load value for a particular deflection can be converted to bending stress or modulus. The load-cell will act in both the extension and compression mode.

Various technical textiles like nonwoven, tarpaulin, coated fabrics, canvas, hessian, etc., have been tested with the developed instrument. This instrument can measure dynamic bending behaviour by graphical bending load–deflection, cyclic bending, bending stress relaxation, etc. Statistical analysis like standard deviation and coefficient of variation can be reported. Hence, complete information of bending is available with this instrument. The repeatability, reliability and accuracy were found acceptable. Data and graphs can be stored and printed. It shows reliable results when compared with standard instrument like Shirley Stiffness Tester. This instrument is user friendly, low cost and informative for technical textiles. Flexural rigidity and bending modulus can be calculated using standard formula from the available data.

Keywords: Bending Behaviour; Fabric; Modified Hanging Loop Technique; Technical Textiles

<u>Metals & Minerals</u>

Mineral Beneficiation and Waste Management

31_IEC13634➲

A Brief Glimpse on the Development of Aluminium Matrix based Composites using Wastes by Powder Metallurgy Route

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Abstract: Aluminium based composites are in demand due to its low density, weight, high strength-weight ratio and others. This class of composites is generated by popular techniques like stir casting process, powder metallurgical routes, additive manufacturing and others. Composites are generated by adding different inorganic ingredients or by incorporating both industrial and agricultural wastes. Wastes (industrial & agricultural) have different oxide constituents which may aid in improving hardness, wear resistance, ultimate tensile strength and corrosion resistance of the composite in compare to virgin Al based material. The present article encompasses a brief insight into the world of composites based on light metal based matrix using agricultural wastes. Powder metallurgy-based metal matrix composites (MMCs) are widely chosen and used for the development of components in the fields spanning aerospace, automotive and even electronic components. Engineered MMCs are known to offer a high strength-to-weight (σ/ρ) ratio. Novel materials based on metal matrix based composites are capable of handling advanced technological needs.

Keywords: Metal Matrix Composite; Powder Metallurgy; Compaction Load; Hardness

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132_IEC57282➲

Dry Beneficiation of Coal by DE-XRT SBS Technology

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Introduction: In order to achieve Sustainable Development Goals, beneficiation of coal without any further burden on environment is obvious imperative. In FY2023 Power Sector and Steel & Washery Sector in India has consumed 787.65MT and 8.58MT coal[1]. Ash content in Indian coal is 25 to 45%. MOEF&CC stipulated <34% Ash content for TPPs. MOC stipulates <15% Ash content for Steel-I Grade of Coal having specific gravity of 1.42[2] CPCB stipulations restrict Emission Standards for all TPPs. Beneficiation of such a huge amount of high Ash content ROM coal necessitates a robust full proof technology. This paper outlines a theoretical multidisciplinary approach towards Dry beneficiation of Coal by DE-XRT technology involving the principles of Physics of Non-destructive Evaluation along with Computer Science & Engineering.

Keywords: Dry Beneficiation of Coal; Dual Energy X-Ray Transmission; Sensor Based Sorting

183_IEC9230➲

Effect of Solids Concentration on the Rheology and Pipeline Transportation of Red Mud Slurry

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Abstract: Red mud, commonly referred to as bauxite leftovers, is a highly alkaline waste product that primarily consists of iron oxide and is generated during the production process of industrial alumina. India generates about 9 million tonnes of red mud annually, and the proper disposal of such large wastes is an important environmental priority for both India and the rest of the world. If these bulk materials are favored over other freight routes, one way of disposing them is by hydraulically moving them through pipes at a much greater solids concentration. The current study presents a detailed flow behavior of a highly concentrated red mud slurry in the weight concentration range of 40–70%. Four candidate pipes (ASTM carbon steel seamless 80 schedule pipes) with nominal bores of 200, 300, 400, and 500 mm were utilized in the investigation of flow characteristics, pressure drop, and specific energy consumption. Contrary to the diluted phase of transport that is customary in the alumina industry nowadays, it was determined that it is quite practical to carry the red mud slurry at around 60% by weight concentration.

Keywords: Rheology; Red Mud; Pressure Drop; Slurry Flow; Specific Energy Consumption

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287_IEC11139➲

Risk Involved in Mining Waste Management

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Abstract: Mining is a huge activity and the waste generated thereof is one of the largest waste streams that can contain a large quantity of dangerous elements /substances. It is estimated that about 170-180 million tonnes of solid waste related to mining is generated in India every year and its substantial increment per year will exceed 350 million tonnes very soon. However, this waste, generated from continuous mining activities of various types of mines is classified as the mine overburden/side burden waste and the ore beneficiation plant waste. Specially from the plant waste, though in small quantities is mostly toxic and sometimes hazardous as well. Toxic heavy metals though of small quantities are mostly toxic and sometimes hazardous as well. Toxic heavy metals e,g Cadmium, Selenium, and Arsenic leak into local water supplies. Mountain top removal mining produces the carcinogenic toxin, e,g Silica into the air. Mine tailings incorporate highly toxic sulfides, heavy metals, and radioactive content and pose highly dangerous conditions pertain to when stored in water in ponds behind tailings dams. Extracting and processing metals and metalliferous compounds can result in acid or alkaline drainage. All these waste materials need proper attention and the latest scientific approach in disposing of and saving the environment from these materials. However, there are several other risks involved in dealing with mining wastes., e,g environmental damage, health risks, tailings dam failure, chemical hazards etc.

Keywords: Mining Activity; Toxic and Hazardous Wastes; Safe Disposal; Damage & Pollution Prevention

Metals & Minerals

Multifunctional Materials

354_IEC74200➲

Emerging New Technologies in Metal Forming of Aluminium Alloys

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Abstract: Performance of casting is dictated by many metallurgical features, such as, secondary dendrite arm spacing (SDAS), intermetallics, oxides/inclusions and porosity. Castings exhibit defects such as shrinkage and gas porosity, hot tears, inclusion and alloy segregation that generally result in lower and more variable mechanical properties than their wrought counterparts. The fatigue endurance of castings is very sensitive to the size of casting defects. On the other hand, solidification time as reflected by secondary dendrite arm spacing (SDAS) and size of Silicon particles also affect it to lesser extent. The complete elimination of gas and shrinkage porosity defects is not always possible without the application of external forces to close voids and porosity. It is also utmost important to get equi-axed / rounded and non-dendritic structure in place of columnar / dendritic structure. Many new technologies have emerged out in recent past to induce the required structure in order to get higher castability & mechanical properties specially fatigue strength. Some of the new technologies which have attracted the Defence, Aero space & automobile industries are Hot Isostatic Pressing (HIPing), Semi Solid Forming (SSF), Metal Spray Casting (MSC) and Electro Slag Refining (ESR) .

Keywords: Aluminium; Strength; Toughness; HIPing; SSF

Metals & Minerals

Sustainability in Mining

59_IEC75739➲

Sustainability in Mining through Cradle to Cradle Approach

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Abstract:

"Mines are the source of wealth; from wealth comes the power of the State" (Arthashastra, 2.12.37; 7.14.25)

Mining sector, being one of the essential sectors of the economy, provides basic raw materials to industries like thermal power generation, iron and steel, cement, fertilizers, precious and semi-precious metals/stones, electrical and electronics equipment, glass and ceramics etc. India produces as many as 95 minerals which include 4 fuel, 3 atomic, 10 metallic and 23 non-metallic minerals and 55 minor minerals (including building and other materials). There continues to be a huge demand for minerals in view of the rapid urbanization and growth in the manufacturing sector in India.

The mining sector is going through various challenges and disruptions that hamper its growth. There are many environmental aspects related to mining activities that create challenges in the expansion of mining. The issues of land use and conversion, waste generation, groundwater depletion, and pollution of air and water are some of the major factors that create concerns on the national level.

One place to start is decreasing waste along the whole mining value chain. Unlike mining site, which has a life span and will cease operations eventually, mine waste is here forever. Finding ways to turn liabilities like large tailings storage facilities and heap leach piles into assets through reuse is crucial to a circular economy.

The mining industry has an obligation to operate within the concept of sustainable development-it must extract resources responsibly. Up cycling transforms waste and unwanted products into new, higher quality products. The waste can be reused by the mine itself or sold to a third party.

Mining operations become sustainable when environmental and social goals are given top priority, incorporating responsible mining practices, improving the health and well-being of workers, prioritising the needs of local people, and increasing the overall efficiency of dayto-day processes.

Keywords: Life of Mine; Land Rehabilitation; Material Characterization; Mine Waste Management; Top Soil Preservation

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240_IEC32253➲

Analysing the Behaviour of PVC Concrete Prop through Laboratory Investigation & Numerical Modelling

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Abstract: Underground mines have conventionally been supported with wooden and steel support systems. However, with evolving time, it has become difficult to gather wood-based support systems like wooden props and cogs owing to the decaying nature of wood with time. Steel supports are made of iron which again is a non-renewable resource and is depleting with time. Hence, the necessity of an alternate support system material such as PVC concrete, is required that can be prepared on site, easily available and economical. This paper focusses on some preliminary investigations on the ongoing research work and highlights the preparation of PVC concrete prop, its laboratory tests with a few pipes and its performance through numerical modelling. From laboratory tests, it is found that a compressive strength of 25 MPa was obtained for L/D ratio of 7.3 and these samples failed at compressive displacement of 13 to 15 mm. The performance has been analysed through stress, strain and maximum deformation. Parameters varied were slenderness ratio, thickness of PVC pipe and grades of concrete. Several 3D models were developed where it was found that the PVC concrete props were capable enough to take large stress and resist sufficient deformation before failure.

Keywords: Prop; PVC Concrete; Support System; Stress; Deformation

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276_IEC69870➲

Study on Hot Hole Blasting for High Temperature Mining Environments: Techniques, Challenges, Mitigation Strategies and Environmental Impacts

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Abstract: In large open-pit operations, Hot hole blasting is an advanced technique used in mining and construction industries to safely and efficiently conduct explosive operations in drill holes with elevated temperatures. High-temperature drill holes, commonly encountered in deep mining or geothermal regions, present unique challenges such as premature detonation, reduced explosive performance, and equipment failure. Traditional blasting methods are often unsuitable in these conditions due to the thermal sensitivity of explosives and increased safety risks. This paper explores the principles of hot hole blasting, with a focus on the thermodynamic interactions between high temperature rock and explosives. It outlines the types of explosives specifically designed for use in elevated temperature environments and highlights the best practices for ensuring safety and operational efficiency. Additionally, the study delves into mitigation strategies for managing the hazards associated with hot-hole blasting, including the use of specialized cooling techniques, protective casing materials, and advanced monitoring systems. Through case studies and technical analysis, this paper demonstrates how hot hole blasting can be optimized for both safety and performance, offering solutions for overcoming the inherent challenges of blasting in high temperature conditions. The findings emphasize the importance of tailored safety protocols and the ongoing development of thermally resilient explosives, making hot hole blasting a critical technique in modern, high-temperature mining operations.

Keywords: Blasting; Hot Hole Blasting; High Temperature Blasting; Premature Detonation

328_IEC56➲

Renewable Energy and Carbon Footprint Reduction in Mining

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Abstract: The mining industry, a cornerstone of global economic development, faces increasing pressure to reduce its environmental impact and carbon footprint. This paper explores the potential of renewable energy (RE) (mainly solar energy) integration and the electrification of mining equipment as pivotal strategies for reducing the carbon footprint in mining activities. By transitioning to electric-powered machinery, mines can significantly diminish greenhouse gas emissions and enhance operational efficiency. By analyzing case studies of successful renewable energy projects in mines, this study highlights the environmental and economic benefits of transitioning from conventional fossil fuels to renewable energy. Various challenges such as high initial costs and technological limitations are discussed in detail, emphasizing the importance of hybrid systems, energy storage solutions, and microgrid implementation as viable pathways toward sustainable mining practices. Furthermore, the paper validates the regulatory frameworks and government policies that facilitate the adoption of green mining practices. The findings suggest that renewable energy integration not only mitigates the environmental impact of mining but also offers long-term cost savings and operational efficiencies. Finally, the need for a comprehensive approach that combines electrification with solar energy initiatives is stressed to achieve substantial reductions in carbon emissions while promoting environmental stewardship within the mining industry.

Keywords: Mining; Carbon Footprint Reduction; Renewable Energy; Solar Power; Economic Benefits; Energy Integration

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350_IEC14285➲

Resource Optimization and Ecohydrological Sustainability of Lignite Mining in Rural Set-up

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Introduction: India is the third largest energy consuming country in the world and the major part of power generation is through thermal power plant. The total thermal power plant capacity of India is 243 Gigawatts (GW). 211 GW is coming from coal and only 6.6 GW coming from Lignite. However, still lignite is considered a good source of thermal power plant fuel. The term lignite is derived from the Latin word lignum meaning wood. It has a carbon content of around 25-35% It is inferior to bituminous coal as it has relatively low heat content. It contains very high moisture. Lignite has a low calorific value of about 10-15 mega joules per kilogram. Other than thermal power generation Lignite has other uses such as in agriculture Lignite can increase organic matter in soil and can be used to distribute biological control microbes that suppress plant pests. Lignite can also be used as soil conditioner. Thick strata of Lignite often occur near the surface and thus it can be mined economically. However, since it contains moisture and crumbles easily Lignite is not suitable for transportation and normally consumed in pit head power plant.

India has lignite deposits in the Tertiary sediments of the southern and western parts of the peninsular shield in Tamil Nadu, Puducherry, Kerala, Gujarat, Rajasthan and Jammu & Kashmir. India's known geological reserves of lignite is about 44 billion tonnes.. About 80% reserves are found in Tamil Nadu.

NLC India limited produces about 30 million tonnes of lignite from opencast mines at Neyveli in the state of Tamil Nadu and at Barsinagar in Bikaner district of Rajasthan. The lignite is used at pithead thermal power plants of 3640 MW installed capacity.

To understand the geological and hydrological features associated with lignite mines some case histories are discussed. The most important feature is available from Neyveli Lignite. Deivam, R and M Sivakumar in NLC’s Experience in Mining Lignite: A case Study has presented a detailed treaties on the Mining methodology and environmental problems faced due to mining of lignite. It is observed that while lignite provides an important resources in the form of energy the mining of lignite causes hydrological problem and in deterioration of quality of another important resource fresh water. The mine and the lignite based thermal plant is located near the semi urban area of Neyveli in the Cuddalore District (divided from South Arcot District) of Tamil Nadu. The mines and power plant is spread over a campus of 480 square km and 200 km south of Chennai. The geological formation encountered in the area consistes of Miocene of the tertiary age including Argillaceous and Ferrpogenous sand stones, c; lays ,lignite and aquifer sand. The top portions of sandstones are lateritic. The lignite seam is underlain by artisian aquifer exerting pressure at 5 to 10 kg/sq cm. The static head is 15-35 m above mean sea level. The neyveli ground water basin is in the form of a syncline with a maximum thickness of 400 met of water bearing sand in the central portion dropping to 50 met in the west and the east. The aquifer is about 50 Km wide in the East West direction and 60 Km long between Gadilam and Vellam river.

Dewatering in deep opencast mines focuses on extraction of seepage water from unconfined aquifer above the mineral strata and the collected storm water in the mine pits. But at the Neyveli Lignite Deposit in the Cuddalore district there was a danger of the mine floor bursting due to the hydrostatic head pressure in the underlying confined aquifer.

Hydrogeological studies (Anandan, K.S, et al (2010) established the feasibility of ground water control techniques for safe exploitation of mining the lignite by maintaining a constant cone of depression (pressure relief) in the surrounding aquifers below the mine by continuous pumping through a preplanned network of wells. This depressurizing method has to be planned and designed to tackle multilayered confined aquifers and unconfined aquifers.

Reichel, F et al (1985) presented a hypothetical hydrogeological model for estimation of mine drainage in German Lignite Mine. According to them Mine drainage in a Lignite Mine is a very costly and essential precautionary measure to handle confined and unconfined aquifers inside opwencast lignite mine in Germany. The economics of the mineral production has to take care of estimation of total discharge of the mine drainage system and design of water treatment plants and overall water management system. Bair, Scott et al (1983) presented a numerical model to design a dewatering and depressurising system by simulation of changes in hydraulic head produced by the interference patterns of various configurations and pumping rates of wells..This paper mainly covers unconfined aquifers but a similar methodology can be designed to tackle the problem arising out of confined aquifer. Singh, R.N, et al (2010) presented a hydrogeological appraisal of mining operations in the Thar Lignite field in Sindh, Pakistan. The three main aquifers surrounding three lignite seams induces pore pressure in the rock mass making the high wall slopes potentially unsafe. A finite element model was used to predict the ground water inflow. Vasileio Eleni et al (2002) presented a comprehensive water management programme for future exploitation of Lignite Mine in Potamia Basin, Thessaly, Central Greece. Dimitrakopoulos et al (2015) analysed both surface water and underground aquifer conditions in Amynteon Open Lignite Mine in West Macedonia Greece and presented a design of dewatering measures.

Chaulya (2003) presented a water balance study on the Lignite of Khadsaliya and Hoidad basin of the state of Gujarat India. The lignite bed in the area extends in length from Lakhanka to Rampur–Navades-Ratanpur and beyond in the North-South Direction. Width of the lignite is about 1 to 3 km east west in the Khadsaliya Basin and is about 2 to 6 km in Hoidad Basin. The length of the Lignite basin is about 12 km. The ground water quality in the area is allowable for human consumption with total dissolved solid 480-500 mg/lit. In many lignite mines there is quality problem and the water needs proper treatment. Glombitza (2001) suggested a treatment of Acid Lignite Flooding Water by means of Microbial Sulfate Reduction.

Nancy E. Driver et al (1986) analysed the aquifer conditions before lignite mining, during mining and post mining operations and arrived at a conclusion that that the aquifer condition both quantity and quality of groundwater will be affected and also the recharge area will be affected.

Surana, D.M. et al (2010) presented a case study of flooding of two lignite pits Kasnau and Matasukh about 2 Km apart near Nagaur Rajasthan. Before opening the mine no hydrogeological and geotechnical investigations were undertaken. Both the pits were developed up to 50 m depth. Both the pits faced slope failure and flooding due to inrush of ground water from the underlain confined aquifer below the lignite seam with hydrostatic head of 22 to 25 m. In order to depressurize the aquifer 15 borewells were drilled and high capacity pumps were installed to pump out water. However, the quantity of water to be disposed of was very hogh and the quality of water was very poor. Thus the overall economic viability of the mine itself was under question.

Keywords: Lignite Mine; Confined Aquifer; Depressurization; Clay Layer

Power & Energy

Advanced Fossil-Fuel Technologies

91_IEC11407 ➲

Energy Transition in Indian Power Sector

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Abstract: At the conference of parties COP 26 in Glasgow summit that was held in 2021, India had announced a target of achieving to 500 GW of the non-fossil fuels based generating capacity by 2030 and as of today nearly 205 GW of the REC is added in to the Grid system and the newly formed Government of India has laid more emphasis to earmark more fund resources in this current budget placed by the Government of India.

India's updated NDC submitted to UNFCCC in 2020 make India committed to reducing the emission intensity by 45% of its GDP by 2030 stands out a major step for long term goal of becoming a Net Zero emitter country by 2070.

The present installed total power generation capacity is 450 GW, out of which 205 GW comes from the non fossil fuels based energy resources and this is the contribution to RCA.

It may be noted that the peak demand reached to 250 GW by the 30th of August 24 with monthly energy demand net 150 BU and is expected to be 450 GW by the end of the year 2030.

The Government should come forward with the objective and take appropriate actions so that the hydrocarbon re source s can be used in the thermal power project in an environment friendly way by introducing SCT and USCT boilers to deliver power to become India as a global leader and also in providing power for all by 2026 by 24#7 into the national grid and for the sustainability of the economic development and to hit NZE by2070.and to use H_2 as a New elements of energy as identified by the Government of India through the NHM 23.

The author talks about his ideas for what is SCT and how it goes towards the sustainability of the society and to stabilize CO_2 emissions from the energy sector and however we must use mixed energy resources to hit developed nation by 2047.

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249_IEC29128➲

Experimental Validation of Palm Biodiesel and Mexicana Biodiesel for Hybrid Biodiesel Testing

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Abstract: World of transportation is fueled by fossil fuels and considering to-days energy scenario, depletion of fossil fuels is one of the major issue to be solved by every nation. As per energy scenario considered, India is leading the position of CO_2 emitted among the top five nations. To overcome these two major issues, alternative to fossil fuels is today's concern and Bio-fuels are emerging source of alternate energy. In this paper, a critical discussion by researchers is done considering major issues related to fossil fuels and finding bio-fuels as an alternative to existing fuels. Adoption of fuel with existing engine system is the advantage of Bio-fuel over other sources of alternate energy. Also, almost same performance characteristics and improved emission characteristics with easily available non-edible oil Bio-fuel and Hybrid Bio-fuel added a special impact for an alternative.

Keywords: Manufacturing; Biofuel; Hybrid Biodiesel; Fuel Energy; Alternate Energy; Non-Edible Oil

<u>Power & Energy</u>

Applications of AI and ICT

78_IEC3083➲

Fault Diagnosis of Induction Motors using Variational Mode Decomposition (VMD) and Artificial Neural Network (ANN)

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Introduction: Induction motors serve various essential functions in industries often operating under demanding operating conditions. For continuous uninterrupted operation in a rough ambient state, identifying the fault in the initial stage through preventative maintenance is very crucial. Condition monitoring and predictive maintenance are important field for academia and industries. Compared to conventional post-fault maintenance, condition-based predictive maintenance reduces machine fault frequency, increases machine life and as a whole, enhances reliability of the whole plant. In recent years, Motor Current Signature Analysis (MCSA) has emerged as a promising technique for fault detection in induction motors and has been widely applied for predicting different faults, including voltage unbalance, bearing, eccentricity / misalignment, bar, winding, etc.

The conventional Fourier Transform is confined to stationary signals. The short-time Fourier transform (STFT) is a valuable tool for evaluating non-stationary signals, but its frequency resolution is heavily dependent on the time frame used, and it may not be adequate for transient signals in some cases. Wavelet transform (WT) techniques have adjustable time and frequency domains. Noise can have an influence on WT performance, and suitable selection or choice of the mother wavelet and amount of decomposition in line with the input signal are required to conduct an adequate analysis. To avoid configuring various parameters in WT, researchers have proposed the use of the empirical mode decomposition (EMD) approach [1], which is an adaptive decomposition algorithm or method capable of analyzing non-linear and non-stationary signals. Despite the EMD method's impressive capabilities, multiple investigations have demonstrated that it suffers from an issue known as mode mixing, which jeopardizes the accurate interpretation of a signal's modes. In order to effectively overcome the shortcoming, Variational Mode Decomposition (VMD) [2] that employs Wiener filtering and the Hilbert transform to place the signal under the variational constraint framework is an advancement over EMD. The constraint model's center frequency is determined repeatedly in order to decrease bandwidth and ensure effective component separation. Compared to the EMD technique, the VMD approach has faster convergence, more resilience, a stronger mathematical theoretical underpinning, more degrees of freedom, and a reduced mode mixing impact.

To improve MCSA's fault detection capabilities, in addition to a thorough examination of fault frequency-based harmonic analysis approaches, feature extraction-based techniques are used to extract important information from current signals. Frequency domain techniques outperform for driver load change, speed differentiation, and the incorporation of physical and other operational conditions. Whereas these feature extraction approaches provide critical input to sophisticated machine learning tools, such as Principal Component Analysis (PCA), Independent

Component Analysis (ICA), Artificial Neural Networks (ANNs), and various statistical methods have been used to extract meaningful features capable of learning and recognizing complex fault patterns with high accuracy. Systems based on Artificial Intelligence (AI) processes replace human specialists by providing vital data regarding framework execution. In AI technologies for fault detection, the most popular classifiers are k-nearest neighbour techniques, support vector machine methods, Bayesian methods, random forest methods, and artificial neural network methods (ANN) [3]. In recent years, with the continual development of AI and computers, deep learning approaches have been proposed to avoid manual feature extraction by employing numerous hidden layers of the deep learning architecture. ANNs, with their great pattern recognition ability and huge data handling power, may be trained to accurately classify many forms of motor defects.

This research focuses on identifying critical features that distinguish between eight forms of induction motor (IM) problems, including rotor failures, stator faults, load variations, and supply system disruptions. The study emphasizes the significance of conventional approaches for feature extraction. This work investigates the integration of MCSA, feature extraction using VMD, and ANN-based classification for defect detection in induction motor health monitoring. This technique intends to improve fault identification accuracy for a wide variety of faults.

Keywords: ANN Classifier; Condition Monitoring; Fault Classification; Feature Extraction; Induction Motor

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361_IEC98767➲

DWT-based Feature Extraction and Machine Learning based Bus Fault Diagnosis in Ring Type Power Distribution Network

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Abstract: The paper deals with discrete wavelet transform-based statistical feature extraction and machine learning-based bus fault diagnosis in ring-type power distribution networks. Design and modeling of a ring system have been done using ETAP. The model was run at normal and different fault conditions in the simulation environment. Time-domain statistical analysis of the bus signals have been carried out at normal and different fault conditions. Then wavelet decomposition-based statistical analysis of different transients was done at different bus fault conditions. The most suitable parameter has been identified for fault diagnosis. Machine Learning based approaches have been applied for fault diagnosis in ring-type distribution networks. In the end, a comparison of different methods has been presented concerning the accuracy level obtained during fault diagnosis.

Keywords: Bus Fault; Kurtosis; Logistic Regression; KNN; Ring Type Distribution Network; Support Vector Machine; Wavelet Decomposition

Power & Energy

Condition Monitoring and Retrofitting

29_IEC33007➲

A Brief Glimpse on the Design and Performance Analysis of Induction Furnaces

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Abstract: The present article aims to review various research journals with focus on enhancing the performance of induction furnaces. It examines the factors influencing the efficiency of these furnaces and considers recommendations from different perspective of researcher’s point of view. Additionally, the paper explores the concept of Total Harmonic Distortion (THD) and its impact on the effective operation of induction furnace. It also evaluates the research on Multi-Level Inverters (MLIs). The findings indicate that induction furnaces powered by MLIs demonstrate improved performance compared to conventional models, with MLIs effectively keeping THD within an acceptable limit of 1% and enabling low-frequency operation of the furnace.

Keywords: Total Harmonic Distortion (THD); Multi-Level Inverter (MLI); Material Selection; Induction Heating; Low frequency Induction Heating

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370_IEC28795➲

Fault Diagnosis and Adaptive Reconfiguration of BLDC Motor Drive

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Abstract: In aircrafts and missiles, actuators are commonly utilized for driving various subsystems including flight control surfaces. Brushless DC motor (BLDC) based electromechanical actuation systems are getting increasingly popular due numerous advantages. Electromechanical Linear actuators (EMLA) are common due to their high torque capability. In addition, the BLDC motors are being increasingly used in critical high-performance industries such as appliances, automotive, aerospace, consumer, medical, industrial automation equipment and instrumentation. The failure modes for these systems transcend to electrical, mechanical, and electronic systems attributed to external forces and the dynamic properties of control systems. This makes the identification of failure modes a vital and challenging process

Fault detection and condition monitoring of BLDC machines is therefore assuming a new importance. The objective of this paper is to devise an algorithm to detect inverter fault in BLDC drives. This work orients to develop a method to detect faults in BLDC motors drive by monitoring their line currents. A new fault analysing algorithm is proposed that can track and detect switching faults in time varying current signals of converters. Once the fault is detected the faulty branch of the inverter is replaced with a fault reconfiguration branch. The performance characteristic of BLDC motor is analysed before and after inducing a switching fault in the drive circuit and the results reveals satisfactory performance of the algorithm under open Circuit and short circuit fault conditions.

The condition monitoring system proposed basically performs fault detection and identification. Once a fault is identified in the circuit the fault occurred branch is isolated from the main circuit and reconfigured. Here the Switching fault detection and identification method is achieved by using current sensors between upper and lower legs of inverter. A Fault reconfiguration block is connected with the inverter circuit, it works by disconnecting the faut occurred branch from the inverter circuit and replaces the faulty branch with a fault reconfiguration branch.

The features extracted from the current signals of Hilbert Transform form the input to the rule-based classifier. The rule-based classifier detects the faults based on the features extracted and in case of faults provides appropriate switching signals to the redundant switches in the inverter. The functionality of this new method is verified by the simulation studies for various faults in different switches and different operating speeds of an BLDC motor carried out using MATLAB. The proposed fault tolerant control system improves safety and reliability of BLDC motor drives.

Keywords: BLDC; Inverter Faults; Switching Faults; Fault Detection; Fault Reconfiguration; Open Circuit Fault; Short Circuit Fault; Hilbert Transform

Power & Energy

Distributed Generation, Micro-Grid and Smart Grid

39_IEC81174➲

3-E Analysis of the Vapour Absorption Refrigeration System with Micro-Steam Turbine Integration: An Efforts towards Energy Conservation in the Thermal Power Plants

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Abstract: All thermal power plants need a suitable air-conditioning system for maintaining the healthiness of its complete system. There is an existing vapour absorption refrigeration system (VAM) is driven by the steam of pressure and temperature are about 3-3.5 bar and 135-145°C, respectively at VAM inlet i.e. after the steam control valve (SCV opening: 50-60%) and consuming the steam flow rate of about 0.70-0.80 kg/s during 3 nos. of VAMs are in service conditions. The root source of steam is being supplied from the main plant high temperature APRDS header and the parameter of steam at this header are about 11- 12 bar and 310-320°C. In the process, there is an individual pressure reducing and de-superheating system in the steam supply line of VAM for getting the required input steam parameter i.e. pressure of about 3-3.5 bar and temperature of about 135-145°C The pressure reducing valves causes throttling loss and irreversibility in the system and resulting in conversion of some available energy into non-recoverable energy form by changing in internal energy, flow work, noise, friction and heat loss as well due to non-adiabatic process in actual and along with the de-superheating system in the existing system also causes irreversibility during mixing and as a whole, total available energy reduces. In the proposed system, a back pressure type micro-steam turbine is proposed where the pressure reduction is done with the help of expander instead of throttling valve and the expanded steam temperature at turbine exhaust will be lower than throttled temperature of existing system but higher than VAM inlet temperature that leads to conversion of waste energy of the existing system (during throttling and de-superheating process) into useful work output without violating the VAM inlet steam condition. The proposed system is modelled in the Cycle-tempo software by using NH3-H2O mixture as a working fluid for the refrigeration system and thermodynamic analysis is carried out based on 3-E analysis (Energy, Environment and Economic analyses). Result shows that about 87-107 kW of electricity may be generated by integrating the proposed system at turbine exhaust pressure of 3-4 bar and it will help to improve the Co-efficient of Performance (COP) from 0.38 to 0.49 at the optimum operating VAM inlet pressure of about 3.5 bar. It is also observed that about 547 tons of coal can be saved annually and resulting in reduction of CO_2 emission by about 754 tons annually. The cost benefit analysis shows that at required refrigeration effect, power generation cost and simple payback period of the proposed system are about INR 3.44 / kWh and 6.17 years, respectively. Lower electricity generation cost and less payback period of the system with positive ROI value shows a good sign for commercial application of the proposed system in the existing power plants having VAM based air-conditioning system.

Keywords: Air-Conditioning System; VAM; Micro-Steam Turbine; Throttling Loss; CO_2; Economic

99_IEC28601➲

Economic Dispatch of a Hybrid Solar-Wind-Biomass based Microgrid using Novel Nilgiri Tahr Optimization

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Introduction: Modern day microgrid include sources of which some are renewable (RES), while others may be conventional, non-conventional, and distributed in nature. Many of the RES are unpredictable and intermittent. Scheduling these sources in tandem with load and grid, while keeping the dispatch economical, is one of major concerns for microgrid management utilities.

Different nature-inspired optimization techniques have been used recently for cost optimization in microgrids. Samy et al. in [1] used multi-objective particle swarm optimization (MOPSO) to reduce the total annual cost of a biomass and fuel cell microgrid. In another paper [2], Ali et al. used a modified ant-lion optimization algorithm (MALO) in a system consisting of a conventional generator along with a modified biomass-thermal power generating system. Rama Krishna et al. in [3] applied Genetic Algorithm (GA) to a hybrid renewable energy microgrid system consisting of hydro, biomass, solar and wind turbines. Patarau et al. [4] optimised a hybrid renewable energy microgrid system comprising of solar panels, batteries of geothermal generator, and a biomass generator in Romania. Thakkar et al. in[5] implemented Satin Bowerbird Algorithm for optimizing generation of a solar and biomass generators based standalone microgrid (SMG). Younas et al. [6] used the HOMER software to perform economic analysis of a microgrid with three renewable energy sources viz. solar, biomass and micro-hydro by optimizing net present cost.

In the present contribution, a novel algorithm based on the grazing behaviour and nature of Nilgiri Tahr, named as the Nilgiri Tahr Optimization (NTO) has been introduced for the first time to optimise the load scheduling of a microgrid under generation and load constraints. The proposed algorithm is implemented in Jupyter using Python coded programming under Python 3.0 environment and tested on a realistic prototype microgrid consisting of diesel generators (DGs), combined heat-power plant (CHP), solar PV (SPV), wind energy conversion system (WECS), and bio-mass plant along with a variable load. The primary objective of the work is to reduce the overall cost of generation of the microgrid while meeting the load demand, and thereby optimally schedule all the generating sources.

The results demonstrate that load demands have been adequately met for every hour during a 24-hour period, with respect to the total generated power. Generating cost of the DGs, CHP, solar and wind have been minimised and the biomass power plant generator utilization have been maximised using the proposed Nilgiri Tahr Optimization. It has been observed that the net generating cost over 24 hours has been substantially reduced.

Keywords: Optimal Scheduling; Microgrid; Economic Dispatch; Nilgiri Tahr Optimization

115_IEC64210➲

Techno-Economic Optimization for Overall Sustainability of Decentralized Hybrid Energy System using Machine-Learning based Forecasting of Load and Weather Data

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Abstract: The global energy transition demands a significant integration of renewable sources into the power mix to achieve a sustainable, low-carbon future. However, the intermittent and diffuse nature of many renewable resources presents considerable challenges. Distributed hybrid energy systems that leverage local renewables are emerging as a viable solution for reliable power generation. Key obstacles include fluctuations in load demand and weather variability, which complicate capacity planning and cost estimation. Accurate forecasting of both load and weather conditions is crucial for optimizing smart energy management. This study employs machine learning techniques, specifically artificial neural networks (ANN), for short- and medium-term forecasting. The results are compared with deep learning methods to evaluate efficiency and are further utilized for technoeconomic optimization through simulation tools. Validation of the models is performed using the Binary β hill-climbing technique, while a sensitivity analysis conducted via the response surface method confirms the robustness of the findings. The study identifies a photovoltaic-lead-acid system as the most cost-effective solution for a remote Indian village, achieving an electricity cost of $0.0386 per kWh.

Keywords: Load and Weather Forecasting; Artificial Neural Network; Techno-Economic Optimization; Sensitivity Analysis; Cost of Electricity

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148_IEC97686➲

Prosumer Power Exchange with Battery Energy Storage Systems Integration in India

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Abstract: The increasing adoption of renewable energy technologies has led to the emergence of prosumers—individuals or entities that both produce and consume electricity. Prosumers primarily utilize solar photovoltaic (PV) systems, generating electricity for their own use and feeding excess power back into the grid. However, current mechanisms such as net metering and Feed-in Tariffs (FiT) have proved inadequate, both financially and technically. These systems offer limited compensation for surplus energy and do not fully incentivize energy storage or dynamic interaction with the grid. As a result, prosumers often face financial disincentives, and the grid struggles to handle the bidirectional energy flow.

This paper proposes the establishment of a Prosumer Power Exchange (PPE) that integrates Battery Energy Storage Systems (BESS) to overcome these challenges. The PPE provides a market-driven platform where prosumers can trade their surplus energy at competitive, real-time prices, while BESS allows them to store excess energy for sale

during peak demand. This approach enhances profitability for prosumers and contributes to grid stability by enabling energy storage and balancing supply and demand. The paper outlines a comprehensive implementation framework, discusses regulatory and infrastructural challenges, and offers policy recommendations to support widespread adoption. Through the integration of PPE and BESS, this model aims to optimize India's energy landscape, contributing to a more efficient, resilient, and sustainable system in line with national renewable energy goals.

Keywords: Prosumer; Power Exchange; BESS; Renewable Energy; Market-Driven Pricing; Grid Stability

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163_IEC93256

Real-Time Performance Monitoring of a Grid-Connected Microgrid with PMSM-based Wind Energy Conversion System

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Introduction: Over the last two decades, the world has witnessed a major concern about the energy crisis and rising environmental pollution, which have triggered the use of renewable energy sources (RES) [1]. Due to the increasing pressure of the energy crisis, wind power is gaining keen interest and is growing rapidly in modern-day power systems as a clean energy source. As per the current trend, wind energy has witnessed exponential growth [2- 3]. Wind Energy Conversion Systems (WECS) can be of two types viz, fixed speed WECS and variable speed WECS that capture more power even under low wind velocities. Variable-speed WECS mainly include the use of a doubly-fed induction generator (DFIG) and permanent magnet synchronous generator (PMSG) [4]. In PMSG, the synchronous generators used in WECS take its necessary DC excitation either by using permanent magnets or by using electromagnets. The PMSG must run at synchronous speed to maintain the synchronism with the grid. As the wind speed is sporadic in nature, PMSG is incapable of producing a constant frequency supply and that's why it requires power converters to match with the frequency of the grid [5]. In comparison with DFIG, PMSG has superior grid support ability, and higher power-producing capability and there is no need of a box arrangement for controlling the speed [6]. The present study therefore attempts to monitor the performance of a PMSG-based WECS inreal-time.

As wind flow is sporadic, it is very difficult to harness wind power smoothly with such intermittent wind speeds. To cope with this situation, BESS is commonly employed along with WECS. BESS employed in the WECS stores surplus power generated from the wind generator and also delivers the deficit power when wind generator output is inadequate. Various control strategies are being employed in the WECS-battery integrated systems for efficient switching between the wind generator and battery depending upon the wind speed and load demand. Microgrids formed by the integration of RES and BESS require precise control strategies that take into account the costs, degradation of the equipment, and equipment design constraints [7].

Various research works have been done or are undergoing on grid-connected PMSG-based WECS along with battery storage. Research into grid-connected PMSG-based WECS using coordinated control strategies for smoothing power fluctuations is outlined in [8]. Authors in [8] proposed two strategies. One is by simultaneous control of dc-link voltage, rotor angle control, and blade pitch control and another is by coordinating the three individual control strategies in a hierarchical manner where the power smoothing tasks are allocated in individual or combination by some intelligent algorithm. Their focus, however, is more on the wind turbine control rather than the generator control except for the DC-link voltage control. The authors of [9] have studied LVRT capability of the WECS by four different control approaches namely, modulation index (MI) control, de-loading, use of crow-bar resistance, and interchanging the duties of two converters to lock the rise in dc-link voltage [9]. As wind energy is stochastic, to address the stochastic issue, an anti-disturbance full-order sliding mode controller (FOSMC) based on Extended

Space Observer (ESO) is designed for controlling the current in PMSG by the authors of [10]. Their proposed FOSMC utilized a continuously controlled sliding mode to rectify the chattering problem and also to eradicate the disturbances estimated by the ESO.

The present contribution deals with real-time monitoring of a grid-connected PMSG-based WECS integrated with BESS. The article describes inverter-control methods including d-q axis control of the grid-side current, PI tuning, and Phase Locked Loop (PLL) for grid synchronization. Here, Synchronous Rotating Frame-PLL (SRF-PLL) is used for the synchronization and a simple if-else condition programming is used for charging and discharging switching of the battery. For real-time validation of the proposed scheme, the whole system is simulated in MATLAB/SIMULINK and then verified in real-time simulator OPAL-RT.

The notable contributions of this paper can be outlined as:

- Performance evaluation of the PMSG based wind energy conversion system in real-time environment.
- Implementation of efficient switching of the charging and discharging conditions of BESS under varying wind profile

Keywords: Permanent Magnet Synchronous Generator (PMSG); Battery Energy Storage System (BESS); OPAL-RT; Microgrid

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193_IEC49191➲

An Economical Micro Grid Architecture for Single-phase to Three Phase Power Governance System

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Abstract: This study suggests using Single-Phase Converters (SPC) connected between the phases of a Three-Phase Power System (TPS) for the effective power supply for a micro grid. The objectives are to lower total distribution costs and raise power quality at a micro-grid's point-of-common-coupling. The method relies on a master/slave structure, in which a centralized master controller (Arduino Uno) controls the distributed TPS as slave units. In the master controller processes and distributes them proportionately among distributed energy resources. The suggested control method is assessed in a simulation environment using a model. Lastly, a summary and discussion of the principal findings regarding both steady-state and transient circumstances are provided. Proposed method utilization of the energy provided by distributed generation (DG) units and independent power sharing per phase have become essential due to the rapid expansion of TPDG units and loads incorporated into micro-grids. Better load sharing can be achieved as well as optimal energy use and load supply among the various phases with the implementation of the suggested power management technique. The suggested hybrid micro-grid structure and control are validated by the results of experiments and simulations has been done on Proteus 8.9.

Keywords: Single Phase; Micro-grid; Three Phase; LC filter; Inverter

267_IEC79686➲

Decentralized Control Strategies for Grid Stability in Peer-to-Peer Energy Trading Systems

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Abstract: The evolution of smart grids has shifted electricity distribution and energy trading from centralized control by power authorities to a decentralized model involving prosumers, leading to dynamic and unpredictable behavior among grid participants. This transition empowers consumers with generation capabilities, demand response, and energy storage, transforming them into active players in peer-to-peer (P2P) energy trading systems within local energy marketplaces. However, this decentralization poses challenges such as grid stability maintenance amidst varying power generation patterns, particularly with the increasing integration of renewable energy sources. Addressing these challenges requires innovative control concepts to identify and mitigate instability-induced effects. This abstract discusses the role of the distribution system operator (DSO) as a pivotal entity in P2P energy markets, ensuring fair price setting, grid stability, and efficient energy management through advanced control mechanisms. The focus is on developing strategies that enable autonomous decision-making at the local level while safeguarding overall grid integrity in the face of evolving energy dynamics and market conditions. In this paper aspect at the possibilities and difficulties brought about by the switch to decentralized energy systems. Through the use of cutting-edge control techniques, it examines how distribution system operators (DSOs) contribute to even handed price setting, grid stability, and effective energy management. The incorporation of digital technology, market design factors for safe and fair transactions, and the creation of specific controls to efficiently manage local energy dynamics are some of the main areas of concentration.

Keywords: Distribution System Operators; Blockchain; Energy Trading

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309_IEC23823➲

Modelling and Impact Assessment of Renewable-based Bidirectional Power Flow on the Performance of Distribution Transformers

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Abstract: Rising global energy demands and the push for ―Affordable and Clean Energy‖ (SDG7) have increased the focus on harnessing renewable energy sources. Microgrids that incorporate solar, wind, and biomass, in addition to powering local loads, also export surplus electricity to the main utility grid. The integration of Distributed Energy Resources (DERs) into the grid introduces bidirectional power flow within distribution systems, which were originally designed for unidirectional flow. This research employs Ansys-based Finite Element modelling to examine the impact of reverse power flow on existing distribution transformers, which are critical, expensive assets with typical lifespans of 30-40 years. The study simulated in PSCAD analyses an 11kV/0.4 kV, 100 kVA dry-type transformer located at a substation in the Kakdwip Islands, Sunderbans, West Bengal, under varying levels and

conditions of renewable penetration and load demand. The objective of the study is to assess how two-way power flow influences transformer lifespan and enables the user to determine the maximum penetration from different DERs that transformers can handle without degrading their lifespan. The findings will assist Distribution Network Operators (DNOs) in optimizing the use of existing Electrical Assets like transformers as they experience an increase in reverse power flow in renewable-integrated smart grids.

Keywords: Enhanced Lifespan; Finite Element Modelling; Four Quadrant Operation; PSCAD; Reverse Power Flow

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324_IEC37567➲

3-Phase Fault Detection using Neural Network by Wavelet Transform on PV-Biomass based Grid Connected Microgrid System

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Abstract: The increasing integration of renewable energy sources such as photovoltaic (PV) and biomass systems into the grid necessitates reliable and efficient fault detection mechanisms. This paper presents a novel approach for power system fault detection in a PV-biomass based grid-connected microgrid system using wavelet transform and neural networks. The proposed method utilizes discrete wavelet transform (DWT) to extract detailed frequency components from the voltage and current signals of the microgrid. These features are then fed into a neural network classifier to identify faults. The performance of the developed model is evaluated using a simulated microgrid environment under various fault conditions, including line-to-line, line-to-ground, and three-phase faults. The results demonstrate high accuracy, fast response time, and robustness of the pro- posed system, making it a promising solution for enhancing the reliability and stability of microgrids integrated with renewable energy sources.

Keywords: Photovoltaic (PV); Biomass, Grid Connected Microgrid System; Power System Fault Detection; Renewable Energy Integration; Discrete Wavelet Transform (DWT); Radial Basis Function Neural Network (RBFNN)

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336_IEC34711➲

Transforming the Indian Renewable energy Rural Microgrid with the Synergy of Block Chain Analytics

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Abstract: Green fuels for a sustainable future are the need of the day as the rising global warming makes it inevitable for the existence of human beings on the planet. India has set a goal of achieving Net –Zero emissions by 2070. Rural households contribute more than 70% of our nation’s population, hence, to achieve the goal of energy transition needs, the inclusion of rural households with a concept of a ―Green Village-Green Grid‖ is the need of the time. The installation of Solar microgrids at the block level could be funded by the Government, Corporates & power-generating companies. Central Electricity Authority also acknowledges the importance of micro-grids and has an estimated potential of about 4GW in the villages which have inadequate power supply. A solar microgrid is basically an integrated network of generation, storage, and transmission of electricity generated by solar PV panels and the distribution of green energy to communities. Although there is large potential of Solar Micro-grid yet of the scalability of the solar micro grid has not been achieved due to system constraints & one of which is an efficient metering & monitoring of the power exchange of the On-Grid Solar Microgrids. This paper illustrates a solution towards efficient metering & monitoring of the power exchange of the On-Grid Rural Solar Microgrids via the use of Block chain data analytics.

Keywords: Rural Electrification; Microgrid; Sustainable Development; Block Chain

Power & Energy

Electrical Machines and Drives

11_IEC00011A➲

Energy Efficient Motors

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Abstract: Efficiency is the most basic parameter to judge operability of any equipment. Equipments application and success depend on the single factor which is efficiency.

Efficiency can be defined in many ways:

Efficiency is defined as: (Useful output power) / Input

For a motor, useful output is the mechanical power delivered by the shaft – the shaft torque times the speed (rpm)

Again efficiency can be defined as: (Input – Losses) / (Output + Losses) = 100 - (Motor Loss / Total Power)

Thus it is apparent that it is the losses which decide the efficiency.

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364_IEC27406➲

Maxwell Analysis of an Induction Motor during Inter Phase Short Circuit Fault using Ansys

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Abstract: Induction motors are widely used in industrial applications due to their robustness and efficiency. However, various fault conditions, such as line-to-line faults, can significantly affect their performance and lead to system failures. This study focuses on the analysis of these faults using ANSYS simulation software. The research investigates the impact of fault conditions, where reduced supply voltage can cause decreased motor efficiency and overheating. Additionally, line-to-line faults result in a severe imbalance in the motor’s electrical system. By employing ANSYS, detailed finite element analysis (FEA) of these fault conditions is conducted to observe their effects on the motor's electromagnetic and thermal characteristics. The simulation results provide valuable insights into the behavior of induction motors under fault conditions, offering potential solutions for early fault detection and prevention. The findings highlight critical fault indicators, including variations in current, torque, and thermal profiles, which can aid in improving motor reliability and reducing maintenance costs. This research serves as a foundation for enhancing fault diagnosis techniques in industrial motors through advanced simulation tools.

Keywords: Ansys; Flux; Motor Torque; Induction Motor; Inter-phase Fault; Maxwell Analysis

Power & Energy

Energy Policy, Economics and Sustainability

15_IEC50058➲

Development and Validation of a New Mathematical Model for Fair Loss Allocation among the Market Participants in Deregulated Power System

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43_IEC81446➲

Transitioning to a Low-Carbon Economy in India: Policy Framework and Economic Outcomes

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Abstract: The global efforts in addressing the climate change issues are at its high and is expected to grow bigger in the years to come. This may be attributed to the personal experience of all humans in this Globe in one way or the other. On other hand the importance of sustainability has gained traction due to the focus on limited availability of resources. These two reasons have become a vital point in the policy formulation framework of any Nation in the Globe. India as the third biggest Economy in the World, coupled with higher growth rate shoulders higher responsibility than other stakeholders. The policy framework of Indian Government towards the journey for low carbon has provided much economic benefit parallelly addressing the sustainable requirements of the society. The resistance in terms of the paradigm shift of a major economy dependent on fossil fuel to a relatively new and efficient state is also being experienced, forcing the country to devise a unique formula. The paper delves into the prevailing policies in the Country in this respect and highlights the major merits and demerits.

Keywords: Climate Change; Sustainability; Low-Carbon; Fossil Fuel

47_IEC67114➲

Energy Scenario in India

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Introduction: This paper presents the Energy Policy, Economics & Sustainability with reference to the Indian context and focuses on the prevailing Energy policy and its implications on economic activity and explores energy sustainability model adopted. Also, this paper provides insight into the proportion of various sources of energy being used in India and offers solution and highlights areas that need intervention to achieve energy security without compromising environment in a sustainable way. Energy is acknowledged as a key input towards raising the standard of living of citizens of any country, as is evident from the correlation between per capita electricity (a proxy for all energy forms) consumption and Human Development Index (HDI). Accordingly, energy policies of India have over the years directly aimed to raise per capita energy (and electricity) consumption, even while the main focus of the country's development agenda has been on eradication of poverty. With nearly 304 million Indians without access to electricity, and about 500 million people, still dependent on solid bio-mass for cooking, it may be acknowledged that the country has to still go a long way on securing its energy security objective. While India strives to achieve a double-digit growth rate in its national income, making clean energy available to all of its citizens, ought to be included as a key component of the poverty alleviation programmes.

Keywords: Energy Security; Renewable Energy; Economic Growth;

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136_IEC69850➲

Energy Policy, Economics and Sustainability for India: Challenges Ahead and their Mitigation Measures

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Introduction: Indian energy sector is presently going through an important phase of transition. This is happening in line with the global mission for clean development and green energy with an ultimate objective of achieving sustainability in every sphere. It is indeed a very crucial juncture to review and critically appreciate the provisions of the prevailing and upcoming energy policies in India, analyse every step of actions needed, determine the challenges in the whole process of implementation and finally be ready with mitigation measures for removing all the road blocks on the way of meeting the nationwide targets in time and within budgets. The paper will aim at highlighting all the relevant issues pertaining to the key areas on the subject. It will include suggested steps to overcome all challenges foreseen towards achieving sustainability while bringing up interrelated economic impacts and involvements.

Keywords: Policies; Mandates; Challenges; Mitigations; Sustainability

227_IEC29273➲

Integration of Virtual Power Plants for a New Generation Smart Grid in Electricity Market

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Abstract: With the aim of reducing the green house emission gases, there has been a significant rise in the increase of the production of renewable units which consists of solar, wind and photovoltaic since the last decade. As the production of the renewable units fully depends on meteorological phenomena, these units restrict the participation for production in significant real time which obstructs the owners to earn profit in the electricity power market. These negative effect of the uncertainties in the production of the renewable units give rise to the birth of the virtual power plant which consists of conventional units, reserve, storage facilities, incorporation of electric vehicles and flexible demands that can paradigm shift part of the energy consumption for the consumers and the owner's social welfare benefit. Here in this paper it is reflected through different components of virtual power plants and are focused through modeling which integrate the stochastic renewable units with the conventional ones. The participation of these units which are within their confidence bounds, so they may be rewarded or penalized for different time horizons to balance the demands and supply in the power market for maximizing the profit. This forefront to model a decision making problem which is solved through DC load flow algorithm under mixed- integer linear programming of MATALAB version 2015A with the mathematical dominance of Branch and Bound algorithm, where the optimization variables can take continuous and discrete values. The uniqueness of this paper infers that virtual power plant participates in scheduling decision of the facilities time by time to settle the market in real time. Here it is concluded that through bi- directional communication between the producer units and the market in real time the facilitator can maximize its profit.

Keywords: Conventional Units; Flexible Demands; Storage; Virtual Power Plants

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230_IEC70431➲

Uncertainty Realization through Stochastic Scheduling through Energy and Reserve Markets

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Abstract: Due to ever increasing consumption all over the world in the last decades, persuaded a new concept of developing pollution free energy sources like, wind, solar photo-voltaics to increase the available generation capacity.

The integration of these re-newable energy sources with the conventional ones based on fossil fuels, a confronts in uncertainty problem since the solar or wind generating units are intermittent in nature which basically depends on weather condition. The participation of these stochastic generating units are limited and are deviated to earn profits or penalized as these limits are degraced from scheduled production. A possible solution to overcome the penalties fetched is the amalgamation these stochastic or uncertain units with conventional plants and reserves to supply the demand in real time. Here in this paper, the precariousness of the available wind production is modelled using two equiprobable scenarios. The un-certainty of the reserve deployment is also modelled using finite equiprobable scenarios allied with probability occurrence . The finite Combination of the scenarios finally depicts the scheduling of energy and reserve power markets. The uniqueness is focused through the uncertainty of the stochastic solution that helps to find optimal solutions for a 2-hour time frame, that balances the risk of power not served at the real time with the incorporation of the reserves. These leads to model a decision making problem solved through optimization problem namely based on linear programming particularly Mixed Integer Linear programming , where the optimization variables can take continuous and discrete values. The optimization problem is solved through Brunch and Bound algorithm through Matlab Version 2015 A.

Keywords: Reserves, Stochastic, Energy Market, Uncertainty, Equiprobable

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321_IEC1404➲

Projecting or Estimating Nodal Congestion Price and IMO Pay by Ada-Boost for a Restructured Electrical Market

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Abstract: Day by day electricity requirement is increasing in a rapid way, due to the enhancement of utilization of electric power. Initially, electrical power supply done by limited numbers of agencies and competition is very less in Electric Market, as a result the consumers did not have any option to choose according to their requirement on economic point of view. At present, electricity is an inseparable commodity for the human being, and a profitable structure introduces where sup-pliers as well as buyers can have their profit from the selling and utilizing electrical power. This restructured electricity market is competitive in nature and changes monopoly market to open deregulated electricity market where profit maximization is main moto by minimizing the cost. In this new structure power supply reliability and financial issues are took care by an independent regulating author-ty or independent market operator (IMO). Power generators (GENCOS) produce energy and that spread to consumers via Transmission and distribution companies (DISCOS). In electrical open market, optimal power flow adopted for profit maximization. In any power system Locational Marginal Price (LMP), Nodal congestion price (NCP) are the important index for optimal power flow studies. In this article IEEE 30 bus system has taken for case study and perform OPF technique on it. Finally, a machine learning approach has taken to predict the LMP, MCP of the system.

Keywords: Gradient Boost; Independent Market Operator (IMO); Locational Marginal Price (LMP); MATLAB-PSAT; Nodal Congestion Price (NCP); Optimal Power Flow (OPF)

<u>Power & Energy</u>

Energy Storage Technologies

66_IEC32274➲

Design and Fabrication of Multi-Material Sodium Anode Filaments for Fused Filament Fabrication using Hard Carbon

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Abstract: In this study, a novel sodium anode filament was developed for Fused Filament Fabrication (FFF). The filament formulation combined Polylactic Acid (PLA) as the polymer matrix with Hard Carbon as the active material, enhanced with Poly (ethylene glycol) dimethyl ether and Carbon Black Timcal Super-P to improve plasticity and conductivity. The initial anode slurry was prepared and optimized based on capacity and cyclic voltammetry studies. The homogeneity and elemental distribution of the slurry filaments were analyzed using scanning electron microscopy and Raman spectroscopy. Filament production was achieved using a filament-making machine, followed by 3D printing with an FFF printer. Subsequent testing showed that the 3D printed samples exhibited a 15% reduction in capacity (230 mAh/g) compared to the slurry-coated films (273 mAh/g). The printed samples displayed a less distinct voltage plateau and a higher discharge voltage profile, suggesting increased internal resistance or less efficient sodium-ion intercalation compared to slurry-coated samples. Additionally, the cyclic voltammetry of the printed samples indicated slightly lower electrochemical activity than the slurry-coated samples. Rheological analysis showed that the developed filaments had elastic and viscous modulus values similar to conventional PLA filaments, suggesting their potential for similar applications with enhanced properties. The frequency sweep test confirmed shear-thinning behavior, advantageous for extrusion and 3D printing processes.

Keywords: Fused Deposition Modelling; Sodium Battery; Filament Formulation; Rheology

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126_IEC52277➲

Pump Hydro Storage Project (PSP) — Energy Storage Technologies

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Abstract: Energy storage technologies are critical to addressing the challenges posed by the increasing integration of renewable energy sources. Each storage solution — Battery Storage, Pumped Storage Plants (PSP), Hydrogen Storage, and Thermal Storage—offers unique strengths that make it suitable for different applications.

- Battery storage is highly efficient, flexible, and ideal for short-term energy needs and decentralized applications, such as electric vehicles and home energy systems.
- PSPs are unmatched for large-scale, long-duration storage, providing a reliable backbone for national grids, especially where renewable energy fluctuations require balancing over extended periods.
- Hydrogen storage presents the best option for long-term, seasonal energy storage, though it currently faces challenges related to efficiency and infrastructure development.

- Thermal storage is a cost-effective solution for heat-specific applications and plays a crucial role in industrial processes and concentrated solar power plants.

As the world accelerates its transition to renewable energy sources, one of the biggest challenges we face isn't generating clean energy — it's storing it efficiently and reliably. From cutting-edge batteries to revolutionary hydrogen solutions, energy storage technologies are rapidly evolving and hold the key to a sustainable future.

These renewables are inherently intermittent—solar power is only generated during daylight hours, and wind power fluctuates with weather conditions. Effective energy storage allows excess energy produced during peak generation times to be saved and used when demand exceeds supply or when renewable resources are not generating power.

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137_IEC92829➲

Prospective Prioritization of Strategies for Sustainable Development of Storage Industry of India by Integrating SWOT-Hesitant Fuzzy MCDM Method

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Abstract: Energy storage systems are crucial for achieving a carbon-neutral economy and facilitating the transition to sustainable mobility and energy. However, with various policies being introduced, it can be challenging to prioritize strategies effectively for marketing sustainable storage solutions. Each country must optimize its available resources while navigating specific constraints. To address this, it's essential to evaluate strategies based on the country's strengths, weaknesses, opportunities, and threats (SWOT) in the energy storage sector. Given the conflicting factors and inherent linguistic uncertainties, employing a hesitant fuzzy linguistic multi-criteria decision-making (MCDM) approach is vital. The proposed methodology integrates SWOT analysis with decision-making techniques to prioritize strategies for developing sustainable energy storage systems. Initially, the SWOT framework is utilized to formulate strategies aligned with the country's announced policies for future energy storage systems. Next, the Hesitant Fuzzy Linguistic Analytic Hierarchy Process (HFL-AHP) determines the weights of these strategies. Finally, the Hesitant Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (HFL-TOPSIS) identifies the optimal priority for implementation. This methodology has been applied using data from India, demonstrating its effectiveness in navigating the complexities of energy storage strategy development.

Keywords: Energy Storage; Sustainability; Strategy Prioritization; SWOT; HFL-MCDM

222_IEC59788

Enhance Current Boosting for MHTG using TP4056 Module and make it Application Suitable

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Introduction: The requirement for energy especially electrical one is demand in the World. It is increasing day by day due to rapidly increasing population and advancement in science and Technology. Since the beginning of electrification, fossil fuel burning has been the main source of primary energy on which electricity generation is based. So, renewable energy resources have had an important development. The production of electricity without creating any pollution in atmosphere is known as green energy.

Hydroelectric power technology is generating electricity from the flowing of water of streams, rivers, and pipe. Water flows through a water channel / pipe to a turbine in turns rotate the shaft when it strikes the blades of this turbine. The shaft of turbine is connected to a generator which converts the mechanical energy into electrical energy. The water flowing is a pollution-free, renewable, safe, incessant, and reliable energy source.

The hydro power which has a maximum electrical output of five kilowatts (5 kw) comes under the category of Pico Hydro turbine. This system is beneficial than other large hydro system as it have low cost, can be installed anywhere, eco-friendly and easily available to people.

In-Pipe Hydro Power System: Divided in two main designs-

Internal system is where the runner is wholly inside the pipe section. Power output ranges from 5-10 watts, sufficient to supply self-powered water metering or monitoring systems.

External system is where the runner is contained in a secondary conduit which bypasses the main line and do not depend on pipe size. This system is usually customized to meet the existing pipe size, whereas the turbine and generator are chosen based on available water flow and head.

The MHTG is capable of generating around 5V, however the current that can be drawn is in range from few tens of mA to less than 150 mA. This combination poses a key problem in order to use with rechargeable battery, typically for Lithium Cell. A typically 1000 mAH Lithium Cell requires to be power drawn at constant current at 1A for an hour to get it fully charged.

A Battery Management System for charging and manage the discharging through algorithm for a known load was carried out [1]. Applications like mobile phone and LEDs are at most common use for any rechargeable barriers and those batteries often need recharging regularly with a controlled source [2]. Any battery that can be help for recharging with an enhanced current requirement for a battery in order to enable optimal power transfer depends on ability to source more electrons. For a typical charging managing hardware solutions like TP4056 this is done with the help of programmable current setting. It is a function achieved through variation in the programming resistance-value that helps over a range of current [3]. The key component of TP4056 has another functional capability of thermal regulation while the required currents is sourced for the battery of type lithium-ion to be recharged and this thermal regulation is an implied to the integrated-circuit chip TP4056. The rest of the circuitry is built around it in order to be able to interface lithium-ion battery, source of the electric power and application interface where the load is to be applied [4]. How a high current application load could be of demand for high current in order to be used with power generation source which generates voltage but at a low current by it's implied functionality. And hence such current need boost and to be regulated[5].

Keywords: Micro Hydro Turbine (MHTG); Electrical Power Generation; Energy Harnessing; Non-Conventional Means of Energy; Pico Hydropower; In-Pipe Power Generation; TP4056 Module; Current Boosting

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313_IEC57991➲

Optimizing Heat Transfer in PCM-based Thermal Energy Storage Systems

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Abstract: This research numerically analyses a phase change material (PCM), specifically Paraffin wax P-66, used in an energy storage system designed for efficient thermal management. The system includes a vertically positioned PCM-filled circular pipe modeled in 2D, with heat transfer occurring through an adjacent water flow pipe separated by a copper barrier. The entire system is insulated to prevent thermal loss, and water, as the heat transfer fluid (HTF), flows vertically from the bottom inlet to the upper outlet. A finite volume-based solver is employed to numerically solve the transport equations governing the system. The study divides both HTF and PCM into multiple sections while maintaining a constant PCM volume across all cases. Results show a significant improvement in energy storage efficiency, with a 52.56% reduction in melting time when the HTF flows in two parts around the PCM. Dividing the HTF into five sections and the PCM into three sections further reduces melting time by 45.08%. The analysis also indicates that more HTF surface area in contact with the PCM enhances heat transfer, but the effect on melting time diminishes as the number of heated surfaces increases, suggesting an optimal surface configuration for maximum efficiency. These findings provide useful insights for designing compact, efficient PCM-based energy storage systems suitable for industrial use.

Keywords: Energy Storage; Phase Change Material (PCM); Enhancement; Thermal Management; Heat Transfer Fluid (HTF)

Power & Energy

Frontier Technologies in Mobility

187_IEC20145➲

Design Innovations and Performance Optimization in Tilting Pad Journal Bearings: A Review

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Abstract: TPJBs are vital components in high-efficiency machinery, providing superior load support and reduced friction through a hydrodynamic lubrication film. However, challenges such as pad fluttering can lead to increased vibrations and noise, compromising operational efficiency and longevity. This study explores the critical factors influencing TPJB performance, emphasizing the significance of tailored lubrication systems. We highlight the importance of selecting appropriate lubricants based on specific operating conditions—load, speed, and temperature—to prevent fluctuations in film thickness that can accelerate wear. Furthermore, we advocate for adaptive lubrication strategies that dynamically respond to varying operational demands and the implementation of predictive maintenance practices to identify potential failures early. The findings aim to provide engineers and practitioners with practical insights to increase the dependability and functionality of TPJBs. This, in turn, will contribute to the creation of more resilient machinery across diverse industrial applications. By applying these insights, professionals can optimize designs and maintenance practices, ensuring better efficiency and longevity in high-performance systems.

Keywords: Tilting Pad Journal Bearings (TPJBs); Pad Fluttering; Lubrication System Design; Friction Reduction

Power & Energy

Hydrogen and Fuel Cell Technologies

142_IEC16175 ➲

A Green Hydrogen Genset

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Abstract: The purpose of this design is to generate electrical power through consumption of hydrogen gas.

It suggests a way of making an efficient engine-generator set operating on hydrogen fuel.

A rotating engine is coupled to an electric generator to form a portable genset.

This engine will be able to produce torque within a manageable rpm and cost and will also be robust and suitable for ground level applications, capable of accommodating contingent atmospheric particulate matter and heated combustion products. The generator will be capable of generating3 phase a.c. electrical power in a range below 100 KW levels. In my opinion, the above objectives can be best met by splitting the stages of the genset into five, discrete, robust pieces of equipment.

A) A 'compressor' for input air.

B) A consumption 'chamber' for burning the fuel air mixture.

C) A pneumatic 'motor' to convert pressurised gas flow, into torque.

D) An alternator to produce 3phase A.C. electric power.

E) A gearbox to connect A, C & D through suitable gear ratios.

Power & Energy

Power System Stability, Reliability and Flexibility

21_IEC75354➲

Power System Flexibility — a Key Enabler for the Energy Transition

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Abstract: Power systems around the world are undergoing significant change, driven particularly by the increasing availability of low-cost variable renewable energy (VRE), the deployment of distributed energy resources (DER), advances in digitalisation and growing opportunities for electrification. Power systems are designed and operated to efficiently manage variability and uncertainty in electricity demand and resource availability. VRE increases this inherent variability and uncertainty, and thus increases the need for flexibility. Systems with significant variability and uncertainty require flexible generators that can rapidly change output, operate efficiently at lower outputs, and operate for short durations. This flexibility in turn can reduce the need to curtail (decrease the output of) solar and wind generation; improve investor confidence in VRE and reduce environmental impacts by increasing system efficiency and maximizing the utilization of VRE. Flexibility has to be harnessed in all sectors of the power system, from power generation to stronger transmission and distribution systems, storage and more flexible demand.

Keywords: Power System Flexibility; Energy Storage; Renewable Energy; Global Warming; Energy Transition

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40_IEC52519➲

Analysis and Risk Assessment of Fault Induced Delayed Voltage Recovery Events and its Interplay with Load Nature

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Abstract: Load growth and its nature have direct impact on power system and with the increased temperature and humidity, concentration of air conditioning load has significantly increased near city and urban areas. Such drastic increase of Ac loads which are mainly single-phase induction motors have increased the risk of FIDVR event in recent years. Nature of load growth and its changing behaviour in past few years have been analysed. This paper showcase root cause analysis of the real event occurred in eastern region and explains the phenomena of FIDVR in details along with mitigating measures and way forward in long term at planning stage and short term in operational horizon.

Keywords: Fault Induced Delayed Voltage Recovery (FIDVR); Battery Energy Storage System (BESS); Air Conditioner (AC)

131_IEC5848➲

Retrofitment of SEALGUARD ASSEMBLY in WAGON TIPPLER for Reliable Operation of Movable Side Beam in Wagon Tippler : A Case Study of NTPC Kudgi

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Abstract: NTPC Kudgi has 3 × 800 MW coal units that get coal from diversified sources. coal is transported from more than 1500 kms of coal mines. Coal comes in different sizes up to 200 mm and above. This coal is unloaded at wagon tipplers, crushed at Ring granulator and after getting crushed it is sent for direct bunker feeding or stacking / reclaiming. Being a non-pit head plant coal unloading healthiness is very much critical. Any failure of tippling equipments may stop functioning of the plant which may cause heavy loss in terms of demurrage and power generation. Coal unloading depends upon different equipment like wagon tippler , apron feeder , Side arm Charger , Dribble Conveyor, flap gates, downloading conveyors etc. Due to several reasons like rake bunching, sick wagons, over heaped wagons, multiple tippling requirements problems in downstream conveyors etc Wagon tipplers are always in a state of high duty operation and there is very less room for any breakdown maintenance. From last three years rake movements increased and coal unloading at KUDGI has been increased from 22.26 lac MT (FY 2018) on annual level to 43.5 lac MT (by Sept 2023). Wagon tipplers at KUDGI are M/s TRF make and it was widely mentioned by OEM that to improve cycle time there is need of wagon tippler guide rod greasing frequently. Due to this WT system was becoming unavailable again and again and require top and bottom guide rod greasing round the clock irrespective of any weather condition. It has both operational and safety hazard including maintenance cost. It causes enhancement of wagon unloading time. In absence of guide rod greasing side beam of WT does not forward fully and top – bottom portion are not inline and not touching wagons body properly. As per RDSO there shall be metal to metal contact between the side support beam and the side stanchions of the wagon. Any lag in contact will cause multiple problems like PU pad falling. Refixation of wagon PU pads cause tippling time over-run and finally cost us in form of demurrage. To attend this problem various checking was done like equal pressure (forward–retard condition) at all guide rods, guide rod alignment, guide rod hardware intactness. To overcome the problem one Sealgaurd assembly was designed in-situ to take care of all the Dust and contamination entry while in operation.

This system is equipped with perfectly sealed Stainless steel bellows from all sides. They restrict the entry of any foreign Particles and dust during the operation. In addition to this, the graphite Embedded bushes are fixed in bracket portion which takes care of sliding friction and lubrication. 3D model of sealguard assembly was made at site and bill of materials were decided with a local vendor. Same was installed in WT-2 during its overhauling on 30th Sept 23. After its installation and completion of three months ONLY ONE DAY greasing was done as a precautionary step. Now guiderod greasing requirement in WT-2 has been totally nullified and performance of this retrofitment has been also recognised by CHP OPERATION DEPARTMENT. Guiderod assembly has multiple advantages like Wagon Tippling Cycle Time Reduction , Electrical module fuses safeguarding (as multiple time isolations and normalisation cause damage to fuse), enhancement of workman’s safety (as even in case of night or rain guiderod greasing was to be done to make system available), Reduction or elimination of persistent problem of repetitive pu pad, spring etc falling and will avoid any problems with Indian Railways.

Keywords: Sealguard Assembly; Wagon Unloading

156_IEC39801➲

A Comparative Study of Various FACTS Devices used in Modern Power Systems for Efficient and Reliable Power Transmission

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Abstract: Over the last few decades, power demand has surged, yet power generation and transmission capacity haven't kept pace. This imbalance strains utilities, pushing them to max capacity, risking Voltage instability and network failures globally. Flexible Alternating Current Transmission System (FACTS) devices offer a solution by enhancing network stability and load handling. To address these challenges, FACTS devices can be a crucial choice for enhancing the stability and loadability of the transmission network. This article provides a comprehensive review FACTS controllers, detailing types, operations, and control features, crucial and power flow capability for power system engineers and researchers. Ultimately, this study hopes to serve as a valuable resource for anyone seeking to improve the stability and efficiency of power transmission.

Keywords: FACTS, TCSC, SSSC, SVC, STATCOM, UPFC

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168_IEC67924➲

An Effective Configuration Approach by Reverse Delete Algorithm based on Graph Theory

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Abstract: Graph theory application based topological modifications have been possible to reconfigure a mashed network to radial network by operating sensationalizing switches. Benefits of main meshed distribution networks, which include reduced short circuit current, shorter total conductors, and improved fault tolerance, the advantages of the radial networks. Due to its lower power losses an optimum radial network may run more effectively. It is one kind of challenging task to identify the optional redial reconfigure network, Reverse Delete minimum spanning tree algorithm successfully identify the optimum solution with minimum time. This paper successfully implemented the proposed algorithm on mesh network and converted to a radial network topology; and given multiple solutions if faults (single transmission line fault or double line fault) occur in different locations. Two different case studies have been examined on IEEE 14 bus system and IEEE 33 bus system to show the effectiveness of the proposed method. Simulation case study has been made in MATLAB and PSAT software.

Keywords: Graph Theory; Reverse Delete Algorithm; Spanning Tree; Mesh Network; Radial Distribution Network

286_IEC88714➲

Modern Concept and Analysis of Power System Stability Improvement by State Estimation and Soft Computing Technique

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Abstract: The power system stability analysis is vital for the power grid. The Power system stability of an interconnected power system is its ability to return to regular or stable operation after having a specific disturbance. Power system stability analysis is critical to future planning and design of power systems. State estimation plays a vital role in monitoring and controlling modern power systems. The load flow analysis is the aim of state estimation to obtain the best possible values of the bus voltage magnitudes and angles by processing the available network data. Power system stability, theoretical and practical, is essential in the power grid for analysis of reliability and efficiency. So, every power system state must analyze and correct transient faults. Modern approaches to state estimation and soft computing techniques directly apply to the real world. State Estimation involves estimating the current operating conditions of a power system based on available measurements such as voltage, current, power flow, load angle, etc. Advanced estimation techniques include Kalman filtering, extended filtering uses, and recent studies involving soft computing techniques to obtain accurate and real-time information about the system's state. Here, we tested these conditions in an IEEE 30 bus system where all situations are created as a real system grid network. When loads are distributed in distribution lines, balanced supply is hampered, i.e., steady-state supply is hampered, and load flow studies will solve these problems. Here, we first optimized the condition using the Newton-Raphson method, but it is seen that the solution is not optimized, so particle swarm optimization (PSO) and Ant Colony Optimization. Techniques (ACO) are used. These techniques have several benefits: enhanced accuracy, real-time optimization, and robustness[1].

Keywords: Power System Stability; State Estimation; Weighted Least Square Method; Particle Swarm Optimization

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335_IEC89195➲

Optimizing Energy Consumption and Enhancing Performance Reliability: The Synergistic Impact of Energy Management Systems and Energy Audits

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Abstract: In an era characterized by increasing resource constraints and rising energy costs, the optimization of energy consumption has emerged as a critical priority for both individuals and organizations. Energy Management Systems (EMS) and Energy Audits are recognized as essential methodologies for enhancing energy efficiency and performance reliability. This paper explores the functionalities, benefits, and significance of EMS and Energy Audits in achieving reductions in energy expenditures, improving energy efficiency, and minimizing environmental impacts. Additionally, case studies illustrating energy savings at the Durgapur Steel Thermal Power Station (DSTPS) through the implementation of EMS and Energy Audits are presented.

Keywords: Energy Management System; Energy Audit; Energy Savings; Reliability

352_IEC33670➲

Enhancing Power System Stability, Reliability, and Flexibility: A Comprehensive Approach to Future-Proofing the Grid

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Abstract: The characteristic features of the modern power systems that are urgently needed for integrating renewable energies, peak loads, and sophisticated distribution networks range from reliability to stability and flexibility. All of them lay the basis for resilient power delivery in light of increasing intermittent renewable energy, distributed generation, and changing load patterns. The paper outlines an integrated approach toward powering systems that can positively enhance these three dimensions, explaining the technical, operational, and regulatory challenges that accompany them.

These are frequency, voltage, and rotor angle stability. Each is vulnerable to fast fluctuations and disturbances of energy supply and demand. More specifically, efforts at renewable sources cause troubles for the issues of frequency stability at times with several deviations that affect grid performance. This encompasses grid-forming inverters and DSM as leading-edge technologies promising answers regarding stability maintenance. This is supported by the faster response of a system to any changes in frequency and better control of reactive power and voltages at the system level. The PMU is considered the revolutionizing tool in real-time monitoring of power flows and disturbances in power systems from an increased situational awareness perspective and, thus, enhances the stability of the grid.

It is only correct to state that reliability in this paper puts emphasis on resilience against power interruptions and faults. Reliability in the context of power systems can be measured through a key performance index, such as SAIDI and SAIFI, which provide a way of coming up with metrics for ascertaining interruptions' frequency and duration. Paper highlights some of the strategies supporting reliability improvement, such as predictive maintenance, automated fault detection, self-healing networks that all work together with grid analytics and machine learning. They provide optimums in schedules of maintenance, bring down downtime by reducing operational cost, and add pre-event failure handling capability to enhance reliability.

Increased sensitivity of future power systems and management of fast, unpredictable changes in supply and demand patterns show the importance of flexibility. The paper discusses the role of ESS, namely batteries, flywheels, and pumped hydro, providing important buffering abilities that are vital for the utilization of operating storage to balance supply-demand mismatches. Demand response mechanisms and dynamic pricing structures increase flexibility in that end-use customers are allowed to adjust usage patterns based on their convenience with regards to grid conditions, thereby lowering the system strain at peak times. Flexible AC transmission systems (FACTS) are also part of the arsenal for optimizing power flow and stabilizing system operations against variable load and generation conditions.

The managing of the modern grid, through an integral perspective on stability, reliability, and flexibility, becomes essential. This paper aims to discuss and understand the scope of smart grid technology, which utilizes IoT and digital solutions in collecting real-time data, thereby enabling faster decision-making and more precise control over system behavior. Some key enablers cited for proactive management include machine learning and artificial intelligence; capacity predictive profiles in advance; and potential disturbances identified before they become major issues. Solutions to resilience during extreme weather, grid disruptions, or any other scenario are suggested through local solutions in the form of microgrids and coordinated renewable-storage systems, offering energy security as well as flexibility.

This paper showcases stability, reliability, and flexibility measures by synthesizing case studies and applying them practically across different regions, such as California and Germany. Challenges are addressed in regulatory hurdles,

cybersecurity concerns, and economic implications with regard to promoting policy support and international collaboration. A sustainable model toward achieving robust performance in power systems against rapid technological advancement and the rising energy demands is proposed through this integrated approach.

Power & Energy

Renewable Energy Technologies

33_IEC20606➲

Hybrid Battery Trolley for Reducing Down-Time: Innovative Solution by Augmenting Renewable Energy based Charging Feature

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Abstract: THCM (Tata Hitachi Construction Machinery Private Limited) has been pro-active to cater to the needs of the customer. The number of NPI (New Product Introduction) has been increasing as the competition in the earth-moving industry is increasing. The construction machinery market demands has been very dynamic, with customer demanding cost effective and reliable product which requires product positioning in the market at right time to capture the market share with shorter development time. A well-executed NPI process can help companies: capture premium pricing, increase market share, increase profit margins and improve customer engagement. Testing and Validation phase constitutes a major part in overall timeline of a NPI model and hence this phase has the most influence in the timeline of the project. In recent times we had been facing frequent delays in the testing timeline. When we tried to list down the sources of delay through Pareto study, we found ―movement‖ as major constraint. Most of the movements are done with the help of ‗battery trolley‖ which has daily down-time of around 4 hours. Considering various advancement in technology, our team came up with the proposal of ―solar powered charging method‖ to eliminate conventional method of charging.

Keywords: THCM; NPI; MPPT; Ergonomics; Sustainability; Hybrid Technology

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76_IEC2946➲

Renewable Energy Sources with Special Effort on Hydropower for Sustainable Development

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Abstract: Water and Power are the two major inputs for the development of a country. Across the spectrum of electricity generation, water and power remains the only renewable and inexhaustible source of energy, which can be exploited on vast scale at a competitive price. Apart from fast depletion of fossil fuel for non-renewable source of energy, the exploitation of these sources is replete with grave ecological consequences. Renewable energy sources received from solar and wind power backed by storage through batteries supported by advanced technology can reduce emissions globally by 43% by 2030 to stay below 1.5 degrees centigrade, which may reach above pre-industrial temperature level, due to global warming.

Keywords: Hydropower; Renewable Energy; Climate Change; Carbon Emission; Global Warming

79_IEC13616➲

Installation and Experimentation of a Vertical Axis Wind Turbine for Domestic Purpose

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Abstract: Vertical Axis Wind Turbines (VAWTs) are an evolving technology, with ongoing research focusing on improving the design and implementation. VAWTs offer a viable solution for fulfilling small scale energy needs, especially in urban domestic settings. In these scenarios VAWTs show certain advantages over the tradition horizontal axis wind turbines and even more crucially come out as viable alternative to fossil fuel energy generation. Vertical axis wind turbines have some unique advantages, such as their ability to capture wind from any direction and their compact design. However, they also face challenges related to efficiency, scalability, and noise. To gain latest insight into the potential of VAWTs, latest methods and technologies have been compared here, focusing on efficient energy generation. In this work, a hybrid type VAWT has been designed to meet domestic energy requirements. Simulation tools have been used to obtain required turbine performance and ensure effective design. The main goal of this work is to install and run a VAWT which could lead to more sustainable energysolutions.

Keywords: VAWT; Renewable Energy; Sustainable Development; Environment; Domestic Energy Need

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97_IEC4687➲

PV based Security Lighting System of 3 Wheeled Electric Vehicles for Rural Transportation

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Abstract: The global sales of Electric Vehicles (EVs) have grown significantly, particularly in India, due to rising pollution levels, rising fossil fuel prices, and increased awareness of renewable energy. However, conventional power supply, primarily from coal-based plants, is often used, leading to system instability and increased electricity costs. The Lithium Ion battery (LIB) in EVs has also experienced exponential development and price increase due to increased demand and limited lithium availability. So in reality we are not achieving our original aim of reducing carbon emission due to use of conventional energy sources to charge EVs batteries. Also in recent years more and more research is being carried out on Sodium Ion Battery (SIB) as a replacement of Lithium Ion battery as Sodium is more easily available, low cost with similar electrochemical characteristics as compared to Lithium. This paper gives the complete design and in depth analysis of a Pulse Width Modulation (PWM) based charge controller which has utilized the solar energy by using Photovoltaic Module (PVM) to charge the SIB which can be implemented in small EVs used mainly in suburban and rural areas to provide necessary energy for interior lighting that in turn can reduce the load of the battery supplying energy to the driving motor and thus achieve the aim of using renewable energy to reduce pollution hazards. Moreover, this charger is used to charge SIB so it will reduce the overall cost of the vehicle which in turn will encourage more people to use EVs in rural and suburban areas of our country where most of our country's population lives.

Keywords: Solar Energy; PWM, Charge Controller; Sodium Ion Battery

127_IEC43608➲

Photovoltaic Efficiency: Breakthroughs in Cell Design and Performance — A Review

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Abstract: Photovoltaic (PV) technology has witnessed significant advancements aimed at enhancing energy conversion efficiency and reducing costs. This literature review examines recent breakthroughs in PV cell design and performance, focusing on novel materials, architectural innovations, and fabrication techniques. Key developments include the emergence of perovskite solar cells, tandem cell architectures, and the utilization of nanostructured materials. Additionally, advancements in light management strategies and manufacturing processes have contributed to improved efficiency and scalability. The review synthesizes findings from various studies to provide a comprehensive understanding of the current state and future prospects of PV technology. Challenges such as material stability, scalability, and cost-effectiveness are also discussed, highlighting areas for future research. This analysis underscores the pivotal role of interdisciplinary approaches in driving the evolution of high-efficiency photovoltaic systems, ultimately contributing to sustainable energy solutions.

Keywords: Photovoltaic Efficiency; Perovskite Solar Cells; Tandem Cells; Nanostructured Materials; Light Management

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139_IEC32699➲

Solar Thermal Energy Storage: Emerging Techniques and Technologies

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Abstract: Solar Thermal Energy Storage (STES) plays a pivotal role in enhancing the efficiency and reliability of solar power systems by enabling the retention and utilization of thermal energy beyond daylight hours. This literature review explores the latest advancements in STES technologies, emphasizing emerging techniques that promise higher energy densities, improved thermal stability, and cost-effectiveness. The review categorizes STES methods into sensible heat storage, latent heat storage, and thermochemical storage, highlighting innovations such as advanced phase change materials (PCMs), novel encapsulation methods, and hybrid storage systems. Methodologies involve a systematic analysis of recent scholarly articles, patents, and industrial reports to assess the performance, scalability, and practical applications of these technologies. Results indicate significant progress in material science and system integration, with several emerging technologies demonstrating enhanced performance metrics compared to traditional methods. The review concludes by identifying key challenges, including material degradation, system complexity, and economic feasibility, while proposing future research directions to address these issues and facilitate the widespread adoption of advanced STES solutions.

Keywords: Solar Thermal Energy Storage; Phase Change Materials; Thermochemical Storage; Molten Salts; Energy Efficiency

140_IEC58244➲

Performance, Emission and Combustion Characteristics of a Variable Compression Ratio Diesel Engine Fueled with Hibiscus Cocos Nucifera Biodiesel

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Abstract: The fossil fuel reserves will be depleted soon. Diesel is used as a fuel in engines, resulting in poor combustion efficiency and more pollutants. Biodiesel is a promising alternate fuel for engines. Biodiesel derived from hibiscus cocos nucifera (HCN) oil is being used as a substitute fuel in a variable compression ratio diesel engine to improve efficiency and reduce emissions. The engine runs under various loads at 1500 rpm. The experiments are conducted on a VCR diesel engine using the biodiesel blend B25 at various compression ratios (CR15, CR16, CR17, and CR18), and the findings are compared to diesel fuel at a standard compression ratio of 17:1 in maximum load load. The performance characteristics of brake thermal efficiency improved by 5.14%, brake specific fuel consumption decreased by 5.71%, the emission characteristics of hydrocarbon decreased by 20.68%, carbon dioxide increased by 19.51%, smoke opacity decreased by 54.38%, and the combustion characteristic cylinder pressure increased by 4.05%. Cumulative heat release improved by 1.04%, net heat release decreased by 0.36%, and the mean gas temperature decreased by 0.56% at CR18. The findings show that the blend B25 can be applied as an alternate fuel for diesel engines without changes to the engine.

Keywords: Diesel; Biodiesel; Performance; Emission; Combustion; Hibiscus Cocos Nucifera Oil

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146_IEC21277➲

Advancements in Photovoltaic Technology with Next-Generation Materials and its Applications — a Review

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Abstract: The photovoltaic (PV) sector has witnessed significant advancements driven by the quest for higher efficiency, reduced costs, and sustainable energy solutions. This literature review explores the evolution of photovoltaic technology, emphasizing next-generation materials such as perovskites, organic photovoltaics, and tandem solar cells. It examines innovative applications, including building-integrated photovoltaics and flexible solar panels, highlighting their potential to revolutionize energy harvesting. The review employs a systematic approach, analyzing peer-reviewed journals, conference papers, and industry reports published between 2015 and 2024. Key findings indicate that emerging materials offer substantial efficiency improvements and cost reductions, while novel applications expand the versatility and integration of PV systems into various sectors. Challenges such as material stability, scalability, and environmental impact are also discussed. The review concludes that ongoing research and interdisciplinary collaboration are essential to overcome current limitations and fully realize the potential of next-generation photovoltaic technologies.

Keywords: Photovoltaic Technology; Next-Generation Materials; Perovskites; Tandem Solar Cells; Flexible Solar Panels

154_IEC59419➲

Utilization of Solar Energy and its Potential for Various uses in the Indian Context: A Comprehensive Literature Review

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Abstract: India, endowed with abundant solar resources, stands at the forefront of harnessing solar energy to meet its burgeoning energy demands and environmental sustainability goals. This literature review explores the multifaceted utilization of solar energy in India, encompassing residential, commercial, agricultural, and industrial applications. The study systematically examines recent advancements, policy frameworks, technological innovations, and economic implications associated with solar energy deployment. Methodologies employed in the reviewed studies include quantitative analyses, case studies, and comparative assessments of different solar technologies. Findings indicate significant potential for solar energy to contribute to India's energy mix, reduce carbon emissions, and promote energy access in rural areas. However, challenges such as high initial costs, grid integration issues, and policy implementation gaps persist. The review concludes with recommendations for enhancing solar energy adoption through supportive policies, financial incentives, and continued technological research. This synthesis provides a foundational understanding for policymakers, researchers, and stakeholders aiming to leverage solar energy for sustainable development in India.

Keywords: Solar Energy; Renewable Energy; Photovoltaic Systems; Energy Policy

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158_IEC42401➲

Design of Interleaved Buck-Boost Converter for Green Energy Application

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Abstract: Now a day's use of green energy in transportation and many other fields are of great importance in view of pollution, cleanliness long lasting energy conservation and of-course low cost and Independence. Generally non-conventional energy i.e. green energy modules produce low output voltages without converters which needs to be boost up. A lot of research work have already been conducted and currently in progress on,‖ Interleaved Boost/Buck-Boost Converters‖ mainly focusing on to achieve an all-round improved version of it. Converters designed so far are application specific in respect of output voltages, power delivering capacity and efficiency and number of stages. This work concentrates on design and simulation of a universal interleaved Buck-boost converter for green energy application which aims at framing a common converter structure using multi – stage interleaving technique, soft-switching circuitry and controlled duty cycle for different graded D.C. output voltages and varying power delivering capability with reasonable efficiency, so that a common green energy source can be utilized for different voltage and power rated devices within its range.

Keywords: Interleaved; Buck-Boost; Green Energy

165_IEC27011➲

Experimental Investigations on a Grid-Connected Microgrid with DFIG-based Wind Generator

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Introduction: Following the Paris Agreement on climate change (2016), worldwide effort for green energy deployment has picked up speed with solar and wind-based energy sources taking up major share. Wind energy conversion systems (WECS) are primarily of two types – the fixed speed and the variable speed. While fixed-speed type wind turbines gained popularity in the past due to their simplicity in construction, operation, and control; they suffered the drawback of higher power losses [1]. In contrast, variable-speed wind turbines based on doubly-fed induction generator (DFIG) have shown superior performance due to their higher efficiency, lower acoustic noise, reduced converter size [1], adaptability to variable wind speeds with maximum power point tracking (MPPT), reduced manufacturing and maintenance complexity [2], reduced shaft stress, controllable active and reactive power output from stator [3]. Several operational features and control schemes of DFIG based WECS are available in the literature. Authors in [1] have simulated a microgrid (MG) with DFIG as the WECS along with other components including solar, diesel generator, and battery. They analysed the system under varying operating conditions of wind speed and load. Simulation results were verified with hardware prototype in laboratory. S. Puchalapalli et al. in [2] worked with a MG structure similar to [1] where they proposed a DFIG control scheme with coordinated control of a voltage source converter (VSC) on rotor side and another VSC on load side. Authors in [3] have demonstrated the performance of a d-q axes rotor current PI controller based direct power controller (DPC) on a simple DFIG based experimental setup, both in stand-alone and grid-connected mode. They presented both simulation and hardware test results for transient as well as steady state performance of their proposed system. K. Khani et al. in [4] used an optimization algorithm for frequency control in an isolated microgrid containing DFIG along with other conventional sources. Their proposed wind-turbine speed controllers demonstrated superior frequency stability under varying degree of penetration of wind in the MG. Reference [5] used an adaptive neuro-fuzzy inference system to control rotor side converter (RSC) of DFIG for power balancing among different components of the MG they simulated. A. Akbari et al. [6,7] used vector control in d-q reference frame for judicious load allocation between multiple DFIGs in a DC MG that had another micro-turbine and DC loads. Reference [8] developed a constant switching frequency (CSF) model predictive control (MPC) in stationary ($\alpha - \beta$) reference frame with voltage-orientation for both the rotor side converter (RSC) and the grid side converter (GSC) in a DFIG-based WECS operating under both stand-alone as well as grid-connected mode. H. Shabani et al. [9] devised a unique circuit equation based equivalent model of DFIG for power system transient studies. The investigated the influence of wind speed and DFIG parameters on reactive power compensation properties of DFIG under grid disturbances. Authors in [10] presented simulation results of a grid-connected wind-farm containing six DFIG based wind turbines. Their results demonstrate the effectiveness of DFIGs to sustain constant output power level even under varying wind conditions.

The present contribution reports investigations performed on a grid-connected MG having DFIG based WECS as the source and variable R-L-C load. Performance of the DFIG under varying wind speed and varying load condition

is simulated in MATLAB-Simulink. Profiles of active power, reactive power, load current, and power factor are studied. Experimental verification of these performance parameters is carried out with a hardware setup consisting of DFIG emulator, 3-phase R-L-C type load box, and grid-emulator.

Keywords: Microgrid; Wind Energy; Doubly-Fed Induction Generator; Active and Reactive Power

166_IEC41721➲

Suboptimal Robust PD Controller Design of Stewart Platform Manipulator based Dual Axis Solar Tracker System with Semi-Isotropic Tool Center Point

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Abstract: This paper presents a robust PD controller for a Stewart platform manipulator based dual axis solar tracker system in the joint space taking into account for modeling error and uncertainty in payload inertia. The proposed methodology of finding suboptimal PD controller gains involves the successive use of genetic algorithm (GA) and Levenberg Marquardt algorithm (LM) optimizer, where the set of values of controller gains obtained from the former has been taken as a well-thought-out initial guess for executing the latter. The control scheme utilizes the Stewart platform model to enforce the PD control by means of computed feedforward control, which accounts for nominal leg inertia and friction in all the active and passive joints. Finally, the simulation results pertaining to the performance robustness of the resulting feedforward PD feedback controller are provided through the study of variation of isotropic property of the Stewart platform subjected to step roll demand under wide range of payload inertia variation.

Keywords: Stewart Platform: Semi-Isotropy; Computed Feedforward; Simulation Optimization; Robust Control

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203_IEC69302➲

A Productive Optimization Strategy for the Relay Coordination Issue

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Abstract: The strategies used to optimize the calibrating and synchronizing of protective relays so that failed power system can fail correctly in real-time operation which tells you how we could prevent the failures or shutdowns as soon and durability as it requires. Setting up Over Relays (OCRs) for applications using the old fashioned way can be quite complex, because of the different types of protection requirements and load situations that are often met in distribution grids.

Keywords: Over-current (OC); Relay Coordination (RC); Particle Swarm Optimization (PSO); Time-Dial Setting (TDS); Coordination Time Interval (CTI)

235_IEC72043➲

Model Development and Analysis of a Greenhouse Airconditioning System Coupled with a Desiccant-Coated Heat Exchanger and a Dew Point Indirect Evaporative Cooler

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Abstract: In hot and humid countries with tropical and subtropical climates, there is a sharp increase in the plea for air conditioning. The conventional vapor compression air-conditioning system consumes high energy as they are incorporated with overcooling and reheating. They are also harmful to the environment. So, alternate cooling technology is essential, as it has energy-saving potential and an eco-friendly nature. A desiccant-coated heat exchanger and Dew point indirect evaporative cooler combined system is a promising technology for greenhouse air-conditioning since both latent heat and sensible heat loads can be handled together. In this paper, a thermal model of a greenhouse is developed. The combined system can supply conditioned air to the greenhouse for the cultivation of strawberries. It is observed that the average greenhouse temperature can be obtained within 26℃ in the daytime on a hot and humid day in July, and the average greenhouse relative humidity can be maintained within 55-70%. The study highlights the need and viability of such systems for cultivating strawberries in tropical and sub-tropical climates that witness scorching and humid weather for a substantial part of the year.

Keywords: Greenhouse Air-Conditioning; Dew Point Indirect Evaporative Cooler

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296_IEC83032➲

Waves & Tides — God's Gift for Power GENERATI

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Abstract: The rapid growth in the entire field of lives of human being is electricity, which is primarily obtained using the once abundant & affordable fossil fuels like coal, oil and gas. The alarming situation is that the once abundant and affordable fuels were depleting rapidly and would soon become expensive to use. The World is rushing towards new source of power at any cost, either it Solar, Wind, bio-energy, etc. Fossil fuel shortages are heightening the need for renewable alternatives like wave and tidal energy generation besides many alternatives these two most important renewable energy sources are yet untouched in many ways by the world. Waves are formed when wind blows over the surface of water and the devices called wave energy converters capture the energy from waves and turned into electricity. Waves have the highest energy density of renewable energy sources. The estimated potential of tidal and wave power in India is 12,455 Megawatts (MW) and 41,300 MW, respectively and in the world it is beyond imagination, wave itself having potential of roughly 29,500 TWh annual power generation as per one estimate. Looking towards Tidal Power about ten to eleven Tidal Projects are generating more than 1000 MW using techniques like, (1)Tidal Barrage,(2)Tidal Stream Generator (3) Dynamic Tidal Power & (4) Tidal Lagoon. Some projects are under planning stage right now having huge potential of tidal power generation. Historically, tide mills have been used both in Europe and America. The earliest occurrences date from the Middle Age or even from Roman Times.

Tidal Power/Energy is a form of hydropower that converts the energy obtained from tides into useful forms of power-mainly electricity. In a simple manner we can say that this is the energy harnessed from ocean tides. As Tidal Power draws on the energy inherent in the orbital characteristics of the Earth-Moon system, it makes power generation very predictable, unobtrusive and reliable. In fact it is the only form of power generation that makes use of this Earth-Moon system. A variety of different technologies are under development throughout the world to harness the energy of Tidal waves. Tidal Power makes use of 60+ years of technology development pioneered by the sub-sea oil & gas industry and most recently the amazing development made by the offshore industry in efficient power transmission back to the shore. Looking at India‟s potential for tidal power generation, we can say that it has a tremendous scope to capture the Tidal Power but due to various financial challenges & high capital cost of Rs 30 to 60 crores per MW power generation something going wrong for this renewable source. Here the challenge comes for engineers of India to show their talent to become a path giver for other countries in this field of Tidal Power Generation. Why we are not putting our efforts to cultivate this technique for the betterment of next generation of Indian people? Why our technocrat's are not eager to develop indigenous, chip & comfortable techniques for tidal power generation, when we are able to reach at Moon. Looking to the present scenario of gap between world's power supply and its demand and less availability of fossil fuels all over the world, one must have to think for development of new renewable energy sources like geo-thermal, wave technology and tidal technologies to fulfil world's endless demand of electricity.

To boost such renewable energy sources, Government can provide funding for Research and Development to promote innovation, reduce costs, and improve the efficiency. They can also establish regulations and policies related to such energy, including environmental impact assessments, grid connectivity & permitting processes. Study on Tidal and Wave Energy in India -Survey on Potential and Proposition of Roadmap-conducted by IIT- Chennai in association with Credit Rating Information Services of India Ltd, suggested a roadmap to set up commercial tidal power projects by 2030. The tidal cycle takes place once every twelve hours as a result of the moon's gravitational pull. The difference in water depth between low and high tides is known as potential energy. To harness the full strength of the tidal energy potential, the high tide must be at least five metres higher than the low tide. India is very fortunate for having roughly 20 locations on the earth where the tides are this high. On Gujarat's west coast, the Gulf of Cambay and the Gulf of Kutch have maximum and average tidal ranges of 11 metres and 8 metres, respectively and may capture the Tidal Power Potential about 8000 MW of tidal energy including 8,200 MW in the Gulf of Kambhat & Gulf of Kutch in Gujarat respectively along with 100 MW in Sunder bans in West Bengal. Tidal power have lots of advantages like-Zero Greenhouse Gas Emission, usefulness for long duration about two billion years, predictable and constant, ensure a relatively steady power supply. Though the initial costs are extremely high it has a big advantage of ―mostly maintenance free over a life span of about 30-40 years. These Green technologies can boost economic growth, energy security, job creation, and global export. Wave energy can power various establishments such as oil & gas, defence bases, ports & harbours, and islands. It also has potential applications such as sea surveillance, coral reef regeneration, navigational buoys, and desalination. Producing green hydrogen from wave energy can also help reduce greenhouse gas emissions. At present about nine to ten Tidal power generation projects are there which generates about 900 MW using any one technique (1)Tidal Barrage,(2)Tidal Stream Generator (3) Dynamic Tidal Power & (4) Tidal Lagoon. Some projects are under planning stage right now having huge potential of tidal power generation. The renewable power generation sector has the potential to expand, boosting economic growth, lowering carbon footprints, and creating jobs not only along the coasts but also inland along supply networks. Though India is generating power through Solar, Wind and bio-gas but the Tidal Power is challenging all of us. Why we are not putting our efforts to cultivate this technique for the betterment of next generation of Indian people? Why our technocrat's are not eager to develop indigenous, chip & comfortable techniques for tidal power generation, when we are able to reach at Moon. Looking to the present scenario of gap between world's power supply and its demand and less availability of fossil fuels all over the world, one must have to think for development of new renewable energy sources like geo-thermal, wave technology and tidal technologies to fulfil world's endless demand of electricity.

Keywords: Renewable Energy; Wave & Tidal Power; Tidal Power Generation; India@2047

306_IEC31181➲

Potential for Generation of Solar PV Waste and its Effective Utilization in the Indian Context: A Literature Review

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Abstract: The rapid expansion of solar energy in India, driven by ambitious renewable energy targets, has led to increased deployment of photovoltaic (PV) systems. Consequently, the potential generation of solar waste, encompassing end-of-life PV modules and associated components, poses environmental and economic challenges. This literature review examines the current and projected generation of solar waste in India, explores existing waste management practices, and evaluates strategies for effective utilization and recycling. The review highlights the necessity for robust policies, technological advancements, and stakeholder collaboration to mitigate the adverse impacts of solar waste. Furthermore, it underscores the potential for resource recovery, job creation, and sustainable development through effective solar waste management. The findings suggest that proactive measures are essential to harness the benefits of solar energy while addressing the environmental implications of solar waste in the Indian context.

Keywords: Solar PV Waste; Photovoltaic Recycling; Renewable Energy; Waste Management

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330_IEC70796➲

Optimizing Mesh Geometry and Orientation for Fog Harvesting in Cooling Towers

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Abstract: Freshwater scarcity is one of the most egregious challenges facing society today. Cooling towers (CT) in thermal power plants are heavily implicated with industrial water losses, as they spew large quantities of water as fog droplets, from the CT cell. Fog harvesting meshes have offered a promising solution to capture a portion of this lost water. A fraction of the drift loss can be recovered by strategically placing optimally engineered meshes near the CT exits, reducing the CT water footprint. The key factors that influence the efficiency of fog harvesting include the mesh's shade coefficient, fibre diameter, and the mesh-inclination relative to the oncoming fog. This study aims to experimentally determine the optimal mesh characteristics for maximizing fog collection in a lab-scale fog tower that replicates actual cooling tower exit conditions.

Keywords: Fog Harvesting; Cooling Tower; Mesh Optimization; Collection Efficiency; Shade Coefficient; Mesh Inclination

331_IEC35695➲

Quantum Dot Solar Cell: Device Modelling and Efficiency Enhancement using CdTe Quantum Dots

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Abstract: The electrical and optical properties of a novel Quantum Dot solar cell (QDSC) using CdTe quantum dots were explored and simulated using the Silvaco TCAD software (version: 5.26.1.R). A proposed structure of a device comprises the incorporating of cadmium telluride quantum dots in the active layer that consists of Gallium Arsenide (GaAs) supported by the nickel oxide (NiO) hole transport layer and by the zinc oxide electron transport layer. QDSCs can accommodate multiple excitation generation (MEG) which helps in multiple carrier generation for one photon absorbed, which gives them the edge compared to other solar cells. Parameters extracted were power output efficiency of 36.95%, V_{oc} of 1.054 V, J_{sc} of 45.84 mA/cm², and a FF of 76.46%, under simulated illumination of AM1.5g at normal incidence. The structure ensured efficient charge separation, reduced the losses due to recombination, and showed maximum photon absorption for the wavelength range of 300–750 nm. I-V characteristic analysis, absorbance across different wavelengths, along with energy band profile, proved that QDSC was superior in its performance and scalability. This study provided the much-needed insight to design and optimize next-generation solar cells and highlighted the future possibility of QDSCs in advancing renewable energy technologies.

Keywords: Multiple Excitation Generation; Quantum Dot; CdTe Q-Dots; Silvaco TCAD; Energy Conversion Efficiency

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334_IEC82704➲

Enhancing Sparse Geothermal Gradient Data at Regional Geological Scales using Generative Adversarial Networks

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Abstract: Geothermal energy is a promising sustainable, low-carbon energy source with significant potential for global heating, cooling, and electricity generation. A critical component in assessing geothermal energy potential is the accurate mapping of geothermal gradients. However, current global geothermal gradient datasets are often sparse, particularly in underexplored regions, limiting comprehensive evaluations. This study leverages Generative Adversarial Networks (GANs), a class of deep learning models, to augment sparse geothermal gradient data in the Puga Valley, Ladakh, India — a region with limited existing geothermal data. By incorporating concentrations of radioactive elements (Uranium-238, Thorium-232, Potassium-40) and petrophysical properties (density, porosity, permeability, thermal conductivity, specific heat capacity) as input features, the developed GAN model generates synthetic geothermal gradient data. The augmented dataset will validate against wellbore measurements, demonstrating improved data density and reliability. The results indicate that GANs can effectively mitigate data scarcity, enhancing the accuracy of regional geothermal assessments and informing more strategic geothermal exploration and development initiatives.

Keywords: Renewable Energy; Geothermal Energy; Ladakh India; AI; Temperature Gradient

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348_IEC25110➲

Performance Enhancement of Rooftop SPV Power Plant by 3C (Continuous Cleaning and Cooling) Process

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Abstract: Dust deposition over solar PV module is one of a major matter of concern from the prospect of energy conversion from photon energy to electrical energy. Deposited dust particles over a solar PV module create a barrier and refuse to transmit solar irradiation through the glass cover of a module. This optical blockade due to deposited dust particles adds on the additional rise of surface temperature of the module, resulting efficiency drop and affecting power generation from a solar PV power plant. Enhancement of power generation under optimum techno-economic solution is possible by maintaining a scheduled solar PV module cleaning. However, cleaning and cooling make an enormous effect over the generation of a solar PV power plant. An 85 kWp solar PV power plant is identified in eastern India to realize the impact of 3C (continuous cleaning and cooling) process over generation from the solar PV power plant. A remarkable power generation gain is observed due to 3C process under nominal variation of incident solar irradiation and ambient temperature. Cleaning of solar PV modules of a power plant involves noticeable amount of usage of water. To avoid the wastage of water during the 3C process, a water recycling scheme is introduced in the solar PV power plant. This recycles 80% of wasted water to reuse water for further cleaning. This approach reduces water wastage at minimum count with an outstanding generation gain.

Keywords: Dust Deposition; Cleaning; Cooling; Power Generation; Module Temperature

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366_IEC83017➲

Decarbonizing Transportation: The Potential of Solar-Powered EV Charging for a Cleaner Future

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Abstract: The urgent need to reduce Green House Gas (GHG) emissions in the transportation sector, which relies heavily on fossil fuels, underscores the transition to Electric Vehicles (EVs) as a viable solution to achieve climate goals. This paper evaluates the environmental impact of a 30 kW solar-powered DC fast EV charging station and its potential to contribute to a sustainable transport system. It explores the carbon emission savings from such a station, with a 30 kWp solar PV plant estimated to generate approximately 38.325 MWh annually, offsetting nearly 36.8 tons of CO_2 emissions annually. In addition to reducing grid dependency, the shift to solar energy for EV charging supports energy resilience and peak demand management. The avoided emissions from Internal Combustion Engine (ICE) vehicles amplify these savings, with around 4.16 tons of CO_2 avoided per 100 EV trips replacing ICE trips of 250 km each. This model demonstrates a scalable solution for cleaner transportation, combining solar energy and EVs to significantly reduce carbon footprint. By establishing a renewable infrastructure for EV charging, the transportation sector can advance toward carbon neutrality, aligning with global sustainability objectives and promoting a greener future.

Keywords: Electric Vehicles; Carbon Emission; Solar Powered EV Charging

Power & Energy

Smart Energy Utilization Technologies

13_IEC00013A➲

Adaptive Intensity Control and Fault Detection in Smart Street Lighting

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Abstract: In this research, the authors introduce an intelligent street lighting system aimed at reducing total electrical energy consumption. The system functions by deactivating all streetlights during daytime and adjusting their brightness to 50% at night. It further modulates illumination based on the detection of vehicles and pedestrians, utilizing an Arduino-based Smart Intensity Monitoring (SIM) module installed in each light. This method significantly decreases unnecessary energy use, leading to lower energy production costs and reduced greenhouse gas emissions. Additionally, the system can pinpoint malfunctioning lights through their designated pole numbers, with this data being updated at a central cloud-based monitoring station.

Keywords: Smart Street Light; Fault Detection; Arduino; IR Module; Energy

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83_IEC45327➲

Case Study on Design and Analysis of Electrical Heat Tracing on Tank Roof Nozzle

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Abstract: In the present scenario, electrical heat tracing cables are used in a variety of industrial applications to maintain or increase the temperature of pipelines and vessels. The heating element, powered by electricity is physically connected with the pipe. There is a high demand for the heat tracing in the colder nations where the mercury level drops below zero. In one of the Coke Oven by product plant, there are three liquor storage tanks and one cold effluent tank with roof nozzles of varying diameter. As the cold nations experience freezing conditions, electrical heat tracing is essential for process pipes and vessels to maintain the required temperatures. The client had raised a query regarding the efficiency of the proposed electrical heat tracing design and the heat transfer rate on the surface of the tank as the client was apprehensive regarding the tank roof acting like a heat sink. The initial perception of client is to apply insulation over the entire tank. The client also suggested a new design by placing the thermal insulator in between flanges to decrease the heat transfer rate. Considering the process constraints and specific conditions, the heat loss calculations, the steady state thermal analysis and the comparative analysis with the thermal insulator in between flanges and without the thermal insulator has been done using Ansys R14.5. It has been found that as per the process constraints and prevalent conditions both the designs are acceptable and there was a minimum heat transfer rate to the surface of the tank. The temperature attained on the outer surface of the nozzle for the design without the thermal insulator is 80°C whereas the temperature attained on the outer surface of nozzle for the design with the thermal insulator is 47°C. The total heat flux generated is 31617 W/m² on the surface of the nozzle when the thermal insulator is placed in between flanges whereas the total heat flux of 58076 W/m² is generated for the design without thermal insulator. As an outcome of this analysis, the efficiency of the proposed heat tracing could be established and cost due to complete insulation of the entire tank could be avoided.

191_IEC93788➲

Performance Evaluation of Solar PV and Hybrid PV/T Systems: A Step to Enhance System Efficiency

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Abstract: This paper evaluates the technical viability of a water-based poly-crystalline silicon (PC-Si) solar photovoltaic-thermal (PV/T) hybrid system compared to a conventional PC-Si solar PV system. The hardware setup of both these systems, each of 560 Wp, is installed at NIT Srinagar (34.1217oN, 74.837oE). Analytical models of both these systems are developed using PVsyst software to assess the technical performances. The simulations demonstrate that the hybrid PV/T system operating at 40°C exhibits performance levels similar to those of a conventional PV system at 25°C, underscoring the superior efficiency of hybrid PV/T systems at higher temperatures. The hardware results confirmed the exceptional performance of the hybrid PV/T system, achieving an open-circuit voltage (Voc) of 71.9 V compared to 70.6 V for the conventional PV system. The results reveal that the (Voc) of the solar PV panel diminishes by 0.4409% with every 1°C rise in temperature. The hybrid PV/T system establishes its efficacy by supplying 7.44% more power than a conventional PV system when subjected to the same load. These findings highlight the dominant performance of the hybrid PV/T system compared to conventional PV systems, indicating an optimistic outlook for its application in improving energy efficiency and sustainability in solar energy solutions.

Keywords: Solar Photovoltaic (PV); Solar Photovoltaic-Thermal (PV/T); PVsyst Software; Sustainable Development Goal (SDG) 7; Efficiency Improvement

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255_IEC36399➲

3D Mixed Convective Analysis in a Vented Cavity with Heated Baffles using a Higher-Order Super Compact Scheme

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Abstract: This work presents a computational analysis of 3D mixed convective heat transfer in a vented cavity with heated baffles, which has applications in building ventilation systems, electronic cooling, automotive thermal management, and industrial heat exchangers. The cavity used in this study has an inlet at the bottom right wall and an outlet at the top left, both of non-dimensional length 0:1. Three vertical heated baffles are positioned near the center of the cavity with constant heat as shown in the schemaic diagram of the problem (Fig.1). The focus of the investigation is on understanding the interaction between forced convection, driven by the inlet-outlet conguration, and natural convection due to the temperature differences generated by the heated baffles. The simulations are carried out for varying Reynolds numbers (Re) and Richardson numbers (Ri), enabling an exploration of how different flow regimes (dominated by either forced or natural convection) impact the thermal and flow behavior in the cavity. A new Higher-Order Super Compact Scheme (HOSC) is used to solve the governing equations, offering enhanced accuracy in capturing the complex flow structures and heat transfer characteristics. Results are presented in the form of streamlines, isotherms, local Nusselt number and total Nusselt number. Results demonstrate significant variations in flow behavior and heat transfer efficiency depending on the relative strengths of the natural and forced convection, influenced by the interplay of Re and Ri values. The findings of this study provide valuable insights into the optimization of mixed convection systems, particularly in engineering applications where heat dissipation is a critical concern.

Keywords: 3D Mixed Convection, Heated Baffles, Higher Order Super Compact Scheme, Nusselt Number, 3D Vented Cavity

259_IEC89821➲

Numerical Investigation on Employment of Cavities on Sidewalls of the Microchannel Heat Sink and Parametric Study of the Cavities on the Effect of Performances of the Heat Sink

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Abstract: Numerical modeling and analysis of flow characteristics and heat transfer performances in a rectangular microchannel with cavities are done in this investigation. Performance of four different cases having cavities on their sidewalls are examined by varying the width and depth of cavity in a rectangular microchannel and comparative study with respect to plain rectangular microchannel has been carried out. Microchannel with cavity exhibits better performance than plain rectangular microchannel in all respect. Furthermore, the microchannel with depth of cavity 50 µm and width of cavity 150 µm shows better performance amongst all. Considered as the optimum channel, this channel exhibits around 10% higher Nusselt number (Nu) and heat transfer enhancement factor (η) than the plain rectangular channel. The formation of suitable vortices inside the cavity which indirectly influences the phenomenon such as enhancement of heat transfer, distributions of fluid velocity, pressure and temperature is found largely dependent on the depth and width of the cavity in the microchannel. Water is taken as working fluid and Silicon is considered as the substrate material in the present study. Knudsen number (Kn) for water under present conditions is less than 10-3 and so no slip boundary condition is assigned for the surfaces. The range of Reynold's number (Re) taken in the study is around from 150 to 650. The SIMPLEC method is used in the Fluent solver.

Keywords: Microchannel Heat Sink; Heat Transfer Enhancement Factor (η); Nusselt Number (Nu); Cavity, Friction Factor (f)

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271_IEC600➲

Development of Energy-Efficient Heating Surfaces of Aluminium

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Abstract: In the present era, scientists are carrying out research for finding the energy efficient heating surfaces made of different materials. This study examines the pool boiling performance of bare aluminum and Al_2O_3 nano-coated surfaces using refrigerant R-600a. Al_2O_3 nano-coatings were applied through the dip coating method, and the crystal structure of the coated surfaces was analyzed using scanning electron microscopy (SEM), while energy dispersive spectroscopy (EDS) was used to determine the element distribution. The Al_2O_3 coatings, with thicknesses of 100 nm, 200 nm, and 300 nm, exhibited improvements in the heat transfer coefficient (HTC) by 25%, 28%, and 35%, respectively, compared to the bare aluminum surface. This HTC enhancement was attributed to the increased surface roughness and the higher density of nucleation sites on the nano-coated surfaces. While some variations from previously published HTC data were noted, publicly available data were used to help predict experimental outcomes. As surface modification continues to progress in energy conversion and thermal management, this research will become increasingly relevant in the coming years.

Keywords: Surface roughness, Pool boiling, Micro-cavity, Microstructure, Enhancement. Heat transfer co-efficient

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Simulation of Bottom Hole Pressure in Managed Pressure Drilling through MATLAB -SIMULINK

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Abstract: Managed pressure drilling process an adaptive technique to control the bottomhole pressure based upon the changes in the density and the bulk modulus of the fluid in the annulus and the drill string. Mananged Pressure Drilling, commonly known as MPD, is comparatively new technology which is very important for mining process. A mathematical model is used to establish the relationship between the two controls volumes considered in the dynamic system. The amount of variation in the pump pressure, choke pressure, bottomhole pressure and the flow rate with respect to change in density and bulk modulus is determined. The variation in the pressure factors with respect to the variation in the height of the vertical drill bit which influence in swap and surge pressure is calculated. The necessity of maintaining the desired flow rate at each instant is determined through the variation in the bottomhole pressure. The rate of change of pump pressure, choke pressure and flow rate is determined.

Keywords: Managed Pressure Drilling; Bottomhole Pressure; Dynamic System; Adaptive Technique; Pressure Determination; MATLAB –SIMULINK

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Low-Cost Self-Cleaning System for Efficiency Enhancement of Onboard Smart Nanogrid in Green Transport

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Abstract: Growing concerns over fossil fuel impact and fuel demand have driven research into renewable energy solutions like solar PV for charging electric vehicles, particularly in remote areas, offering a sustainable alternative for green transportation. However, the accumulation of dust, dirt, and bird droppings on solar panels significantly reduces their performance, especially in regions with high solar irradiance. This paper presents a low-cost automated self-cleaning system designed to enhance the efficiency of onboard solar photovoltaic (PV) panels in green transport, specifically light electric vehicles (LEVs). The proposed system integrates an automated cleaning mechanism with smart sensors to optimize energy capture, ensuring consistent power output. The cleaning process is controlled by a microprocessor that activates the system based on voltage and dust levels detected by sensors. The system operates in both automatic and manual modes, providing flexibility in different environments. Experimental results demonstrate a 14.45% increase in solar energy harvested after cleaning, making the system highly effective and economically viable. The study may also be used to model self-cleaning mechanisms in applications that required solar PV panels.

Keywords: Automated Self-Cleaning; Enhanced Efficiency; Light Electric Vehicle; Solar PV

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