Abstracts of the 29th International Congress on Condition Monitoring and Diagnostic Engineering Management (COMADEM 2016) held in Xi'an, Shaanxi, P.R. China – Part 3

COMADEM 2016 was hosted by Xi'an Jiaotong University located in Shaanxi Province of China during the 20th to 22nd August 2016. More than 240 delegates participated in this event. Refereed technical papers numbering more than 100 covering various themes such as Monitoring, Diagnosis, Prognosis and Health Management, System Fault Diagnosis and Control, Advanced Signal Processing and Big Data Technology, Maintenance Engineering, Technologies and Integrated Systems, Modelling, Analysis and Optimization, Risk, Safety Assessment and Management and Sensor Technologies, Damage Detection were presented. Abstracts of some of the papers presented in this event were published in the previous issues of the journal in Part 1 and Part 2.

Wear testing methods and on-line monitoring study of Wet Clutch Friction Plate

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Abstract: In this paper the authors have designed a test system and developed a method to monitor the wet clutch friction plate temperature and oil wear particles on line. A hydraulic flexible system is used as the dynamic input. To monitor the wear particles in oil an on-line monitoring sensor was used.

Key words: wet clutch; hydraulic flexible connector; wear and temperature monitoring

Rolling Bearing Fault Feature Extraction method based on Synchrosqueezed Wavelet Transform

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Abstract: In this paper, a novel method based on Synchosqueezed Wavelet Transform (SST) is proposed. SST was proposed by Daubechies in 2011 and it is a combination of wavelet transform and reassignment. It is a time-frequency reassignment algorithm and it supports signal reconstruction, which is different from the original reassignment algorithm. This is done by transforming the rolling bearing vibration signal into envelope spectrum using the Hilbert Transform. The envelope signal is decomposed into different intrinsic mode tpe function using the SST. The results reveal that this method is superior to the traditional empirical mode decomposition.

Keywords: Feature extraction; rolling bearing; Synchrosqueezed Wavelet Transform; intrinsic mode type function; fault characteristic frequency

Research on Machining Centre Spindles Condition Monitoring System based on Wavelet Theory

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Abstract: This paper establishes a spindle condition monitoring system based on wavelet theory. The hardware system consisted of wireless vibration sensor, current transformer,

temperature transmitter and frequency transducer. The data was transmitted to an industrial computer through PCI data acquisition card. The results of the cutting experiments are presented in this paper.
Keywords: Machining center spindles; condition monitoring; cutting experiments; signal analysis

The Fault Diagnosis of Rolling Bearing based on Synchrosqueezing Cross Wavelet
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Abstract: In this paper the authors present a new feature extraction method based on Synchrosqueezing Cross –Wavelet. First, the compressed the pre-processed vibration signal. Then the synchrosqueezing transform spectrum was processed by cross wavelet transform. This method combined the high resolution of synchronous compression transform in time-frequency domain and the noise immune ability of cross wavelet, making the signal time-frequency spectrum had both good time-frequency aggregation, and can eliminate the random noise interference. The experimental results showed that the proposed method can enhance fault characteristic frequency in time-frequency domain and thus realize accurate and reliable diagnosis of the bearings faults.
Keywords: Rolling bearing; Synchrosqueezing Transform Cross-Wavelet Fault diagnosis

Condition Monitoring of Closed Metal Structure based on Ultrasonic Technology
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Abstract: A new condition monitoring technology is used monitor the closed metal structure using ultrasonic technology. By using this technique data communication could be achieved without physical penetrations. This paper is focused on the key technology of high reliability communication through a metal wall using ultrasound. A bi-directional data transmission method is employed. Stochastic resonance theory is used to improve the reliability of digital signal in a noisy background.
Keywords: Closed metal structure; wireless communication; energy harvesting; impedance modulation

A Fault Diagnosis method based on WPD and t-SNE
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Abstract: A fault diagnosis method based on the method of time-frequency analysis and manifold learning using vibration signals from rotating machinery is presented. To construct high dimensional data vectors as matrix, the sampled vibration signal is decomposed into multilayer information based on Wavelet Packet Decomposition (WPD) method. The matrix structure is different for different fault conditions. In order to extract the modulation signal at every level, wavelet decomposition is processed by using envelop demodulation of Hilbert, FIR filter and resampling. Autocorrelation computation and normalization methods are used to construct high dimensional data vectors at every level. Finally, the manifold learning methods of t-distributed Stochastic Neighbour Embedding (t-SNE) is applied to carry out dimensional reduction to generate 2D visualization manifold map. The generated map of vibration signal is applied to diagnose faults in rotating machinery. The feasibility and effectiveness of this method is discussed in this paper.

Keywords: Wavelet Packet Decomposition (WPD); t-distributed Stochastic Neighbour Embedding (t-SNE); Visualization fault diagnosis method; rotating machinery.

Grinding Burn Identification based on Acoustic Emission

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Abstract: Grinding burn is a general phenomenon during machining process. It induces great damage to metallic structures. Hence grinding burn monitoring is very important to improve the product quality. Acoustic Emission (AE) is widely used to monitor grinding burn. However, the AE signals from grinding process are contaminated. A laser experiment is set up pure metha burn signals. Three degrees of burn are produced by laser (a) no burn (b) slight burn and (c) severe burn. The characteristic AE parameters are extracted by using the Empirical Wavelet Transform (EWT). Principal Component Analysis (PCA) method is applied to classify the degrees of burn. Using this methodology different levels of grinding burn are successfully classified.

Keywords: Grinding burn identification; Acoustic Emission; Empirical Wavelet Transform (EWT); laser

A Feature Extraction approach for Fault Diagnosis of a Planetary Gear Set

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Abstract: The aim of this paper is to apply feature extraction approach to diagnose and prognose failures induced in the planetary gears used in the helicopter transmission system. A methodology based on the dynamical model with faults seeded is adopted to generate run-to-failure data. Statistical algorithms are used to evaluate the feature parameters. First, the dynamical model of a planetary gear set with seeded fault was developed. Then the run-to-failure data was obtained from the simulation results of the model. Relevant feature parameters were extracted using statistical algorithms.

Keywords: Planetary gear; dynamic model; feature extraction; failure diagnosis; statistical algorithms

The application of Variational Mode Decompositon for Diagnosing Rub-Impact fault of Dual-rotor system based on Acceleration measurements

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Abstract: In the case of aero engines it is relatively difficult to directly measure displacement signals. In this paper the authors have used a dual-rotor system test ring to simulate the rub-impact and the acceleration signals collected from the bearing pedestal are analysed to extract the characteristics of rubbing faults. A novel method of diagnosing rubbing faults based on Variational Mode Decomposition (VMD) is proposed. VMD is a newly developed technique for adaptive signal decomposition which can non-recursively decompose a multi-component signal in to a number of quasi-orthogonal intrinsic mode functions. When the rub-impact

between the rotor and stator occurs in the dual-rotor system, the amplitude modulated feature will be embedded in the acceleration signals. VMD is then applied to detect multiple rubbing signatures. The paper presents how the noise signals can be separated from the rub-impact signals to reveal the faults induced by rub-impacts.
Keywords: Dual-rotor system; rub-impact; failure diagnosis; Variational Mode Decomposition; amplitude measurement; acceleration measurements

The Fault Diagnosis of Aero-engine Intershaft Bearing on EEMD and Fastica
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Abstract: The vibration signals obtained from the aero-engine bearing dual-rotor test stand has a low signal to noise ratio (SNR). Hence it is difficult to extract the fault features from such poor signals. This problem has been resolved by applying Blind Source Separation (BSS) technique based on Ensemble Empirical Mode Decomposition (EEMD) and Fast Independent Component Analysis (FastICA). The effectiveness of this proposed method is discussed in this paper.
Keywords: Aero-engine; intershaft bearing; Ensemble Empirical Mode Decomposition (EEMD); Fast Independent Component Analysis (FastICA); fault diagnosis

Rolling Bearing Operation Reliability assessment based on the Normalised Wavelet Information Entropy
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Abstract: This paper puts forward a method which employs the normalised wavelet information entropy to evaluate the operational reliability of rolling bearings using small samples. In order to establish the relationship between information entropy and the reliability, this paper utilizes second generation wavelet transforms to denoise the vibration signals from the rolling bearings. After de-noising the fault features become more apparent and as the fault increase the reliability decrease.
Keywords: Rolling bearing; information entropy; second generation wavelet; fault diagnosis; reliability

Research on a Fault Diagnosis method based on DT-CWT and SVD for Wind Turbines
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Abstract: Aiming at the difficulty to extraxt the fault feature frequencies from vibration signal of wind turbine transmission, a new fault feature extraction and denoising method based on the Dual Tree Complex Wavelet Transform (DT-CWT) and the Singular Value Decomposition (SVD) is proposed. Because of the non-stationarity and modulation characteristics of fault signals, the original vibration signal is decomposed into several different frequency band components by Dual Tree Complex Wavelet Transform. Then for the layered signal containing fault characteristic frequency, Hankel Matrix is constructed and decomposed by using the SVD to eliminate noise and reconstruct the signal. Finally, the fault characteristic frequency is identified accurately by the Hilbert Envelope Spectrum. Both the experimental and simulation shows that this method is effective for wind turbine transmission fault feature extraction.

Keywords: Wind turbine gearbox; failure diagnosis; Dual Tree Complex Wavelet Transform; Hankel Matrix; Singular Value Decomposition

Rolling Bearing degradation trend Prognostics based on Cumulative Transformation

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Abstract: The performance of data-driven prognostics approaches is closely dependent on the trend of extracted features. To achieve significant trend features, a new algorithm mapping raw vibration data into trend cumulative features is proposed. Feature selection based on monotonicity and trendability measurement criteria are then calculated to get a degradation index which is used as input of Support Vector Regression (SVR) model for prognostics. The rolling bearing run-to-failure experiments are carried out and the results show that the method can effectively and accurately predict the degradation trend of rolling element bearings.

Keywords: rolling bearing; degradation trend prognostics; cumulative transformation; feature selection

Online Condition Monitoring of Gas Circulation Fans in Hardening Process

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Abstract: Vibration analysis and the Shock Pulse Mehod (SPM) are two of the most popular condition monitoring techniques used in Condition Based Maintenance (CBM) policy, especially for rotating equipment. To illustrate the extent to which advanced CBM techniques are applicable and cost effective in a manufacturing company, a real-time pilot project was undertaken. This pilot project was performed at a large manufacturing site in Sweden. This paper presents some of the main findings of the online condition monitoring of the fans for a period of two years. Consequently, based on the empirical data, the company was able to gain great benefits due to preventing production losses by preventing breakdowns of the fans.

Keywords: Gas circulation fans; condition monitoring, condition based maintenance; vibration monitoring; shock pulse method; manufacturing

Feature Mining with Convolutional Neural Network for Bearing Fault Diagnosis

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Abstract: Rolling element bearings operate in very harsh operational environments. Gathering sensitive features is still a great challenge for effective failure diagnosis of rolling element bearings. This paper propose a novel feature mining methods based on Wavelet Packet Energy (WPE) image and Convolutional Neural Network (CNN) for bearing fault diagnosis. Wavelet packet transform is first applied here to rebuild the WPE of the frequency subspaces in a 2-D image space. This special image reconstructs the local relationship of the WP nodes and retain the energy fluctuations of the signal. The CNN is used to sense the local kernels and learn the essential identifiable characteristics from this special architecture. The results shows that the proposed feature mining method is suitable for bearing fault diagnosis regardless of load fluctuations.

Keywords: Rolling element bearings; feature extraction; convolutional neural network; wavelet packet energy image; failure diagnosis

An ARDE based method for Bearings Fault Diagnosis under Variable Speed condition

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Abstract: Envelope analysis is a widely used method for fault feature extraction of bearing at a steady rotational speed. However, the rotational speed of bearing fluctuates with the variation of working condition, which leads to the phenomenon of daub in envelope spectrum. In this paper, the Angular Domain Resampling Envelope (ADRE) method is introduced to investigate how the rolling element bearing operate under variable rotational speed conditions. Firstly, the rotational non-stationary vibration signal in time domain is transformed into stationary signal in angular domain by resampling. Secondly, the envelope spectrum of the angular domain is obtained by Hilbert Transform (HT) and Fast Fourier Transform (FFT). In order to consistently and distinctly identify the fault which is not clearly visible in the envelope of the time domain signal, the peaks of Fault Characteristic Order (FCO) are shown in the envelope spectrum of angular domain signal.

Keywords: Rolling element bearings; variable speed conditions; angular domain resampling; envelope analysis, fault characteristic order.

On the Evolutionary Adaptive Noise Cancellation Algorithms

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Abstract: The Adaptive Noise Cancellation based Evolutionary Digital Filter (EDF-ANC) can optimally eliminate the noise and improve the Signal-to-Noise Ratio. This paper gives an overview of the EDF-ANC and the related improved algorithms to obtain better de-noising performance and convergence behaviour. The de-nosing performance and convergence behaviour of the proposed improved methods are compared with simulated signals.

Keywords: Evolutionary digital filter; Adaptive noise cancellation; algorithm review

Bearings Condition Trend Prediction based on Feature of Spectrum Demodulation

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Abstract: Condition trend prediction of rolling element bearings play an important role in real-time machinery monitoring and predictive maintenance. In this paper, the authors have presented a method based on wavelet neural network and Local Mean Value Decomposition (LMD) with Singular Value Decomposition (SVD). The rolling bearing vibration signal is decomposed to different nodes by applying the wavelet packet analysis to establish rolling fault band. Based on the feature of spectrum demodulation, a condition trend prediction method is proposed and the accuracy and validity of the prediction model is discussed.

Keywords: Bearings; condition trend prediction; wavelet neural network; local mean value decomposition; singular value decomposition

Continuous Condition Monitoring of High Voltage Transformers by Direct Sensor Monitoring of Oil Aging For a Stable Power Network

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Abstracts: The new online oil sensor system, OilQSens®, enables continuous condition monitoring and power grid protection of high voltage transformers by sensor monitoring of oil aging. The requirements for transformers in the renewable energy is on the increase. Ever more flexibility, operational reliability and a long life are required of them. So, the demand for the transformer oil grow correspondingly. The new online oil sensor system measures the components conductivity kappa, dielectric constant epsilon r and temperature T independently and calculates the break-down voltage, loss angle tan delta, acidification and the humidity. The new approach utilizes sensor detection of chemical aging of the insulating oil and its inhibitors. Based on a very sensitive measurement method with high accuracy even small changes in the conductivity and dielectric constant of the transformer oil composition can be detected reliably. The new sensor system effectively controls the proper operation conditions of High Voltage Transformers, oil filled circuit breakers and oil regeneration systems.
Keywords: High voltage transformers; condition monitoring; sensor monitoring; OilQSens

Quasi-OCVT technique for Damage Detection of Beam-like Structures

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Abstract: A Quasi-optical Coherence Vibration Tomography (Quasi-OCVT) measurement system for structural damage detection was investigated using the concept of two-dimensional OCVT technique. A printed Quasi-Interferogram Fringe Pattern (QIFP) which is similar to the interferogram of 2D-OCVT system was used as a sensor. This was pasted on the surface of the vibration structure. A high-speed camera was used as a detector to capture the image sequence of the QIFP. As the period density of the imaged QIFP changed, due to the structural vibration, the structural vibration information was obtained. The system was used to monitor the vibration of a beam-like structure with a roving auxiliary mass. The frequency shift curves obtained by the proposed method was in good agreement with the ones obtained by the Finite Element Method (FEM). This investigation confirmed that the damage location of the beam-like structures could be obtained by employing the Quasi-OCVT technique.
Keywords: Beam-like structures; Vibration monitoring; damage detection; Quasi-optical coherence vibration tomography; frequency shift

Improved Empirical Wavelet Transform based Rotor Rubbing Fault Diagnosis

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Abstract: Empirical Wavelet Transform (EWT) is a novel method for analysing multi-component signals. In this paper, an adaptive separation of Fourier Spectrum in EWT called an improved EWT (IEWT) is introduced. The IEWT is composed of two parts; adaptive segmentation of Fourier Spectrum and WT based filter group. By using the simulation signal, the IEWT is compared with Empirical Mode Decomposition (EMD). The results have demonstrated the effectiveness of the proposed method. The method was then applied to diagnose the failures induced by rotor rubbing. Encouraging results have been obtained.
Keywords: Rotor rubbing; failure diagnosis; empirical mode decomposition; empirical wavelet transform

Adaptive Multiwavelet for detecting Transient Impulse Responses of Wind turbines

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Abstract: Due to the characteristics of spectral diversity and complexity as well as the amplitude and frequency modulation nature of vibration signals of wind turbines, diagnosing early failures becomes a challenging task. Multiwavelet is a powerful tool to extract the non-stationary fault features. However the existing predetermined multiwavelet bases are independent of the vibration measurement and the sensor-based dynamic response signals make the result imperfect. To overcome this drawback, this paper proposes an adaptive multiwavelet method by taking a new index which combines Minimum Quantizing Error (MQE) with spectral entropy as target in the construction process. MQE shows the minimum distance between definition and input vector, and spectral entropy reflects the uniformity of the probability distribution. Based on the lifting scheme and taking maximum index as the optimization objective, optimal multiwavelet can be constructed for best matching the rolling bearing fault. Moreoever, benefitting from the valuable features of the Hilbert Transform Demodulation analysis of the multiwavelet decomposition results, the fault features are extracted. The effectiveness of this proposed technique is validated via numerical simulation.
Keywords: Wind turbine; transient impulse response; adaptive multiwavelet; failure diagnosis

Spatial Location Identification of Clearance Nonlinearities for a Continuum Structure
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Abstract: Due to the need of the assembly and lubrication, clearance is unavoidable in engineering structures. These clearances can cause deviation between the deal position and the actual position of structures to degrade the dynamic performance. Parameter Identification of clearance nonlinearity would prove better understanding of dynamic behaviours of the clearance and contribute significantly for the control of the induced disturbance and deviation. However, the spatial location of clearance nonlinearity which may not always be known beforehand is the important basis for the parameter identification, and obtaining this information is not an easy task, especially for continuum structure. In this paper, based on the characteristic of clearance nonlinearity, a two-step identification method is proposed to detect the location of clearance in a continuum structure. For the proposed approach, the clearance-nonlinearity force is regarded as the internal feedback force, and the multiple coherence function is used to find the approximate location of the clearance nonlinearity. Afterwards, four sensors are respectively rearranged on both sides of the approximate location, and the amplitude indices are utilized to determine the precise location of the clearance nonlinearity. The feasibility of the proposed method is verified by simulation data from a continuum structure with clearance nonlinearity.
Keywords: Continuum structure; clearance nonlinearities; location identification

Use Case Study for Wind Farm Condition Monitoring
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Abstract: Given capability to detect early defects of wind turbines in advance of developing to real failure, remote condition monitoring can dramatically reduce downtime losses and maintenance expenditure for wind farm operator. Meanwhile condition monitoring constantly send false alarm to misguide maintenance activity, which would oppositely increase operating

cost. Hence it's worthwhile carrying out a comprehensive techno-economic analysis to analyse the cost efficiency of remote condition monitoring for wind farm operator. A generic procedure to solve the problem is proposed in the paper with consideration of key factors for example failure rate of wind turbine, detection rate of monitoring technique, repair cost for early defect detection, false alarm consequence, influence of efficiency reduction on power generation, etc. Besides, minimum required detection rate and maximum endured equipment cost are also evaluated to guide the online monitoring system design.
Keywords: Wind farm; condition monitoring; techno-economic analysis; cost efficiency

Research on the Severity Evaluation method for Defective Bearing
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Jiangxi Agricultural University, Nanchang, China
Abstract: Different severity of outer ring defects exist in the roller bearing. When the defects differ from each other distinguishing the defects becomes very challenging. It is very difficult to identify the defects when the signals are in the time domain form. In order to assess the severity of defects the time domain index is proposed in this paper. Firstly, a nonlinear dynamic model of rolling bearing is established. Using this model different severities are simulated. Finally the severity values of the large and small defects are established.
Keywords: Rolling bearing; outer ring defects; single impact; severity index

Rolling Bearing Fault Diagnosis based on Laplacian Score and Adaptive Juzzy C-Means Clustering
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Abstract: Rolling element bearing are key components of rotating machinery. For the non-stationary features and the problem of feature selection for high dimensional data of the vibration signals of a bearing with faults, a fault diagnosis method based on Laplacian Score and Adaptive Fuzzy C-Means Clustering (FCM) is proposed in this paper. Firstly, nine typical time domain parameters of vibration signals are calculated, from which an initial feature vector is formed. Secondly, by applying Laplacian Score method to the initial feature vector, the optimal fault feature vector is obtained. Thirdly, by using Adaptive FCM Clustering to the fault feature vector, the optimal clustering number and centres are obtained and then different fault patterns are classified. Finally, the fault pattern has been identified by calculating the Hamming Nearness Degree between the unknown fault samples and known fault ones. Experimental results showed the effectiveness of this method in diagnosing rolling bearing faults.
Keywords: Rolling bearing; fault diagnosis; time domain parameters; adaptive fuzzy C-Means clustering; Laplacian Score; Hamming Nearness Degree

The Axle AE Signature Feature Extraction based on the LMD and Demodulated Resonance Technique
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Abstract: To characterize the Acoustic Emission (AE) signal, a new approach of combining the method of resonance demodulation and Local Mean Decomposition (LMD) is presented in this paper. The LMD is used to decompose the AE signal into several PF components and a

residual. The energy in each PF component is calculated to draft the percentages of each component on total energy. Based on the Demodulation Resonance technique most energy which is embedded in PF components is extracted. The effectiveness of this new method is discussed in this paper

Keywords: Acoustic emission signal; feature extraction; local mean decomposition demodulated resonance

Automatic Condition Monitoring method for Rolling Bearings

Dawei Gao, Yongsheng Zhu, Ke Yan, Chuang Gao, Penghui Cao and Yuwei Liu
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Abstract: The authors propose a new monitoring method to diagnose failures in rolling element bearings based on the correlation coefficient of envelope spectrums. Both continuous and automatic monitoring methods have been used. Auto-Regressive (AR) model is used to observe the break points in correlation coefficient of envelope spectrums. The validity of the proposed method is discussed in the paper.

Keywords: Rolling bearings; Automatic condition monitoring; envelope spectrum; correlation co-efficienct; aut0-regressive model

Advanced Fault Diagnostic techniques for Centrifugal Compressor

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Author: Centrifugal compressors have been widely employed in the industrial field and can be a core component in petrochemical and industrial processes. However, breakdowns or deteriorated performance of centrifugal compressors can be bring significant adverse impacts on the profitability of a business. This paper presents the working principle and common faults for centrifugal compressors. The state-of-the-art fault diagnostic methods for each fault are reviewed. Furthermore, condition indicators which are helpful for diagnosis are recommended. The paper provides an applicable guide for setting up a systematic condition monitoring and fault diagnosis system in industries.

Keywords: Centrifugal compressors; condition monitoring; vibration analysis; performance analysis

31st International Congress and Exhibition on Condition Monitoring and Diagnostic Engineering Management
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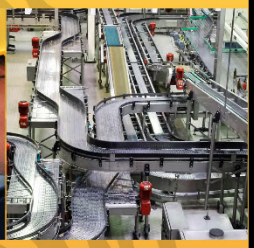

COMADEM International is inviting technical papers for the 31st COMADEM congress on condition monitoring which will be held in sunny South Africa. Authors are invited to submit original, unpublished research on condition monitoring and diagnostic engineering management to be presented to the global condition monitoring forum at this conference. All contributions will be peer reviewed and all accepted papers will be published in the conference proceedings. Selected papers will be considered for publication in the on-line version of the International Journal of COMADEM. Industrial exhibitors are encouraged to exhibit their latest products and services.

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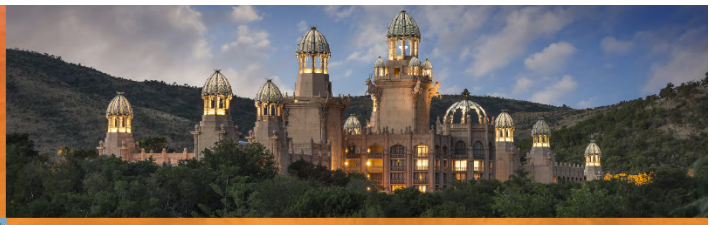


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Notification of acceptance of full papers:	27 April 2018
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