Development of Computerized Maintenance Management System for Thermal Power Plant, Yamunanagar

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The current methods for recording and maintaining data are often laborious, inefficient, and time-consuming when done manually. Software solutions greatly improve maintenance planning and execution. Computerized Maintenance Management Systems (CMMS) and Enterprise Asset Management (EAM) are essential tools for planning, controlling, and scheduling maintenance activities. These systems reduce downtime, streamline work order management, optimize inventory control, reduce paperwork, extend equipment lifespan, lower lifecycle costs, and improve risk management. This paper explains the development of a customized CMMS for a thermal power plant. Effective asset management requires comprehensive design, quality inventory, and high service efficiency through systematic inspection and maintenance. Implementing such systems eliminates manual data entry, saving time by automating calibration processes and maintaining records through continuous online monitoring of plant activities.

Introduction:

In the current age of technological progress, automation has permeated every industry, resulting in machines increasingly supplanting human labour. Consequently, the significance of maintenance has been accentuated. In today's cutthroat market, the operational availability and reliability of machines or equipment are pivotal determinants. Despite this, maintenance is frequently overlooked, leading to frequent breakdowns, prolonged downtime, deficient work order management, burdensome record-keeping, equipment deterioration and exorbitant costs. Maintenance embodies a recurring process essential for upholding a specific machine or system in its optimal operating condition, thus ensuring consistent performance without time loss due to accidental damage. This approach facilitates the creation of a

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hassle-free environment that is conducive to the organization's pursuit of its objectives.

Computerized Maintenance Management System

Efficient preventive maintenance is facilitated by implementing a Computerized Maintenance Management System (CMMS). Strategies like Total Business Maintenance (TBM), Reliability Centered Maintenance (RCM) and Condition-Based Maintenance (CBM), along with CMMS, optimize production, reduce costs and improve maintenance planning and control. CMMS enables swift reporting and immediate action by continuously monitoring field devices, preventing breakdowns and production halts. It maintains comprehensive equipment histories for meticulous planning and enhances managerial oversight by minimizing paperwork.

Integrating CMMS with IoT and AI enables predictive maintenance and real-time analytics. CMMS manages maintenance schedules, policies, standards, inventory & plans, and is accessible to maintenance managers, asset planners and inventory managers. This paper focuses on developing a CMMS for a specific plant.

Literature Review

Gupta and Tewari (2007) implemented a CMMS within the sugar industry, focusing on reducing downtime, lowering total maintenance costs, and minimizing failure frequency to better predict maintenance budgets and policies. Following this, Tumiran (2008) designed a CMMS to digitalize customer connections, distribution line networks, asset inventories, and manpower management. This system, supported by Geographical Information System (GIS) technology, was particularly beneficial in developing countries such as Indonesia, where it reduced system restoration time during faults. Initially, GIS applications were developed, followed by integration with customer service, payment systems and power failure services. Kundu et al. (2011) conducted a comprehensive study on the root causes of failures in thermal power plant units. The software was developed in Java Server Pages which included modules for equipment details, Preventive Maintenance (PM) tasks, PM task schedules, work orders, employee overhaul schedules and critical issues.

Yadav and Tewari (2017) described a general framework of CMMS for a National Thermal Power Plant. It wasn't easy to maintain the record of data and retrieve it. CMMS software was used for this purpose which led to efficient planning of maintenance aspects along with controlling and scheduling of maintenance activities. Patel and Kumar (2020) investigated the use of CMMS in the automotive industry. Their findings highlighted the potential of CMMS to enhance maintenance strategies and reduce downtime through intelligent data analysis.

Nguyen et al. (2021) examined the role of CMMS in the utility sector. Their study showed how CMMS could facilitate better asset management and operational efficiency by integrating with other enterprise systems. Lee et al. (2022) explored the implementation of a cloud-based CMMS for large-scale facilities. Their findings highlighted improved maintenance management and cost savings through enhanced system accessibility.

Choudhury et al. (2023) focused on the adaptation of CMMS for the pharmaceutical sector, incorporating advanced data analytics to optimize maintenance schedules and reduce equipment failures. Their approach addressed industry-specific challenges, such as stringent regulatory requirements and high operational costs. Finally, in recent studies, Brown et al. (2024) explored the implementation of CMMS to improve maintenance efficiency in thermal power plants. The research highlighted how CMMS adoption led to optimized maintenance schedules, reduced downtime and enhanced operational reliability, showcasing the system's significant impact on maintenance practices in the power generation sector. This body of research reflects ongoing advancements in CMMS technology and its applications across various sectors, underscoring the importance of continuous development and adaptation in maintenance management systems.

Data and Methodology

The flowchart in Figure 1 shows the various steps involved in developing CMMS software for a power plant.

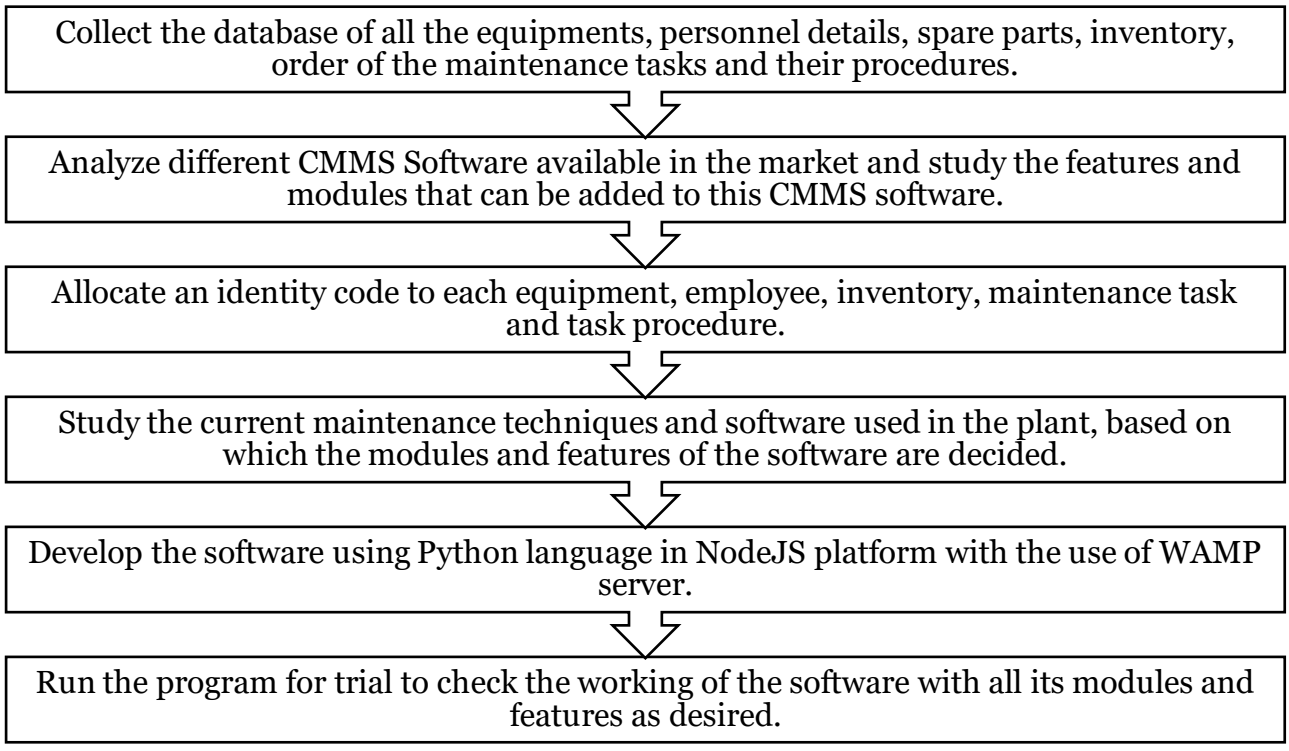

Figure 1: Schematic Flow Model Describing the Methodology for the Development of CMMS

Plant Profile

Deenbandhu Chhotu Ram Thermal Power Plant (DCRTTP), located in Yamunanagar, Haryana, is a pivotal thermal power facility under the Haryana Power Generation Corporation Limited (HPGCL). Commissioned in 2008, the plant commemorates the

legacy of the esteemed political leader Shri Chhotu Ram. It plays a vital role in bolstering the region's power generation capabilities.

DCRTTP includes several important departments including Boiler Maintenance, Turbine Maintenance, Electrical Maintenance, Instrumentation Maintenance, Auxiliary Services, Operations & Control, Quality Assurance, Safety & Environment and Administration & Human Resources. The plant employs a comprehensive array of maintenance strategies: Breakdown Maintenance, Corrective Maintenance, Preventive Maintenance, and Predictive Maintenance. Adhering to Total Productive Maintenance (TPM) principles, DCRTTP integrates Autonomous Maintenance, Continuous Improvement, Planned Maintenance and Quality Maintenance. Currently, maintenance and downtime records are meticulously maintained and displayed manually within each department. While plans are underway to implement a Computerized Maintenance Management System (CMMS), the plant has yet to adopt online access for maintenance activities.

Results and Discussion

Proposed Modules of the CMMS Developed for Power Plant

After analyzing the requirements of the plant and the different softwares available in the market, two general modules (Login Page and Home Page) and twelve other modules were proposed.

Login Page: This page secures important data by providing access only to authorized personnel with the provision of the user ID and Password.

Home Page: The Home Page displays the name and some information about the organization and consists of all the other modules for navigation within the application.

Module 1: Equipment Management

Oversees information about all equipment within a facility, including specifications, maintenance history, location and criticality assessments.

Module 2: Tool Records

Keeps track of tool details used for maintenance tasks, including inventory levels, calibration schedules and usage history.

Module 3: Work Orders

Manages the creation, assignment, and tracking of maintenance tasks and projects, covering scheduling, labour, materials and completion status.

Module 4: Staff Management

Maintains information on maintenance personnel, including their skills, certifications, availability and work assignments.

Module 5: Maintenance Calendar
Provides a visual schedule of maintenance activities, including preventive maintenance tasks, work orders and staff availability.

Module 6: Reporting
Produces various reports and analytics related to maintenance activities, equipment performance, labour utilization, inventory levels and costs.

Module 7: Supplier Information
Store details about suppliers and vendors, including contact information, pricing, lead times and purchase history.

Module 8: Suggested Modules
Recommends additional modules or features based on organizational needs and industry best practices.

Module 9: Spare Parts Inventory
Monitors inventory levels of spare parts and maintenance materials, including stock levels, reorder points and usage history.

Module 10: Inspection Management
Facilitates the scheduling, execution, and documentation of equipment inspections, including checklist creation, inspection results and follow-up actions.

Module 11: Service Requests
Enables users to submit maintenance requests or work orders, detailing equipment location, issue description and priority level.

Module 12: Condition-Based Monitoring
Tracks equipment condition in real-time or through periodic assessments using sensors, data analysis, or manual inspections to predict maintenance needs and optimize schedules.

Programming of CMMS for DCRTPP

With basic programming skills, CMMS software built with Node.js allows developers to create scalable, high-performance network applications. We developed custom modules tailored to the plant's maintenance needs, providing an intuitive interface for easy data entry and retrieval. WampServer serves as the platform, connecting users across different systems and ensuring access to regular updates while maintaining comprehensive data records.

NodeJS

Node.js is a powerful, open-source JavaScript runtime environment designed for server-side execution. Built on Google Chrome's V8 engine, Node.js enables the creation of scalable, high-performance network applications. Its non-blocking & event-driven architecture efficiently handles multiple concurrent connections, ideal for real-time applications like chat services and online gaming. Node.js boasts a rich ecosystem of libraries and modules managed by npm (Node Package Manager), simplifying the addition of functionalities such as web development, database interactions and API integrations. It is cross-platform, running on Windows, macOS and Linux, leveraging JavaScript's flexibility. Renowned for its large and active community, Node.js offers a wealth of resources and tools to boost development productivity. Emphasizing asynchronous programming and efficiency, Node.js is a top choice for modern web development and server-side programming.

WampServer

WampServer refers to a software stack for the Microsoft Windows OS, which stands for 'Windows, Apache, MySQL and PHP'. In this stack, Microsoft Windows is the Operating System (OS), Apache is the web server, MySQL handles the database components and PHP or Python represents the dynamic scripting languages. It is often used for internal testing and web development, but may also be used to serve live websites.

WampServer provides a server platform to connect various computer systems in or out of the plant. The data is maintained and recorded in WampServer which can be exported as an SQL file.

Conclusion

This paper outlines the development of a CMMS for a plant to enhance resource management within the maintenance department. Earlier, the maintenance data was manually recorded, leading to reactive maintenance practices. The CMMS automates and streamlines these processes, improving efficiency and maintaining a comprehensive database for easy access. This system saves time, reduces strain on personnel, and provides quick access to maintenance records while ensuring security through personnel authentication.

Given the plant's complexity, the CMMS handles data such as inspection schedules, service records, spare parts management, manpower planning, failure analysis and preventive maintenance. It is an essential tool for minimizing downtime, reducing production costs, and increasing production capacity by ensuring higher availability and reliability.

Scope for Future Studies: Looking ahead, CMMS offers significant potential for advancement. Integrating IoT technology enables real-time asset monitoring and predictive maintenance, while AI algorithms provide more accurate maintenance

forecasting. Mobile platforms enhance accessibility, empowering maintenance teams to operate efficiently, reduce costs and extend asset lifespans. These innovations promise to revolutionize maintenance management, driving industry efficiency and reliability.

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