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Abstract -- The project focuses on the centralization maintenance in the areas of High Volume Bearings (H.V.B.C.) and Metallurgy, applying Total Productive Maintenance (TPM). The initial diagnosis showed deficiencies in maintenance planning, lack of a centralized system and a high dependence on production, which generated frequent failures and long response times.

It was proposed to implement a digital system for maintenance management, improving the organization of preventive schedules, work order requests, and inventory control of critical spare parts. The methodology included the creation of standard operation sheets (HOE) for supervisors and technicians, as well as the use of thermographic cameras for predictive maintenance.

The results were remarkable. Response time was reduced from 9.5 to 3 minutes and preventive maintenance compliance increased from 30% to 85%. It was also possible to attend to 100% of work , improving operational efficiency. The system enabled effective centralization, which facilitates the analysis of key indicators such as MTBF and MTTR, optimizing decision making in real time.

In conclusion, the project significantly improved maintenance management, promoting efficiency and reducing downtime. It is recommended that the computer equipment be kept active and that the inventory and work orders be monitored to ensure the correct operation of the implemented system.

Keywords: Centralization of maintenance, maintenance management, preventive maintenance, total productive maintenance (TPM), work orders.

Abstract -- The project focuses on centralizing maintenance in the High Volume Bearings (H.V.B.) and Metallurgy areas, applying Total Productive Maintenance (TPM). The initial diagnosis revealed deficiencies in maintenance planning, the absence of a centralized system, and a high dependency on production, leading to frequent failures and prolonged response times.

A digital system was proposed for maintenance management, improving the organization of preventive maintenance schedules, work order requests, and critical spare parts inventory control. The methodology included the creation of standard operating procedures (SOP) for supervisors and technicians, as well as the use of thermographic cameras for predictive maintenance.

The results were significant. Response time was reduced from 9.5 to 3 minutes, and preventive maintenance compliance increased from 30% to 85%. Additionally, 100% of work orders were completed, enhancing operational efficiency. The system enabled effective centralization, facilitating the analysis of key indicators like MTBF and MTTR, optimizing real-time decision- making.

In conclusion, the project significantly improved maintenance management, promoting efficiency and reducing downtime. It is recommended to keep the computer equipment active and monitor the inventoryand

work orders to ensure the correct operation of the implemented system.

Key words-- Centralized maintenance, maintenance management, preventive maintenance, total productive maintenance (TPM), work orders.

INTRODUCTION

Industrial maintenance has evolved significantly over the years, moving from reactive approaches to more proactive strategies that seek to minimize downtime and maximize operational efficiency. In the late 19th century, the mechanization of industries gave rise to the need to keep equipment in optimal condition, which led to the development of concepts such as preventive maintenance. However, despite advances in techniques and tools, many companies, such as the Federal Mogul Cojinetes plant, still face significant challenges in maintenance management, particularly in the context of older equipment that has operated for decades. [1]
The Federal Mogul plant, which has been in operation for more than 50 years, has seen a gradual deterioration in the condition of its equipment, resulting in a high number of failures and production stoppages. Currently, the maintenance area lacks a centralized system that allows effective management of preventive and corrective maintenance. Activities have been carried out in a disorganized manner, and the dependence on the production department to schedule maintenance interventions has complicated the situation. This lack of a systematic approach has generated significant economic losses and a decrease in production efficiency. [2]
The central problem of this research lies in the inefficiency of the existing maintenance system in the plant, which results in a high mean time between failures (MTBF) and an unacceptably long mean time to repair (MTTR). The lack of an adequate Total Productive Maintenance (TPM) plan has prevented the maintenance area from operating effectively, leading to reactive management and increased production downtime. [3]
The objectives of this work are clear: to centralize the maintenance of the High Volume Bearings (H.V.C.) and Metallurgy areas, implementing a digital system that facilitates the management of preventive and corrective maintenance, thus optimizing the attention to work orders and the control of critical spare parts inventories. The goal is also to increase compliance with preventive maintenance, reduce response times to failures and, ultimately, improve the performance indicators of the maintenance area.

The justification for the present project is based on the need to transform maintenance management in the plant to ensure its competitiveness in the market. Implementing a centralized and digitized system will not only optimize operational efficiency, but will also help extend equipment life and improve safety in operations. By taking a proactive and systematic approach, the plant will be able to reduce costs associated with downtime, improve production and ultimately meet market demands more effectively. [4]
This work not only addresses an immediate need in the plant, but also lays the groundwork for future research in maintenance management, exploring how technology and digitization can continue to transform this ever-evolving field.

DEVELOPMENT

In the development of this project, methods and tests were implemented focused on the centralization of maintenance in the areas of High Volume Bearings (H.V.B.C.) and Metallurgy, based on Total Productive Maintenance (TPM). The research sought to improve the efficiency of the maintenance management system by automating and digitalizing the processes. The methods, calculations, instruments, procedures and results obtained are detailed below.

Participants

The key participants in the development of the project were the maintenance supervisors, responsible for coordinating preventive maintenance activities, and the maintenance technicians, responsible for performing corrective, preventive and predictive maintenance on the production lines. Plant management was also involved in overseeing the project, providing support in the implementation of the digital system and approving the necessary resources.

Design

The project design was based on the integration of a digital maintenance management system, which allowed the automation of preventive maintenance scheduling and work order control. A methodological approach focused on the collection of historical data on downtime and equipment failures was used. The system allowed the automatic generation of key indicators such as MTBF (Mean Time Between Failures) and MTTR (Mean Time to Repair). [5]

Instruments used

The main tool used was a digital maintenance system, developed to automate the administrative and technical tasks of the area. This system made it possible to register every work order generated, which included details of the failure, the start and end time of the maintenance, and the equipment affected.

Standard operation sheets (HOE) were also used to train technicians and supervisors in the use of the system and the correct execution of maintenance. For predictive maintenance, thermographic cameras were used to help detect potential failures by analyzing the temperature in critical equipment. [6]

Procedure

1. Initial diagnosis: An analysis was made of the current maintenance situation at the plant, identifying the main failures and points for improvement. Data was collected on downtime, unattended work orders and preventive maintenance efficiency.

Figure 1. Maintenance schedule.

2. Implementation of the digital system: The maintenance management system was developed and implemented. which made it possible to centralize work orders, control critical spare parts inventories and organize preventive maintenance schedules.

Figure 2. Previous work order

Figure 3. Work order in new maintenance system.

3. Personnel training: Standard operation sheets (HOE) were designed and delivered to train supervisors and technicians in the use of the new system. This training included the use of thermographic cameras for predictive maintenance.

4. Calculations and mathematical models: Mathematical models were used to calculate the MTBF and MTTR of each production line. These indicators were obtained using the formula:

$$MTBF = \frac{Tiempototalde \quad opeeración\,.}{Númeero \ defallos} \qquad \text{Eq. (1)}$$

$$MTTR = \frac{Tiempototalde \quad repparación \\ repaación}{Númeero \ defallos} \qquad \text{Eq. (2)}$$

[7]

5. Results monitoring: Throughout the project, performance indicators (MTBF, MTTR) were monitored and adjustments were made to the system based on the results obtained.

Figure 4. Performance indicators.

DISCUSSION AND ANALYSIS OF RESULTS

The implementation of the maintenance management system in the High Volume Bearings (H.V.B.C.) and Metallurgy areas has provided significant results in relation to the objectives set. This analysis is based on the data collected throughout the project, focusing on improving operational efficiency and reducing downtime.

Table 1. Comparison before and after implementation.

Activity	Before implementation	After implementation
Data collection for each maintenance nto	5 minutes	30 seconds
Graphing results monthly	8 hours	30 seconds
Notice from faults in accordance with criticality	Not implemented	30 seconds
Evaluation of technicians	24 hours	30 seconds

Figure 5. Installation of data collection equipment.

As mentioned by the professors of the Technological University of Pereira, industrial maintenance is crucial to ensure the proper functioning equipment and maximize production, highlighting its evolution from corrective approaches to preventive and predictive strategies.

Figure 6. Maintenance alert system.

Although they approach this topic from a practical perspective and focused on the implementation of digital systems in a specific plant, we can intuit that the combination of structured planning and advanced technology is key to improving operational efficiency. We learn that maintenance not only impacts the productive continuity, but it is also a driver of innovation and competitiveness in the industrial field. [8]

Likewise, from the perspective of engineer Miguel Rivera, who compares the maintenance management systems in our country with those implemented in various European countries, both similarities and significant differences are identified. These comparisons provide a valuable guide for technological, regulatory and systemic advances, allowing us to evaluate and contrast the systems currently employed in large Mexican industrial plants. [9]

As pointed out by engineer Raul Yavarone in his paper *'The importance of efficient diagnosis in industrial maintenance'*, in the manufacturing industry, the availability and reliability of productive means, such as machines, devices and automatisms, are closely linked to the fulfillment of production objectives. Therefore, industrial maintenance management is considered fundamental to ensure the availability and reliability of industrial equipment, which is achieved through the system described in this paper. [10]

Important Observations

One of the most noteworthy findings was the reduction in response time to failures, which decreased from 9.5 minutes to 3 minutes, representing a 68% improvement. This improvement aligns directly with the objective of optimizing work order attention, ensuring that equipment is available for production more quickly. This result highlights the effectiveness of the new digital system, which automates the work order generation and tracking process.

Test Results
MTBF and MTTR calculations showed a favorable evolution. MTBF increased significantly, indicating higher equipment reliability, which responds to the objective of improving preventive maintenance planning. This increase is crucial in an industrial environment where operational continuity is essential to meet production demand. [11]

On the other hand, MTTR was reduced thanks to the implementation of standardized procedures and the use of tools such as thermographic cameras, which allowed early detection of faults. This aspect translates into fewer unscheduled shutdowns, which contributes to a more stable and efficient production environment. [12]

Discussion of Results
The centralization of maintenance has improved administrative management, making preventive maintenance schedules more accessible and easier to follow. By increasing preventive maintenance compliance from 30% to 85%, it was possible not only to improve equipment reliability, but also to establish a proactive maintenance culture within the operational area. [13]

It is relevant to mention that, although significant improvements in operational efficiency were observed, resistance to change on the part of some technicians and supervisors was a challenge. Ongoing training and reinforcement of the use of the new system are crucial to maintain the sustainability of these results in the long term. [14]

CONCLUSIONS
The maintenance centralization project in the High Volume Bearing (HVB) and Metallurgy areas of the Federal Mogul plant has been successfully completed. with the objectives The implementation of a digital system has facilitated the implementation of a new system for the centralization of maintenance in the C.A.V. and Metallurgy areas of the Federal Mogul plant. The implementation of a digital system has facilitated the organization of preventive maintenance schedules, the handling of work orders and the control of critical spare parts inventories, transforming the way in which maintenance activities are managed at the plant. One of the most outstanding achievements has been the reduction of the response time to failures, which has been reduced from 9.5 minutes to 3 minutes, representing a 68% improvement. This improvement has not only optimized equipment availability, but has also contributed to production stability by reducing unscheduled shutdowns. In addition, preventive maintenance compliance increased from 30% to 85%, reflecting a cultural change towards a more proactive and organized maintenance management.

Calculations of key indicators such as mean time between failures (MTBF) and mean time to repair (MTTR) have demonstrated the effectiveness of the implemented system. The increase in MTBF suggests higher equipment reliability, while the reduction in MTTR indicates an improvement in the responsiveness of maintenance personnel. These results confirm that centralization of maintenance and automation of administrative processes are effective strategies to improve plant operation. [15]
Despite the positive results, areas for improvement were identified that could be explored in future research. For example, resistance to change on the part of some technicians and supervisors highlighted the importance of implementing ongoing training and change management programs. Future research could focus on developing strategies for motivating and involving personnel in the adoption of new technologies, as well as analyzing the long-term impact of digitization on industrial maintenance. Another line of research could explore the use of advanced technologies, such as the Internet of Things (IoT) and artificial intelligence (AI), to further improve predictive maintenance management. Integrating these systems could enable deeper analysis of operational data, facilitating early fault detection and optimizing maintenance planning. [16]

As is well known, technological progress and data management have proven to be very helpful factors in various fields. In this context, the company CEGID, through the use of IoT, presents a prospective vision of how maintenance management could evolve in the next ten years. [17]

In addition, EMAINT presents significant advances in data collection and database management focused on industrial maintenance. Its data collection equipment, integrated into its software, promises unprecedented improvements since the early days of TPM. Likewise, its five-year vision aims to establish itself as a standard in the industry. [18]

In summary, the project has not only succeeded in meeting its initial objectives, but has also laid the groundwork for future research and improvements in industrial maintenance management. Centralization and digitization of maintenance appear as promising approaches to increase competitiveness and efficiency in the industrial sector.

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BIBLIOGRAPHY .

[1] González, F. J. (2018). *Theory and practice of advanced industrial maintenance* 1st edition). Madrid: Fundación Confemetal.

[2] Tenneco Inc. (2022). "Overview of Tenneco: History and Acquisitions".

[3] Crespo Márquez, A. (2017). *Maintenance engineering. Techniques and methods of application to the operational phase of equipment* (1st edition). Madrid: AENOR.care

[4] Dounce Villanueva, E. (2018). *Maintenance Administration*.

[5] García Garrido, S. (2019). *Organization and integral management of maintenance* (2nd edition). Madrid: Díaz de Santos.

[6] López, M. (2020). *Preventive Maintenance: Strategies and Effective Practices (*1st edition). Mexico: Ed. Universitaria.

[7] Alfonso, A. (2018). *Elementos de mantenimiento (*1st edition). Mexico City: CENAPRO.

[8] Olarte, W., Botero, M., & Cañon, B. (2010). Importance of industrial maintenance within production processes. *Scientia et technica*, *16*(44), 354-356. Available at: https://www.redalyc.org/

[9] Sosa, J. V. G., Quijada, J. L., Ontiveros, M. Á. L., Montoya, P. P., & Hernández, A. C. (2018). Industrial maintenance in machine tools by means of FMEA. *Revista Ingeniería Industrial*, *17*(3).
Available at: https://core.ac.uk/

[10] Yavarone, R. (2019). The importance of efficient diagnosis in industrial maintenance. *AADECA Magazine*. Available at: https://editores-srl.com.ar/sites/default/files/aa11_yavarone_diagnostico._efficient.pdf

[11] Newbrough, E. T. (2016). *Industrial maintenance management* 1st edition). Mexico: DIANA.

[12] Higgins, L. R. (2017). *Maintenance Engineering Handbook (*8th edition). New York, USA: McGraw Hill.

[13] Piotrowski, J. (2019). *Shaft Alignment Handbook* (3rd edition). New York, USA: CRS Press.

[14] U.S. Department of Labor (2021). "Industrial Maintenance and Repair: Best Practices".

[15] Silva, R. (2021). "TPM implementation in manufacturing companies: A case study". *Journal of Maintenance and Management*, 12(2), 100-112.

[16] Cardenas, J. (2021). "Total productive maintenance: Methodologies and benefits". In *Actas del Congreso Internacional de Ingeniería*, pp. 23-30. Mexico City: Universidad Nacional Autónoma de México.

[17] CEGID (2024) "Industrial maintenance management software, Spain. Available at: https://www.cegid.com/

[18] EMAINT (2024) "Industrial data collection equipment", United States of America. Available at: https://www.emaint.com/

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