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Artículos científicos

Metodología de administración para el mantenimiento preventivo como base de la confiabilidad de las máquinas

Management Methodology *for Preventive Maintenance as Base for Reliability of the Machines*

Metodologia de gestão da manutenção preventiva como base para a confiabilidade das máquinas

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Resumen

El mantenimiento preventivo comprende todas las actividades involucradas en la conservación en buen estado de los equipos tecnológicos de cualquier empresa. En la actualidad, la implementación del mantenimiento preventivo dentro de la industria es fundamental para minimizar las averías en la maquinaría. Este estudio muestra el sistema de mantenimiento preventivo como un elemento clave del proceso general de las organizaciones. Mediante un diagrama de flujo se muestran los diferentes pasos a seguir para implementar y mantener un sistema de este tipo. La metodología propuesta se implementó en una empresa que fabrica productos médicos y entre los resultados se registró una mejora del tiempo medio entre fallas de 1.176 horas a 1.699 horas y la eliminación de variaciones entre programas de 79.5 horas a solo 17 horas, entre otros. Este artículo muestra el entramado de los elementos clave del mantenimiento preventivo total: desde técnicas de mantenimiento, pasando por la efectividad del equipo, la estandarización de las prácticas de mantenimiento, el encuadre del mantenimiento preventivo total, hasta las barreras, limitaciones y éxitos del mantenimiento preventivo.

Palabras clave: análisis de fallas, mantenimiento preventivo, programa de mantenimiento.

Abstract

Preventive maintenance includes all the activities involved in keeping the technological equipment of any company in good condition. Currently, the implementation of preventive maintenance within the industry is essential to minimize breakdowns in machinery. This study shows the preventive maintenance system as a key element of the general process of organizations. A flowchart shows the different steps to follow to implement and maintain a system of this type. The proposed methodology was implemented in an institution in the medical area and among the results, the variation in the meantime between failures from 1.176 hours to 1.699 hours and the elimination of variations between programs from 79.5 hours to only 17 hours, among others. This article shows the framework of the key elements of total preventive maintenance: maintenance techniques, the effectiveness of equipment, the standardization of maintenance practices, the framework of total preventive maintenance, the barriers, limitations, and successes of preventive maintenance.

Keywords: failure analysis, preventive maintenance, maintenance program.

Resumo

A manutenção preventiva inclui todas as atividades envolvidas em manter em boas condições os equipamentos tecnológicos de qualquer empresa. Atualmente, a implantação de manutenções preventivas dentro da indústria é fundamental para minimizar quebras em máquinas. Este estudo mostra o sistema de manutenção preventiva como elemento chave do processo geral das organizações. Um fluxograma mostra os diferentes passos a seguir para implementar e manter um sistema deste tipo. A metodologia proposta foi implementada em uma empresa fabricante de produtos médicos e os resultados incluíram a melhora do tempo médio entre falhas de 1.176 horas para 1.699 horas e a eliminação de variações entre programas de 79,5 horas para apenas 17 horas, entre outros. Este artigo apresenta o enquadramento dos elementos chave da manutenção preventiva total: desde as técnicas de manutenção, passando pela eficácia dos equipamentos, a padronização das práticas de manutenção, o enquadramento da manutenção preventiva total, até às barreiras, limitações e sucessos da manutenção preventiva.

Palavras-chave: análise de falhas, manutenção preventiva, programa de manutenção.

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Introduction

A retrospective analysis of the maintenance implementation process shows that the reactive type predominated in the early days of the industry. The belief of being efficient was not yet established, since at that time the demands of the companies' clients were low, so the demands of the maintenance area were also low (Khamba & Ahuja, 2008). There was a surplus of workers and cheap labor, which was used to apply reactive maintenance. When production stopped, for any reason, the maintenance department was informed; then the problems were solved and production restarted (Ahuja, 2009). This exercise was repeated every time a machinery stoppage occurred: corrective maintenance predominated (Gebauer, Putzr, Fischer, Wang, & Lin, 2008). Awareness of avoiding breakdowns was lacking (Kareem, H.; Ahmed, J.; Talib, N. A.;, 2015). Any preventative maintenance was limited to the use of a wrench, hammer, oil gun, or grease gun. However, to be fair, it should be noted that the machines that were manufactured before were of better quality than today.

Preventive maintenance looks for the root causes of machine problems, identifies and implements root cause solutions. Through fault analysis as support, preventive maintenance management becomes a key point to achieve minimum unscheduled downtime of the machine (Jain, A.; Bhatti, R.; Singh, H.;, 2014) (Jain, Singh, & Bhatti, 2018). However, at this stage of modernization, there are still a large number of companies that seem to ignore the potential gains generated by correctly following preventive maintenance recommendations, such as a good inventory, updated database, adequate preventives for machines, balanced workload, minimum preventive maintenance cost and more (Khamba & Ahuja, 2008) (Garcia Alcaraz, 2011) (Garcia, Romero Gonzàlez, & Noriega Morales, 2012).

In recent years the industry has changed exceptionally. The number of changes and the short time between one and the other have sustained an exponential growth, one could say, involving different companies, places, types of administration, products, technologies, customer expectations, supplier attitudes and affecting the entire flow. of the supply chain (Kanti Agustiady & Cudney, 2018) .

Preventive maintenance is a path that guides companies towards excellence, since it promotes processes that are closer to continuous flow, at a defined pace and with set goals (Drożyner, 2020). Communication between those involved is improved, from the highest positions to the lowest, because the path in question allows visualizing the planning and what is necessary to comply with said planning, which in turn allows taking the necessary actions to continue working on time and form. It also promotes the optimal use of the equipment, according to the takt time requirements and with the highest possible levels of effectiveness; In short, it maintains the equipment at optimal levels of performance and reliability ((Kanti Agustiady & Cudney, 2018), (Schutz, J.; Chelbi, A.; Rezg, N.; Ben Salem, S.;, 2019).

According to Kanti Agustiady and Cudney (2018), management has been strongly dedicated to improving productivity management through testing, measurement, reporting, and manufacturing cost analysis. And along these lines, the integration of production scheduling and preventive maintenance scheduling have proven to reduce lost hours (Dutta, S.; Reddy, N.;, 2021). Thus, following these trends, the present work exposes the application of a preventive maintenance system, from a deeper descriptive point of view, in activities that do not fit in the analysis of failures, but serve as a support structure for the entire system. preventive maintenance system (Hooi & Leong, 2017).

The objective of this work is to develop a methodology for the management of preventive maintenance by decentralizing failure analysis and making a more objective approach to the way in which preventive maintenance programs are implemented and creating a friendly structure to mitigate problems. that affect the optimization of preventive maintenance processes; such as, equipment not registered in the database, database with variations, unbalanced load of hours between periods, inadequate maintenance routines for the machines or inadequate frequencies and more.

As a complementary objective, there is the validation of this methodology when implementing it in a medical area. For this, the current mean time between failures of 1,176 hours was established as the main measurable measure, and the goal of improving it by 20% for a total of 343 machines in the area. After the implementation of the preventive maintenance methodology, the average before the improvement was 1,176 hours and after 1,699 average hours, that is, 44.47% improvement.

Method

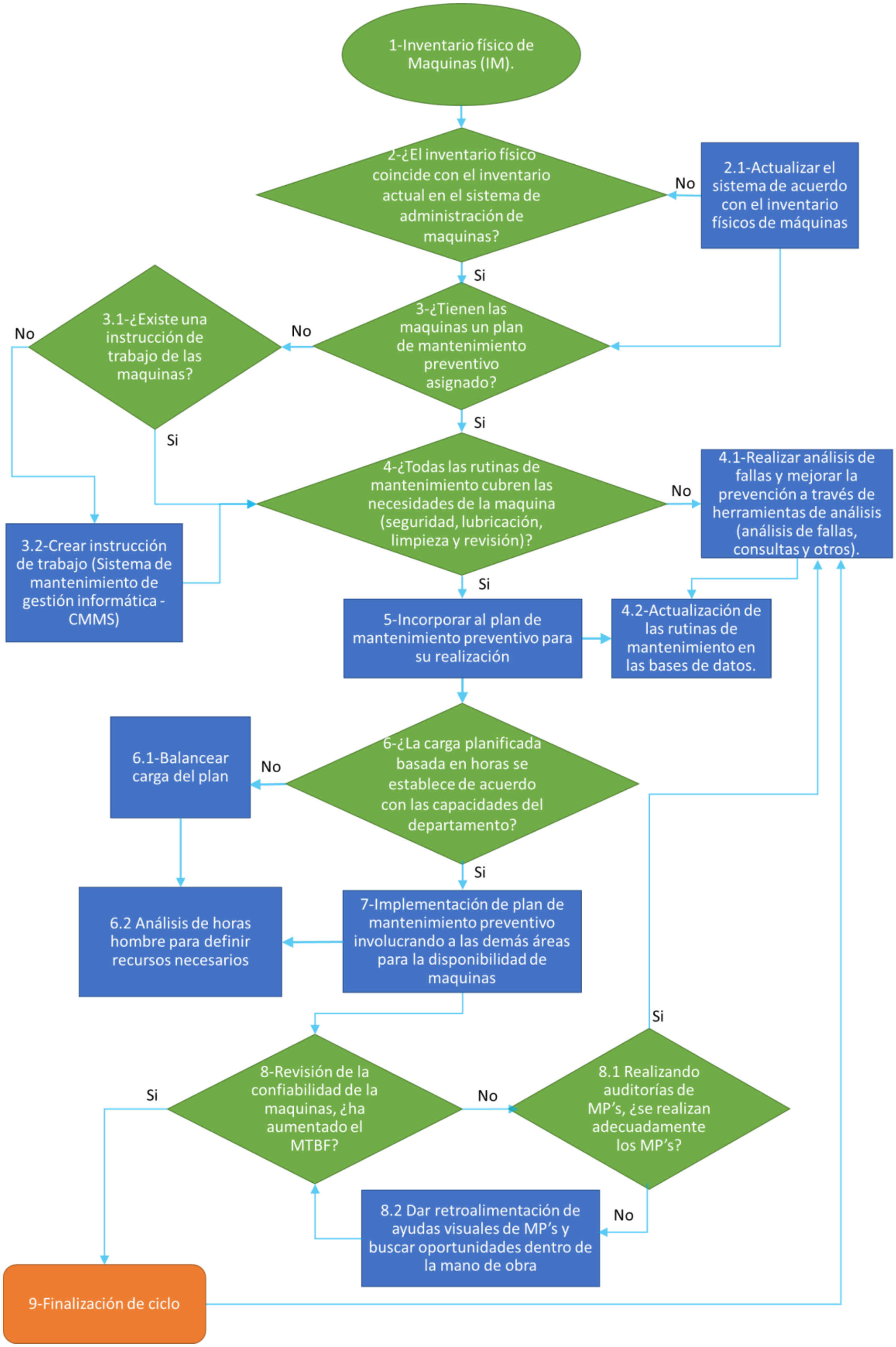
The representation of the methodology for the preventive maintenance implementation process is shown in Figure 1. Preventive maintenance program implementation process. The description of each step of the methodology is presented below:

1) Physical inventory of machines. It must show a clear view of what machines are in the area so that none are left out of the preventive maintenance program. The method in which the information is collected depends on the criteria of each developer: it can be a simple sheet of paper or an Excel file, depending on the needs or possibilities to specify it. 2) Does the physical inventory match the current inventory in the machine management system? All machines recorded in the physical inventory must match in the management system database. Management systems vary depending on the area where it is implemented: it can be from a physical paper file, an Excel file or a computerized maintenance management system (CMMS). 2.1) Update the system according to the physical inventory of machines. All discrepancies between physical and virtual must be eliminated by system adjustment (series number, model number, machine number, registrations and other data). 3) Do the machines have a preventive maintenance plan assigned? Once the machine inventory and system tuning are complete, it is necessary to detect machines outside the preventive maintenance program. 3.1) Is there a work instruction for the machines? Not necessarily because a machine is out of the maintenance program indicates that there is no instruction already developed for it; There are already additional identical machines in the maintenance program, which facilitates incorporation into it, so it is necessary to detect which machine already has an instruction and avoid duplicating it. 3.2) Create work instruction (CMMS).

Once machine routine opportunities have been identified, proceed to write preventive maintenance tasks using the machine manual and the experiential knowledge of the maintenance technician. 4) Do all maintenance routines cover the needs of the machine (safety, lubrication, cleaning and revision)? Once the routine has been developed, it must be checked that the needs of the machine are within the routine. 4.1) Perform fault analysis and improve prevention through analysis tools (fault analysis, queries, and others). In the improvement opportunities detection phase, an analysis of the failure history is carried out using data management tools. To analyze the history of the machines, the company's data management system is used, whether it is sheets of paper, Excel or some maintenance management software. 4.2) Updating of maintenance routines in databases. Once the maintenance routines are finished and to ensure that all the opportunities are covered, the database must be updated. 5) Incorporate the preventive maintenance plan for its implementation. Any maintenance routine generated should be added to the preventive plan to have a complete picture of what is to be done, including all preventive maintenance. 6) Is the planned load based on hours established according to the capacities of the department? A comparative analysis is carried out between the number of hours of preventive maintenance from one cycle to another (day, week, month or according to needs). 6.1) Balance plan load. The workload of the maintenance program should be prorated so that the difference from one cycle to another is as close to zero as possible. 6.2) Analysis of man hours to define necessary resources. Through the number of daily hours for working days that the worker has, the number of hours available to the worker is obtained. For a more accurate analysis, you should take a full year and rule out holidays and vacations to make the analysis as accurate as possible. 7) Implementation of the preventive maintenance program involving other areas for the availability of machines. The program must work through the collaboration of the teams that use the machines, since they can affect it: delay the dates and generate a backlash of the load balance. It is a fact that preventive maintenance must be done at some point so that the time spent remains the same, but the committed task must be kept on schedule to avoid overloading the plan, and to avoid postponing it until it overlaps each other. It is recommended to keep other teams informed of the preventive maintenance schedule from one week to one month before it is carried out, depending on the area. 8) Review of the reliability of the machines, has the mean time between failures increased? It is recommended to carry out a comparative analysis of the mean time between failures carried out six months before and graph it weekly or monthly to appreciate if it is really working. 8.1) Carrying out audits, is preventive maintenance adequately carried out? When the trend of the mean time between failures is negative, wait for the performance of preventive maintenance. If the performance is correct, go back to point 4.1 and discover the improvement of the routines. 8.2) Give feedback on preventive maintenance visual aids and look for opportunities within the workforce. If routine performance is inadequate, there are two options: provide feedback to workers on how maintenance should be performed, or seek opportunities in the workforce through specialized training, cross-training, or more, depending on the job site situation. worked. 9) End of cycle. If the plan is in accordance with the methodology, finish at this step; if it is convenient to continue with the improvement, make an exit and return to point 4.1.

For a new analysis of machine failures, it is recommended to let the system work for at least six months between one analysis to another, in order to obtain different data and avoid using the same data from previous analyses.

Figura 1. Proceso de implementación de programa de mantenimiento preventivo



Fuente: Elaboración propia

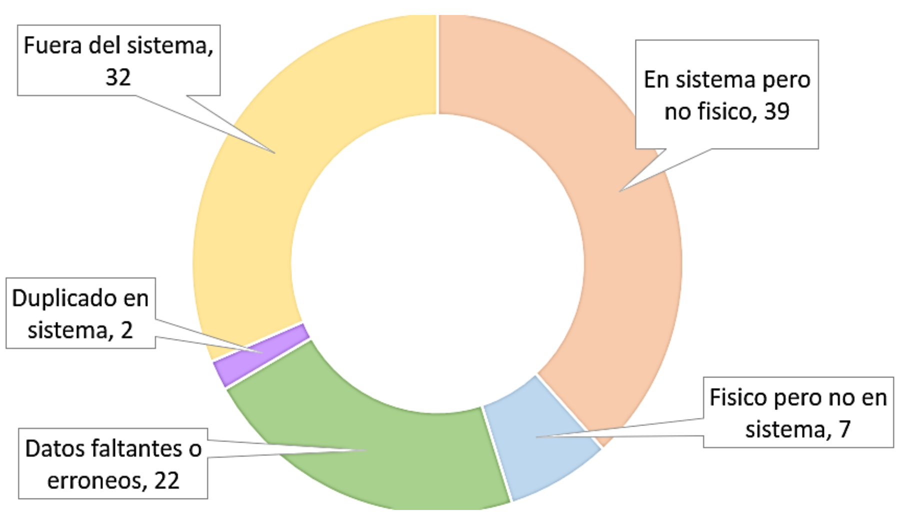
Results

The present work was developed in a company in charge of manufacturing medical products. As the methodology marks, we began with the physical inventory of all the machines. In total, 343 machines were found within the area, which were registered with all the necessary data to feed the maintenance management system, in this case the Strategic Asset Management Solution (SAMS) platform was used, which provides the inventory of machines , history of failures and preventive maintenance, number of preventive maintenance and more data on the machines and maintenance personnel.

When applying step two, and as shown in Figure 2. Findings when comparing physical inventory against system, some findings were found that compromise the preventive maintenance program. Among the most relevant, 32 machines were found physically in the area, but outside the system, and 39 machines that were in the system but were not physically in the area.

Inventory system fixes started with equipment that was in the work area, but not registered in the database. Those registered in the system but not in the area were eliminated, as well as data adjustments and duplicate information was eliminated from the database.

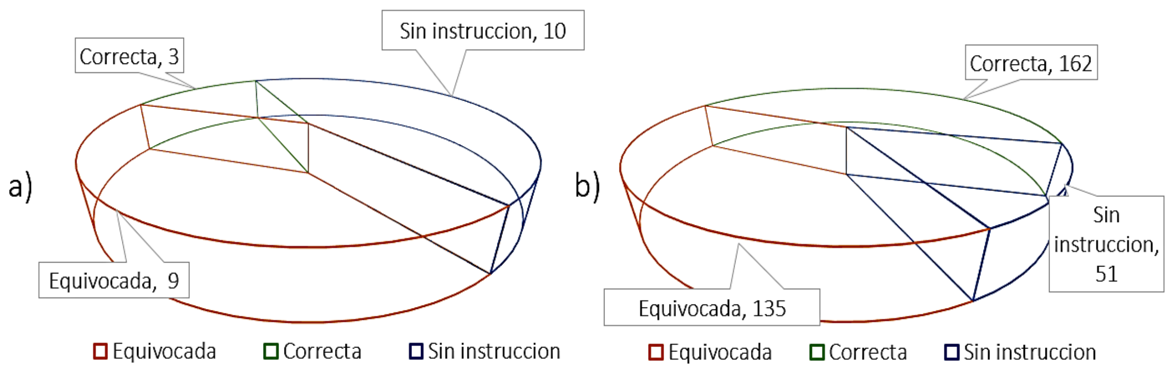
Figura 2. Hallazgos al comparar inventario físico contra sistema



Fuente: Elaboración propia

After the machine inventory was completed and adjustment made within the maintenance management system, each machine was checked for preventive maintenance assigned. Here it was found that, out of a total of 343 machines, 162 had the correct work instruction and 135 had an incorrect instruction. This is because at some point it was decided to use the same instruction for different machines or because initially an instruction was assigned that indicated activities that did not correspond to the machine to which it was related. Finally, 51 machines did not have any instructions. But of those 51 machines without instructions, not all required the creation of a new instruction. By separating the instructions by groups of equal machines, as shown in Figure 3. Work instructions by group (a) and by machines (b), it was found that only 10 new instructions needed to be created and nine updated.

Figura 3. Instrucciones de trabajo por grupo (a) y por máquinas (b)



Fuente: Elaboración propia

Thus, using the information in Figure 3, opportunities for incorrect or missing instructions were detected. From there, the improvement of the work instructions began, as marked in step four. In this case, the company's methodology was used, which consists of the analysis of the recurrence of failures through the methodology of the 80-20 principle. Figure 4. Fault graph 80-20 shows an example of the equipment analyzed.

Through the 80-20 methodology, 20% of the failures were selected in order to eliminate 80% of the downtime (Rahman, Chowdury M. L.; Hoque, M. A.; Uddin, Syed Misbah;, 2014). Figure 4 shows the fault codes analyzed. According to the failures that had the most recurrence, new tasks were included in the maintenance routines to minimize the impact. Maintenance routines were also revised and critical safety, lubrication, cleaning and servicing tasks were added when necessary.

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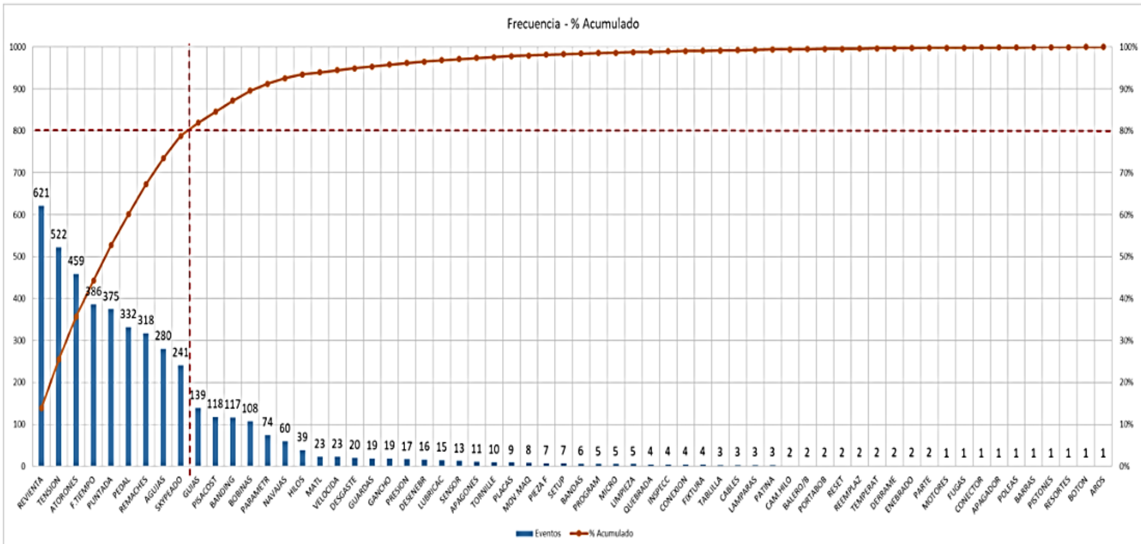
Figura 4. Gráfico de fallas 80-20



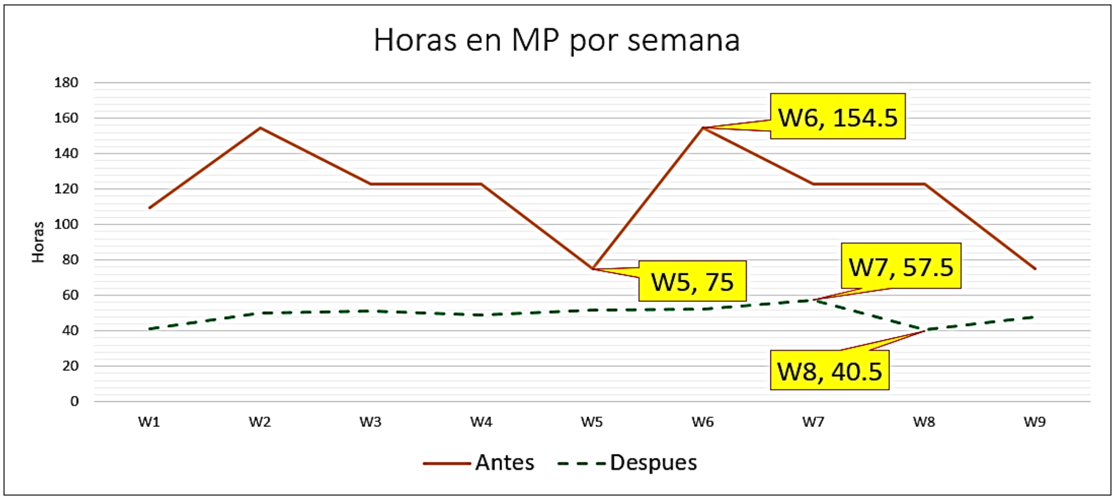
Fuente: Elaboración propia

After all the machines were on the preventive maintenance plan (step five), the preventive frequencies were reviewed. And an improvement was found in the change of frequency, from monthly to every two months, this through the process of taking the equipment to the point of failure and thus finding the optimal point between preventive and corrective maintenance (Heizer, 2009). The analysis resulted in an optimal point of more than two months without the equipment reaching the point of failure, leaving the door open to perform another analysis and perhaps take the preventive ones to more than this time and change the preventive maintenance program every three months with no problem, but for now it was decided to continue every two months.

Figure 5. Table of hours of the maintenance plan before and after, shows the difference between the previous and the current program. Making the balance of preventives and the analysis of overpreventive, an improvement of 77.98% of the difference in time needed between one week and another is obtained, since previously there was a gap of 79.5 hours (154.5 hours-75 hours) and now only 17 hours (57.5 hours-40.5 hours).

In addition, the availability of machines for production will increase because the time spent on preventive maintenance will now only be halved, from 410 hours per month to 205 for maintenance, leaving 205 available. Within this improvement, the workforce responsible for carrying out preventive maintenance stands out. Once the overpreventive was determined, and making the system adjustments, the number of maintenance technicians required to carry out preventive maintenance was reduced from three technicians needed to 1.5. With this improvement, 1.5 maintenance technicians are available to carry out other activities.

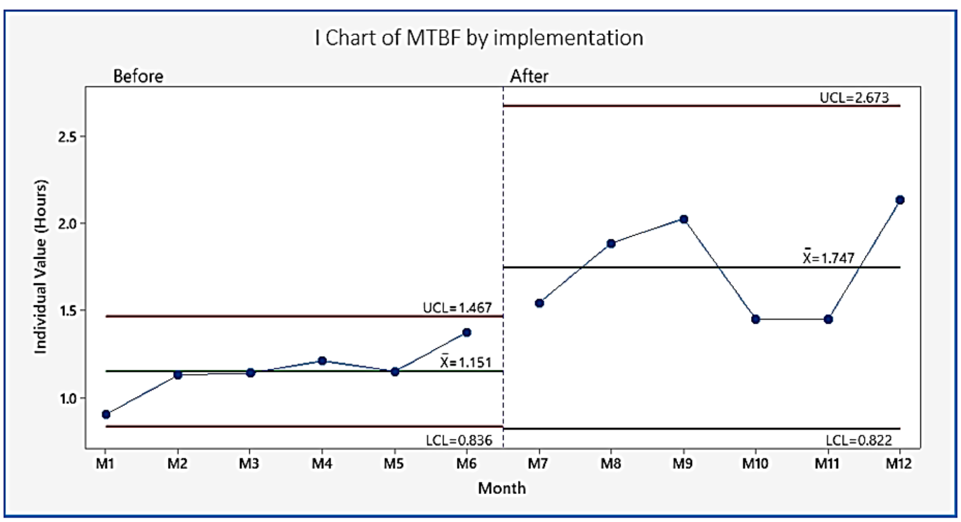
Figura 5. Cuadro de horas del plan de mantenimiento antes y después



Fuente: Elaboración propia

The mean time between failures was reviewed before and after the implementation of the preventive maintenance methodology and, as shown in Figure 6. Individual table by stages of implementation, the average before the improvement was 1,176 hours and after 1,699 average hours, that is, 44.47% improvement.

Figura 6. Cuadro individual por etapas de implementación



Fuente: Elaboración propia

Discussion

Preventive maintenance management is not only based on failure analysis; there are many more points to consider for this to work harmoniously. The results shown from the implementation of this methodology reflect a great administrative improvement. From the first step to the last, opportunities were discovered that could go unnoticed on a day-to-day basis. Some of the most outstanding results are listed below.

- Added 32 machines to inventory within the preventive maintenance management system.
- 51 machines were added to the preventive maintenance plan that were not included in it.
- Created 10 new preventive maintenance instructions and updated nine to align with the machine, improving the way preventive maintenance is performed.
- Change in the frequency of preventive maintenance from monthly to bi-monthly, which reduced the labor requirement of three technicians to 1.5 and reduced the downtime for preventive maintenance from 410 hours per month to only 205.
- Balance of labor discharge between periods of a difference of up to 79.5 hours to only 17 hours; This way, you have a program with less variation and you can avoid unexpected high requirements that are usually covered with overtime.
- The mean time between failures went from 1,176 hours to 1,699 hours, that is, an improvement of 44.47%.

The results show that the directed administration of preventive maintenance improves the operating conditions of the machines, achieves compliance with the times of each stage of the process with the highest level of effectiveness of the machinery and maintains the equipment at an optimal level of performance. performance and reliability.

The work carried out reinforces what Moore (2004) points out that the best practices for preventive maintenance should allow time-based maintenance, but only when the time periods are justifiable.

Conclusions

It is clear that the opportunity for improvement within preventive maintenance programs is achieved through proper management of the activities carried out to start the implementation of said program.

Failure analysis is a very important point to ensure the correct operation of the machines; but, if the administration of these systems is left aside, it is easy to fall into different problems, as shown in this article, whether it is from the omission of incorporating the machines in the inventory to carrying out preventive maintenance totally different from those that teams require.

With studies like the one presented, companies can reduce maintenance costs by at least a third and improve productivity levels, giving maintenance the place it should have. This type of analysis must be shared with the organization's management in such a way that it is understood at each and every one of the levels and is given the level of significance it has. The success or failure of the company may depend on the creation of awareness of the impact of the maintenance function.

Future lines of research

Undoubtedly, the research works give the guidelines for new ideas and the development of new criteria regarding the subject, so the future lines of research resulting from the work carried out are listed below:

- Replication of the methodology described in the article in different conditions of preventive maintenance programs in search of new limitations for the development of a more robust methodology.
- Implementation or adaptation of the methodology described in the article in different planning programs and its comparison with current programs.
- Analysis of the optimization of the workload per hour in preventive maintenance programs per period and its benefits in production plans.
- Analysis of tasks in preventive maintenance routines, what, when and why of each task and its adaptation to the optimal frequency.
- Determine when failure tends to be a better option than preventive maintenance regarding cost and machine availability for non-maintenance activities.
- Profitability in maintenance: the value of the machines against the investment value for their maintenance.

Each of these new lines is an opportunity to develop new ideologies for improvement regarding preventive maintenance programs and even other programming areas.

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