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APPLICABILITY OF PRODUCTION MANAGEMENT TOOLS FOR REDUCING DOWNTIME IN RUBBER VULCANIZATION EQUIPMENT FOR MANUFACTURE OF CONVEYOR BELT

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Abstract: Pará has one of the largest mineral reserves in the world, establishing itself as one of the main producers and exporters in this segment. With the resumption of investments in the sector and due to the need to transport ores over long distances, it is observed that the use of conveyor belts in the mining and metallurgical sector has been an appropriate solution for moving large volumes of material, reducing truck traffic. and the cost of this type of service, which has a production capacity of an average of 430 tons per month. Therefore, with this information in mind, a case study was carried out in a conveyor belt manufacturing industry, with the aim of using Industrial Production Management tools to increase productivity and reduce the rate of downtime due to equipment breakdown. With these tools in use, it was possible to identify, analyze and apply improvements to the main equipment in the production process, such as the implementation of the preventive maintenance plan, mapping of critical equipment, development of new components and suppliers, resulting in an increase in reliability of operation (23 hours) which was previously from 12.53% to 139.05%, the increase in Mean Time Between Failures (MTBF) from 37.73 hours to 87.71 hours, with cost reduction and elimination of waste and reworks.
Keywords: Conveyor belts, Pareto, Reliability, Five whys.

INTRODUCTION

The manufacturing of conveyor belts is divided into different processes and sectors consisting of: Mixing, Calendering, Construction, Vulcanization and Inspection. All of these processes are intermittent, that is, they do not depend on each other, and any failure in any of them does not lead to a general shutdown of the other processes [1]. Basically, the failures of these equipment are separated by electrical, mechanical and operational reasons.

In 2021 there was a large increase in production line stoppages, more specifically in the vulcanization sector. Given this survey, a case study was implemented for investigation as [2]: Failure, which is the loss of function or performance of the equipment; The failure mode, which is the way symptoms present themselves in the production process; The effect of the failure, characterized by the impact or consequence that the failure brings to the production process and the occurrence of failures, that is, how many times this has happened or is likely to happen in the equipment, demonstrating standards that are not suitable for productivity.

The history of equipment failures in the vulcanization area was surveyed, with the aim of also identifying the failures that most impacted the generation of major stoppages. For this, the Pareto chart [3] was used, then availability, reliability and maintainability [3-4] were calculated, and finally, to solve the problems, the Five Whys management tool was used [5-6], along with brainstorming [7-8]. The analysis time considered was six (06) months, using as a base the second half of 2021, the period in which the greatest number of stoppages appeared, and the first half of 2022, the year in which quality control improvements were applied. for maintenance management.

Once the improvement activities were completed, the scheduled maintenance plans (preventive, predictive inspection and autonomous maintenance) were updated with the established tasks and frequencies. Using the “80/20” rule, Pareto Diagrams and other quality tools, these proved to be effective and simple to use, without the need for the use of complex tools.

MATERIAL AND METHODS

The research sought to develop answers to the essential question raised to mitigate the risk that each component poses to the machine, and consequently to the process. It was necessary to establish preventive and predictive maintenance routines and route inspections, in order to structure planning that aims at final results.

The research was carried out over an interval of 5 (five) months. Accordingly, some steps were necessary, and in total 5 (five) crucial steps were outlined, namely:

a) Review of the literature on the topic and its main keywords: stage responsible for providing essential theoretical basis for analysis and decision-making regarding the research [9-17], given that it represents the starting point for development knowledge, in addition to assisting the author in the position he must have towards the company's employees when implementing improvements;

b) Analysis of the stages of the maintenance process [18]: Concerns the alternatives found and used, that is, throughout this analysis, observations were made.

c) In the area, unstructured interviews were carried out with employees directly involved in the sector, as well as data collection via the maintenance management software used;

d) Mapping the stages of the maintenance process: This stage was initiated after a detailed analysis of the activities that make up the process. Thus, the Lucidchart software was used as a notation criterion for mapping, in order to assist in modeling the process in question, corresponding to the way in which the activities were developed during the course of the study;

e) Structuring and implementing a routine for preventive, predictive maintenance and route inspections [19];

f) Definition and implementation of indicators to control maintenance performance [20]

RESULTS AND DISCUSSION

PARETO CHART FOR THE YEAR 2022

After executing the action plan proposing improvements in the vulcanization process, more specifically in the components of the Flex Press, it was noticed that there was a significant decrease in interventions aimed at this machine, as can be seen in figure 1 below:

It was found that the Flex press, throughout the study, had only 25 hours of downtime for maintenance in the second half of 2022. It was also observed that there was a reduction in the number of failures of this equipment, as shown in the image below (figure 2).

The Flex press presented only 40 failures after similar improvement actions and there was also a reduction in the number of failures between the components of this same equipment, as shown in figure 3 below.

CALCULATION OF INDICATORS FOR THE YEAR 2022

A survey of machine downtime for maintenance and equipment failures was carried out in the second half of 2022, with this, data from the Flex press equipment can be gathered, as shown in table 1 below.

History of 2022	
Total operating time (TO)	3500 hours
Stop Time (TP)	25 hours
Number of stops (N)	40

Table 1: Updated 2022 data histories

Source: authors

With the data in hand, it was possible to

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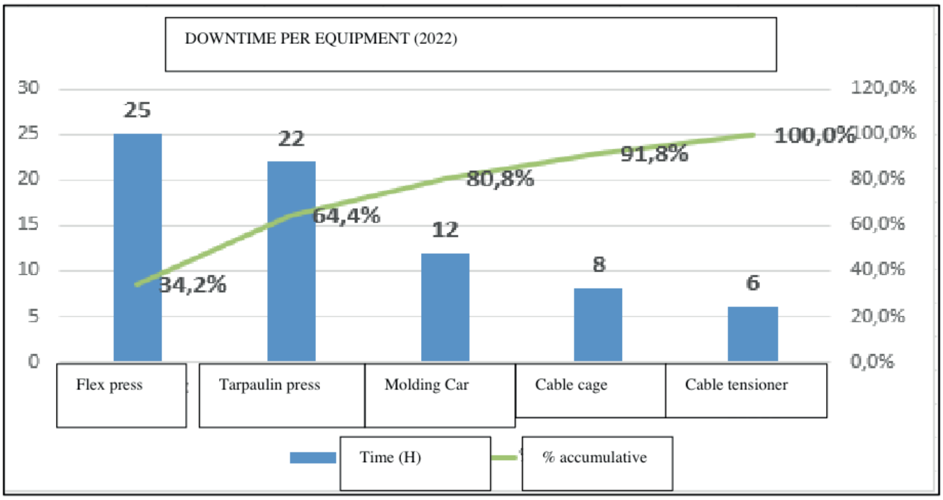

Figure 1: Equipment downtime in 2022. Source: Authors.

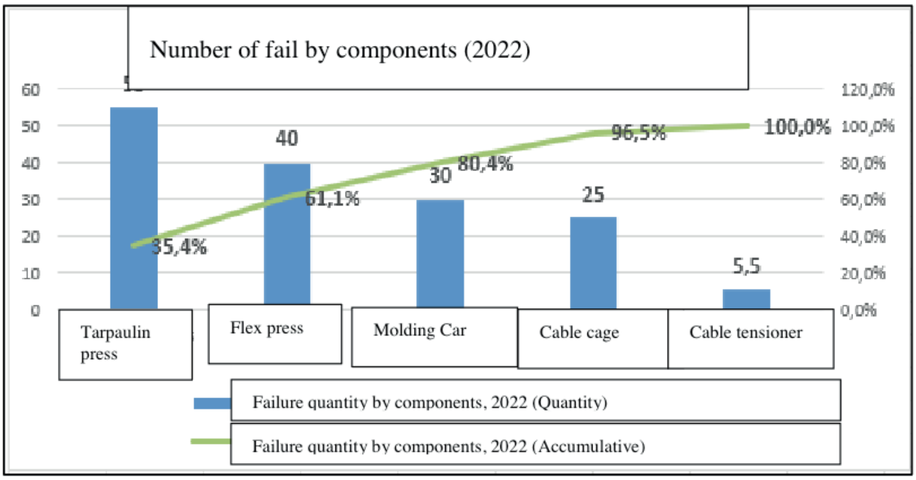

Figure 2: Numbers of equipment failures 2022. Source: Authors.

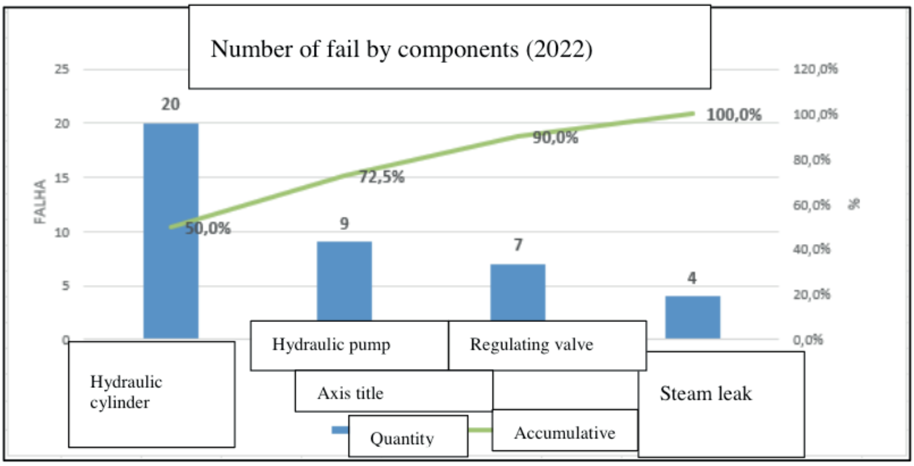

Figure 3: Number of failures by components 2022. Source: Authors.

recalculate the maintenance indicators for the year 2022, as shown in table 2 below:

Maintenance Indicators 2022	
Indicator	Value
Failure rate (λ)	0,125
Reliability (23 H)	139,05%
Average Failure Time (MTBF)	87,71 Horas
Average Time for Repairs (MTTR)	0,25 Horas
Availability	99,20%
Repair Fee (μ)	1,60
Maintainability (0.597 Hours)	12,09%
Maintainability (1 Hour)	39,20%

Table 2: History of maintenance indicators in 2022.

Source: Authors

This way, it was possible to analyze the maintenance indicators and it was identified that the possibility of the equipment operating for 23 hours straight is 139.05%, in addition, the availability for operation of the Flex press is 99.2%. The probability of repairing the Flex press during the interval of 0.597 hours is 12.09%, however if the time interval is 1 hour, the possibility of the maintenance team delivering the maintained equipment increases to 39.9 %.

COMPARISON 2021 AND 2022 AFTER IMPROVEMENTS

After collecting the data, a comparison could be made between the year 2021 before the improvements were applied, and the year 2022 after the improvements, in relation to the downtime of the Flex press, as shown in figure 4 below:

When comparing the downtime numbers, Prensa Flex in 2022 showed a significant reduction in machine downtime compared to 2021. This fact occurred due to the implementation of improvements in the components that presented greater criticality, thus resulting in a general reduction in time of corrective stoppage for maintenance, and with this, increased productivity and efficiency of the equipment.

Based on the analysis of the table above, it was noticed that in the year 2022 the reliability indicator showed a large variation in relation to the year 2021, that is, this means that the failure rate (λ) which was previously at 0.0265, reduced the percentage of unavailability to 0.0125, presented by the equipment due to maintenance reasons (breakdowns) during this period. The reliability of the equipment to be in full operation for 23 hours straight increased to 139.05%.

In addition, there was an increase in the mean time between failures (MTBF) of the equipment, which previously was 37.73 hours to 87.71 hours and a reduction in the meantime to repair (MTTR) to 0.25 hours in the year 2022, thus increasing the availability of equipment for production. Therefore, this demonstrates that the proposed improvements were efficient, as they achieved good results in terms of reducing equipment downtime and repair.

A comparison was also made between the years 2021 and 2022 in relation to maintenance indicators, with the aim of verifying and analyzing the performance of the equipment for its maintainability and improvements, as can be seen in table 3 below.

CONCLUSIONS

The use of production management and quality control tools, especially Pareto, made it possible to identify the main equipment and most critical components of the plant, which, after deployment, were analyzed and treated using other tools such as the five whys, which have as objective to detect the root cause of component failures. Furthermore, through these and other tools, solutions and improvements were proposed with action

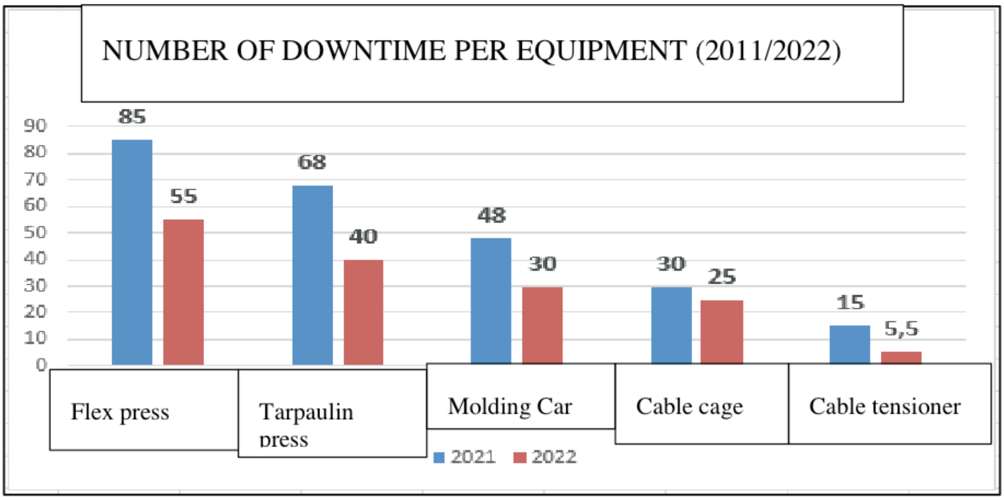

Figure 4: Comparative downtime for equipment. Source: Authors.

COMPARISON OF RELIABILITY INDICATORS		
Indicator	**2021**	**Year 2022**
Failure rate (λ)	0,0265	0,125
Reliability (23 H)	12,53%	139,05%
Average Failure Time (MTBF)	37,73 Horas	87,71 Hours
Average Time for Repairs (MTTR)	0,56 Horas	0,25 Hours
Availability	98,50%	99,20%
Repair Fee (μ)	1,77	1,60
Maintainability (0.597 Hours)	22,10%	12,09%
Maintainability (1 Hour)	48,40%	39,20%

Table 3: Comparative reliability indicators.

Source: Authors

plans to resolve such failures.

With the application of Production Management and Quality Control Tools, it became possible to obtain significant results in relation to the reduction in downtime and number of failures in the Flex Press, which was the equipment that presented the greatest criticality, according to data collection. collected and therefore it was prioritized.

Furthermore, the maintenance indicators in 2022 suffered large variations in relation to the year 2021 before the improvements, with the year 2022 after implementing the improvements it was possible to adjust these indicators in a more assertive way. Therefore, with these numbers presented there was an increase in productivity, availability and efficiency of the equipment.

All tools were of great importance in contributing to the final result of this work, improving equipment maintenance, reducing process failures, reducing rework, improving maintenance time, increasing equipment reliability, and in several cases contributed to the safety of employees involved in production and maintenance activities.

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