ISSN 2286-4822
www.euacademic.org

EUROPEAN ACADEMIC RESEARCH
Vol. X, Issue 10/ January 2023

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

# Use of Lubrication in Equipment Maintenance as a Way to Reduce Mechanical Failures in the Production Line

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**Abstract**

*Nowadays, industries are investing more and more in modern machinery and automation equipment for their processes to increase their production capacity, seeking to improve the safety of their employees and also to guarantee the manufacture of products with higher quality and reliability, for to satisfy the needs of its customers, aiming to become more competitive in the market. In this sector, there are several machines and equipment aimed at making life easier for its users, however, these machines need constant maintenance to maintain the correct functionality and achieve the objectives for which such machines were designed. In this way, this study is presented, which aims to reduce mechanical failures in the production line, pointing out the importance of lubrication in the maintenance of machines in the industry. Conducted by bibliographic and qualitative bases, this research correlates and describes the concepts of autonomous maintenance to the correct lubrication methods, so that, seriously emphasizing the reasons that make lubrication necessary and the benefits that adequate lubrication provides to equipment. Due to the importance of different equipment in large companies, the advancement of global technologies has made lubrication techniques more accessible, in this sense, it is necessary to understand that for continuous improvement in productivity, this is a crucial topic to be addressed.*

**Keywords**: Failures, Maintenance, Lubrication.

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## INTRODUCTION

Currently, in the globalized world in which we live, it is increasingly evident the need for industries to do more with less and eliminate the waste that cause damage to companies and that ultimately impact the price of products manufactured by them. Customers are more demanding and competitors are sparing no efforts to stand out in the industry market. It is not news to anyone that industries have invested heavily in the acquisition of new machinery and equipment to increase their production capacity and thus meet their customers in a satisfactory manner. With so many machines working towards a safer, more modern and competitive industry, we cannot let those that were designed to help us produce faster and with more quality become villains, by presenting failures and or breaks that interrupt the production process for lack of proper lubrication. This can lead to forced wear of parts and a reduction in the useful life of parts, and with it the unavailability of equipment.

In order to reduce or eliminate these failures in products or processes, several companies develop maintenance plans in their machinery and equipment among the maintenance measures can be cited: inspections, industrial lubrication and exchange of parts and components. Among these measures in the maintenance plan, lubrication stands out as an important operation, because it consists of introducing a substance (oil and grease) between the moving metal parts, to avoid metal friction between the parts in order to prevent breakages, breakdowns and stops in the production process. Given this scenario, the market demands professionals in Mechanical Engineering with skills to work in problem solving and who know how to plan, organize and determine the best maintenance plan to be used in the assets of a company. In this context, the need for this study arose, which has as its general objective the reduction of mechanical failures in the production line, through detailed analysis of the mechanical failures of machines and the specific objective of eliminating the constant interruptions of the process due to crimping failures by locking the machine heads.

## DEVELOPMENT

Conceptualizing maintenance involves a central paradigm of caring for a specific item. This action can be understood as the junction of processes and management activities that intend to care for or restore the functionality of the items in question, thus providing continuous improvements and greater security to their users.

According to Sullivan et al. (2017, p. 03) this concept aims to "[...] maintain: equipment, facilities, and buildings, with: Longer time of use; higher performance; safe conditions work; cost reduction".

This functionality applies when one aims for higher quality through the promise of destroying the root cause of failures and not only their correction, so that the good or service is better developed.

Gomes (2015) states that in autonomous maintenance the procedures in development act directly connected to the resolution of problems such as condensation of residues and spurts, difficulties in lubrication and bad fitting of parts. However, the qualification of employees to the point of developing autonomy is the core of autonomous maintenance.

This autonomy is sought in the environment so that the machinery in its work area is easily recognized by the operator and he understands the causes of failures, and if any anomaly occurs, he can solve it more easily.

The concept of autonomous maintenance has several subdivisions and involves the use of other tools to help manage organizational operations. Among these, the use of the 5 senses concepts and Lean Manufacturing production stand out.

The 5S methods is a set of procedures for continuous improvement of process management, which aims to cause high levels of efficiency, cleanliness in a particular workspace humanized under favorable circumstances for the execution of the same.

According to Souza et al. (2012) the 5S was developed in a categorical and interactive way in institutions through bases of understanding capable of demonstrating significant results, the name refers to the initials of the Japanese term: Seiri, Seiton, Seiso, Seiketsu and Shitsuke that in Portuguese are the senses that mean: utilization, organization, cleanliness, standardization and discipline.

Lean manufacturing is a powerful production management system that aims to raise productivity efficiently, increasing profits by reducing costs, eliminating losses and failures that do not add value to the product. It also goes by another name: Toyota Production System, or lean manufacturing, developed by the automaker Taichi Ohno, which lists the 7 main losses, such as: overproduction, waiting, transportation, processing, inventory, handling, and defects.

Among the classifications of this preventive method, there are other subdivisions that individually address a specific model of action. These are: Corrective; Planned Corrective; Preventive; Predictive and Detective. These concepts are addressed below in a related way.

Also known as unplanned corrective maintenance, it does not involve time for detailed division of parts or programming of repair activities. It is formulated as the collection of mechanisms that are committed with the intention of quickly dispatching the manufacturing, machinery, or tool that has stalled. The case is that in many times even with lightning speed it becomes impossible to avoid unexpected damage caused by downtime, such as indolent employees, late production, operators working under duress, offering risks of incidents.

Sullivan et al. (2017, p. 03) describe this model "[...] is characterized by maintenance teams acting on facts that have already occurred, whether these facts are lower-than-targeted performances or a failure [...]".

It is planned and monitored, executed in fixed periods, in a way that sustains the machinery or instruments in exact performance and maintenance circumstances, avoiding unexpected stops.

According to Marques (2014), this maintenance mode develops in fixed periods of time, or previously defined guidelines that intend to restrict breakdowns and degrades. This method is subdivided into Systematic Maintenance, which is formulated periodically or in small numbers, however, without previous definition, and Conditional Maintenance, which through constant observation of the machinery and its good performance bases, seeks the adherence of the necessary operations.

For Fabro and Baldissarelli (2019, p. 03) predictive maintenance "[...] is based on the attempt to define the future state of an equipment or system, through the data collected over time by a specific instrumentation, checking and analyzing the trend of equipment variables."

Over a long period of time, maintenance was considered a time-consuming exercise, inappropriate, without expressive return, and currently it benefits one of the keys to the unraveling of factories in terms of efficiency and accessibility of instruments.

The authors Sullivan et al. (2017) state that there may be several reasons why the use of planned maintenance is feasible, among these, the following stand out: team and demand downtime, actions to safeguard employees, scheduling of production activities, reserve items for operations, and others that may involve the production staff.

The detective maintenance is developed in protective systems, performing scans in search of hidden errors and/or those that cannot be detected by the operational and conservationists. This model is used when it is desired to find and extinguish in advance, possible imperfections in the machinery.

Fabro and Baldissarelli (2019, p. 03) formulate that "[...] is the action performed in protection, command and control systems, seeking to detect hidden or unnoticeable failures to operation and maintenance personnel".

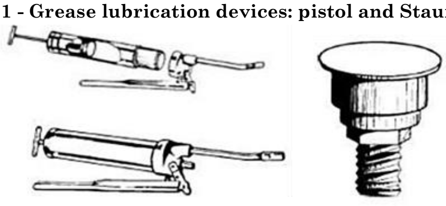
The maintenance in focus for the lubrication process is identified as autonomous, understood as one of the bases of - Total Productive Maintenance - TPM (Total Productive Maintenance) is associated with the possibility of formulating adjustments, through the user of the machinery, that is, the employee himself must keep it functional, restoring the basic operating conditions, according to training and qualification, aimed at recognizing and eliminating failures, through basic knowledge about autonomous maintenance.

According to Marques (2014) the autonomous method was formulated in the mid-1960s, by Japanese organizations with the purpose of eradicating constant maintenance and developing continuous improvement thoughts, in this period, these activities were understood by the term productive maintenance, in its formulation the union of knowledge to the machinery coordinators, in order to enable the best resolutions to failures.

Tribology is the study of wear between surfaces, that is, the analysis of friction, lubrication and wear of parts. The science of tribology comes from bases in physics, chemistry and mechanics, and seeks above all, to anticipate and clarify the procedure of physical and mechanical systems in industry.

In tribology, there are currently four classifications of wear, which are adhesive, abrasive, fatigue and corrosive, as elucidated in Figure 01, below.

**Figure 1 - Grease lubrication devices: pistol and Staufer cup**



Source: Carreteiro and Belmiro, 2006 apud Quadros (2018)

The lubrication process occurs according to natural wear or not, according to the use of the equipment. This is why the study of tribology is so necessary; after all, it seeks to classify the wear modes of equipment.

According to Freitas (2017), the wear classifications can be divided into four: adhesive, abrasive, corrosive, and abrasive wear.

Adhesive wear is formed when the adhesive union of the surfaces starts to oppose each other under pressure, which causes asperities between them and the surfaces become adhesive to the point of not producing the correct sliding, so as to generate a deformity in the contact area and produce a crack with the possibility of forming a new structure with general material transmission.

Abrasive wear can be defined as wear by abrasion, where the surfaces in contact cause loss of material by rigid particles, which removes part of the surface of the part in question.

As its name describes, corrosive wear is caused by liquids or gases that corrode the surface, where reactions occur due to chemical and electrochemical reactions, such reactions are identified as tribo-chemical reactions.

And finally, this process of wear by fatigue occurs because of the constancy in the repetition of a certain action.

The lubricant is understood as the substances that form a kind of layer or "film" of direct interaction on the parts, which should reduce friction between parts, minimize wear and protect surfaces against corrosion.

Sullivan et al. (2017, p. 05) state that "as lubricants evolved, they began to accumulate new functions such as protection against corrosion, sealing aid, heat transfer, and removal of undesirable products from the system, among others.

Freitas (2017) reiterates that there are lubricants in three physical states, the liquid ones like oil, the pasty ones like grease, and the solid ones like powders, their consistencies varying according to the suitability of their functionalities. In lubrication there are the most used, in this case, the oils that are subdivided into three forms, according to their sources, which are: organic, mineral and synthetic.

The concept of the lubrication process began to emerge in the first half of the 1940s, as formulated by the American Society of Lubrication Engineers, which is currently referred to as the Society of Tribologists and Lubrication Engineers. The relevance of this concept in industrial maintenance is visibly understood when one visualizes all the inconvenience that a stopped equipment provides to the production line.

According to Silva (2015), lubrication systems are currently resorted to for their reliability in solving these failures that occur in the machinery subsystems, through the loss of some specific function.

Currently, there are several methods, as well as tools for applying the various types of lubricants, these tools facilitate the overlapping of lubricants based on oils and greases, in addition to devices for lubricating them, there is also the automated system. The adequacy of the use of the correct type of lubricant on the machinery, aims to balance the amount of material, so that there is no excess or lack of it, and so that the machinery is protected and without waste.

For the application of lubricants in the form of oil, there are some lubrication devices, such as the oil pan; the cups with dipstick, dropper and wick; as well as the circulation systems; The lubrication can also occur by tow; By Ring and Collar; in addition to the by Spray, by Immersion and by Loss.

For grease lubrication, we highlight the following: Gun; Brush; Staufer Cup; Lubrication by filling and by centralized systems in mechanical and automatic.

All these instruments are used as application methods, what differentiates them are the models of machinery and the needs of each one.

The transformation from solid to fluid friction exponentially reduces surface contact, which in turn reduces equipment wear. A benefit that stands out in lubrication is the reduction in the period of periodic repairs, as well as greater reliability in the equipment, with less risk of frequent failures.

According to Oliveira (2016) some benefits obtained with lubrication are found in:

Decrease friction between moving parts. Reduce wear on contact surfaces. Reduce or prevent corrosion. Act as a coolant, dissipating the heat produced by friction. Evacuate from the friction zone the harmful sediments deposited therein, either by dragging them or dissolving them, without, however, altering the basic qualities of the lubricant. Allow the machines to work more smoothly and quietly. (p. 16)

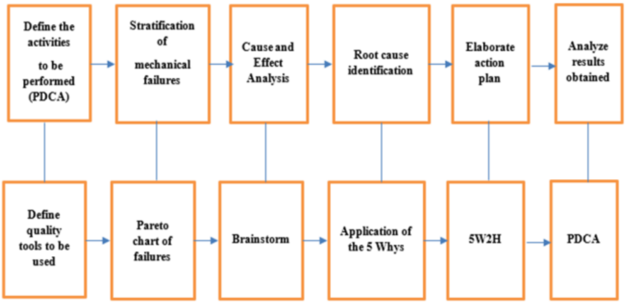
According to Quadros (2018) among some of the benefits that lubrication provides, the following stand out: The limitation of the use of non-returnable energies; the attenuation of degradation in the extensions in contact and Reduction of tempere during the use of the equipment; in addition to the retention of corrosion and shock between the elements.

## MATERIALS AND METHOD

The Monobloc is a priority machine of one of the aerosol production lines of a multinational company in the industrial hub of Manaus.

For the development of the work, it was necessary to conduct a visit to know and identify possible failures during the aerosol production process. Some quality tools were used as the Pareto charts and based on the production indicators, a cause-and-effect diagram was also developed for surveys of possible failures during the process and the PDCA to perform the planning of possible solutions. In the figure below are presented the actions developed.

**Figure 2 - Block diagram of the activities performed in the resolution of the failure.**




Fonte: Autores, 2022

## RESULTS AND DISCUSSIONS

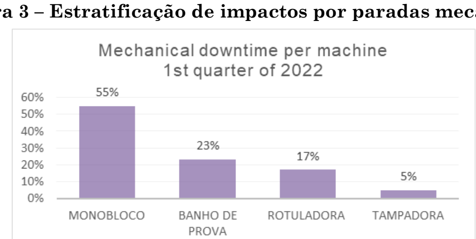
The process of crimping the valves on the aerosol cans is an extremely important activity because it contributes to prevent the leakage of LPG from the aerosol cans and thus leave room for accidents to happen, whether by explosions or fires.

Given the importance of this activity, the heads' lubricant was changed to meet the machine manufacturer's guidelines, as shown in figure 12, by not using grease and starting to lubricate with oil, as shown in figure 13.

It was also observed the need to change the vacuum generation system of the crimpers, because the system used was generating long stops for repair and was still affecting the quality of the product, since it was sending water into the heads and thus removing part of the lubrication, making it difficult for the pincers to move due to increased friction and consequently causing the heads to lock or the pincers to break. Thus, the system was upgraded, as shown in figure 3

It can be seen that the action plan was effective, because it was possible to reduce from 55% to 5% the mechanical failures in the monoblock crimping heads. It is also observed that a detailed and assertive analysis points to the real offenders of the company's results and thus enables the eradication of mechanical failures and process failures as a whole.

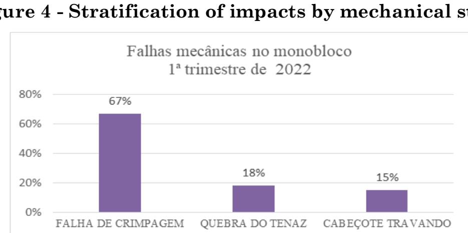
**Figura 3 – Estratificação de impactos por paradas mecânicas**




Source: company database of the Manaus 2022 industrial park

After getting to know the process on the production line, the mechanical failure indicators were evaluated and it was defined that the focus would be on the analysis of the mechanical failures of the monoblock machine, which is the greatest impact, representing 55% of the impacts of the production line due to mechanical failures, as shown in figure 4.

**Figure 4 - Stratification of impacts by mechanical stops**




Source: company database of the Manaus 2022 industrial park

Continuing with the stratification, the Pareto chart showed that the 03 mechanical failure modes that are occurring in the Monoblock machine, are all in the crimping system of the valves on the cans in the 1" heads. Placing the crimping system, the main offender of the mechanical failure indicators in this machine, as shown in figure 5.

**Figure 5 - on the left is the valve crimped onto the can; in the center is the clamp being assembled; on the right is the crimping head.**


Fonte: Manual da máquina monobloco, Pamasol 2018

In Figure 6, we can see a valve properly crimped on the can, in the center of the image we see a set of tongs, which are inside the heads and if they are not properly lubricated, they generate a crimping failure of the valves on the cans, because they cannot make the necessary movements due to the high level of friction. Many times, they break one of the tenacious segments and consequently generate the crimping failure. To the right we can see a set of complete head, highlighted in yellow, head that has presented constant locking problems, causing failure in the crimping.

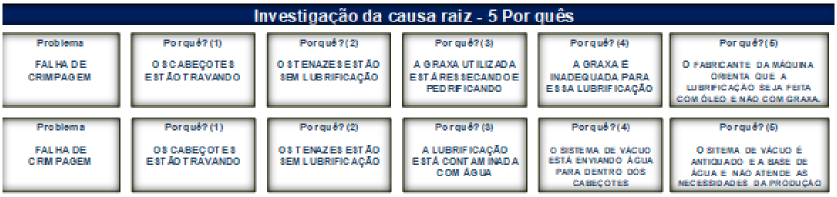
The analysis of the causes of the constant mechanical failures in the crimping heads was performed, using the form of analysis of causes of failure, which is composed of the cause-and-effect diagram, where brainstorms were conducted to evaluate the 6M's and raise the possible causes of the problem.

**Figure 6. Failure Cause Analysis**


Fonte: Authors, 2022

The 5 whys were also used to identify the root cause, where the following root causes were identified: Figure 7.

**Figure 7. 5 Whys Tool**




Source: Authors, 2022

Inadequate lubricant was used for the heads' lubrication, grease was used, while the machine manufacturer recommended the use of oil.

The vacuum system of the water-based heads is outdated, contaminating the internal lubrication of the head with water.

The causes were prioritized to be treated by the GUT matrix.

**Figure 8. Severity, Urgency, Tendency (GUT) tool**

| Nº | Causes encountered | G | U | T | Total | Legenda |
|---|---|---|---|---|---|---|
| 1 | Use of inadequate lubricants to lubricate the heads | 5 | 3 | 3 | 45 |  |
| 2 | Outdated vacuum system contaminating the internal lubrication of the crimp head with water. | 5 | 3 | 3 | 45 | |

Source: Authors, 2022

The action plan was developed and executed.

**Figure 9. Action plan**

| Action plan | | | | |
|---|---|---|---|---|
| **Nº** | **Action** | **Responsible** | **Deadline** | **Situation** |
| 1 | Change lubricant of crimp heads from grease to SP oil | Almir Sarmento | 09/04/2022 | Concluded |
| 2 | Revise lubrication pattern of the crimping heads and train the team | Almir Sarmento | 12/04/2022 | Concluded |
| 3 | Install a modern vacuum generator at the monoblock inlet and disable the old one | Almir Sarmento | 14/04/2022 | Concluded |

Source: Authors, 2022

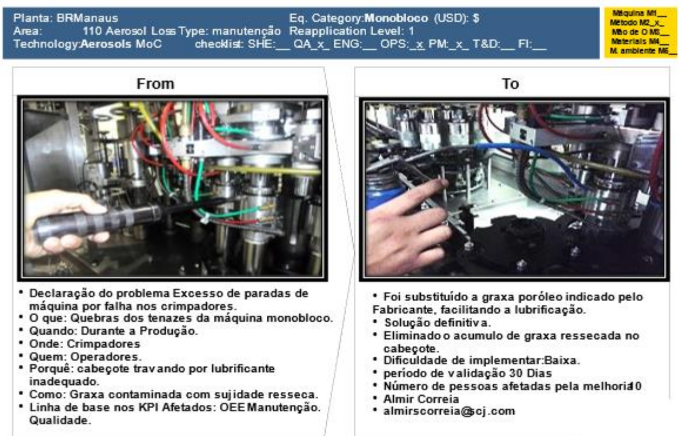
The relevant points identified during the analysis by the GENBA tool in the area:

- It was observed that the heads were contaminated with water, coming from the vacuum generation system that works on the basis of water and that is outside the factory and is antiquated.
- It was also observed that the water was contaminating the lubricant and causing it to lose its chemical properties.

- It was observed that both the locking of the head, the breakage of the pincers, and the crimping failure are due to failure in the lubrication of the heads, either by inadequate lubricant or contaminated lubricant.

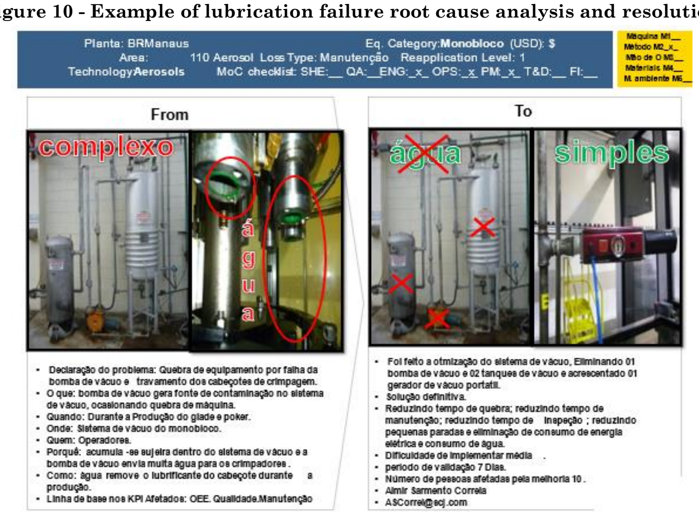
Regarding the proposal to change the grease for SPT oil, it is noteworthy that the analysis of documents (in this case the manufacturer's manual) allowed to establish that what the manufacturer proposes is SPT oil, thus justifying the proposal in the action plan.

**Figure 9- Example of lubrication failure root cause analysis and resolution**




Source: company database of the Manaus 2022 industrial park

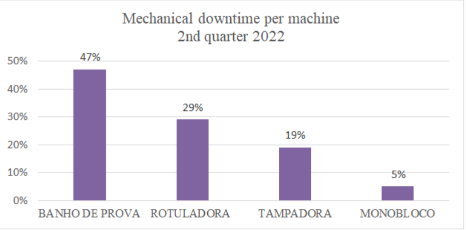
**Figure 10 - Example of lubrication failure root cause analysis and resolution**




Source: company database of the Manaus industrial hub, 2022

Regarding the impacts obtained once the process improvements have been introduced, it is possible to see gains as shown in the figure below:

**Figure 11 - Stratification of impacts by mechanical stops after improvements**




Source: company database of the Manaus 2022 industrial park

From the analysis of this graph, it is possible to observe that there was a reduction in the failures of the proofing bath (from 47% down to 55%); of the labeling machine (from 29% down to 23%); and of the capping machine that went down from 19% to 5% if compared with the previous semester.

## CONCLUSION

It is concluded that the objective of this article was achieved, because it was possible to reduce mechanical failures on the production line, demonstrating that the procedures for lubricating equipment are essential to maintain the machines in basic operating conditions, because they eliminate the forced wear of parts and help to preserve the equipment so that it can achieve the objectives for which it was designed.

Proper lubrication contributes to increase the reliability of the equipment during the processes, reduces the occurrence of failures and interruptions that affect productivity and generate unnecessary costs.

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