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Impact of Machine Overhauls on the Breakdowns in the Manufacturing Industry

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ABSTRACT

This study focuses on a new maintenance strategy called Machine overhaul, which uses the concepts of Reliability Centered Maintenance and how it is different from other traditional maintenance strategies that various manufacturing companies use to improve machine reliability and increase productivity by creating opportunities for longer production runs without suffering from breakdowns through performing minimal periodic maintenance activities and reducing overall cost. The framework of this study addresses the development of this strategy by working with different Original Equipment Manufacturers as they are the subject matter experts in their respective fields and how it is planned and executed by the Maintenance team in an organization. It helps the management and leadership team of an organization to make decisions using the data-driven approach through analysis and comparison of the impact of this strategy against traditional ones to improve reliability and productivity to achieve organizational objectives every year.

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Introduction

The manufacturing industry in today's market constantly faces extreme challenges of improving productivity and decreasing operation costs, which affect the quality of the products they manufacture. The investment in the Maintenance department to formulate and strategize schemes to repair machines is not seen as giving a return like other sections of the industry like finance, business, etc. The selection and proper execution of a maintenance strategy for the production equipment is a critical part of the overall maintenance program that helps organizations achieve their goals. The maintenance team, which includes maintenance managers, engineers, supervisors, and technicians, plays a vital role in selecting and defining a strategy. They participate in the planning and executing of the overall repair process aligned with the concepts of the defined strategy by gathering data from equipment. Every manufacturing company develops its strategy using concepts from various other proven methods. They use valuable information from live case studies of how different industries tackle similar problems of maintaining and managing equipment reliability. There is no defined correct strategy that works for all sectors. It varies from one company to another, and it is the responsibility of the employees to make it robust and valuable by studying the history of issues and repairs performed on equipment. A data-driven analytical approach taken by an organization helps it maximize the production run without causing breakdowns and affecting the quality of the product. There must be a balance between the resources allocated and the money spent to get the resources available to tackle the breakdown. Different maintenance strategies include scheduling equipment repair downtime at certain defined intervals during the production run. The machine is inspected during downtime, and repairs are made as needed. This strategy has challenges as there is no predictability of what issue might be unearthed during the downtime. Another strategy includes periodic equipment inspections and gathering information on which equipment sections need repairs. Parts are usually ordered and kitted for the repair work beforehand, and resources are allocated to complete the repair. This strategy is challenged through the number of resources that can be made available to do all repairs. Sometimes, after the repair, the section of the machine that was not serviced fails and causes additional downtime to repair it. In the manufacturing industry, equipment failure is inevitable. With the correct strategy, resources can be efficiently used to get a maximum return on the investment made to maintain the equipment.

Types of Maintenance Strategies

Four major types of maintenance strategies have been used in the past by various manufacturing industries to keep their equipment in optimal running condition while ensuring reliability through performing inspections, monitoring, and applying proactive measures to reduce downtime. The four main strategies that are used are as follows

• **Reactive Maintenance:** Reactive Maintenance also known as run-to-failure, it involves performing repair work once a specific section of the equipment has failed. This scenario is applied when there is a production breakdown, and the maintenance team is asked to deploy its resources to repair and get the machine back in production. This strategy requires very little planning, but sometimes the repair cost is tremendous due to losses in the production run, the unavailability of critical parts in stock, and the long lead time of parts through OEMs. Irrespective of all the

disadvantages of this strategy, it can still be applied to areas of the plant that are considered non-essential and low-cost equipment.

• **Predictive Maintenance:** They also called proactive maintenance, which involves the planned shutdown of plant assets based on the frequency that Maintenance leaders and highly experienced technicians have set. The periodic shutdowns are coupled with planned inspections and repair work based on task lists created beforehand. This helps direct resources to perform their work in a defined sequence rather than let them wonder what needs to be done on a machine. This strategy is cost-effective, reduces the chances of any malfunction happening in the future, and improves the asset's lifespan. Some challenges in using this strategy are overwhelming maintenance resources in doing repetitive tasks, thus wasting resources, and replacing parts as per the plan even though they are in good condition. Sometimes, breakdowns happen between the planned maintenance, causing additional downtime and adding to production loss.

• **Predictive Maintenance:** This strategy uses condition-monitoring tools to record the performance of any equipment during the production run. It notifies maintenance personnel by creating a work order or generating a notification that could be converted to a work order to perform repairs or replacements before a significant breakdown occurs. This strategy mainly relies on the data collected through machine sensors, PLC drives, and other advanced technologies to predict potential failure points before they happen. The advantages of this strategy over the others are that it provides deeper insights into a machine's condition and lets maintenance personnel make decisions in real time rather than performing inspections at a set frequency or waiting for a breakdown to happen. However, deploying such a strategy requires a considerable investment in installing intelligent gadgets and devices to collect data and predict reliability. To succeed with this type of strategy, having a solid base and understanding of preventive maintenance is critical.

• **Reliability-Centered Maintenance:** This strategy applies maintenance techniques to each asset individually with custom-tailored plans for every piece of equipment. It is a data-driven approach using analytical tools to predict potential failure scenarios and addresses machine stability on a sectional level through custom plans. The driving factor of this strategy is to have the equipment available for maintenance once it is flagged for maintenance activity, irrespective of how critical the equipment is for production. Establishing this type of strategy requires professionals with vast experience and knowledge of equipment to manage and execute multiple plans simultaneously. Reliability-Centered Maintenance (RCM) acknowledges that equipment failure isn't always predictable [4]. An organization with highly skilled mechanics and a team of experienced professionals who have previously worked to establish multiple preventive and predictive measures and set up an asset hierarchy should consider adopting RCM.

Table 1: Comparison of Maintenance Strategies

Strategy	Summary	Cost to Implement	Pros	Cons
Reactive	Fix it when it breaks	Low	Ideal for low-priority equipment	This can lead to runaway repair costs
Preventive	Maintenance on a predetermined schedule	Average	Best strategy to implement without expertise	Without optimization, "PM creep" can occur
Predictive	Condition-based monitoring triggering work orders	High	Timely and informed monitoring. More insight into causes of breakdowns	Can be expensive to set up
RCM	Investigation of failure modes to determine best maintenance strategy	Highest	If executed properly, provides the most efficient maintenance schedule	Requires time, skill and financial resources to be effective

Source: https://fiixsoftware.com/blog/evaluating-maintenance-strategies-select-model-asset-management/

A fifth strategy has been established and frequently used in the food industry, proving beneficial for maintaining the assets to an optimal reliability and performance level. This strategy is called "Machine overhaul," which uses the concept of Reliability-Centered Maintenance (RCM) as it is tailored to specific assets and varies from one to another.

Machine Overhaul Process Layout

The machine overhaul strategy is a reasonably new approach to performing maintenance work on a specific asset using the data collected through various breakdowns, inspections, monitoring, preventive maintenance task lists, and other reactive and proactive repairs. All the assets in an organization are first broken down into different categories, such as high, medium, and low. High-category machines are always used in production runs and are critical components of producing a product. These machines are mainly heavy-duty and are bought through various OEMs. They would stop an entire production line if a failure occurred to them. The medium category represents those machines that do not stop a whole production line, and there are contingencies to run a bypass line using physical labor while the machine is being repaired. The low category involves auxiliary equipment that only supports the production line. They are not critical to an entire production run, and there might be more than one machine of a similar kind in the facility that can be activated when there is a failure on one machine. Medium and low-category machines can use the concepts of traditional maintenance strategy, such as preventive maintenance, to ensure the equipment is serviced and maintained at periodic intervals and failures are avoided by replacing worn parts through analysis of data collected from inspections and monitoring applications.

A machine overhaul strategy is applied to high-category assets in a company. Figure 1 explains the overall process layout of this strategy. First, the Original Equipment Manufacturer (OEM) of the asset is contacted and asked to send their technicians who are subject matter experts (SMEs) in their respective fields. Their job is to thoroughly inspect the machine and evaluate different areas of the machine in both running and non-running conditions. The company's Maintenance team helps the OEM technicians during this evaluation phase. During the evaluation phase, the focus is on analyzing data collected related to various issues on the machine in past years, collecting data through sensors, plc (as part of Reliability Centered preventive Maintenance strategies).

Emphasis is also given to evaluating worn parts like bearings, couplings, shafts, sprockets, chains, etc., that usually wear out after running the machine for specific years. After the evaluation is completed, a detailed report is provided to the company by the OEM. The report provides the current condition of the equipment and what parts need to be replaced on the machine to bring it back to the original standard that the machine was when it was bought from the OEM. The concept that is used during this overhaul is not just to replace the part that is worn out but also to replace the parts that are in the same vicinity or of similar critical nature that currently look in good condition with minor wear and tear but might possess a threat of failure in the future causing significant breakdowns. The next phase of this strategy is planning and parts ordering. The Maintenance leaders and OEM project managers sit together to create a detailed scope of the entire machine overhaul. All the tasks are captured using a Gantt chart with the number of person-hours needed to complete each task. This plan is reviewed, and revisions are made to accommodate contingencies if something goes wrong. Once the plan is set, the next phase includes scheduling and execution. The scheduling team in the company is given advanced notice that a machine overhaul is needed for an asset, and a certain amount of time, based on the plan made, will be required to complete the overhaul. After the scheduling team confirms, the plan is set in motion. The technicians from the OEM travel to the company, and along with the Maintenance technician at the company, they work together to replace all the parts as per the detailed plan created by project engineers at the OEM along with the Maintenance leader at the company. After completing the work, the OEM tests the machine under dry runs and runs with product scenarios for at least 8 hrs. This helps to visualize any issues after the machine overhaul has been completed and rectify them before the machine is handed over for production run. The machine overhaul helps improve the machine's reliability and reduce failures during production.

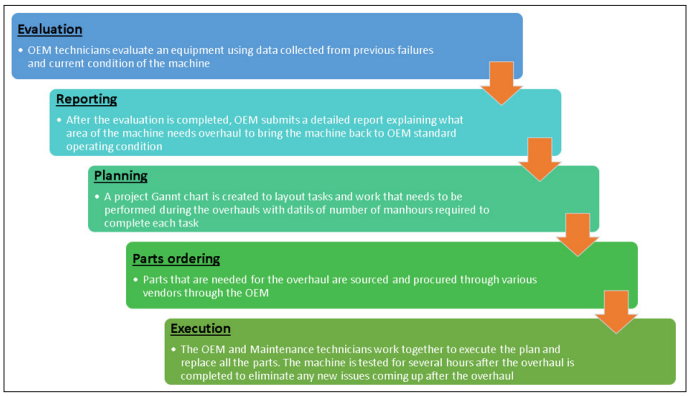

Figure 1: Process Layout of Machine Overhaul Strategy

Data Collection and Analysis

In a food and beverage company, the machine overhaul maintenance strategy was employed on two different assets in two years. Figure 2 shows a carton machine with much repair work performed during 2020. A first machine overhaul was performed on this machine in December 2020, and after that, the count of breakdowns went down by more than 50%. The second machine overhaul was performed in December 2022, which reduced the breakdown occurrences even more.

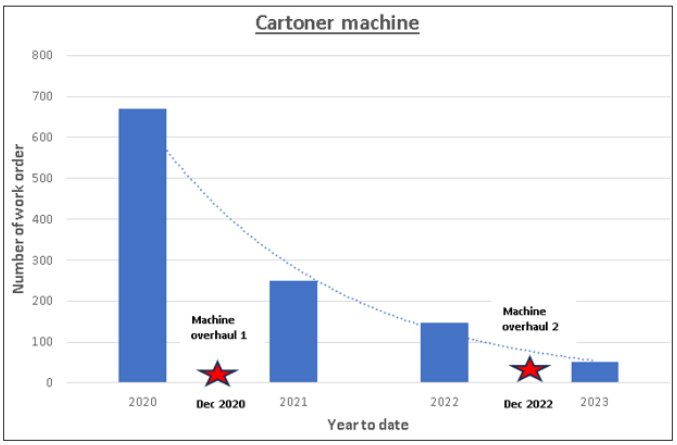

Figure 2: Analysis of Work Order Performed on Carton Machine between 2020-2023

Similarly, a machine overhaul on the carton scale in December 2021 reduced the breakdown frequency by more than 30%.

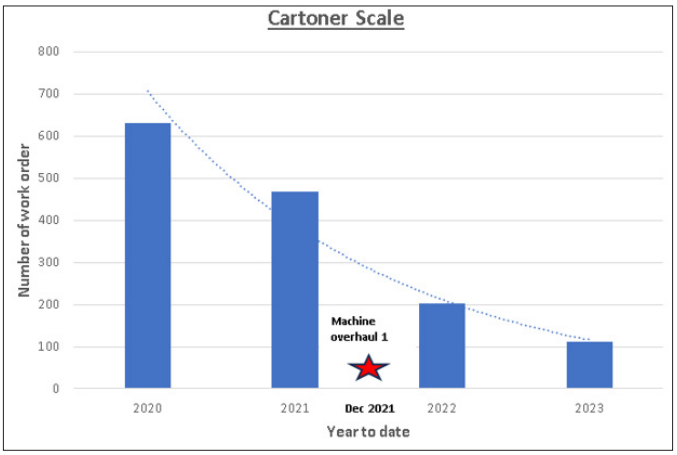

Figure 3: Analysis of Work Order Performed on Carton Scale between 2020-2023

Both the above scenarios support the benefits of this custom strategy that can be effectively utilized in any manufacturing industry to improve machine reliability and productivity without compromising product quality [1-4].

Conclusion

In today's world, when Industry 4.0 and the Industrial Internet of Things (IIoT) have dominated conversations about the future of manufacturing, industries must constantly evolve their current maintenance strategy, learn from what other companies are doing, and adapt to run their operations successfully. Machine overhaul is an exciting strategy. If executed and planned correctly, it can reduce the number of breakdowns on the production floor and help an organization reach its goals and objectives by strategically investing in repair activities aligned with a data-driven approach. There is still scope for improvement in this strategy, which will keep improving as more and more companies adopt this to support maintenance programs. The inventory department is an area that benefits from this majorly because it reduces the need to carry stock of all spare parts for a machine as the majority of the critical parts are replaced during overhaul, which reduces the chances of them failing during the production run. The process also helps an organization build the technical knowledge of their current workforce by assigning them to participate in the machine

overhaul projects run with the help of OEM subject matter experts and eventually raise the knowledge level across the company's personnel.

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