Optimisation of predictive maintenance by lean manufacturing strategies

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Abstract: Maintenance is essential to ensure long-term reliability and availability of equipment, while minimizing downtime and associated costs. This article discusses different optimization models in maintenance management and provides information on their applications and benefits. Starting with predictive maintenance, the article describes its importance in proactive equipment management and cost reduction. He then discussed the principles of lean maintenance, emphasizing the ability to streamline processes and reduce waste, which would ultimately lead to an increase in efficiency. Additionally, Reliability and Risk Centered Maintenance (RRCM) provides a methodological framework for recognizing critical maintenance tasks and using resources more efficiently. Finally, the implementation of Total Productive Maintenance (TPM) based on lean manufacturing tools is examined, showing its potential to improve equipment performance and foster a culture of operational excellence. Through these models, organizations can enhance equipment reliability, reduce maintenance costs, and gain a competitive edge in the market. Choosing the appropriate model tailored to specific organizational needs is crucial for achieving optimal maintenance performance and operational efficiency.

Key-Words: Predictive maintenance ,lean maintenance, Internet of Things, Computer-assisted maintenance management, Total Productive Maintenance. Reliability and Risk Centered Maintenance.

Contents

1. Introduction

When a company manages maintenance well, it's super important to make the best use of resources. Maintenance keeps equipment working smoothly, prevents unexpected breakdowns, and makes sure things last longer. To do this right, you need to be smart about using people, materials, and time efficiently while keeping costs down.
Companies are using new ideas like fancy technology, automated processes, special software, and data analysis to help with maintenance. These ideas help predict problems, plan fixes ahead of time, and make maintenance schedules better. Also, gadgets like the Internet of Things sensors let companies check equipment in real-time, making it easier to predict when things might go wrong and manage resources better.
In factories, where keeping machines running is super important, there are big challenges like not enough skilled workers, high maintenance costs, and managing lots of equipment. But there are smart ways, called optimization models, that help find the best balance between how much maintenance costs and how well things work. These models also figure out the best time to do maintenance to keep everything running smoothly.
To make these models work, companies need to spend money on training staff and using advanced computer systems to collect and analyse data.
Even though there are challenges, using optimization models in maintenance for factories can make a big difference. These smart approaches not only help companies deal with problems now but also get ready for what might come up in the future, making sure they stay competitive. The article is structured into six sections. It begins with an introduction, followed by section 2 on predictive maintenance and optimization of your equipment, section 3 lean maintenance, section 4 Reliability and Risk Centered Maintenance, section 5 implementing total productive maintenance (TPM) based on lean manufacturing tools, and finally, conclusion.

2. Predictive maintenance and optimization of your equipment

Industrial companies today face fierce competition and budgetary constraints. Equipment maintenance requirements have changed significantly in recent years. For a long time, maintenance was seen as a cost driver, but in an era of increasing digitalization, it has a different role.
In order to reduce the failure of machines and production devices, as well as to cope with the rapid growth of intelligent systems, it is essential to implement effective strategies. This is where predictive maintenance comes into play.[1]

2.1. The importance of data prediction and analysis in the era of Industry 4.0

Industrial maintenance is a major issue for companies because it directly impacts their productivity and competitiveness. Unplanned downtime, costly breakdowns and economic damage caused by production interruption can have serious consequences across the entire supply chain. To avoid these problems, maintenance departments must be able to prevent breakdowns before they occur. This involves constant monitoring of equipment for signs of emergency and impending failures. A traditional approach could prove ineffective in the long term with the advent of Industry 4.0. Companies that rely solely on reactive and preventive maintenance strategies could be overtaken by competitors using big data, artificial intelligence and machine learning to implement more effective maintenance. To remain competitive, companies must therefore evolve and adopt new strategies, more in keeping with the times. They must invest in sophisticated skills and tools to implement proactive data analysis systems.[1]

2.2. Predictive maintenance tools

Predictive maintenance therefore relies on several tools and techniques to collect and analyze all this information. Indeed, the integration of the tools mentioned later is very important because it helps maximize the effectiveness of the strategy in question.

2.2.1 Iot sensors

Through a myriad of intelligent sensors distributed across equipment, IoT enables real-time collection of crucial data on asset condition, performance and usage. This data, once aggregated and analyzed, provides unparalleled visibility into equipment behavior, facilitating a proactive approach to maintenance. IoT sensors continuously monitor various parameters such as temperature, pressure, vibration, and other equipment health indicators. This information is fed to data analytics platforms that use advanced algorithms to detect anomalies and predict potential failures. This proactive approach helps anticipate problems, optimize maintenance planning, and minimize unplanned downtime. Another significant advantage of IoT in optimizing maintenance resources is the real-time management of spare parts inventory. Sensors built into storage warehouses can monitor inventory levels, automatically report replenishment needs, and help reduce costs associated with overstocking or delays due to insufficient inventory. IoT also makes it easier to implement predictive maintenance. By closely monitoring equipment performance, maintenance teams can schedule interventions at the optimal time, avoiding costly repairs and extending asset life. However, successful adoption of IoT for optimization of maintenance resources requires robust infrastructure, rigorous security protocols to protect sensitive data, and training of personnel to effectively interpret the information generated. This allows for more efficient use of resources, avoiding costly unplanned interventions and extending the life of equipment.[2]

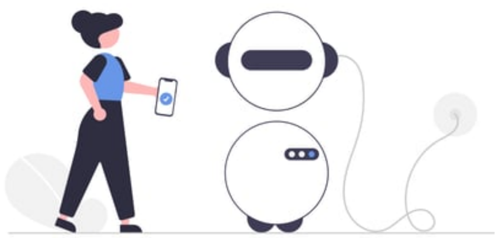

Figure 1: IOT Sensors

2.2.2 Computer-assisted maintenance management

CMMS means computer-assisted maintenance management, it is specialized software for managing a technical service. The CMMS consists of a "historical" database which is populated by maintenance personnel via a form. Each CMMS is personalized according to the specific needs for operating the history or operation of a site.[3]

1) The CMMS software allows you to build a database in which you will find :

• Store items, suppliers, • Management of intervention requests. Item entry and exit, • Purchasing management, • Asset management (equipment and sub-assemblies), • Management of corrective and preventive interventions, • Financial analyzes and monitoring of maintenance indicators, • Management customer contacts and invoicing.[4]

2) Objectives of a CMMS system [5]

To achieve these objectives, the goals of a CMMS system are: • Improve cost control • Optimize the maintenance budget • Optimize purchasing and inventory management (cost reduction) • Increase the availability of equipment (reduction in production shortage) • Improve and facilitate maintenance planning • Capitalize on experience (easy and quick consultation of history) • Reduce the number, frequency and severity of breakdowns • Improve the quality of service (meet needs and increase the satisfaction rate) • Increase maintenance productivity • Reduce urgent interventions as much as possible • Reduce response times • Provide anyone in the maintenance department with more detailed and reliable information.[4]

.3) Role of a CMMS system

• A CMMS system has the role of participating in better organization, saving time and efficiency, and reduction of tasks. • A CMMS system is designed to manage, pilot, monitor and analyze the activity; taking charge of planning, for example, is difficult to achieve because some of the maintenance work cannot even be planned.[5]

4) Analysis of the different functional modules of a CMMS software package:

All CMMS software packages have in common the same modular structure offering the same functions. But, depending on the software, the functions performed are variously named, variously distributed and variously organized. In this section we present the functional modules common to all CMMS software packages. This figure shows an example of the modular structure of a CMMS.

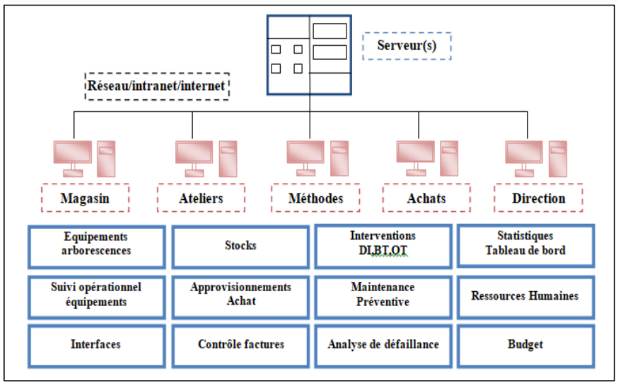

Figure 2: Example of modular structure of a CMMS.[5]

2.2.3 Machine learning and artificial intelligence

Machine learning and artificial intelligence (AI) play a crucial role in your strategy, helping to improve the management and analysis of information more accurately and efficiently. This is called maintenance 4.0, which corresponds to the 4th level of maturity in predictive maintenance. Using machine learning algorithms, AI can analyze the information collected by the different tools to detect warning signs of failure. It helps uncover hidden patterns and relationships between data, which can help predict failures with high accuracy.[6] AI can also be used to optimize maintenance intervals based on the actual condition of equipment rather than based on pre-established maintenance schedules. It helps maximize machine availability while reducing maintenance costs, provide real-time recommendations and help identify best practices for different asset types. Various controls, including programmable logic controls (PLC) and OPC technology, send information to CMMS software and detect when you exceed thresholds predefined by you. The teams then analyze this data to derive usable information. Based on this information, automated responses, such as work orders, alerts and other notifications, can be set up.[1]

2.3. The different monitoring conditions for effective targeting of failures

Initially, managers must establish the conditions that need to be monitored through the CMMS for each machine. This analysis can be visual, auditory, thermal or, most often, a combination of these criteria and more. The technological step at this stage is to determine the right sensors and monitoring tools to equip:

- Vibration analysis helps provide insight into possible failures, as excessive vibrations can indicate signs of failure.
- Acoustic monitoring has the ability to indicate which machine is experiencing a malfunction, using sound.
- Infrared analysis relies on temperatures. High temperatures can, for example, cause components to melt or burn and, depending on the equipment, may need to be addressed before causing collateral damage.
- Oil analysis is a process where oil is extracted from a machine and tested for wear particles, presence of water and viscosity.
- Etc.[1]

2.4. The impact of predictive maintenance on optimizing equipment performance

Even if some breakdowns will always remain unpredictable, predictive maintenance is an avenue to avoid breakdowns and optimize equipment. Here are some of its main advantages: • Improved availability • Reduced downtime and maintenance costs • Optimization of maintenance processes • Increased equipment lifespan • Improved worker safety • Etc.[1]

Thanks to this approach, only the parts of the machine or installation that need to be exchanged are replaced. Instead of making a change just because standard procedure requires it, even if the parts are still fully functional. This avoids wasting materials and resources and brings an environmental perspective to your strategy. Ultimately, there is also a major benefit for the customer: less machine downtime and therefore less frustration. Customer satisfaction increases.

3. lean maintenance

Lean maintenance is the combination of lean and maintenance, allowing the approaches, methods, and tools of each to be combined. It is mainly the application of lean principles in the field of maintenance and repair [7]. The objective of lean maintenance is not just to minimise the maintenance budget but to increase profitability through efficiency, reliability, and customer satisfaction. Thus, it is not necessarily to minimise "inputs" or maximise "outputs," but to optimise their combined impact on results. The "outputs" include improving quality, costs, and meeting delivery dates while improving safety and health conditions, as well as the working environment in general[8].[9]

3.1. The principles of Lean maintenance

Knowledge of the principles of Lean maintenance is a preliminary step to integrating the lean approach into maintenance processes. These principles may also be of interest to organizations that want to start Lean transformation from the maintenance department. The principles of Lean maintenance illustrated in Figure come from the principles of Lean Manufacturing ([10][11]).

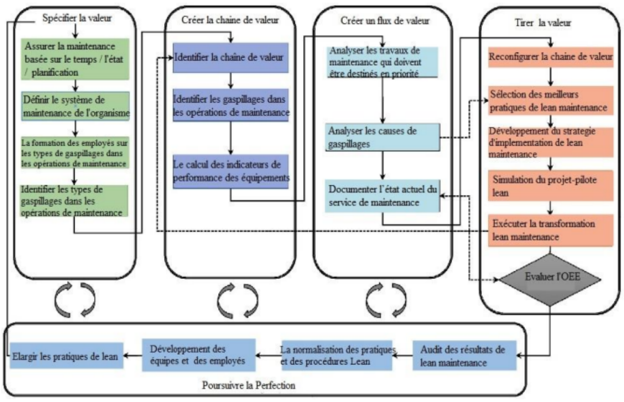

Figure 3: Map of Lean maintenance principles [10]

Step 1:

Specify the value Set the value from the customer perspective. Express the activity that can create value and that meets the real needs of the customer at a predefined cost and at a specific time (maintenance planning, maintenance strategies and teams). This step also defines the training of employees on waste linked to Lean maintenance. Production operators and production equipment represent the internal customer of the maintenance function.

- Step 2:

Create the value chain Identify the value chain, or set of actions required for a specific product. Create the map of the current situation and the future state of the value chain, then identify and classify the wastes in the current situation, and eliminate them! This step ends with the calculation of equipment performance indicators such as availability, overall efficiency rate (OEE), and mean time between failure (MTBF).

- Step 3:

Create a value stream Complete the remaining steps in the value stream. Eliminate functional obstacles, interruptions and detours. Finally, it is a question of carrying out the analysis of the causes of waste and then the analysis of the maintenance work which must be intended as a priority for key equipment which affects the quality of the product. This step evaluates the current status of the maintenance service.

- Step 4:

Deriving Value This step involves confirming that the equipment is creating value through all maintenance processes. The execution of Lean principles takes place in this stage. This step involves reconfiguring the value chain or designing the future map of the value chain, selecting best Lean maintenance practices, developing the Lean maintenance transformation strategy and evaluating the OEE.

- Step 5:

Pursue Perfection This step is about continuing to eliminate waste from the maintenance process so that maintenance tasks are done right the first time and every time. This could be achieved by standardizing Lean practices and procedures, developing teams and employees, and expanding Lean maintenance practices.

3.2. Lean maintenance tools:

The Lean maintenance improvement approach uses lean manufacturing tools in an appropriate framework specifically adapted to their application to maintenance. We present certain tools that we consider appropriate for this approach. The success of Lean maintenance depends on the application of each tool. Each tool provides certain benefits within the maintenance process. Therefore, the performance of the entire maintenance department can be improved.

. • 5S: They are an essential prerequisite for the introduction of Lean maintenance .[12]

- Visual work: It constitutes the support for the daily animation of progress at the level of the work unit. It is about having a positive attitude towards problems, considered by everyone as an opportunity for improvement ([13]

- Value chain mapping: Necessary tool at the start of the implementation of Lean maintenance. It helps provide a global perspective and highlights sources of waste. When all participants are consulted in the value chain mapping and the scenario is developed, there is often a consensus that current methods are not optimal. Thus, several improvements become visible. This is especially important when the process crosses multiple activities such as purchasing, maintenance, production and engineering,. . .

• Standard work: The objective of standard work is to define the best way to carry out an operation [13] It must simultaneously guarantee:

- operator safety, the best level of quality, from the first operation, without resorting to control and rework, - an easy (ergonomic) and economical operating mode, - the deadline, i.e. being able to deliver the part or assembly to the following process at the planned time.

• Planning and Scheduling: Planning and scheduling are among the most important activities for increasing efficiency in a maintenance organization. To achieve this, maintenance technicians must communicate and cooperate effectively with the scheduler, the work management manager and the production and operations teams.

• Store MRO (Maintenance, Repair and Operations): Companies are moving towards a proactive TPM culture characterized by planned work, it is necessary for maintenance to order the material and receive it in a JIT scenario, before the failure occurs. Additionally, better organization of spare parts storage eliminates inventory duplication and calculates economic order quantities and appropriate maximum and minimum stocking levels. It also allows the identification of obsolete stock which can be returned to the seller or discarded [10].

• Jidoka: Maintenance must respect the Jidoka philosophy which postulates that quality must be built a priori. The equipment is supposed to produce quality otherwise it must be stopped and adjusted immediately.[14]

• Just In Time (JIT): Spare parts and materials are used when they are needed in order to avoid unnecessary stocks and thus reduce storage costs. Without JIT-based management, the cost of inventory can reach a significant value, up to 20

• Analysis of failure modes and their effects (FMEA): it is a systematic set of activities that identifies and evaluates the potential failure modes of a system. It provides for actions that can eliminate or reduce the chances of a breakdown occurring.

• Autonomous maintenance: Autonomous or independent maintenance is generally carried out by machine operators. It refers to repetitive maintenance such as equipment cleaning and lubrication. . . etc. In this regard, those responsible for maintenance and production must collaborate to establish the appropriate policy.

• The overall equipment performance rate (OEE): it constitutes a key performance indicator of the equipment, particularly as part of a continuous improvement process and also as part of TPM.

• Documentation: Documents and technical manuals must be accurate, relevant and up-to-date to maintain a waste-free environment. Technical documentation is a relevant source of informations which helps to take care of the equipment since it is put into service. Thus, an effective computerized maintenance management system (CMMS) is essential.

3.3. How Lean maintenance helps with optimization

Lean maintenance aims to eliminate waste and improve efficiency, reliability and customer satisfaction in the maintenance process. Here are some ways Lean maintenance can help maintenance: [15]

1. Eliminate waste: Lean maintenance identifies and eliminates waste in maintenance processes, thereby maximizing efficiency and reducing costs

2. Quality Improvement: By focusing on eliminating waste, Lean maintenance helps improve the quality of products and services by reducing downtime and ensuring equipment reliability . 3. Increased profitability : Rather than simply minimizing maintenance costs, Lean maintenance aims to increase profitability by improving efficiency and reliability, while satisfying customer needs

. 4. Alignment with business objectives: The objectives Lean maintenance must be aligned with those of the company, and management plays a crucial role in the success of its implementation .

4. Reliability and Risk Centered Maintenance:

The proposed RRCM method is composed of a set of activities that support to define and periodically update the maintenance plans of an engineering system. Figure 5 presents a method that depicts such activities

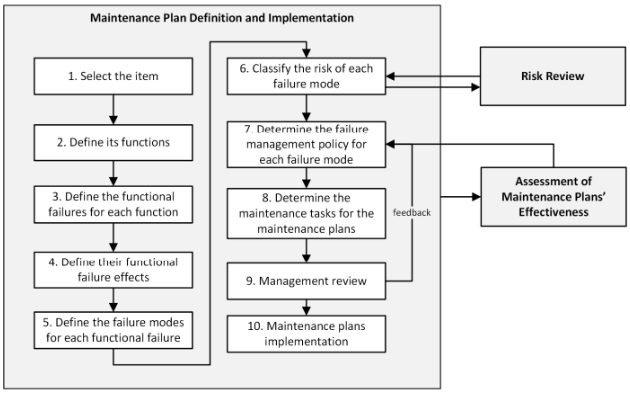

Figure 4: The activities comprised in the proposed RRCM method. [16]

As can be seen in Figure 5, the RRCM method comprises three main processes: the Maintenance Plan Definition and Implementation, the Risk Review, and the Assessment of Maintenance Plans' Effectiveness.
The first one, which will be described in more detail in Section 5.1, is the main process and is responsible for determining the best set of maintenance tasks for each failure mode based on the failure mode risk classification and recommended failure management policy.
The second process, Risk Review, is responsible for periodically reassessing the risk level of each failure mode to verify if there has been any significant change that would imply a change in failure management policies. Periodic reviews allow the organizations to update the input data used for risk categorization as well as review the method and decisions made to be better aligned with the organization's context.
Finally, the third process, the Assessment of Maintenance Plans' Effectiveness, aims to assess whether the maintenance plans defined and implemented in the process present the expected results. This assessment can be supported by predetermining several maintenance performance indicators, such as benchmarks for unscheduled downtime, mean time between failures, maintenance costs, and others. Thus, it is possible to verify whether the implementation of the maintenance plans derived from the determined maintenance policies has achieved the maintenance objectives and, eventually, update them.
It is worth mentioning that both proposed periodic reviews through the second and third process of the RRCM intends to ensure that the method is a living application. In other words, the RRCM does not end with the implementation of maintenance plans as the organization needs to periodically review the risks of failure modes and the effectiveness of the defined maintenance plans. [16]

4.1. . Maintenance Plan Definition and Implementation

The first RRCM process, the Maintenance Plan Definition and Implementation, comprises ten steps, as shown in Figure 5. Steps 1 to 5, briefly described below, comprise a series of activities that are also covered in a traditional RCM [17]. The first step consists of the simple selection of all items, e.g., physical assets, that will be studied and that will have their maintenance plans determined by the method individually. Due to the increasing complexity and number of items in modern engineering systems, some techniques can support this definition to be carried out in an organized and structured way, such as the Functional Tree or a Block Definition Diagram. In general, organizing assets into systems and subsystems and presenting them in a tree-like structure can help to define the items that will be analyzed. It is worth noting, therefore, that the RRCM does not require or define a specific technique for selecting items and is capable of being executed even with the one that is eventually used by any organization. The second step is the definition of the functions performed by each of the previously selected items. The functions of a given physical asset represent what its owner wants it to do, including issues of protection, control, appearance, structural integrity, and other secondary aspects. After determining the functions of an item, it is possible to define the functional failures for each function in the third step. Then, in step four, the effects that each identified functional failure can have on the system, people, and the environment need to be defined. Finally, in step five, the failure modes that can cause each listed functional failure also need to be identified. From the sixth step, the RRCM starts to distance itself from the traditional RCM. Here, the risk associated with the eventual occurrence of each failure mode shall be evaluated, which will be used in the next step to determine a recommended maintenance policy. There are several techniques used for risk assessment, which in general quantify both the severity of the impact and the probability of occurrence of the uncertain event (in this case, the failure mode) and classify it in a risk category. Such quantification and classification shall be designed following the organizational objectives and context. Although the RRCM does not require the use of a specific technique for risk classification of the failure modes, it requires that it be classified into five possible risk levels: very high, high, medium, low, and very low. By postulating that risk assessment should be limited to these five categories, the proposed method can properly prioritize failure management policies according to each Failure Mode Risk Level (FMRL) to ensure reliability while considering the costs. Once the risk level of each failure mode has been determined, the seventh step of the RRCM method determines a tailored failure management policy for each of them. Each failure management policy comprises guidelines for each type of maintenance task that can be used for failure mode control and mitigation. There are proposed seven possible failure management policies: • On-condition: it recommends the continuous monitoring of the physical asset condition, for instance through online measurements or periodic inspection routes. In this policy, maintenance tasks are scheduled and performed only when there are signs of degradation that indicate the future occurrence of the failure mode; • Scheduled restoration or replacement: it recommends preventive maintenance as it comprises a set of pre-scheduled periodic maintenance tasks of replacement or restoration of the item, regardless of its condition, to avoid the occurrence of the failure mode; • Combination of tasks: it recommends a combination of on-condition and scheduled restoration or replacement tasks; • Failure finding: it recommends a set of periodic maintenance tasks that seek to verify the occurrence of a hidden failure mode, i.e., a failure mode not perceptible to the system operators; • No scheduled task; run to failure: it recommends that maintenance tasks only intervene in the physical asset when the failure mode occurs, i.e., when the item does not perform at least one of its functions; • No scheduled task; redesign may be desirable: it includes a consideration to be made by the maintenance team about a possible update or modification in the physical asset. It is a one-time task to allow other types of policies to be used or to reduce the risk associated with the occurrence of the failure mode; • Redesign is mandatory: it indicates that none of the previous failure management policies can effectively reduce the risk associated with the failure mode, requiring, therefore, that an asset redesign is carried out to make the risk acceptable according to organizational objectives.

4.2. Risk Review

These fundamental five steps are followed by the classification of the risk of each failure mode according to the five possible Failure Mode Risk Level (FMRL) categories: very high, high, medium, low, and very low. As the RRCM does not indicate or restrict how the analysis to categorize each FMRL should be performed, it allows for the utilization of supporting tools that are better suited to the characteristics and context of each system being analyzed. In this case study, a risk matrix was chosen to be used and each FMRL is obtained from the relationship between the Functional Failure Impact (FFI) and the Failure Mode Probability (FMP) given by the risk matrix presented in Figure.

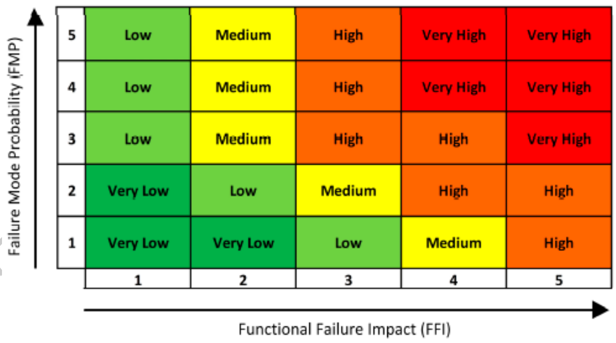

Figure 5: Risk matrix for FMRL classification.

		RCM	RBM	RRCM
Item study	Select the item	X	X	X
	Determine the functions and performance standards	X		X
	Determine functional failures/failure scenarios	X	X	X
	Determine the associated failure modes	X		X
	Determine the failure effects for each failure	X		X
	Determine the failure consequence category (FCC) for the functional failures	X		
Risk estimation and evaluation	Perform hazard quantification/impact assessment		X	X
	Perform a probabilistic assessment		X	X
	Estimate/classify the risk		X	X
	Set up acceptance risk criteria		X	
	Compare the assessed risk with acceptance criteria		X	
Maintenance planning	Select the failure management policy based on FCC	X		
	Select the failure management policy based on the failure mode risk classification			X
	Apply a decision tree diagram as support for cost-effective decisions	X		X
	Determine maintenance tasks and interval	X		X
	Determine maintenance plans to reduce risk to items that exceed the acceptance criteria		X	
Periodic review	Re-estimate/reclassify the risk		X	X
	Review the input information and decisions made	X		X

Figure 6: Comparison of main features of RCM, RBM, and RRCM methods.[16]

5. Total Productive Maintenance (TPM) Implementation Based on Lean Manufacturing Tools

5.1. Research Method

In order to achieve the objectives of this study and to get a good and valid result, a series of research activities was systematically constructed. Those research activities can be explained as follow:

a. Selecting of significance indicators for TPM and LM implementation according to previous research (based on literature review).

b. Determining MP indicators that will be measured as the impact of the implementation of TPM and LM programs. [18]

c. Formulating the models (measurement models and Structural Model) using Struc-tural Equation Modelling (SEM) tools.

d. Generating a questionnaire to measure variables, conducting pilot study (1 st data collecting n=30).

e. Performing validity and reliability test. vi. Revising the questionnaires based on validity and reliability test.[19]

f. . Determine research object and conducting 2nd data collecting (n= 250). viii. Data processing using Smart-PLS software.

g. . Analysing and comparing the results through SEM standard values.

h. Conclusion, documentation and publication. [20]

5.2. Research Hypotheses and Expected Results

5.2.1 Proposed Model

The model proposed for investigating the relationship of TPM, LM and MP was provided on Figure.

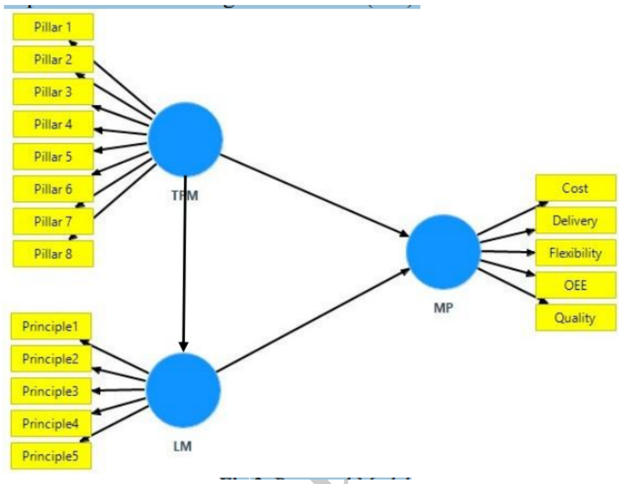

Figure 7: Proposed Model[20]

5.2.2 Research Hypotheses

Four (4) hypotheses (H1 to H4) will be tested. H1: TPM practices has significantly impact to Lean Manufacturing (LM); H2: TPM practices has significantly impact to Manufacturing Performance (MP); H3: LM practices has significantly impact to Manufacturing Performance (MP). H4: TPM and LM practices have significantly impact to Manufacturing Performance (MP).

5.2.3 Expected Results

In summary, the expected outcomes of this research are: 1.Providing updated barriers and enablers factors in implementing TPM and LM in Manufacturing Industries. 2. Provided reliable CFA (measurement) models for TPM, LM and MP. 3. Proposing reference (structural) model of the relationship between TPM, LM and MP for Indonesian manufacturing industries.[20]

6. Conclusions

Finally, in the era of Industry 4.0, industrial maintenance is crucial for the productivity and competitiveness of companies. Unplanned downtime, costly breakdowns and production interruptions can have serious consequences. To address this, failure prevention is essential, which requires constant monitoring of equipment. Predictive maintenance tools, such as IOT sensors and data analytics, are essential for detecting anomalies and predicting failures, enabling targeted interventions. Additionally, adopting lean maintenance practices helps optimize processes, thereby reducing costs and improving customer satisfaction.

The integration of models such as RRCM provides structured frameworks for informed maintenance decision making. Also, the application of TPM based on Lean maintenance tools in Indonesian manufacturing industries demonstrates the growing importance of integrating advanced maintenance management practices to improve overall business performance. In the end, we say that we must invest in the creation of new AI tools or technologies to integrate industrial data from different sources in one place, use it in real time to make the best decisions.

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