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Reliability Improvement Process Case Study: PT HMS Tbk

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Abstract

Purpose: This study investigates the impact of unplanned and planned downtimes on PR (Production Reliability) performance in the tobacco industry, focusing on a company facing challenges due to COVID-19.

Method: A mixed-method approach is employed, combining quantitative data analysis of production lines (Q1 2024) with qualitative interviews. Root cause analysis (Current Reality Tree) and prioritization (Analytical Hierarchy Process) are used to identify and evaluate solutions.

Results: The research reveals maintenance focus on critical parts only and untested new materials as key contributors to low PR.

Conclusions: Improving Process Reliability at PT HMS requires a dual focus on minimizing unplanned disruptions through predictive maintenance and structured response strategies, while also optimizing planned maintenance to reduce its operational impact. Implementing a comprehensive maintenance framework and validating new materials through rigorous testing will ensure smoother production, fewer disruptions, and enhanced overall performance.

Limitations: The study focuses on one company during a specific timeframe.

Contributions: This research proposes a framework for improving PR by recommending a comprehensive maintenance plan, thorough material testing, and an implementation plan based on the PDCA cycle. This is expected to lead to enhanced PR, reduced downtimes, and improved operational efficiency.

Keywords: *Analytical Hierarchy Process, Current Reality Tree, Performance Improvement*

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1. Introduction

The aftermath of the COVID-19 pandemic presented the tobacco industry in Indonesia with a myriad of challenges, exacerbating existing issues within the sector (Hajar, Supriyanto, & Syaifudin, 2021). While the precise impact varied, discernible trends emerged in the wake of the crisis. Primarily, the tobacco industry grappled with an economic downturn akin to many other sectors in Indonesia. The implementation of lockdown measures, coupled with decreased consumer spending and disruptions in supply chains, culminated in a diminished demand for tobacco products (Harfianto & Mukhlas, 2022). Consequently, this downturn significantly impacted the sales and revenue of tobacco companies operating within the country.

Moreover, the pandemic spurred notable shifts in consumer behavior across Indonesia. COVID-19-induced concerns surrounding health and hygiene prompted alterations in purchasing patterns and preferences among consumers (Cruz-Cardenas, Zabelina, Guadalupe-Lanas, Palacio-Fierro, & Ramos-Galarza, 2021). Notably, some smokers opted to curtail tobacco consumption or explore alternative options such as e-cigarettes or vaping products in response to heightened health consciousness.

Furthermore, the regulatory landscape experienced a resetting in the wake of the pandemic. Governments were prompted to reassess public health policies, including those pertaining to tobacco control. While certain measures sought to discourage smoking through initiatives such as increased taxes or sales restrictions, others prioritized mitigating the health risks associated with COVID-19. Such regulatory adjustments potentially impacted tobacco sales and marketing endeavors within the industry. The intricate global supply chains upon which the tobacco industry relies faced significant disruptions during the pandemic. Lockdowns, transportation constraints, and labor shortages collectively impeded the production and availability of tobacco products, presenting logistical hurdles for businesses operating within the sector. COVID-19 also accentuated prevailing health concerns and vulnerabilities, particularly among populations with pre-existing respiratory conditions. This newfound awareness of the health risks associated with smoking potentially influenced public perceptions and attitudes towards tobacco use, contributing to concerted efforts aimed at smoking cessation (Yingst et al., 2021).

In response to evolving market dynamics and changing consumer behaviors, tobacco companies in Indonesia accelerated their digital transformation initiatives (Pratiwi, Karta, Ramanita, Aprilia, & Wardani, 2023). Embracing online sales platforms, implementing contactless delivery methods, and deploying digital marketing strategies emerged as key strategies to engage consumers amidst social distancing measures (Wardhani & Romas, 2021). Lastly, governments faced competing priorities during the pandemic, necessitating strategic allocation of resources and attention. While grappling with public health emergencies and economic recovery efforts, governments also contended with tobacco control initiatives. The varying degrees of emphasis placed on these priorities had discernible implications for the tobacco industry within Indonesia.

Due to the aforementioned issues, PT HMS also felt the impact of Covid-19 on conventional cigarette sales. The decline in volume prompted PT HMS to compete internally among its factories to achieve higher production reliability to ensure that volumes are allocated to those factories. The Indonesian tobacco industry faces significant challenges and changes due to the recent increase in tobacco excise tax (CHT) rates (Gunardi, Veranita, Agung, & Febyola, 2021). This tax hike has led to various responses from consumers and tobacco companies, influencing market dynamics and corporate strategies. The increase in CHT rates has resulted in higher prices for different types of cigarettes, such as machine-made white cigarettes (SKM), machine-made clove cigarettes (SPM), hand-rolled clove cigarettes (SKT), and other tobacco products. These price adjustments impact consumer behavior, with some consumers shifting to lower-tier cigarette brands to cope with the increased prices, while others remain loyal to their preferred brands despite the price hike (Solihat, 2023).

The purpose of Process Reliability is to provide the operational and manufacturing teams with a clear understanding of the manufacturing losses, enabling them to establish strategies for eliminating these losses. This metric is employed to drive various objectives such as increasing throughput, reducing costs, improving productivity, identifying and eliminating losses, and fostering a unified approach. This research aims to provide a recommendation of PR improvement strategy to meet the following objectives; To identify the effect of Unplanned Downtime to PR Performance at PT HMS Karawang Factory. To identify the effect of Planned Downtime to PR Performance at PT HMS Karawang Factory. To propose solutions to improve PR performance at PT HMS Karawang Factory.

2. Literature Review

2.1 Lean Manufacturing

Lean manufacturing, initially perfected by the Toyota Production System (TPS), has been widely adopted by numerous companies in developed countries to enhance their performance. It involves combining various tools and techniques into a cohesive system through human dedication and perseverance. The outcomes are often remarkably impressive. However, in many developing countries like Bangladesh, most companies still employ a "just-in-case" approach and frequently experience underwhelming results.

The implementation of lean manufacturing relies heavily on several fundamental principles. The initial implementation of lean manufacturing, known as "only-on-time," was pioneered by Toyota Motor

Company in Japan in the early 1970s as part of the just-in-time (JIT) management philosophy (Irsan, Taba, & Hakim, 2022). It achieved incredible success in waste and inventory reduction. In the TPS, waste is defined broadly, encompassing all aspects of manufacturing and assembly. The success story of Toyota quickly spread, leading to the broad adoption of lean manufacturing approaches beyond national borders, including in the United States. However, the concept of lean manufacturing was first introduced in the book "The Machine that Changed the World" (Womack, Jones, & Roos, 2007). It is referred to as lean manufacturing because it requires fewer resources compared to traditional systems to produce goods or services of the same quality (Habib, Rizvan, & Ahmed, 2023). Lean focuses on pull demand instead of the traditional market push, emphasizing productivity that considers quality in all aspects, achieved as quickly and cost-effectively as possible by improving process efficiency (Rizka, Asbari, & Setiawan, 2024). Consequently, lean manufacturing has become a highly discussed topic in developing countries nowadays.

Lean thinking can be regarded as a tool for identifying customer value and can be implemented in diverse areas, ranging from manufacturing to services, mass production to small-volume production, and labor-intensive industries to technology giants (Habib et al., 2023). In the past decade, there has been a positive trend in process industries to implement lean principles throughout the entire supply chain system in order to enhance competitiveness in the modern market (Moyano-Fuentes, Maqueira-Marín, Martínez-Jurado, & Sacristan-Diaz, 2021). The fundamental principle of lean is the willingness to embrace change and the ability to minimize waste while ensuring product or service (Asnan, Nordin, & Othman, 2015). It is renowned for eliminating waste and non-value-added activities using minimal resources. The decision to implement lean manufacturing can be challenging due to significant differences in employee management, floor layout, machine types, and the flow of process information (Buer, Semini, Strandhagen, & Sgarbossa, 2021). Ultimately, lean has received considerable attention in academic research in recent years and has become a paradigm for manufacturing companies (Fiorello et al., 2023).

The paper showcases various TPM strategies, including autonomous maintenance, focused improvement, and planned maintenance, which were implemented to minimize equipment downtime and enhance operational efficiency. By integrating TPM, the company managed to improve the reliability and performance of their machines, leading to a more efficient production process. This approach not only tackled existing maintenance challenges but also encouraged a proactive maintenance culture among the employees. The result was a smoother, more productive operation that significantly elevated the company's overall productivity.

2.2 Key Performance Indicator

Key Performance Indicator (KPI) is one of the essential tools that can help organizations achieve their goals. KPI is a main performance indicator used to measure and evaluate the achievements of individuals, teams, and the organization as a whole.

2.2.1 Planned Downtime Loss

Planned Downtime losses refer to the scheduled downtimes recorded under category 600 Scheduled Downtimes, which correspond to the time allocated for planned activities based on the definition of Working Time as reported in Manufacturing Key Performance Indicators. A "pit stop" refers to the downtime taken by the team to restore the equipment to its base condition, execute tasks outlined in the Autonomous Maintenance (AM) steps (such as DH, SOC elimination, CL checks, IPS, and capability building), perform root cause analysis, and carry out improvement tasks.

Activities can only be considered as planned if they are agreed upon during Line and Shift DDS meetings and executed during the pit stops. The duration of the pit stop can be adjusted based on the defined activities and priorities during the Line and Shift DDS for the next 24 hours, but the number of pit stops executed during each shift must be fixed for each SKU/Format. In cases where a material replacement (e.g., manual replacement of inner frames) is necessary and no automatic system is installed on the equipment, the stops should be considered as planned and categorized as Unavoidable stops. The frequency of material change and Unavoidable stops should be agreed upon. The time spent on reworking products due to market requests should be considered as planned downtime. For aggregation based on machines, periods, and products (formats, inserts, etc.), the same principles as Uptime and PR should be applied.

2.3 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a structured decision-making methodology developed by Thomas Saaty in the 1970s. It is designed to help individuals or groups systematically evaluate and prioritize alternatives or criteria in complex decision-making situations (Ramadhan & Buani, 2023). AHP is widely used across various disciplines, including management, engineering, economics, environmental science, and healthcare, among others (Sreenivasan, Suresh, & Nedungadi, 2023). The AHP process involves several key steps:

2.3.1 Hierarchical Structuring

The decision problem is decomposed into a hierarchical structure consisting of multiple levels of criteria and alternatives. At the top level is the overall objective or goal of the decision, followed by sub-criteria and alternatives at lower levels.

2.3.2 Pairwise Comparisons

Decision-makers are asked to make pairwise comparisons between elements within each level of the hierarchy. For example, they may compare criteria to determine their relative importance or alternatives to evaluate their performance against each criterion. These comparisons are typically made using a numerical scale, such as Saaty's 9-point scale, which ranges from "equal importance" to "extremely more important."

2.3.3 Priority Derivation

Based on the pairwise comparisons, numerical weights or priorities are assigned to each element within the hierarchy. These priorities reflect the relative importance of criteria or the relative performance of alternatives. Saaty's eigenvector method or the geometric mean method is commonly used to derive these priorities.

2.3.4 Consistency Checking

AHP includes a consistency check to ensure the reliability of the pairwise comparisons. Consistency measures, such as the Consistency Ratio (CR), are calculated to assess the degree of inconsistency in the decision-maker's judgments. If the CR exceeds a predefined threshold, adjustments may be needed to improve consistency.

2.3.5 Aggregation and Synthesis

The priorities derived from pairwise comparisons are aggregated and synthesized to determine overall rankings or recommendations. This may involve combining priorities using mathematical operations, such as weighted sums or products, to obtain a consolidated ranking of alternatives.

2.3.6 Sensitivity Analysis

Sensitivity analysis is conducted to assess the robustness of the results to changes in decision-maker preferences or input data. This helps identify critical factors that may influence the final decision and provides insights into the stability of the decision-making process.

2.4 Conceptual Framework

In this project, the conceptual framework will explain the value of Process Reliability (PR) in PT HMS that did not reach the target. To achieve the desired target, which is the appropriate PR value, a problem loss analysis is conducted to determine the root causes of the decline in PR. Subsequently, the tools for improving the PR value in PT HMS will be discussed. The research framework can be seen in Figure 1.

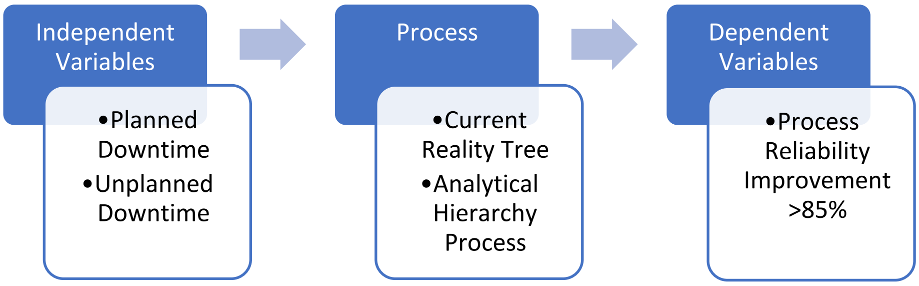

Figure 1 Conceptual Framework
Source: Personal analyze (2024)

Based on the conceptual framework on Figure 1 above, it is evident that PT HMS's Karawang Factory faces issues related to PR (Process Reliability) that affect production performance. The method employed is 5W1H and current reality tree, which aims to identify the root cause of the decline in PR while the components of PR include Planned Downtime and Unplanned Downtime. The identified issues are then analyzed using AHP. The ultimate objective of this study is to enhance the PR value so that PT HMS's Karawang Factory can efficiently produce cigarettes that meet quality criteria.

3. Methodology

3.1 Research Design

In general, the steps of the research design procedure can be observed in **Figure 14** to achieve a business solution, develop the solution, and implement it.

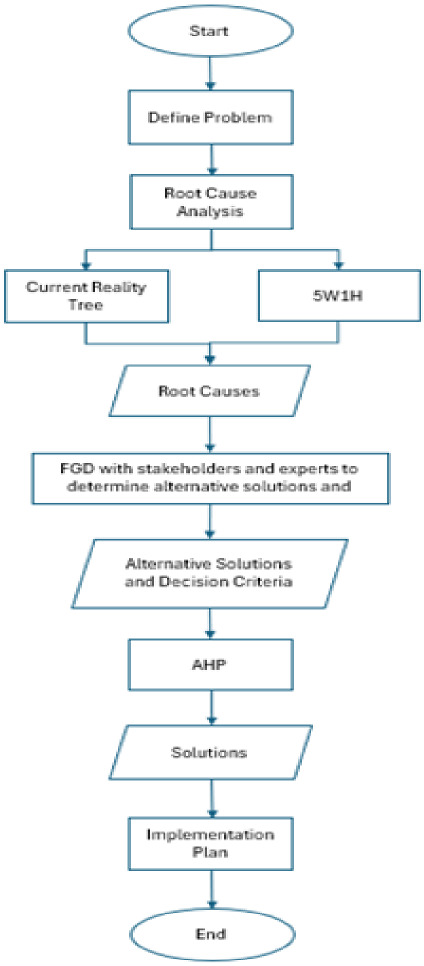

Figure 2. Research Process Flow Chart
Source: Personal analiyze (2024)

3.2 Data Collection Method

In this research endeavor, the collection of data serves a crucial purpose, facilitating the assessment of variables under scrutiny, validation of hypotheses, and evaluation of outcomes. The data acquisition process prioritizes reliability and accuracy, ensuring its suitability as a foundation for informed decision-making. The project predominantly relies on primary data, sourced directly from the field through a combination of on-floor observations and interviews with floor personnel (qualitative). Specifically, attention is directed towards the production line exhibiting the lowest Process Reliability (PR) percentage at PT HMS Karawang, a factor detrimentally impacting site performance. The data collection period spans one week for interviews, from Mar 18th to 22nd, and one week for observations, occurring between Mar 24th and Mar 29th. The following are the methods used to collect data.

3.3 Interview

Interviews are conducted by delving into the subject matter using the 5W1H framework, which encompasses the who, what, when, where, why, and how aspects of the topic under investigation. In this study, the subjects of the interviews are stakeholders categorized based on their levels of importance and influence within the organizational structure. These stakeholders include those with high importance and high influence, such as functional management and production managers, as well as those with high importance but low influence, namely the line team and deployment lead. Additionally, stakeholders like technical services are identified as having high influence but low importance within the context of the project. Through interviews tailored to these specific stakeholder groups, comprehensive insights are gathered to inform decision-making processes and drive project outcomes effectively (Pramann et al., 2023).

The 5W1H method will help to ask the right questions, expand your inquiry, and obtain the right information, which in turn helps you find the best solutions. This tool is very popular amongst journalists whilst also being used and applied to different contexts. This method allows to guide all team members and to gather all the factual elements needed for a complete and objective understanding (Imarah & Jaelani, 2020). The 5W1H method is widely utilized to give a comprehensive and delicate analysis to a specific issue or knowledge, such as in production management, marketing, and so on (Awal, Mishra, Usman, & Abdul, 2018)

In this final project, the process begins with an initial statement comparing the Process Reliability gap to the expected performance. The next step is to create a clear and detailed problem statement using the 5W1H (Who, What, When, Where, Which, and How) approach. The 5W1H is executed on the production floor while observing the operations. To gain deeper insights into the occurrences, discussions are held with individuals familiar with the process and potential losses, such as the line team and operators. This helps in better understanding the timing and circumstances surrounding the issues. Subsequently, the information gathered through the 5W1H analysis is utilized to formulate a plan for collecting fresh data.

3.4 Define Root Causes using Current Reality Tree

Process reliability is a critical factor in ensuring the smooth and efficient operation of any organization. However, when faced with the undesirable effect of unachieved process reliability, it becomes imperative to conduct a thorough analysis to identify the root causes and implement effective solutions. Current Reality Tree (CRT) method are utilized to address the issue of unachieved process reliability. Below are the steps-by-steps to utilize CRT:

1. Data Collection: Gather relevant data and information pertaining to the processes, systems, and personnel involved in the operations where process reliability is not being achieved.
2. Stakeholder Interviews: Conduct interviews with key stakeholders, including process operators, maintenance personnel, and management, to gather insights into their perspectives on the challenges and factors influencing process reliability.
3. Cause-and-Effect Analysis: Use the Fishbone Diagram technique to identify potential causes and categorize them into different categories such as people, process, equipment, environment, and management.

4. Current Reality Tree (CRT): Develop a CRT using the identified causes from the cause-and-effect analysis to visually map out the causal relationships leading to the undesirable effect of unachieved process reliability. The CRT will help in understanding the systemic nature of the problem and uncovering the core issues.
5. Validation and Verification: Validate the findings of the CRT through discussions and feedback sessions with relevant stakeholders and experts to ensure accuracy and completeness.
6. Action Plan Development: Based on the insights gained from the CRT analysis, develop an action plan outlining specific steps and initiatives to address the root causes and improve process reliability.

Implementation and Monitoring: Define best solutions using AHP and plan implementation using PDCA process.

3.5 Data Analysis Method

In this project, a mixed methods approach will be employed to investigate the multifaceted dynamics of process reliability within the organizational framework. Quantitative methodologies will be utilized to quantitatively assess process reliability, employing equations tailored to calculate its performance metrics. The integration of quantitative and qualitative methodologies offers a holistic approach to understanding process reliability, encompassing both its quantitative metrics and qualitative insights. Through the synthesis of numerical data and contextual narratives, researchers can gain a deeper understanding of the factors influencing process reliability within the organizational context (Tonon, 2015). By employing equations to calculate process reliability metrics and utilizing on-floor observations and interviews analyzed using AHP, this mixed methods design aims to triangulate findings, validate conclusions, and provide a nuanced perspective on process reliability.

In quantitative research, numerical data is gathered and analyzed using statistical methods. Williams (2007) describes quantitative research as involving data collection to quantify information, which is then subjected to statistical analysis to either support or refute alternative knowledge claims. The process of quantitative research typically begins with stating a problem, generating hypotheses or research questions, reviewing related literature, and conducting a quantitative analysis of the collected data. Williams (2007) also notes that quantitative research utilizes inquiry strategies such as experiments and surveys, and data is collected using predetermined instruments that yield statistical data. In this final project, quantitative methods are use to analyze the data, which is Analytic Hierarchy Process.

Utilizing the Analytical Hierarchy Process (AHP) offers a structured methodology for determining priorities through pairwise comparisons. This involves systematically evaluating the relative importance of different criteria and alternatives. The process is facilitated by specialized AHP software tools, which streamline the calculation and analysis of pairwise comparisons. One crucial aspect of this method is the calculation of the consistency ratio (CR), which serves as a measure of the consistency of the judgments made during the pairwise comparisons.

In accordance with established guidelines, such as those outlined by (Saaty, 1980) a consistency ratio of less than 0.1 is generally considered acceptable. This threshold ensures that the pairwise comparisons are sufficiently consistent and reliable to generate meaningful results. By adhering to this criterion, the AHP process maintains its validity and effectiveness in guiding decision-making processes.

4. Results and Discussions

4.1 Business Analysis

Data is collected from total 7 (seven) production line operates in Quarter 1 2024 Periode (January to March 2024) as describe in Table 1:

Table 1. Process Reliability PT HMS per Production Line

Month Year	Jan 2024			Feb 2024			Mar 2024		
LINE_NAME	Strategic PR	Unplanned Downtime	Planned Downtime	Strategic PR	Unplanned Downtime	Planned Downtime	Strategic PR	Unplanned Downtime	Planned Downtime
Link-up 10-ID02	77,96%	7,94%	8,16%	82,05%	5,84%	8,87%	80,40%	6,83%	8,87%
Link-up 11-ID02	78,10%	9,43%	8,22%	82,88%	5,04%	8,78%	82,82%	5,44%	8,24%
Link-up 12-ID02	82,00%	4,63%	7,58%	84,99%	2,88%	7,38%	84,51%	3,86%	7,09%
Link-up 14-ID02	80,36%	7,28%	7,86%	76,78%	8,85%	7,63%	78,00%	7,32%	8,04%
Link-up 15-ID02	84,46%	4,02%	7,44%	85,90%	2,08%	7,81%	85,69%	3,07%	7,12%
Link-up 17-ID02	80,40%	7,06%	7,23%	74,73%	8,92%	10,24%	81,13%	5,07%	7,42%
Link-up 25-ID02	80,65%	6,89%	6,89%	82,53%	5,18%	7,47%	81,56%	6,27%	7,32%
Total	**80,80%**	**6,54%**	**7,56%**	**81,80%**	**5,25%**	**8,25%**	**82,37%**	**5,18%**	**7,61%**

The Table 1 provides an overview of Strategic Process Reliability (PR), Unplanned Downtime, and Planned Downtime for various production lines at PT HMS Karawang Plant across the first three months of 2024.

In January 2024, the average Strategic PR across all lines was 80.80%. Link-up 15-ID02 stood out with the highest PR at 84.46%, indicating a well-maintained and efficient process. This line also had relatively low unplanned and planned downtimes (4.02% and 7.44%, respectively). Conversely, Link-up 11-ID02 had a Strategic PR of 78.10% but faced significant challenges with the highest unplanned downtime at 9.43%, suggesting a need for better predictive maintenance.

Over the first quarter, the total average Strategic PR was 81.63%. Link-up 15-ID02 consistently demonstrated the highest reliability with a PR of 85.31%, thanks to low downtimes. In contrast, Link-up 17-ID02 and Link-up 14-ID02 had lower performance due to higher downtimes. On qualitative analysis, author will be focusing on lower performance Link-up, which is Link-up 14-ID02 and Link-up 17-ID02.

4.2 Qualitative Analysis

As outlined in Chapter 3, the qualitative analysis for this research draws on insights from key individuals holding seven different roles within the organization, each of whom plays a crucial part in this project. These roles and their responsibilities are as Table 5 follows:

Table 2. Roles and Responsibilities of Respondent

Role	Responsibilities
Line Lead	Manages the daily operations of a production line, oversees the team, ensures safety and efficiency, coordinates with other departments, resolves issues.
Maintenance Lead	Keeps all machinery running smoothly, schedules regular maintenance, fixes equipment, implements preventive measures, and maintains detailed maintenance records.
Process Lead	Focuses on improving manufacturing processes, evaluates current methods, develops enhancements, ensures quality standards, and works to increase efficiency.
Production Business Unit Manager	Oversees the entire production unit, handles strategic planning and resource allocation, manages production schedules, ensures targets are met, aligns goals with company objectives.
Technical Services Manager	Provides technical support, solves complex issues, introduces new technologies, trains staff, and ensures all technical operations meet industry standards.

Production Manager	Manages the production process from start to finish, creates and oversees production schedules, coordinates with the supply chain, ensures quality, and handles production issues.
Continuous Improvement Lead	Leads efforts to enhance production efficiency and quality, identifies improvement areas, implements lean manufacturing principles, and promotes continuous improvement.

To understand the company's key problem of process reliability, which is falling short of targets and could lead to reduced output, interviews were conducted using the 5W1H as mentioned on paper by (Pramann et al., 2023). The findings from these interviews are detailed in Appendix 1. Using the insights gained, the author identified potential root causes through the Current Reality Tree, which is illustrated in Figure IV.1.

These interviews provided a comprehensive understanding of the issues at hand by leveraging the expertise and experiences of the stakeholders. The diverse perspectives helped pinpoint specific problem areas and informed the development of targeted solutions aimed at enhancing process reliability and achieving the desired operational targets.

Based on interviews using the 5W1H method, several causes were identified for the failure to meet PR targets, organized into a fishbone diagram focusing on five main areas: Man, Machine, Methods, Materials, and Environment, as seen on Figure 15.

In the "Man" category, inconsistent skills among employees and differences in performance between shifts were found to be significant issues. For "Machine," frequent unplanned downtimes, older equipment, constant maintenance needs, and machines not being in optimal condition were identified as major problems.

Under "Methods," quick fixes to meet volume demands and a reactive approach to problem-solving without a structured method were found to be contributing factors. In the "Materials" category, high contamination from cigarette materials like tobacco and foil, disruptions caused by new materials, and the need for frequent adjustments to accommodate these materials were significant factors.

Finally, in the "Environment" category, problems tended to arise during peak production hours, sudden schedule changes, and high-demand periods when equipment upgrades were happening. This fishbone diagram visually represents how these various factors interconnect and impact the ability to meet PR targets, highlighting the complexity and interrelated nature of the issues. Addressing these root causes requires Current Reality Tree as best approach, where the Current Reality Tree can be seen in Figure 16.

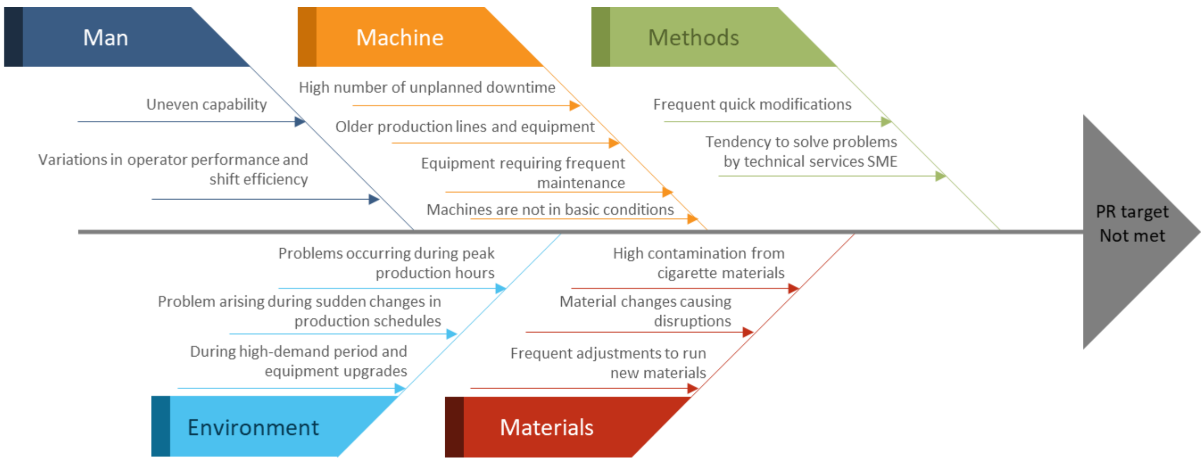

Figure 3. Fishbone Diagram of PR Target Not Met

4.3 Current Reality Tree

The Current Reality Tree (CRT) shown in Figure 16 reveals significant insights into the issues surrounding the company's inability to meet process reliability targets and deliver planned production volumes. At the core of the problem is the fact that process reliability targets are not being met, leading to a shortfall in volume delivery. This situation stems from two primary root causes: a maintenance strategy focused solely on critical parts and the introduction of material improvements.

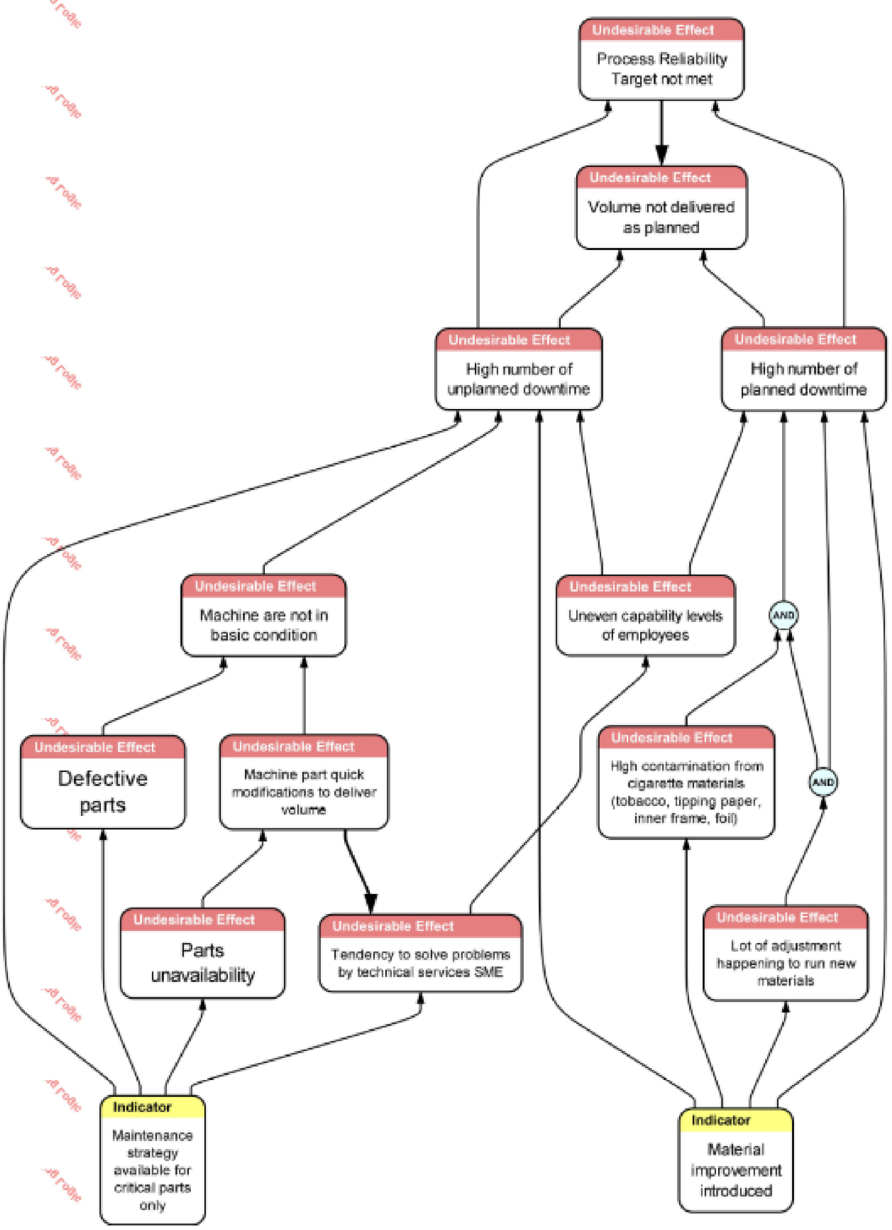

Figure 4. Current Reality Tree

4.3.1 Maintenance Strategy for Critical Parts Only

The maintenance strategy's focus on critical parts only has several undesirable effects that cascade through the production process. Firstly, this limited maintenance scope results in defective parts as non-critical components deteriorate without proper upkeep, as seen on Table 6. This can halt production lines and reduce product quality. Secondly, there is parts unavailability when non-critical parts fail unexpectedly, leading to delays as these parts are not readily available for replacement.

Table 3. Number of Defects by Link-Up

LU	Jan	Feb	Mar
HMS	**1496**	**908**	**1433**
10	168	84	165
11	151	146	174
12	251	143	232
25	236	124	228
15	250	147	242
17	251	113	232
14	189	151	160

Another consequence is the tendency to solve problems by Technical Service SMEs. Because the maintenance strategy does not cover all parts comprehensively, technical experts are frequently called upon to address issues that could have been prevented with a more inclusive maintenance approach.

Additionally, there is a reliance on machine part quick modifications to deliver volume. These ad-hoc fixes are often temporary and compromise the machinery's long-term reliability. This is shown at Graph 17 that countermeasures to prevent defects happening in the future was lacking, showing that less than 30% countermeasures created since 1st week of 2024 up until end of March 2024.

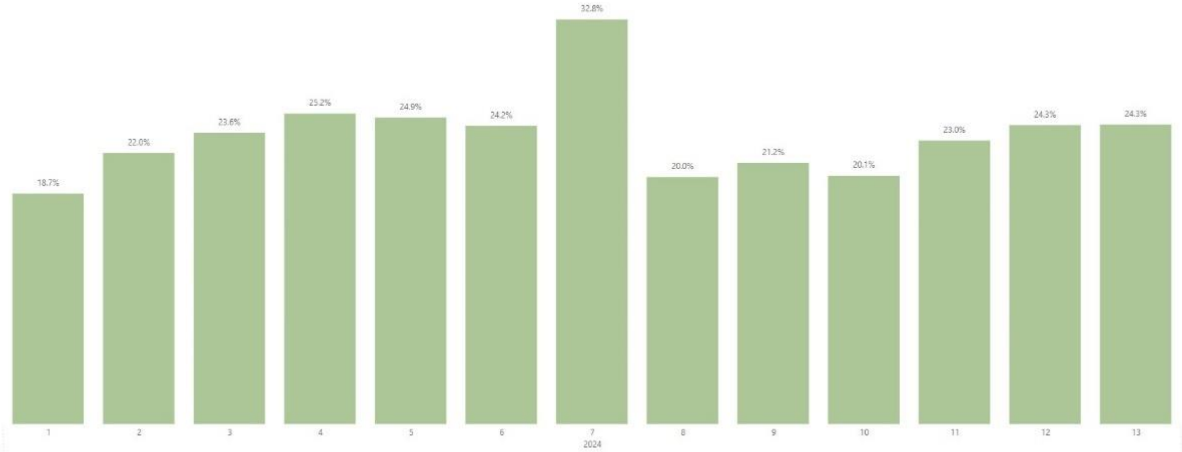

Figure 5. % Countermeasure Created After Defect Fixing
Source: Data analiyze (2024)

Finally, the focus on critical parts means machines are not maintained in their basic condition, leading to a general decline in equipment health. This neglect exacerbates the occurrence of defective parts and further contributes to unplanned downtime, reducing overall production efficiency.

4.3.2 Material Improvement Introduced

The introduction of new materials intended to improve the product has also led to significant challenges. One major issue is the lot of adjustments happening to run new materials. These adjustments require extensive time and effort, causing disruptions in the production process. Moreover, the new materials introduce high contamination risks from cigarette materials such as tobacco, tipping paper, inner frames, and foil, which further complicates production.

There is also a disparity in the workforce's ability to handle these new materials, resulting in uneven capability levels of employees. This inconsistency affects production quality and efficiency, as some employees struggle to adapt to the changes. The introduction of new materials also necessitates a high number of planned downtimes for adjustments and maintenance, significantly reducing the time available for actual production.

Table 4. Unplanned Downtime due to Material Improvement

tanggal	shift	task/list	Unplanned Downtime (Minutes)
08/01/2024	1	preparion start up (adjusment knife IF,adjusment gear IF notcher kurang geser ke atas)	-
	2	1. reposisi sensor end core IF bagian kanan 2. pemasangan guide contras marking (cakar) bagian kanan copy 26	10,9
	3		18,9
18/01/2024	1	1. penambahan guide preparation IF	12,7
	2	1. reposisi sensor spice detect outer 2. lepas guide lifspring contras sensor IF marking 3. adjust guide contras roller sebelum unwinding (titik mati depan pin)	21,1
	3	1. pemasangan guide contras cakar bagian kiri	18,3
02/02/2024	1	1. adjust guide unwinding IF (di atas notcher) 60.75 => 61.25 2. ukur jarak tengah guide IF notcher 61.85 3. ukur jarak guide IF bawah notcher 61.45 4. guide akrilic entry notcher (contras sensor mark) 5. cek jarak support sensor IF mark 29.45	16,2
	2	1. cek back lash gear unwinding IF (1.5mm) 2. penambahan guide preparation marking IF kanan	50,7
	3		30
08/02/2024	1	1. perubahan consecutive reject IF centering mark 3=> 10 2. adjust guide entry unwinding IF (geser lebih longgar) NOK di kembalikan lg ke marking 3. Upgrade program minimum error do to stop dari 1-2 => 2-4	33,5
	2	1.adjust fork preparation IG dengan jarak splacing mark to mark 30mm (toleransi +- 2)	53,7
	3	motor fault motor pre unwinding (abnormal sound)	52,8
13/03/2024	1	inspect motor pre unwinding (putaran sedikit berat)	29,8
	2		14,6
	3	-	-
14/03/2024	1	-	23,2
	2	adjust stoper upper contras pre-unwinding IF (issue motor fault)	446,6
	3		35,7
18/03/2024	1	motor fault motor pre unwinding abnormal following error gear reducer preparation ganti gear reducer dan motor pre unwinding IF dari P16	100,9
	2		
	3		

Table 7 highlights the significant impact of improper material improvements on production efficiency, as shown by the frequent and extended unplanned downtimes.

On January 8, 2024, during the first shift, adjustments were made to the knife IF and gear IF notcher without causing any downtime. However, during the second and third shifts, repositioning sensors and installing guides led to unplanned downtimes of 10.9 and 18.9 minutes, respectively.

On January 18, 2024, various adjustments and installations, such as adding preparation guides and repositioning sensors, resulted in substantial downtime across all shifts, totaling 52.1 minutes. This indicates recurring issues that required frequent attention and maintenance.

By February 2, 2024, the tasks became more complex, involving detailed measurements and guide adjustments for unwinding IF. These tasks resulted in a significant total downtime of 96.9 minutes over three shifts. Activities included checking back lash gear unwinding and adding preparation marking guides, reflecting ongoing operational instability.

On February 8, 2024, changes to the consecutive reject IF centering mark and adjustments to entry unwinding guides caused an additional 33.5 minutes of downtime. Further adjustments and motor faults in the subsequent shifts compounded the issue, leading to a total downtime of 140.2 minutes for the day. This was followed by motor inspections and adjustments in March, including a substantial 446.6 minutes of downtime on March 14, 2024, due to motor faults.

Finally, on March 18, 2024, preparations for replacing a gear reducer and motor led to 100.9 minutes of downtime. These incidents illustrate how improper material improvements can cause a cascade of issues, leading to frequent and prolonged downtimes.

Subsequently, based on Amansyah, Putri, Akila, and Amelia (2023) the root causes identified are used as topics for FGDs (Focused Group Discussions) and brainstorming sessions with stakeholders to determine proposed solutions. From these discussions, the best solutions are selected for implementation using the Analytic Hierarchy Process (AHP). This collaborative approach guarantees that diverse perspectives are taken into account, leading to the identification of the most effective and feasible solutions. By engaging stakeholders in focused discussions and brainstorming sessions, the collective expertise and insights can be leveraged to devise comprehensive strategies. These strategies are then evaluated and prioritized through AHP, ensuring a structured and data-driven decision-making process.

4.4 Criteria Used to Analyze Business Issue

In the next step, Analytical Hierarchy Process (AHP) are used to choose the best solutions from six alternative solutions mentioned in chapter 4.2.1. In the Analytic Hierarchy Process (AHP), three primary criteria are used to analyze and prioritize potential solutions: implementation cost, feasibility, and implementation time.

4.4.1 Implementation Cost

This criterion assesses the financial investment required to implement each solution. It encompasses various expenses, including those related to equipment, training, software, and any additional resources needed to execute the proposed solutions. While lower costs are generally preferred to minimize financial burden, it is equally important to consider the potential return on investment (ROI). Solutions that offer significant long-term benefits and savings, even if they involve higher initial costs, may be more desirable.

4.4.2 Feasibility

Feasibility evaluates how practical and achievable each solution is within the company's current context. This criterion takes into account the technical complexity of the solution, the availability of necessary skills and expertise, and how well the solution aligns with existing processes and infrastructure. A feasible solution is one that the company can realistically implement without encountering insurmountable obstacles, making it crucial to assess the compatibility of the solution with the organization's capabilities and resources.

4.4.3 Implementation Time

Implementation time considers the duration required to fully implement each solution. Solutions that can be implemented quickly are generally favored because they enable faster realization of benefits and help minimize disruptions to operations. However, it is also essential to ensure that the quality and sustainability of the implementation are not compromised by the speed of execution. Balancing quick implementation with thorough and sustainable practices is key to long-term success.

4.5 Analytical Hierarchy Process (AHP)

In this analysis, we focus on two primary goals: ensuring that the maintenance strategy is available for critical parts only, and addressing the challenges associated with material improvement introduced. For each goal, we consider three alternative solutions to identify the most effective approach. The analysis uses three criteria: Implementation Cost, Feasibility, and Implementation Time.

4.6 Result of Business Analysis

PT HMS Karawang Factory faces significant downtime issues impacting PR performance. Unplanned Downtime, due to unexpected machine failures, leads to immediate production losses, increased costs, and reduced productivity. Frequent unplanned downtimes also strain maintenance resources and affect workforce morale. Planned Downtime, involving scheduled maintenance activities, also impacts PR performance by causing temporary production halts, requiring effective management to minimize its impact.

The root causes of low PR performance were identified as follows:
1. Limited Maintenance Strategy: Focusing mainly on critical parts leads to neglect of non-critical components, causing unexpected failures.
2. Material Improvement Introductions: Introducing new materials without thorough testing causes compatibility issues and frequent machine adjustments.

Priority recommendations based on AHP analysis are:
1. Develop a Comprehensive Maintenance Plan: Include all machine parts in the maintenance strategy, conduct thorough inventory, establish regular maintenance schedules, document procedures, and integrate with a CMMS.
2. Thorough Testing and Validation of New Materials: Conduct comprehensive testing before full integration to ensure compatibility with existing machinery.

4.7 Implementation Plan and Justification
Develop a Comprehensive Maintenance Plan and Thorough Testing and Validation of New Materials will follow a structured PDCA timeline. Each phase will ensure thorough planning, execution, monitoring, and adjustment to optimize maintenance strategies and material integration for PT HMS Karawang Factory. This approach will enhance PR performance, reduce downtimes, and improve overall operational efficiency. Below on Table 5 is the detail Plan:

Table 5. 90 Days Plan for Recommended Action

Phase	Task	PIC	Expected Result	April				May					June			
				1	2	3	4	5	6	7	8	9	10	11	12	13
Planning	Define Scope and Objectives (Maintenance)	Process Lead	Clear understanding of maintenance goals and objectives	p												
Planning	Form Planning Team (Maintenance)	Production Business Unit Manager	A dedicated team ready to execute the maintenance plan		p											
Planning	Define Scope and Objectives (Materials)	Process Lead	Clear objectives for material testing and validation	p												
Planning	Identify New Materials	Technical Services Manager	List of new materials to be tested and validated		p	p										
Planning	Conduct Inventory of Machine Parts	Maintenance Lead	Comprehensive list of all machine parts, categorized by importance		p	p	p									
Planning	Categorize Parts	Maintenance Lead	Prioritized list of parts based on criticality and usage		p	p	p									
Planning	Design Testing Protocols	Process Lead	Defined protocols for material testing			p	p									
Planning	Establish Maintenance Schedules	Maintenance Lead	Regular maintenance schedule for all machine parts			p	p									
Planning	Develop Maintenance Procedures	Maintenance Lead	Documented procedures for maintaining all parts			p	p									
Implementation	Select and Plan CMMS Integration	Technical Services Manager	Plan for integrating CMMS to track and manage maintenance activities					p	p							
Implementation	Implement Inventory and Schedules	Maintenance Lead	Maintenance schedules implemented and inventory tracked in CMMS							p	p					
Implementation	Document Procedures	Maintenance Lead	Maintenance procedures documented and distributed							p						
Implementation	Train Staff on Procedures	Line Lead	Staff trained on new maintenance procedures								p					
Implementation	Start CMMS Integration	Technical Services Manager	CMMS integration begins								p					
Testing	Conduct Prototype Testing	Continuous Improvement Lead	Initial performance data for new materials									p	p			
Testing	Analyze Test Results	Continuous Improvement Lead	Analysis of prototype testing data									p	p			
Testing	Perform Stress Testing	Continuous Improvement Lead	Data on how new materials perform under stress									p	p			
Testing	Collect Data and Feedback	Continuous Improvement Lead	Comprehensive feedback on material performance									p	p			
Evaluation	Evaluate Compatibility	Technical Services Manager	Assessment of new material compatibility with existing machinery											p	p	
Evaluation	Review Test Results	Process Lead	Final review of all test data											p	p	
Evaluation	Implement Adjustments	Technical Services Manager	Adjustments made based on test feedback											p	p	
Evaluation	Conduct Final Validation Tests	Continuous Improvement Lead	Confirmation of material performance and compatibility													p
Evaluation	Prepare Final Documentation	Production Manager	Comprehensive documentation of the entire process													p
Evaluation	Review and Approve Final Plans	Production Business Unit Manager	Final approval of maintenance and material testing plans													p

4.7.1 Month 1: Planning Phase

The first month is all about laying the groundwork. For the comprehensive maintenance plan, the team defines the scope and objectives, ensuring everyone is clear on the goals. They form a dedicated planning team and conduct a detailed inventory of all machine parts, categorizing them based on how critical they are and how frequently they're used. Simultaneously, for the new materials, the team sets up the testing scope and objectives, identifying the properties and potential issues of the new materials. They also design testing protocols, which include methods for prototype testing and stress testing.

4.7.2 Month 2: Implementation Phase

The second month focuses on putting the plans into action. The team establishes regular maintenance schedules for all parts and develops detailed maintenance procedures. They also select and plan the integration of a Computerized Maintenance Management System (CMMS) to streamline these processes. For the new materials, prototype testing is conducted under various conditions, and the initial test results are carefully analyzed. Stress testing is performed to identify any weaknesses in the materials, and the team collects data and feedback to guide further steps.

4.7.3 Month 3: Testing and Evaluation Phase

In the third month, the focus shifts to evaluating and refining the efforts. The inventory and maintenance schedules are fully implemented, and the CMMS is updated with all the inventory data. Maintenance procedures are documented, and staff training sessions are conducted to ensure everyone is up to speed. The CMMS is used to track maintenance activities, addressing any initial technical issues that arise. For the new materials, the team evaluates their compatibility with existing machinery, reviews test results, and makes any necessary adjustments. Final validation tests are conducted, and detailed documentation of the testing process is prepared. The testing and validation process is then standardized to ensure consistent quality and reliability moving forward.

This structured approach ensures that both the comprehensive maintenance plan and the new material testing are thoroughly planned, implemented, and refined, leading to improved process reliability and operational efficiency at PT HMS Karawang Plant.

4.8 Results

The results of the 90-day plan implementation have shown significant improvements in the overall process reliability (PR) and reductions in downtime at PT HMS Karawang Factory. Comparing the data from March 2024 to May 2024, we can see a positive impact on both Strategic PR and downtime metrics, as shown on Table 15.

In March 2024, the total Strategic PR was 82.37%, with Unplanned Downtime at 5.18% and Planned Downtime at 7.61%. By May 2024, the total Strategic PR had improved to 83.14%, reflecting a 0.77% increase. This improvement indicates that the factory's processes have become more reliable. Additionally, Unplanned Downtime decreased slightly from 5.18% to 5.08%, showing better management of unexpected disruptions. Planned Downtime remained relatively stable, with a minor change from 7.61% to 7.60%.

Focusing on Link-up 14-ID02, the data reveals a remarkable improvement. In March 2024, the Strategic PR was 78.00%, with Unplanned Downtime at 7.32% and Planned Downtime at 8.04%. By May 2024, the Strategic PR had increased to 81.04%, a notable 3.04% rise. Unplanned Downtime decreased from 7.32% to 6.05%, indicating a significant reduction in unexpected issues. Planned Downtime also reduced from 8.04% to 7.54%, further enhancing operational efficiency.

Similarly, Link-up 17-ID02 showed considerable progress. The Strategic PR improved from 81.13% in March 2024 to 83.32% in May 2024, reflecting a 2.19% increase. Unplanned Downtime decreased from 5.07% to 4.92%, and Planned Downtime dropped from 7.42% to 7.12%. These changes demonstrate a more stable and efficient production process.

Overall, the 90-day plan's implementation has led to substantial improvements in the factory's performance. The comprehensive maintenance plan, along with condition-based monitoring and predictive maintenance strategies, has effectively enhanced process reliability and reduced downtime. The positive outcomes, particularly in Link-up 14-ID02 and Link-up 17-ID02, underscore the success of the implemented strategies and the continuous efforts towards operational excellence and reliability.

Table 6. Process Reliability PT HMS, Mar – May 2024 Periode

Month Year	Mar 2024			Apr 2024			May 2024		
LINE_NAME	Strategic PR	Unplanned Downtime	Planned Downtime	Strategic PR	Unplanned Downtime	Planned Downtime	Strategic PR	Unplanned Downtime	Planned Downtime
Link-up 10-ID02	80,40%	6,83%	8,87%	81,31%	6,82%	8,56%	82,00%	6,34%	8,34%
Link-up 11-ID02	82,82%	5,44%	8,24%	81,28%	6,75%	7,87%	79,53%	7,46%	8,65%
Link-up 12-ID02	84,51%	3,86%	7,09%	81,86%	4,98%	7,41%	84,40%	4,41%	7,20%
Link-up 14-ID02	78,00%	7,32%	8,04%	77,57%	8,00%	8,53%	81,04%	6,05%	7,54%
Link-up 15-ID02	85,69%	3,07%	7,12%	84,59%	3,33%	7,59%	84,44%	3,36%	8,06%
Link-up 17-ID02	81,13%	5,07%	7,42%	83,13%	4,51%	7,49%	83,32%	4,92%	7,12%
Link-up 25-ID02	81,56%	6,27%	7,32%	84,40%	4,07%	6,28%	85,12%	4,34%	6,64%
Total	**82,37%**	**5,18%**	**7,61%**	**82,45%**	**5,09%**	**7,50%**	**83,14%**	**5,08%**	**7,60%**

These improvements have also translated into considerable cost savings, particularly for Link-up 14-ID02 and Link-up 17-ID02. For Link-up 14-ID02, the PR increased from 78.00% in March 2024 to 81.04% in May 2024. This 3.04% improvement in PR represents a substantial enhancement in the efficiency and reliability of the production line. Given that each 1% improvement in PR corresponds to a cost saving of 12,794 USD per year, the total cost savings for Link-up 14-ID02 amount to approximately 38,889.76 USD. This significant saving underscores the effectiveness of the implemented maintenance and operational strategies.

Similarly, Link-up 17-ID02 also saw remarkable improvements. The PR for this line increased from 81.13% in March 2024 to 83.32% in May 2024, reflecting a 2.19% improvement. This enhancement not only boosts production efficiency but also translates into notable cost savings. With the same cost-saving metric, the total savings for Link-up 17-ID02 are around 28,024.86 USD. These savings highlight the positive financial impact of the implemented process improvements.

These results highlight the importance of continuously improving our processes. By doing so, the factory not only boosts operational efficiency and reliability but also enjoys significant cost savings. Furthermore, increased efficiency in production could position us to absorb additional production volume from Surabaya, enhancing our overall capacity and competitiveness.

5. Conclusion

Unplanned Downtime, comprising unexpected machine failures and operational disruptions, has a direct and immediate negative impact on Process Reliability (PR) at PT HMS. These unforeseen issues lead to production delays, reduced output, and increased operational costs. Frequent occurrences can also lower workforce morale and place added pressure on maintenance teams, ultimately compromising overall productivity and factory performance.

Planned Downtime, while necessary for equipment inspections, scheduled maintenance, and preventive procedures, also affects PR performance. Although these activities are intended to reduce the risk of future failures, they still cause temporary halts in production. If not carefully managed, planned downtime can accumulate and reduce overall production efficiency, offsetting the benefits of proactive maintenance.

To address these issues, PT HMS should focus on two main strategies: minimizing unplanned disruptions through a comprehensive maintenance plan, and optimizing planned maintenance activities. The proposed solutions involve expanding the maintenance scope beyond critical parts, integrating CMMS for better oversight, and ensuring new materials undergo rigorous testing and validation before full implementation. These steps are essential for improving reliability and maintaining consistent production output.

Limitations and Future Study

This study primarily focused on internal maintenance strategies and material integration processes, without evaluating external supply chain factors or workforce skill levels that may also influence PR performance. Future research should explore these external and human elements in greater depth, and assess the long-term impact of CMMS implementation and new material usage on overall operational metrics across multiple production lines.

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