Preventive maintenance approach for improving the efficiency of SCM Olimpic K-800 Auto Edgeband machine

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Abstract. This study aims to improve the efficiency of the SCM Olimpic K-800 Auto Edgeband machine at PT ABC, a furniture manufacturing company. From January to June 2024, frequent machine breakdowns disrupted production flow and reduced productivity. The main problem identified was low machine effectiveness, measured using the Overall Equipment Effectiveness (OEE) method, with an average value of 74%, below the world-class standard of 85%. The research contribution is the development of a cost-efficient preventive maintenance schedule that minimizes downtime and improves production reliability. The study applied a quantitative approach using OEE and Six Big Losses analysis to identify the main causes of inefficiency. Results show that the largest loss (58.4%) was due to reduced speed losses. Preventive maintenance scheduling was then developed by classifying spare parts into A (20%), B (30%), and C (50%) cost categories. The proposed maintenance intervals are every 6 months for class A and C, and every 5 months for class B. Cost comparison showed that preventive maintenance reduced total expenses by 25–30% compared to the repair maintenance method. Therefore, implementing a preventive maintenance policy can increase machine effectiveness, reduce costs, and ensure smoother production operations.

1 Introduction

In modern industrial systems, machinery performance and reliability play a vital role in ensuring production efficiency, cost optimization, and product quality. Machine behavior is fundamentally governed by physical and engineering principles such as heat transfer, friction, vibration, and wear mechanisms that cause gradual degradation of mechanical components [1], [2]. When the thermal or vibrational load on rotating parts exceeds their design tolerance, the resulting fatigue accelerates failure rates and decreases the operational life cycle of the equipment [3].

In manufacturing industries, Overall Equipment Effectiveness (OEE) is a widely recognized indicator that quantifies machine performance in terms of availability, performance efficiency, and quality rate [4]. Low OEE values are frequently associated with the so-called "six big losses," including breakdowns, setup and adjustment, idling, reduced speed, quality defects, and yield losses [5]. Studies across mechanical and process industries show that unplanned downtime resulting from physical degradation mechanisms can reduce OEE by 20–30% annually [6], [7].

The Auto Edgeband SCM Olimpic K-800—a high-speed finishing machine used in furniture manufacturing—is highly sensitive to physical factors such as frictional wear on bearings, motor vibration imbalance, and thermal expansion in conveyor assemblies. These physical phenomena directly affect operational accuracy and throughput [8], [9]. Despite the importance of such physical influences, many factories still rely on reactive or corrective maintenance, repairing machines only after failures occur. This reactive strategy not only increases costs but also contradicts the principles of reliability engineering, which emphasize proactive monitoring of physical degradation [10], [11].

Recent research emphasizes that physics-informed preventive maintenance (PIPM)—combining OEE with physical diagnostics such as vibration analysis, thermography, and wear modeling—can enhance reliability and reduce total maintenance costs [12], [13]. For example, vibration-based monitoring detects micro-imbalances earlier than standard statistical controls, preventing severe breakdowns and enabling scheduling optimization [14]. Integrating such science-based approaches with OEE analysis provides both economic and engineering benefits by predicting machine failure through measurable physical indicators [15].

However, limited studies have applied these physics-based preventive maintenance frameworks to medium-scale furniture manufacturing in developing regions such as Indonesia. The absence of predictive scheduling leads to suboptimal spare-part usage and inconsistent maintenance intervals. Therefore, there is a need for a comprehensive framework that integrates OEE metrics, six big losses analysis, and physics-based degradation modeling to design cost-effective maintenance policies.

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Table 1. Machine downtime at January-June 2024.

Machine	Downtime (minute)
Auto Laminating Machine - Matic	1434
Panel Saw - KDT - KS-828C	396
Spindle Moulder - Rulong - SS-512T	129
Auto Edgeband - Biesse - Lato 23S	155
Auto Edgeband - SCM - Olimpic K-800	3224
Manual Edgeband - Marunaka - KCB-2000ES	332
Modul Drilling Machine - KDT – 6062	540
Modul Drilling Machine - KDT – 6262	171
Modul Drilling Machine - KDT - 6032D	225
Modul Drilling Machine - KDT – 6252	74
Modul Drilling Machine - MZB - 73212	212
CNC Drilling & Routing Machine - KDT - KD-612MSH	16

Based on Table 1, the machine that often experiences damage is the Auto Edgeband SCM Olimpic K-800 machine. Prolonged machine damage can result in decreased machine effectiveness and affect the production process.

According to [16], [17], OEE is a ratio that describes the level of effectiveness of machine or equipment use in the production process. OEE as a performance indicator in its calculation requires a certain period of time, such as a work shift, daily, weekly, monthly, or annually [18]. OEE is calculated based on aspects that can reduce the total actual machine time available in the production process, including machine availability (A), process performance efficiency (P), and product quality rate (Q) [19]. After determining the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine, we can identify the losses affecting the Auto Edgeband SCM Olimpic K-800 machine through the six big losses.

According to [20], [21], six big losses are six types of losses that every company needs to avoid because they can cause a decline in machine performance and low OEE values. These six big losses are divided into three main categories based on the type of loss: downtime losses, speed losses, and defects losses. Downtime is wasted time during which the production process stops, usually due to machine breakdowns. Downtime consists of two types of losses: Breakdown Losses and Setup and Adjustment Losses. Speed losses occur when the speed of the production process is disrupted, so that production does not reach the expected level. Speed losses consist of two types of losses: Reduced Speed Losses and Idling Minor Stopages Losses. Quality losses occur when the products produced do not meet the specified specifications. Quality losses consist of two types, namely Reduced Yield Losses and Process Defect Losses [22], [23].

In view of these problems, preventive measures are needed to reduce the possibility of downtime. The researchers conducted measurements using the OEE method to determine the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine before taking further action. A machine is considered not to meet world-class standards if its OEE value is ≤ 85% [24]. The next calculation, the six big losses analysis, was used to determine the biggest causes of losses in the Auto Edgeband SCM Olimpic K-800 machine [25].

The results obtained are used as an evaluation for creating a maintenance schedule by calculating the most optimal maintenance costs using a comparison between the repair maintenance policy and preventive maintenance policy methods.

According to [26], repair maintenance or corrective maintenance is maintenance activity carried out after a machine experiences damage, which is then repaired. According to [27], preventive maintenance is maintenance activity aimed at minimizing sudden damage to machines. This method is used to compare costs and schedule machine maintenance, so that the estimated maintenance costs and optimal maintenance times for the Auto Edgeband SCM Olimpic K-800 machine can be obtained. The main objectives are to minimize downtime caused by the six big losses, increase the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine, and improve its maintenance system.

This study aims to improve the efficiency of the SCM Olimpic K-800 Auto Edgeband machine by developing a structured preventive maintenance approach that combines OEE evaluation and physical degradation principles. The analysis identifies major loss sources through the six big losses method and classifies spare parts into categories A, B, and C based on wear severity and replacement cost.

The research contribution is the formulation of a physics-informed preventive maintenance framework that integrates OEE and six-loss modeling to determine optimal maintenance intervals and cost efficiency, providing a scalable model for other manufacturing systems seeking world-class OEE standards.

2 Research methodology

This research was conducted using the OEE method and preventive maintenance policy tools. The data used in this research included machine inspection time, setup time, and so on.

2.1 Research flow chart

From The Figs. 1 and 2, there are six stages of this research. The stages are mention at 2.2 to 2.7.

2.2 Data collection stage

The problem that occurs in the Auto Edgeband SCM Olimpic K-800 machine is that it often experiences damage, so the researcher wants to calculate OEE. This calculation is used to determine the effectiveness of the machine and the improvements that must be made so that the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine can be increased. This study uses a quantitative method.

There are two types of data in this study: primary data and secondary data.

1. The primary data used in this study are as follows:
   a. Data on the setup and adjustment of the Auto Edgeband SCM Olimpic K-800 machine.
   b. Data on the time of machine failure checks.
2. The secondary data used in this study are as follows:

a. Company profile and organizational structure.
b. Production volume data.
c. Defective product volume data.
d. Planned downtime data for the Auto Edgeband SCM Olimpic K-800 machine.
e. Downtime data for the Auto Edgeband SCM Olimpic K-800 machine.
f. Operating data for the Auto Edgeband SCM Olimpic K-800 machine.
g. Spare part data for the Auto Edgeband SCM Olimpic K-800 machine.

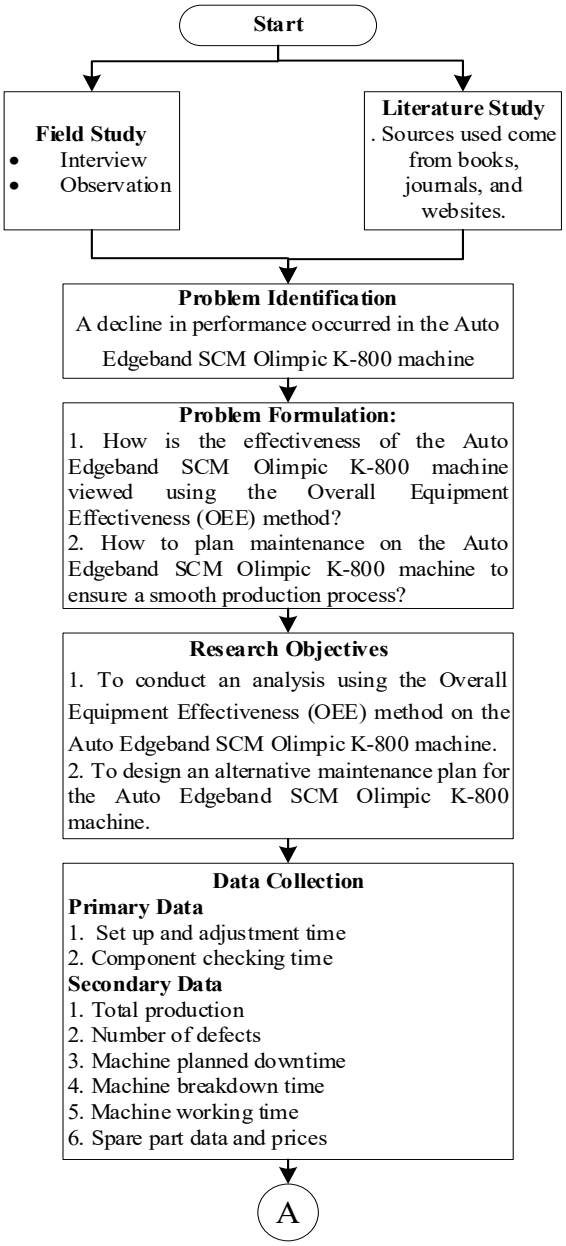


Fig. 1. Reseach flowchart.

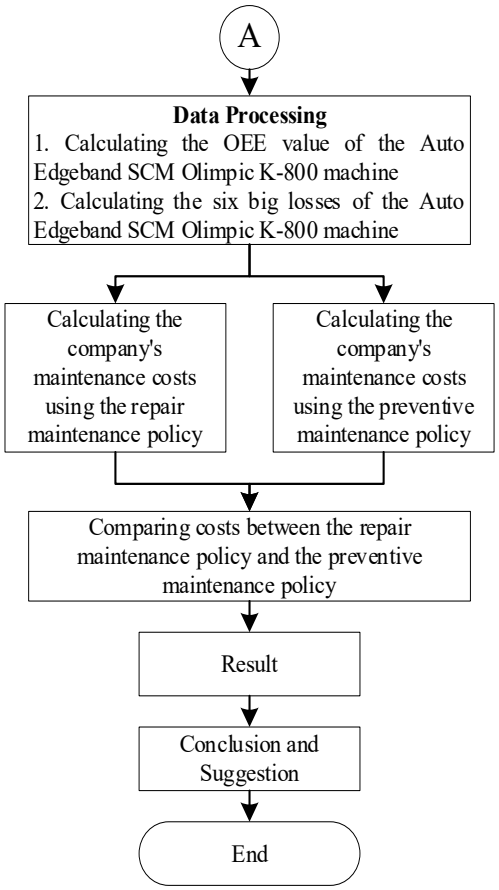


Fig. 2. Research flowchart.

2.3 Data collection techniques

The data collection techniques used in this study are as follows:
1. Observation
2. Field study
3. Interviews
4. Literature study
5. Problem identification

2.4 Research procedure and data processing stages

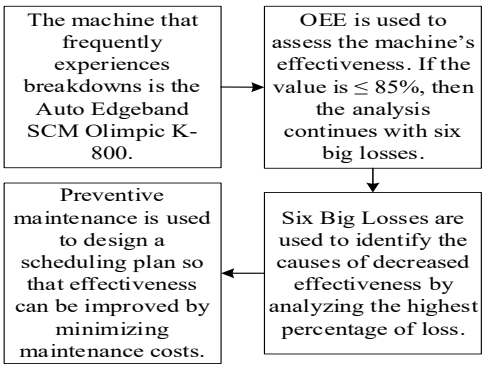
The procedures and data processing in this study are as follows:
1. Conducting field studies and literature studies on problems occurring in the object to be studied in order to solve the problems and provide suggestions for improvements to the problems occurring in the object, especially the edging machine.
2. Determining the problems that exist in the edging machine during the production process.
3. Determine the research objectives based on the problem formulation that has been made, namely regarding the measurement of effectiveness in the edging machine and providing suggestions for improvement so that the effectiveness of the edging machine can be increased.
4. Collect the data needed to support this research. The data needed includes:

a. Production volume data
b. Defective product data
c. Machine operation data
d. Machine downtime data
e. Planned machine downtime data
f. Machine setup and adjustment data
g. Machine spare part data

5. Performing data processing stages, namely:
   a) Calculating the OEE value
   b) Calculating the six big losses value.
   c) Calculating the preventive maintenance policy (maintenance scheduling)
6. Drawing conclusions and recommendations from the research that has been conducted.

2.5 Relationship between OEE and preventive maintenance policy

Table 2. Critical thinking relationship between OEE and preventive maintenance policy.



2.6 Cost comparison between repair maintenance policy and preventive maintenance policy

This cost comparison is based on the price of spare parts used in machine repairs during this study. The comparison is made by looking at the total price of spare parts spent using the repair maintenance method and the price of spare parts spent using the preventive maintenance method. If the comparison shows that the minimum price is spent using the preventive maintenance method, then that method will be used.

2.7 Alternative maintenance scheduling design

The alternative maintenance scheduling design for this study began with measuring the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine using the OEE method. The next step after determining the effectiveness value was to analyze the six big losses that could reduce the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine. The next step is to compare maintenance costs between the repair maintenance policy and the preventive maintenance policy. If the preventive value is smaller, a maintenance schedule will be prepared using the preventive maintenance policy method. The next stage is to determine and calculate the most optimal maintenance cost estimate and the appropriate maintenance time. The goal is to reduce machine downtime due to six big losses, while increasing the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine. This analysis is a corrective measure and preventive action to minimize the risk of six big losses, so that the effectiveness of the Auto Edgeband SCM Olimpic K-800 machine can be improved compared to its previous condition.

3 Result and discussion

3.1 Data collection for the SCM Olimpic K-800 Auto Edgeband Machine

The data used in this study is from January to June 2024. The data used includes machine delay data, machine working data, and so on.

3.2 OEE (Overall Equipment Effectiveness) calculation results for the SCM Olimpic K-800 Auto Edgeband Machine

The OEE value is calculated using three ratios, namely availability (machine operating time), performance (number of units produced), and quality rate (production quality) [28]. According to [29], [30], [31], the formula for calculating OEE is as follows:

1. *Availability rate* $= \frac{Operation\ Time}{Loading\ Time} \times 100\%$
$= \frac{8995}{990} \times 100\%$
$= 91\%$

2. *Performance Rate* $= \frac{Processed\ amount \times Ideal\ Cycle\ Time}{Operation\ Time} \times 100\%$
$= \frac{29850 \times 0{,}25}{8995} \times 100\%$
$= 83\%$

Work time percentage $= 1 - \frac{Delay\ Time}{Total\ Working\ Time} \times 100\%$
$= 1 - \frac{2885}{11880} \times 100\%$
$= 76\%$

Cycle Time $= \frac{Loading\ time}{Processed\ amount} \times 100\%$
$= \frac{9900}{29850} \times 100\%$
$= 33\%$

Ideal Cycle Tim $=$ *Presentase Jam kerja* $\times$ *Cycle Time*
$= 76\% \times 33\%$
$= 0.25$

3. *Quality Rate* $= \frac{Total\ Produk - Reject\ Produk}{Total\ Produk} \times 100$
$= \frac{29850 - 833}{29850} \times 100\%$
$= 97.2\%$

OEE = Availability rate × performance rate × quality rate
= (91% × 83% × 97%) × 100%
= 74 %

Table 3 summarizes the OEE calculations obtained from January to June 2024:

Table 3. OEE value data.

OEE Data					
No	Month	Availability Rate	Performance Rate	Quality Rate	OEE Result
1	January	91%	83%	97%	74%
2	February	91%	83%	98%	74%
3	March	92%	83%	97%	74%
4	April	91%	83%	98%	75%
5	May	91%	83%	97%	74%
6	June	90%	83%	98%	74%
	Average	91%	83%	98%	74%
OEE Ideal (>85)					
OEE Not Ideal (<85%)					

Based on Table 2, during the 6-month production period, the performance of the Auto Edgeband SCM Olimpic K-800 machine showed inefficiency. The availability rate was 91%, which is in the ideal category because it is above 90%. The performance rate was 83%, which is in the non-ideal category because it is below 95%. The quality rate was 98%, which is in the non-ideal category because it is below 99%. and the OEE value of the Auto Edgeband SCM Olimpic K-800 machine was 74%, which is in the non-ideal category because it is less than 85% [32]. This condition indicates that there are problems with the machine that need to be analyzed further. Through the six big losses analysis, the factors causing the low effectiveness of the machine can be identified.

3.3 Results of the six big losses calculation for the Auto Edgeband SCM Olimpic K-800 machine

According to [33], [34], the formula for finding the six big losses is as follows:

1. *Breakdown losses* $= \frac{Breakdown\ time}{Loading\ time} \times 100\%$

2. *Setup and Adjustment Losses* $= \frac{\text{Set up time}}{\text{Loading time}} \times 100\%$

3. *Idling and Minor Stoppage Losses*
$= \frac{\text{Idling and minor stoppage}}{\text{Loading time}} \times 100\%$

4. *Reduce Speed Losses*
$= \frac{\text{Operating time - Ideal cycle time x processed amount}}{\text{Loading time}} \times 100\%$

5. *Defect Losses* $= \frac{Ideal\ cycle\ time\ x\ defect}{Loading\ time} \times 100\%$

6. *Reduced yield Losses* $= \frac{Ideal\ cycle\ time\ x\ defect\ setting}{Loading\ time} \times 100\%$

After the calculations were performed, the recapitulation of the six big losses data can be seen in Table 4. Table 4 shows the recapitulation of the six big losses data for the Auto Edgeband SCM Olimpic K-800 machine from January to June 2024. The losses with the longest duration were reduce speed losses with a duration of 9013 minutes and a percentage of 58.42%, breakdown losses with a duration of 3677 minutes and a percentage of 23.84%, setup and adjustment losses with a duration of 1364 minutes and a percentage of 8.84%, defect losses with a duration of 976 minutes and a percentage of 6.33%, idling and minor stoppage losses with a duration of 282 minutes and a percentage of 1.83%, and finally reduced yield losses with a duration of 115 minutes and a percentage of 0.74%. Based on the data obtained, the first thing that needs to be evaluated is the cause of the Auto Edgeband SCM Olimpic K-800 machine's OEE value not reaching the standard, which is related to reduce speed losses or losses caused by a decrease in machine speed, by minimizing the difference between the ideal cycle time and operation time.

Table 4. Summary of data on the six big losses.

No	Six Big Losses	Total Time (minutes)	Losses (%)
1	*Breakdown Losses*	3677	23,84%
2	*Setup and Adjustment Losses*	1364	8,84%
3	*Idle and Minor Stoppage Losses*	282	1,83%
4	*Reduce Speed Losses*	9013	58,42%
5	*Defect Losses*	976	6,33%
6	*Reduce Yield*	115	0,74%
Total		15427	100%

The large difference between the ideal cycle time and the operation time is partly caused by frequent machine stoppages. The main factor contributing to this condition is the lack of regular machine maintenance scheduling; machines are repaired only after damage has occurred. The next step that needs to be taken is to design a preventive maintenance schedule and compare the costs of preventive maintenance and repair maintenance.

3.4 Determining the best machine maintenance schedule for the Auto Edgeband SCM Olimpic K-800 machine using the preventive maintenance method

According to [35], the formula for determining the repair maintenance policy is as follows:

Cr = (Biaya Tenaga Kerja × Waktu Kerja × Jumlah Tenaga Kerja) + $\frac{Total\ biaya\ komponen}{Jumlah\ komponen\ yang\ diganti}$

Tb = $\sum_{i=1}^{n} Pi.Ti$

B = $\frac{Jumlah\ mesin\ (N)}{Rata{-}rata\ runtime\ mesin\ (Tb)}$

TCr = B × Cr

Description : Cr = repair cost
TCr = total repair cost
Tb = average machine run time mesin
B = average breakdown per period

According to [36], the formula for determining a preventive maintenance policy is as follows:

Bn = N × Pn

B = $\frac{Bn}{n}$

TCrn = B.Cr

TCmn = $\frac{N.Cm}{n}$

TMCn = TCr(n) + TCm(n)

Description :
Cm = mantenance cost calculation
Bn = cumulative number of breakdowns per month
B = average number of breakdowns per month
TCr n = estimation of repaircost per month

TCmn = preventive maintenance cost per month
TMCn = total maintenance cost permonth

Table 5. Determination of the best maintenance based on the determination of time and costs each month.

No	Brake down	Maintenance Cost		Best Machine Maintenance Scheduling Time
		Repair Policy	Preventive Maintenance Policy	
1	Classification A	Rp.3.412.014,86	Rp2.149.594	6 month (first week)
2	Classification B	Rp.2.792.239,30	Rp2.167.021	5 month (first week)
3	Classification C	Rp.2.649.446,69	Rp1.944.890	6 month (first week)

Table 5 shows the timing determination for scheduling the SCM Olimpic K-800 Auto Edgeband machine. Damage types are divided into three classifications: A, B, and C. Classification A covers approximately 20% of the total component types with the highest value, classification B covers 30% after classification A, and classification C covers the remaining 50% with the smallest value contribution [37]. Table 4 contains the costs of the repair maintenance policy, preventive maintenance policy, and machine maintenance scheduling time. Machine scheduling for classification A is carried out once every 6 months in the first week, for classification B once every 5 months in the first week, and for classification C once every 6 months in the first week.

Table 6. Example of preventive maintenance spare parts for the Auto Edgeband SCM Olimpic K-800 machine.

No	Sparepart	Preventive Maintenance Efforts	Class	Implementation Time
1	Motor	Lubricate bearings/shafts	A	6 month (first week)
		Check electrical connections		
		Clean with a cloth		
2	Selenoid Valve	Lubricate pole parts	A	6 month (first week)
		Check pole function and tighten connections with nuts/bolts		
		Clean with a cloth		

Examples of preventive maintenance actions that can be taken, as listed in Table 5, which aim to prevent damage to the solenoid valve spare parts, are to clean with a soft cloth, check the valve function, tighten the connections with nuts/bolts, lubricate the valve parts, and perform this maintenance once every 6 months (first week).

4 Conclusions and recommendations

4.1 Conclusions

The following are the conclusions drawn from the research that has been conducted:

1. The SCM Olimpic K-800 Auto Edgeband machine has an average Overall Equipment Effectiveness (OEE) value of 74%, which means that it has not yet reached the world-class OEE standard of 85%. This value indicates that the machine's effectiveness still needs to be improved, especially in terms of performance rate, which is 83%, which is still below the global standard of 95%. A six big losses analysis was also conducted to identify the main sources of losses that cause low OEE. The results of the analysis show that the losses with the longest duration are reduce speed losses with a duration of 9013 minutes and a percentage of 58.42%, breakdown losses with a duration of 3677 minutes and a percentage of 23.84%, setup and adjustment losses with a duration of 1364 minutes and a percentage of 8.84%, defect losses with a duration of 976 minutes and a percentage of 6.33%, idling and minor stoppage losses with a duration of 282 minutes and a percentage of 1.83%, and finally reduced yield losses with a duration of 115 minutes and a percentage of 0.74%. Based on the data obtained, the first thing that needs to be evaluated is the cause of the Auto Edgeband SCM Olimpic K-800 machine's OEE value not reaching the standard, which is related to reduce speed losses or losses caused by a decrease in machine speed, by minimizing the difference between the ideal cycle time and operation time.
2. The calculation results for machine scheduling using the repair maintenance policy and preventive maintenance policy methods show that repair maintenance for classification A costs Rp. 3,412,014 and preventive maintenance costs Rp. 2,149,594 for a period of 6 months. Therefore, for classification A, it is better for the company to use preventive maintenance because it is less expensive. The calculation results for classification B show repair maintenance costs of IDR 2,792,239 and preventive maintenance costs of IDR 2,167,021 over a period of 5 months. Therefore, for classification B, the company should use preventive maintenance because it has a lower cost. The calculation results for classification C show that the repair maintenance cost is IDR 2,649,446 and the preventive maintenance cost is IDR 1,944,890 with a duration of 6 months. Therefore, for classification C, the company should use preventive maintenance because it has a lower cost. An example of preventive maintenance for a SELENOID VALVE is to clean it with a soft cloth, check the valve function, tighten the connections with nuts/bolts, and lubricate the valve parts. This is classified as Class A with a maintenance interval of 6 months.

4.2 Recommendations

The recommendation for further research is to also consider the machine's age when scheduling maintenance.

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