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Conveyor Belt Machine Maintenance Planning Using FMEA and RCM Methods at PT. SBM

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ABSTRACT

PT. SBM is a bulk material handling company that focuses on conveyor maintenance and surface protection. The conveyor belt machine operates 24 hours non-stop resulting in damage to each component which disrupts the production process. So that an analysis is carried out using the FMEA method with the results of the calculation of the RPN value showing that the belt component gets an RPN value of 180, gear of 150, idler roller of 80, and chain of 80. RCM method to determine an effective maintenance strategy with the results of a new activity schedule, namely belt components must be checked and maintained about 4.36 hours/day once and idler rollers about 7.08 hours/day once by performing scheduled on-condition task maintenance activities. Gear must be checked and maintained about 4.12 hours/day once and chain about 0.23 hours/day once by performing scheduled discard task maintenance activities. By applying the results of this research in the company, it can determine a more effective and data-based maintenance schedule with increased machine reliability, maintenance schedule optimization, cost and operational efficiency, and implementation in the manufacturing industry. It is recommended that companies implement IoT-based monitoring systems, conduct training, and establish maintenance standards with periodic evaluation.

INTRODUCTION

In an industrial plant there are a number of buildings and installations that operate in producing products that will be sent to be processed by each installation. Transportation equipment plays an important role in the transportation of concentrate material to be processed in the smelter plant, therefore transportation equipment must be maintained so that it is always operating without any damage that can result in stopping the production process. Errors or failures in the concentrate transportation process can result in the obstruction of the factory. Regular maintenance operations are carried out to keep the plant equipment operating properly and avoid unwanted events.

PT. SBM is a company engaged in bulk material handling. Its main focus is conveyor maintenance and surface protection. The problem that arises in this company is the frequent occurrence of damage to the machine or breakdown of the engine components that are damaged so that this can result in working hours stopped or downtime. Damage to machinery and equipment can interfere with the production process. As a result of these disruptions, among others, the production target is not achieved, which per day is produced 1800 tons/day to be

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reduced and production costs are getting higher. So to optimize the running of production machines, good maintenance of production machines is needed.

The machine that will be the object of research is a conveyor belt at PT. SBM, a conveyor belt is a material transfer machine along a horizontal direction or with a certain slope continuously. This tool is used to transport concentrates by placing them on a belt that will move as far as the distance between the two ends of the pulley at a constant and continuous speed. Conveyors are a simple but efficient means of transportation in large industrial plant operations that operate 24 hours non-stop. This machine operates during the production process, when there is downtime, this machine will be checked immediately by the maintenance department. Therefore, proper handling is needed in the event of a failure mode that can cause a very significant impact and hinder the pace of the company's production process.

According to (Harma et al., 2024) the implementation of FMEA and RCM methods provides a more structured and effective solution in dealing with maintenance problems, thus aiming to increase the life of the machine, reduce unexpected maintenance costs, the quality of the production process can be maintained properly, and the company's operational efficiency can be increased. This condition shows the urgency of conducting comprehensive and structured maintenance planning.

The FMEA (Failure Mode and Effect Analysis) method assisted by the RCM (Reliability Centered Maintenance) method is seen as a strategic approach to overcome these problems, because this method is able to identify failure modes, determine the consequences of failure, and design the most effective maintenance strategy. This approach aims to increase machine life and reduce unexpected maintenance costs, so that the company's productivity and operational efficiency can increase.

RESEARCH METHODS

Flowchart of Problem Solving

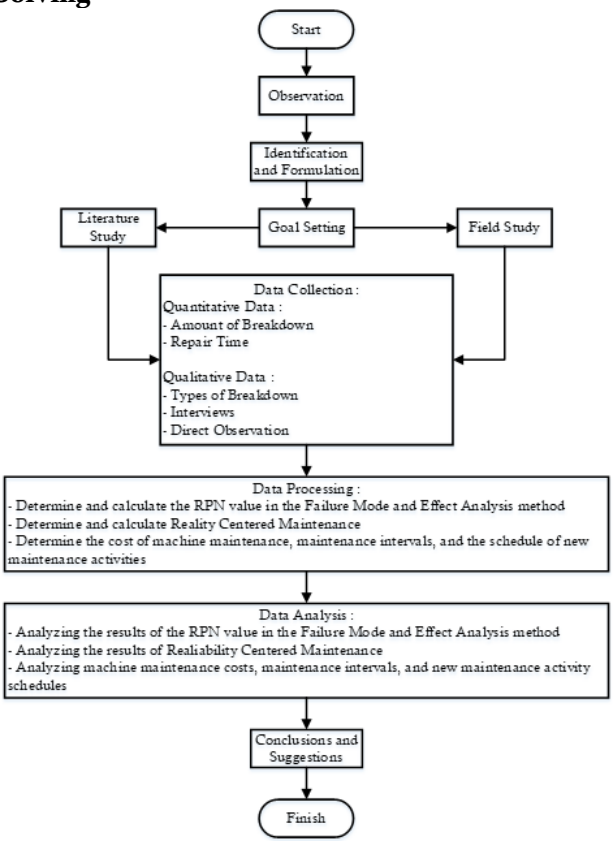

Figure 1. Flowchart of Problem Solving

Failure Mode and Effect Analysis (FMEA)

The method used to identify the failure forms that may cause each malfunction and for failures (Simanungkalit et al., 2023). To identify the cause of the highest failure in each failure or failure that occurs in the component, an analysis is carried out using FMEA with several stages, namely (Azhari et al., 2024) :

1. Failure identification
2. Identification of machine failure function
3. Identify the cause of failure
4. Identification of the effect of the failure
5. Determine severity rating

   The first step to analyzing risk is an assessment of the severity of the effects of failure modes with a ranking value starting from the most beautiful value of 1 to the highest value of 10 (Wicaksono & Rosady, 2024). The assessment is based on the type of damage if the type of damage can cause production downtime, the greater the ranking value (Purnomo et al., 2021).

Table 1. Severity

Rating	Failure Rate	Explanation
1	Negligible severity	Bad potential that can be ignored
2 and 3	Mild severity	Slight adverse potential
4,5, and 6	Moderate severity	Moderate adverse potential (still within the tolerance limit position)
7 and 8	High severity	High adverse potential (indicating beyond the tolerance limit of high repair costs)
9 and 10	Potential safety problems	Harm to user safety (related to violating government regulations related to safety)

6. Determine the occurrence rating

   Occurrence is the probability of the frequency of a fault occurring. Occurrence is identical to the possibility of risk occurrence. With a ranking value starting from the lowest value of 1 to the highest value of 10 (Bangun et al., 2024). The assessment is based on the length of time the machine is damaged if the machine damage is more severe and takes a long time, the greater the occurance value (Firmansyah & Rizqi, 2024).

Table 2. Occurrence

Rating	**Failure Rate**	**Explanation**
1	1 from 1.000.000	The degree of likelihood that the cause of the value that resulted in the potential failure mode
2 3	1 from 20.000 1 from 40.000	Level of likelihood that this failure is rare
4 5 6	1 from 1.000 1 from 400 1 from 80	Level of likelihood that this failure is often likely to occur
7 8	1 from 40 1 from 20	The level of likelihood that this failure is almost likely to occur
9 10	1 in 8 1 in 2	This level is almost certain that the potential failure will definitely occur

7. Determine the detection rating

   Detection is the possibility to detect an error about to occur or before the impact of the error occurs. Detection is synonymous with understanding the source of risk or understanding the control of the observed process. With a rank value starting from the lowest value of 1 to the highest value of 10 (Huda et al., 2021). The assessment is based on the detection of damage if the damage cannot be detected, the greater the detection value (Wibowo et al., 2021).

Table 3. Detection

Rating	Failure Rate	Explanation
1	1 from 1.000.000	Highly effective and productive prevention method
2 3	1 from 20.000 1 from 4.000	Probability that the cause will occur in low mode
4 5 6	1 from 1.000 1 from 400 1 from 80	The probability of the cause occurring is moderate. In the prevention or detection method, sometimes the cause occurs repeatedly
7 8 9 10	1 from 40 1 in 20 1 in 8 1 in 2	The probability of the cause occurring is very high and the prevention or detection method is less effective because the cause occurs repeatedly or continuously

Reliability Centered Maintenance (RCM)

A process used to determine what must be done to ensure that each physical asset continues to work as desired or a process for determining effective maintenance (Gustiawan & Affandi, 2021). RCM is a maintenance approach that combines the practices and strategies of preventive maintenance (pm) and corrective maintenance (cm) to maximize the life time and function of assets/systems/equipment at minimal cost (Fahrurroji et al., 2021). The biggest emphasis on Reliability Centered Maintenance (RCM) is to realize that the consequences or risks of failure are far more important than the engineering characteristics themselves (Prasetyo, 2021).

RESULTS AND DISCUSSION

Data Collection

Data collection was carried out in September-December 2024 and January 2025 by direct observation and interviews at PT SBM. The data used includes the type of damage, the amount of damage, and the length of repair, on the conveyor belt machine components. By using 2 methods, namely failure mode and effect analysis and reliability centered maintenance.

In table 4 below is a recap of the type of damage, amount of damage, length of repair and time between damage to the conveyor belt machine components.

Table 4. Types of Damage, Number of Damages, Duration of Repair and Time Between Damages of Conveyor Belt Machine

Convenyor Belt Machine					
Month	**Amount of Breakdown**	**Types of Breakdown**		**Repair Time/Hour**	**Total Hours/Month**
		Amount	**Breakdown**		
September 2024	3	2 2 1	Belt Gear Roller Idler	6,50 8,35 1,00	16
October 2024	2	1 1	Chain Gear	2,00 4,25	6
November 2024	2	1 1	Belt Gear	3,40 4,50	8
December 2024	2	2 1	Belt Roller Idler	6,80 1,50	8
January 2025	3	1 1 1	Gear Roller Idler Chain	4,45 1,45 2,50	8
Total	**12**	**15**		**46,7**	

Based on table 4 above, it shows that in September-December 2024 and January 2025 there were a total of 12 damaged components on the conveyor belt machine.

Table 5. Conveyor Belt Machine Component Breakdown

Component	Number of Breakdown	Duration of Repair (Hours)	Percentage of Breakdown (%)	Cumulative (%)
Belt	5	16,7	33%	33,3%
Gear	5	21,6	33%	66,7%
Roller Idler	3	4	20%	86,7%
Chain	2	4,5	13%	100%
Total	**15**	**46,7**	**100%**	

Based on table 5 above, the total number of damage to each type of damage to the conveyor belt machine is 15, with a long repair time carried out on 5 belt damage totaling 16.7 hours, 5 gear damage totaling 21.6 hours, 3 idler roller damage totaling 4 hours, and 2 chain damage totaling 4.5 hours. In total, the repair time of these components is obtained at 46.7 hours of repair.

Table 6. Repair Time and Intermediate Time Between Belt Component Breakdown

Belt		
Date	**Repair Time (Hour)**	**Time Between Breakdown (Hour)**
02/09/2024	3	1
19/09/2024	3,5	405
12/11/2024	3,4	1292,5
07/12/2024	3,35	620,6
15/12/2024	3,45	188,65

Table 7. Repair Time and Intermediate Time Between Gear Component Breakdown

Gear		
Date	**Repair Time (Hour)**	**Time Between Breakdown (Hour)**
05/09/2024	4	1
25/09/2024	4,35	476
10/10/2024	4,25	379,65
07/11/2024	4,5	643,75
08/01/2025	4,45	1483,5

Table 8. Repair Time and Intermediate Time Between Roller Idler Component Breakdown

Roller Idler		
Date	**Repair Time (Hour)**	**Time Between Breakdown (Hour)**
06/09/2024	1	1
21/12/2024	1,5	2567
12/01/2025	1,45	502,5

Table 9. Repair Time and Intermediate Time Between Chain Component Breakdown

Chain		
Date	**Repair Time (Hour)**	**Time Between Breakdown (Hour)**
02/10/2024	2	1
06/01/2025	2,5	2278

In tables 6, 7, 8, 9 above is a recap of the repair time and the time between breakdown to the conveyor belt machine components.

Data Processing

Analysis Failure Mode and Effect Analysis (FMEA)

The initial step of data processing is to conduct FMEA analysis for critical components by determining the RPN value of conveyor belt machine components, using the Severity, Occurrence, and Detection values. (RPN = SxOxD)

Table 10. Analysis FMEA

Component	Failure Mode	Cause of Failure	S	O	D	RPN
Belt	Rubber belt breaks	Belt installation and splicing is too tight	6	6	5	180
Gear	Tooth wear and damage	Improper load transport and alighment	5	6	5	150
Roller Idler	Jammed and not turning	Too much tension on the shaft	4	5	4	80
Chain	Broken and loose	Chain installation is too tense and irregular	5	4	4	80

Table 10 above shows that the cause of failure in the conveyor belt machine components. The results of the RPN value calculation show that the belt component gets an RPN value of 180, gear of 150, idler roller of 80, and chain of 80.

Reliability Centered Maintenance (RCM)

The second step of data processing is to determine the time to failure (TTF) and time to repair (TTR) parameters from tables 6, 7, 8, 9 using minitab 19 software with the Weibull distribution in order to produce parameters α and β. The parameter results are shown in table 11.

Table 11. TTF and TTR parameter

Component	Parameter	TTF	TTR
Belt	α	0,65	29,91
	β	416,39	3,41
Gear	α	0,67	32,95
	β	513,39	4,38
Roller Idler	α	0,41	8,08
	β	517,39	1,40
Chain	α	0,31	10,75
	β	322,98	2,36

After obtaining the TTF and TTR parameters, the calculation of the mean time to failure (MTTF) and mean to time repair (MTTR) for Weibull-distributed data will be carried out and the calculation results are as follows :

Calculation example :

$$\text{MTTF Belt} = \beta \text{ x } \Gamma\left(1 + \frac{1}{\alpha}\right) \quad (1)$$

$$\text{MTTF Belt} = 416{,}39 \text{ x } \Gamma\left(1 + \frac{1}{0{,}65}\right)$$
$$\text{MTTF Belt} = 416{,}39 \text{ x } 1{,}36779 = 569{,}53 \text{ hour}$$
$$\text{MTTR Belt} = \beta \text{ x } \Gamma\left(1 + \frac{1}{\alpha}\right) \quad (2)$$
$$\text{MTTR Belt} = 3{,}41 \text{ x } \Gamma\left(1 + \frac{1}{39{,}91}\right)$$
$$\text{MTTR Belt} = 3{,}41 \text{ x } 0{,}98355 = 3{,}35 \text{ hour}$$

Table 12. MTTF and MTTR Calculation Results

Component	MTTF (Hour)	MTTR (Hour)
Belt	569,53	3,35
Gear	677,70	4,30
Roller Idler	1.203,96	1,32
Chain	2.528,28	2,25

From the MTTF calculation, the hourly time results are obtained, namely the belt of 569.53, gear of 667.70, idler roller of 1,203.96, and chain of 3,528.28. MTTR obtained the results of hourly time, namely belt of 3.35, gear of 4.30, idler roller of 1.32, and chain of 2.25.

Determination of Machine Maintenance Cost, Optimal Maintenance Interval, and New Maintenance Schedule

Damage and repairs to engine components cannot be separated from the cost of maintaining the engine itself, maintenance costs include components and labor costs.

Calculation of component replacement cost due to damage (CF) :

$$\text{CF} = [(\text{Labor Cost} + \text{Downtime Cost}) \text{ x MTTR}] + \text{Component Price} \quad (3)$$
$$\text{CF} = [(300.000 + 10.000.000) \text{ x } 3{,}35] + 20.000.000 = \text{Rp. } 54.505.000$$

Calculation of component replacement costs due to maintenance (CM) :

$$\text{CF} = (\text{Labor Cost x MTTR}) + \text{Component Price} \quad (4)$$
$$\text{CF} = (300.000 \text{ x } 3{,}35) + 20.000.000 = \text{Rp. } 21.005.000$$

Table 13. Component Cost Calculation Results Due to Damage and Maintenance

Component	MTTF (Hour)	MTTR (Hour)	CF (Rp)	CM (Rp)
Belt	569,53	3,35	Rp54.505.000	Rp21.005.000
Gear	677,70	4,30	Rp64.290.000	Rp21.290.000
Roller Idler	1.203,96	1,32	Rp33.596.000	Rp20.396.000
Chain	2.528,28	2,25	Rp43.175.000	Rp20.675.000

Table 13 above shows the MTTF and MTTR values for various components, as well as the costs associated with damage and repair. The next step is to perform calculations to determine the optimal maintenance interval, which is as follows :

$$\text{TM} = \beta\left[\frac{\text{CM}}{\text{CF} - \text{CM}} \cdot \frac{1}{\alpha^{-1}}\right]^{1/\alpha} \quad (5)$$
$$\text{TM} = 416{,}39\left[\frac{21.005.000}{54.505.000\text{-}21.005.000} \times \frac{1}{0{,}65^{-1}}\right]^{\frac{1}{0{,}65}} = 104{,}66 \text{ hour}$$

Then in the same way as above, the results of the calculation of the optimal maintenance interval on each critical component are obtained as shown in table 14.

Table 14. Optimal Maintenance Interval Calculation Results

Component	CF (Rp)	CM (Rp)	TM (Hour)
Belt	Rp54.505.000	Rp21.005.000	104,66
Gear	Rp64.290.000	Rp21.290.000	98,90
Roller Idler	Rp33.596.000	Rp20.396.000	169,93
Chain	Rp43.175.000	Rp20.675.000	5,62

From the calculation results in table 14 above, the maintenance interval time and the right type of maintenance activity are shown in table 15.

Table 15. Maintenance Activity Type and Maintenance Interval Time

Component	Maintenance Activity	Maintenance Interval (Hour)
Belt	Scheduled on-condition task	104,66
Gear	Scheduled discard task	98,90
Roller Idler	Scheduled on-condition task	169,93
Chain	Scheduled discard task	5,62

In table 15 above, the component that has the highest maintenance interval is the idler roller component of 169.93 hours, indicating that it has a very large durability compared to the belt component of 104.66, gear of 98.90, and chain of 5.62. Next determine the new maintenance schedule for conveyor belt machine components in table 16.

Table 16. New Maintenance Schedule

Component	New Maintenance Schedule (Hour)	New Maintenance Schedule (Day)
Belt	104,66	4,36
Gear	98,90	4,12
Roller Idler	169,93	7,08
Chain	5,62	0,23

In table 16 above is a new maintenance schedule showing the optimal time interval for performing maintenance on each component. The belt component must be checked and maintained every 4.36 days, the gear must be checked and maintained every 4.12 days, the idler roller must be checked and maintained every 7.08 days, and the chain must be checked and maintained every 0.23 days. This schedule can be used as a guide to plan and carry out more effective preventive maintenance, so as to improve the reliability and efficient operation of the conveyor belt machine.

Previous Research

Table 17. Previous Research

Researcher Name	Title	Results
Beni Harman, Mutiara Yetrina, Susriyanti, dan Riyan Pebriyanto (2024)	Research on Maintenance on Cap Roller Press Machine with FMEA and RCM Methods	This research was conducted at PTPN VI Solok on the Close Roll Printing Machine in the tea pressing process. The results of FMEA analysis show that the crankshaft is the dominant cause of damage with an RPN value of 17.07%. RCM analysis shows the MTTF of components ranges from 1433.4 to 1811 hours. Other maintenance proposals include direct prevention of the source of damage and proper maintenance, regular replacement and checking of bearings on schedule, and regular checking of current and temperature

CONCLUSION

Research conducted at PT. SBM analyzed conveyor belt machine components using the FMEA method. The RPN value calculation showed that the belt component had the highest RPN value of 180 (37%), followed by the gear at 150 (31%), and both the idler roller and chain at 80 (16% each). Using the RCM method, a new maintenance schedule was developed for each component. The belt component requires inspection and maintenance every 4.36 hours/day through scheduled on-condition maintenance, while the gear needs maintenance every 4.12 hours/day through scheduled discard task maintenance. The idler rollers should be checked every 7.08 hours/day using scheduled on-condition maintenance, and the chains require maintenance every 0.23 hours/day using scheduled discard task maintenance. Implementing these findings can help the company establish a more effective, data-driven maintenance schedule, leading to improved machine reliability, optimized scheduling, cost reduction, and increased operational efficiency in the manufacturing industry. It is recommended that the company adopt IoT-based monitoring systems, conduct employee training, and establish maintenance standards with periodic evaluations. Future research can further explore the economic impact of applying FMEA and RCM in reducing maintenance costs and enhancing production efficiency.

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