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Analysis of Repairing Maintenance Schedule and Maintenance Management Designing in PT Horizon Investment

Angeline Claudia[1], Fenty Novianti[2], Siellawati[3], Fransisca Dini Ariyanti[4]
[1] Industrial Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480
[2] Industrial Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480
[3] Industrial Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480
[4] Industrial Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480, email: dini.ariyanti@binus.ac.id

ABSTRACT

Production target is important for the company to do. To achieving production targets there are some that become problems. Production problems can be internal and external problems. This study discusses the problem of achieving production targets that are internal. Based on the information from the company, component availability is one of the problem of production targets for the machines. Therefore, a schedule is made for the supply of machine components so as to reduce engine breakdown time and make engine performance to the maximum by using Maintenance Management method. Other than that, performed the calculation of the cost for maintenance of the machine by using two methods to be selected based on the lowest cost. The result of the calculation shows the best method to generate the lowest cost is the Repair Maintenance Policy Method. The results that have been obtained are expected to be a consideration of the company for improvement in the future.

Key words : Achieving Production Target, Maintenance Management, Preventive Maintenance Policy, Repair Maintenance Policy.

1. INTRODUCTION

PT Horizon Investment is engaged in the food industry namely wheat flour where the company has 3 superior products. The products produced are flour, polar, and crush wheat. Flour making process at PT Horizon Investment, starting from the grain entering the storage warehouse or raw material storage silo, then using the elevator to the wheat washing silo and left for 8 hours, then the wheat is ground using a degan machine through 10 stages of the grinding process, then the wheat that has been ground and then sifted and separated into flour and polar. At PT Horizon Investment engine damage is a major cause that can hamper the production process. This causes a decrease in machine productivity, causing new problems namely late delivery of products to customers. The following is a diagram showing the average percentage of production targets from 2015-2017(figure 1).

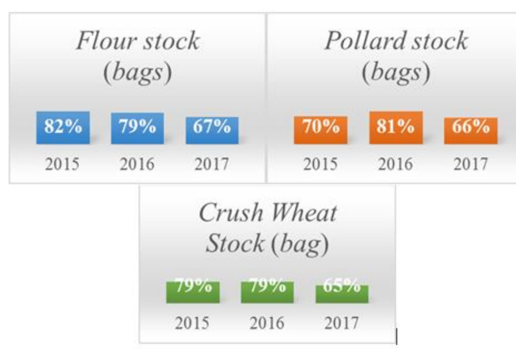


Figure 1: The Average Percentage of Production Targets from 2015-2017

Problem solving at PT Horizon Investment can be solved using fault tree analysis, FMEA and Maintenance Management methods.

2. RESEARCH METHOD

This research was conducted at PT Horizon Investments engaged in food with products that are issued namely polar flour and crush wheat. The following is a research methodology that was conducted:

1. Fault Tree Analysis

Fault Tree Analysis is a very effective risk assessment tool but when it comes to systems that are quite complex, which includes large amounts of equipment and process variables. The advantage of using an FTA is that the problem starts from the top chosen by the user for special interests and is then elaborated on or developed to identify the root cause [1].

2. Failure Mode Effects Analysis

FMEA is a methodology used to identify potential failure modes before a problem occurs. The risk component in the FMEA method is similar to the risk dimension determined by: the likelihood of a particular event or outcome occurring; the consequences of certain events or outcomes that occur; and the causal pathway leading to the event to assess risk factors that need to be prioritized, critical values are taken from both the RPN and RSV. To determine the critical value you can use the Pareto principle (80/20) %. The purpose of FMEA is to anticipate a possible problem that will occur [2]. The following are the formulas used, namely RPN (Risk Priority Number) and RSV (Risk Score Value) [3]:

$$RPN = O \times D \times S$$
$$RSV = O \times S$$

Information:
O = Occurrence
D = Detection
S = Severity

3. Minitab 18

Minitab is a software that is used to process statistical data quickly and banner. Minitab software is very easy to operate, the user only needs to prepare the data to be processed and then the Minitab software can do complex statistical analysis so that it is very easy for the user as well as determining data distribution, regression analysis (variable relationship), forecasting analysis and so on [4].

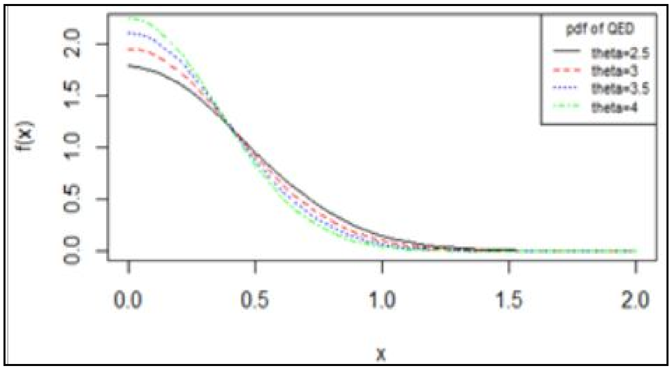
4. Mean Time to Failure

Mean Time to Failure is the average value of the time of use of the component until the component is damaged or the old expected value of a component can be used until damaged [5].
Main Time to Failure can be calculated using formula as follows [6]:

a. Exponential Distribution

An exponential distribution is a distribution used for constant damage. In other words, the damage is not due to the age of the asset [6].

Here is a curve generated from an exponential distribution:



Source: [7]
Figure 2: Exponential Distribution Curve

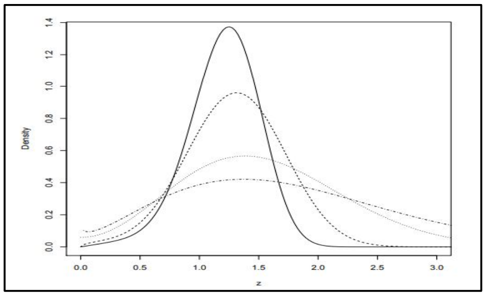
Following is the formula used to calculate the mean time to failure (MTTF) exponential distribution:

$$MTTF = \frac{1}{\lambda}$$

Information:
λ = Average damage rate

b. Normal Distribution

Normal distribution is the distribution used to model the condition of assets with poor condition. The μ parameter indicates the middle value. Normal distribution has a relationship with the lognormal distribution, therefore this distribution can be used to calculate and analyze the lognormal probability [6]. Following are the curves generated from the normal distribution:



Source: [8]
Figure 3: Normal Distribution Curve

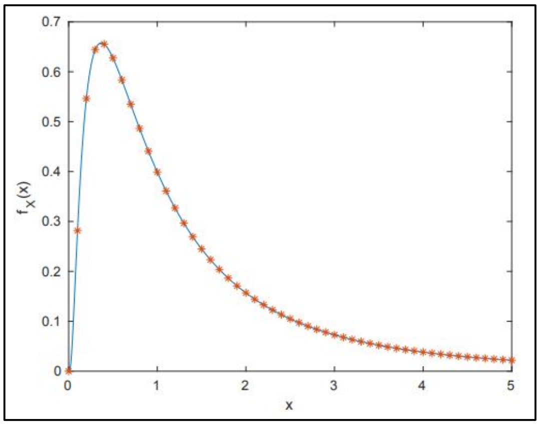
Following is the formula used to find the mean time to failure (MTTF) in a normal distribution:

$$MTTF = \mu$$

μ = Average

c. Lognormal Distribution

The parameters used in this distribution are the shape parameter (s) and location parameter (Tmed) [6]. Following are the curves generated from the normal distribution:



Source: [9]

Figure 4: Lognormal Distribution Curve

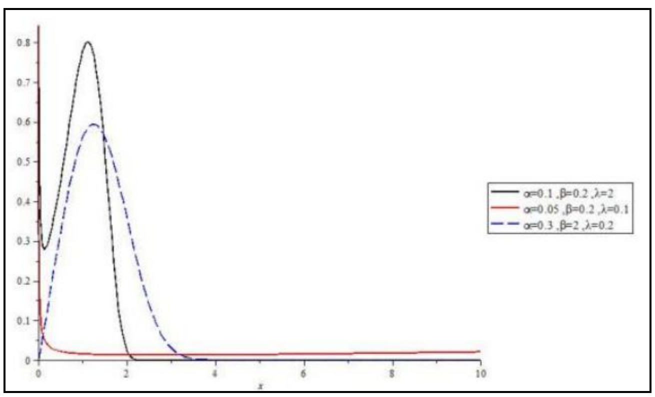
Following is the formula used to find the mean time to failure (MTTF) in a lognormal distribution:

$$MTTF = Tmed * e^{\frac{s^2}{2}}$$

Information:
Tmed = Location Parameters
S = Shape Parameters

d. Weibull Distribution

Weibull distribution is a distribution that uses more than 1 parameter so that it can be closer to reality. Following is the shape of the curve of the Weibull distribution [10]:



Source: [10]

Figure 5: Weibull Distribution Curve

Following is the formula used to find the mean time to failure (MTTF) value for the Weibull distribution:

$$MTTF = \theta * \Gamma(1 + \frac{1}{\beta})$$

Information:
ϴ = Theta, scale parameters
B = Beta, shape parameters
Γ(x) = Gamma function table

5. Mean Time to Repair Formula

Mean Time to Failure states the average length (time) of use of a component until the component is damaged or the expected value (expectation) of a component can be used until damaged [5].

Following is the formula for calculating Main Time to Repair [6]:

a. Exponential Distribution

$$MTTR = \frac{1}{\lambda}$$

Information:
λ = Average damage rate

b. Normal and Lognormal Distribution

$$MTTF = Tmed * e^{\frac{s^2}{2}}$$

Information:
Tmed = Location parameters
S = Shape parameters

c. Weibull Distribution

$$MTTF = \theta * \Gamma(1 + \frac{1}{\beta})$$

Information:
ϴ = Theta, scale parameters
β = Beta, shape parameters
Γ(x) = Gamma function table

6. Repair Maintenance Policy

Repair policy on this method will be carried out if the components in need of repair, this repair policy is also commonly referred to as emergency maintenance. The duration of repair depends on how severe the damage is to the component, the factory productivity will not be interrupted if the factory has a spare component. Repair maintenance policy is carried out to restore the damaged system to its original condition within a short period of time. Below is the formula used to calculate the cost of the repair maintenance policy [11]:

TMC (repair policy) = TCr = expected cost of repair

$$TCr = B \times Cr$$

$$B = \frac{N}{Tb}$$

$$Tb = {}_{i}^{n}p_i.T_i$$

$$TMC = TCr + TCd$$

Information:
TCr = Expected cost of repair
TCd = Total cost downtime
B = Average number of breakdowns for N engines
Cr = Maintenance cost
Tb = Average runtime per machine before it breaks
N = Number of machines

7. Preventive Maintenance Policy

This repair policy is carried out to prevent machine damage where if the machine is damaged the factory productivity will also decrease. Preventive management policy relies heavily on repair schedules that require accurate damage pattern data, repair costs, preventive management, and loss production time. The following is a formula used to calculate costs for a preventive maintenance policy [11]:

$$TCr_{(n)} = \frac{B_n}{n} Cr$$

$$TCm_{(n)} = \frac{N.Cm}{n}$$

$$TMC = TCr + TCm + TCd$$

Information:

TMC = Total cost of care

$TCr_{(n)}$ = Repair cost per month

$TCm_{(n)}$ = Preventive maintenance costs per month

n = Number of periods (months)

3. RESULT AND DISCUSSION

3.1 Fault Tree Analysis

This discussion is intended to determine which parts of the company are experiencing problems that require more attention so that the achievement of production can be in accordance with production targets. Therefore, brainstorming is done with managers in companies such as HR Managers and Operations Managers. Here are the results of the brainstorming that has been done:

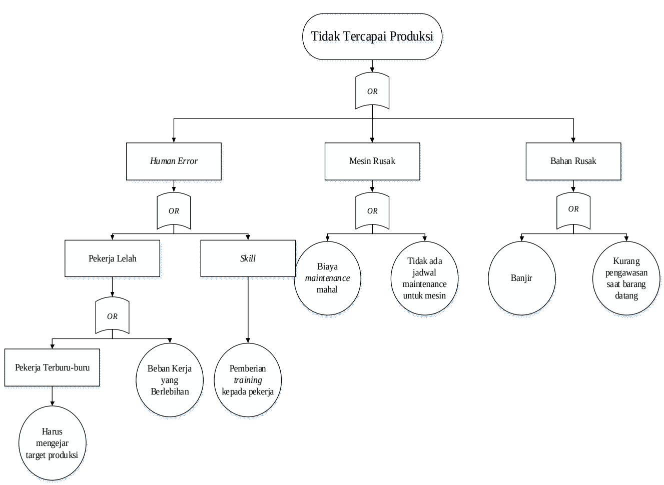


Figure 6: Fault Tree Analysis

3.2 Failure Mode Effects Analysis

Then the five respondents also provided input in making mitigation strategies. Following are the results of the FMEA and mitigation strategies:

Table 1: FMEA Data Processing Results

No	Failure Mode	Code	O	S	D	RPN	RSV
1	There is no maintenance schedule for the engine	D	10	5	2	100	50
2	High maintenance costs	B	8	5	2	80	40
3	Excessive workload	A	6	2	1	12	12
4	Must pursue production targets	C	5	2	1	10	10
5	Lack of supervision when the goods arrive	F	4	1	1	4	4
6	Flood	E	2	1	1	2	2
7	Skill	G	2	1	1	2	2

Table 2: Mitigation Strategy

No	Failure Mode	Code	Mitigation Strategy
1	There is no maintenance schedule for the engine	D	Maintenance schedule is designed as well as possible using the method of maintenance management
2	High maintenance costs	B	Determine the right maintenance policy for the company based on maintenance costs
3	Excessive workload	A	Improve SOP so that workers better understand what needs to be done
4	Must pursue production targets	C	Maintain the machine regularly
5	Lack of supervision when the goods arrive	F	Implement SOP properly and correctly
6	Flood	E	Make a buffer in each area affected by flooding
7	Skill	G	Providing training to workers

The following below is a Pareto and scatterplot diagram of the RPN and RSV of FMEA:

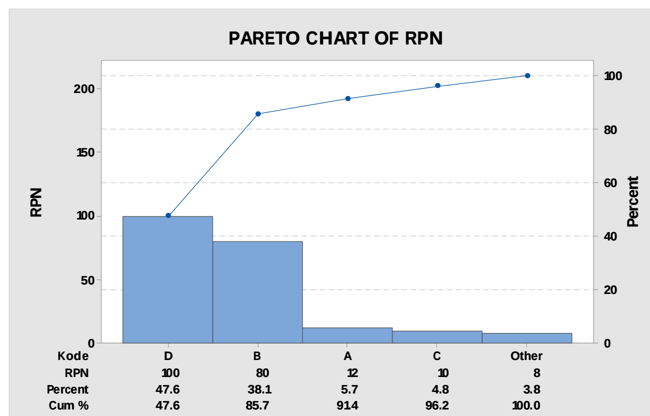


Figure 7: RPN Data FMEA Pareto Diagram

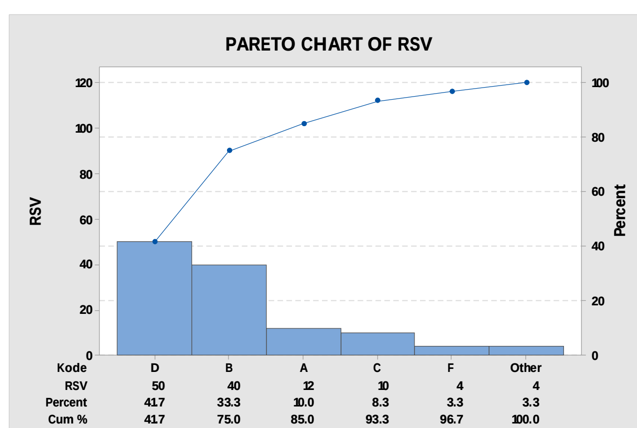


Figure 8: RSV Data FMEA Pareto Diagram

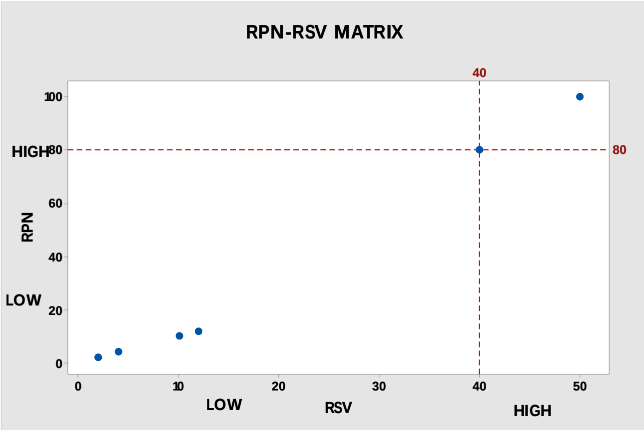


Figure 9: Scatterplot RPN vs RSV

Based on the results of data processing using FMEA (Failure Mode Effects Analysis) and then made a pareto diagram on the RPN and RSV then made RPN vs RSV scatterplot. Can be seen from the scatterplot problem that will be taken is the problem of lack of maintenance schedules and problems targeting production targets.

3.3 Determination of Distribution Using Minitab Software 18

The following is a summary of the results of determining the distribution of each component of damage using Minitab software:

Table 3: Summary of Distribution Results Using Minitab

No	Machine Type	Damage Type	Damage Distribution	Maintenance Distribution
1	Sift Machine	Unload the sifter	Normal	Weibull
		Change the filter hose	Lognormal	Normal
		Grease Sift machine	Normal	Normal
		Change machine oil	Normal	Normal
2	Elevator machine	Change v-belt	Lognormal	Normal
		Grease of elevator machines	Normal	Lognormal
		Change oil elevator	Normal	Lognormal
3	Kerici Machine	Change Kerici filter	Lognormal	Normal
		Change Kerici oil	Normal	Lognormal
		Grease Kerici machine	Lognormal	Normal
4	Machine B1	Change machine oil B1	Lognormal	Lognormal
		Grease B1 Machine	Lognormal	Lognormal
		Unload the filter	Exponential	Normal
5	Compressor Machine	Replace the hydraulic hose	Lognormal	Normal
5 6	Compressor Machine Machine B2	Change compressor oil	Normal	Normal
		Grease compressor machine	Normal	Normal
		Change B2 oil	Lognormal	Lognormal
6	Machine B2	Grease B2 machine	Normal	Lognormal
		Grease B2 machine	Normal	Lognormal

3.4 Mean Time to Failure/Mean Time between Failure and Mean Time to Repair

Based on the results of calculations that have been carried out, the following is a summary of the results of MTTF/MTBF and MTTR calculations:

Table 4: Summary of MTTF / MTBF and MTTR Calculation Results

No	Component	Value		
		MTTR (hour)	MTTF (minute)	MTBF (minute)
1	Unload the sifter	19,268	334,4	
2	Change the filter hose	6,040		99,062
3	Grease Sift machine	0,878	808	
4	Change engine oil	0,783		6060
5	Change v-belt	2,140		148
6	Change elevator oil	0,148		420
7	Grease of elevator machines	0,148	248	
8	Change Kerici filter	6,233		75,047
9	Change Kerici oil	0,065	182,000	
10	Grease Kerici machine	0,779	114,356	
11	Change B1 oil	0,035		55,952
12	Unload filter B1	3,000	240	
13	Grease B1 machine	0,127	57,689	
14	Replace the hydraulic hose	1,923		49,531
15	Change compressor oil	0,823		222
16	Grease compressor machine	0,929	90,667	
17	Grease B2 machine	0,079	90,667	
18	Change B2 oil	0,091		32,985

3.5 Scheduling Orders and Replacement Components

Based on the results of the analysis, the problem that must be solved first is that there is no maintenance schedule on the machine so that the results of the calculations in table 4 are the results of the MTTF / MTBF and MTTR then made in the design of a time schedule ordering and replacement of machine components. The following is the scheduling for ordering components:

Table 5: Component Order Scheduling

No	Machine Type	Damage Type	Order Time
1	Sift Machine	Replace the Filter hose	6
		Change machine oil	753
2	Elevator Machine	Change v-belt	10
		Change elevator oil	28
3	Kerici Machine	Change Kerici filter	4
		Change Kerici oil	18
4	Machine B1	Change machine oil B1	2
		Unload the filter	4
5	Compressor Machine	Replace the hydraulic hose	1
		Change Compressor oil	23
6	Machine B2	Change oil B2	8

Following below is the scheduling for the replacement of components on critical machines:

Table 6: Component Replacement Scheduling

No	Machine Type	Damage Type	Replacement Time
1	Sift machine	Unload the sifter	38
		Grease Sift machine	98
2	Elevator machine	Grease elevator machine	48
3	Kerici machine	Grease Kerici machine	11
4	B1 machine	Grease machine B1	20
5	Compressor machine	Grease compressor machine	6
6	B2 machine	Grease B2 machine	4

The purpose of making scheduling time for ordering and replacing components is to reduce breakdowns on critical machines so that machines can work optimally in production processes and are expected to meet production targets, the following is a comparison chart of old and new machine breakdowns (figure 9):

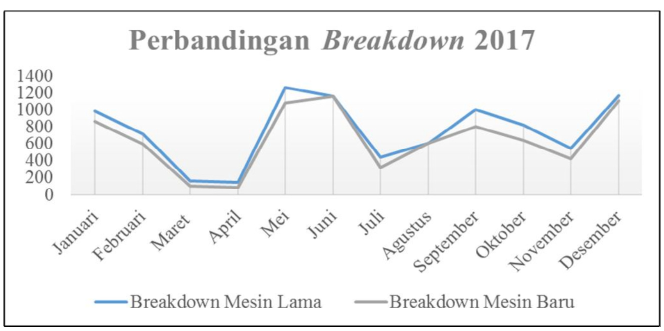


Figure 9: Comparison of Old and New Machine Breakdowns

3.6 Determination and Comparison of Old and Proposed Maintenance Costs

The results of calculations that have been carried out state that the most optimal maintenance policy is taken from the lowest maintenance costs, so that it can be seen in the graph below the repair policy is the policy with the lowest maintenance costs. The following is a comparison chart of old and new maintenance costs that use preventive maintenance and repair policy:

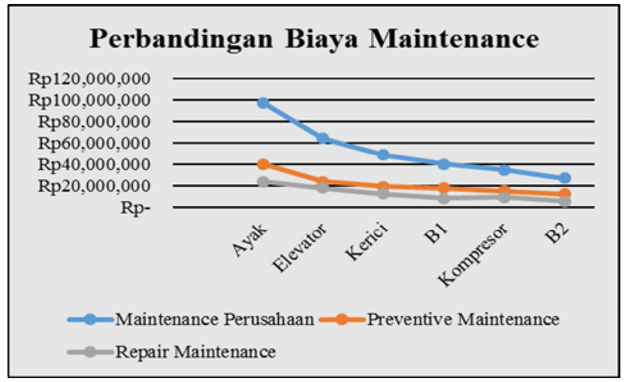


Figure 10: Comparison of Maintenance Costs

Based on the results of determining the maintenance policy based on the lowest maintenance cost that is repair policy to ensure further then the estimated maintenance costs are made for the next 5 years and then compared again with the old maintenance costs, the following is a comparison chart of the old maintenance costs with the repair policy:

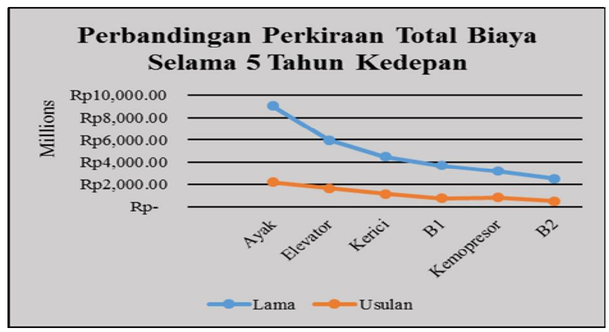


Figure 11: Comparison of Estimated Maintenance Costs for the Next 5 Years

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

Based on FMEA results, the main cause of the production target is not achieved is there is no maintenance schedule on the machine. Subsequently, scheduling of component orders is made by taking into account the time of component replacement with lead time, then a calculation is made to determine the maintenance policy that will be used based on minimum costs. It also aims to minimize the breakdown of the machine so that the machine can work optimally for production. Determining the time for ordering components is done by calculating the time of component replacement with repair time and component lead time. Calculation of ordering time for components that aim to reduce breakdown time. Based on the calculation of the cost for the machine it can be concluded that the optimal maintenance policy for all critical machines is the repair policy. The results of the calculation of the cost of the repair policy are smaller than the cost of the preventive maintenance policy and the company's current maintenance costs.

4.2 Suggestion

The maintenance policy uses a repair policy based on calculations on all critical machines and has been calculated for the next 5 years and the results show that the new maintenance cost policy is lower than the old one. And the second is the effort to avoid delays in handling maintenance, it will be suggested ordering time by taking into account the replacement of components before it is damaged, the length of time for ordering components to arrive as well as the time of installation.

REFERENCES

[1] A. B. Baig, A. A., Ruzli, R., & Buang, **Reliability Analysis Using Fault Tree Analysis: A Review**. *Int. J. Chem. Eng. Appl.*, 2013. https://doi.org/10.7763/IJCEA.2013.V4.287

[2] R. Taylor, **Operation Management Along the Supply Chain**. United State: Wiley Plus, 2009.

[3] Ariyanti, F. D., & Andika, **Supply Chain Risk Management in the Indonesian Flavor Industry: Case Study from a Multinational Flavor Company in Indonesia**. In *Proceedings of the 2016 International Conference on Industrial Engineering and Operation Management*, 2016.

[4] V. S. Sitio, **Penerapan Model ARIMA Dalam Rangka Forecasting Pengunjung Nasabah Prioritas dan Non-Prioritas Bank Mandiri di Executive Lounge Blue Sky, Bandara Soekarno Hatta**. *J. od Econ. Bus. Aseanomic*, vol. 2, no. 2, 2017.

[5] J. Pandi, S. D., Santosa, H., & Mulyono, **Perancangan Preventive Maintenance pada Mesin Corrugating dan Mesin Flexo di PT. Surindo Teguh Gemilang**. *J. Ilm. Widya Tek.*, 2014.

[6] C. E. Ebeling, **An Introduction to Reliability and Maintainability Engineering**. New York: McGraw Hill, 2010.

[7] D. Rama Shanker, **A Quasi Exponential Distribution**. *Biometrics Biostat. Int. J.*, 2018.

[8] O. V. Neveka & M. Olmos, **Modified Generalized Half-Normal Distribution with Application to Lifetimes**. *Appl. Math. Inf. Sci.*, pp. 637–643, 2018.

[9] J. Miles, **The Laplace Transform of the Lognormal Distribution**. *Math PR*, 2018.

[10] H. G. K. Iden & Hassan Hussein, **Comparison of Four Non-Bayesian Methods to Estimate the Scale Parameter for Modified Weibull Distribution by Using the Simulation**. *J. AL-Qadisiyah Comput. Sci. Math.*, pp. 22–27, 2018.

[11] Fauziyyah, A., & Sriyanto, **Analisis Perhitungan Biaya Perawatan Sebagai Dasar Evaluasi Penggantian Mesin CTCM (Continuous Tandem Cold Mill) Pada Divisi Cold Rollinng PT Krakatau Steel**. *Ind. Eng. Online J.*, 2015.

[12] S. Sorooshian & Tan Seng Teck, (2020), **Information Technology for Supply Chain Management: Literature Review**, *International Journal of Advanced Trends in Computer Science and Engineering*, Vol 9 No 1, 80-86, 2020 https://doi.org/10.30534/ijatcse/2020/13912020