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Optimization Machine Maintenance Model With Consider Repair Costs and Number of Repairman at PT. SNP

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ABSTRAK

Untuk memperlancar proses produksi, perusahaan perlu melakukan penyesuaian terhadap perkembangan teknologi untuk mendukung kinerja perusahaan. Hal ini dilakukan agar perusahaan tidak mengalami kendala dalam proses produksi. Salah satu teknologi yang digunakan pada perusahaan manufaktur adalah mesin yang dapat mempermudah proses produksi sehingga perusahaan dapat mengoptimalkan waktu dan tenaga. Mesin yang digunakan harus dijamin memiliki kinerja yang tinggi, sehingga harus dilakukan pemeriksaan secara berkala. Dalam kegiatan perawatan mesin di PT. SPN, belum berdasarkan data kerusakan sebagai acuan, dan dalam pelaksanaannya masih belum terprogram. Pada penelitian ini akan dicari solusi untuk mengatasi masalah penjadwalan mesin yang optimal dengan mempertimbangkan biaya perbaikan dan jumlah operator perbaikan. Data historis kerusakan mesin akan digunakan untuk menghitung Mean Time Between Failure (MTBF) dan Mean Time to Repair (MTTR) serta memodelkan perawatan mesin, sehingga diharapkan mampu menekan biaya perbaikan.

Kata Kunci: Perawatan, Mesin, Ongkos Perbaikan

ABSTRACT

To expedite the production process, companies need to make adjustments to technological developments to support company performance. This is done so that the company does not experience problems in the production process. One of the technologies used in manufacturing companies is a machine that can simplify the production process so that companies can optimize time and energy. The machine used must be guaranteed to operate at high performance, so periodic inspections must be carried out. In machine maintenance activities at PT. SNP, not based on damage data as a reference, and in its implementation is still not programmed. In this study, a solution will be sought to overcome the problem of optimal machine scheduling by considering the cost of repairs and number of repairman. The historical data of engine failure will be used to calculate the Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) and model the engine maintenance, so that it is expected to be able to reduce repair costs.

Keywords: *Maintenance, Machine, Repair Cost*

Introduction

In the era of increasing global industrial competition accompanied by technological developments, the industry continues to strive to increase the quantity and quality of the products it produces [1] [2]. The development of industrial products that continues to increase requires the support of a good production process [3]. One form of supporting the production process lies in the technology used. The technology used in manufacturing companies is production equipment, namely production machines that can simplify the production process so that companies can use time and energy optimally [4], [5], [6], [7]. To expedite this production process, companies need to make adjustments to technological developments to support company performance. This is done so that the company does not experience problems during the production process. To maintain the condition of the machines so that they are in optimal condition when used, maintenance activities are needed on these machines to maintain system reliability and provide spare machines to avoid a decrease in system availability due to maintenance actions. Damage to one of the machines can cause a decrease in profits due to the resulting delay in production. In addition, it can lead to increased repair costs [2].

Maintenance is a combination of various actions taken to maintain an item in an acceptable condition [8], [9]. In general, maintenance is divided

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into two, namely preventive maintenance and corrective maintenance. Preventive maintenance is carried out before failure or damage occurs, while corrective maintenance is carried out after failure or damage to a system [10], [11]. Impacts that occur due to irregularities in the maintenance of machines or equipment include not achieving production targets; lost production process time; higher repair costs; and overtime costs due to lost production time [12], [13].

PT. SNP is a national company engaged in cabling, especially for domestic cable companies. The ability to absorb high technology and apply it consistently makes PT. SNP is still in demand by consumers throughout Indonesia. Cable products PT. SPN is produced through several stages by relying on draw frames, stranding, insulation, cable, and outer sheating. Given the importance of the draw frame's role in ensuring smooth production, the maintenance of the draw frame must be a concern for the maintenance department so that the opportunity for downtime due to machine damage can be minimized.

The problems that have occurred so far, machine maintenance activities at PT. SPN is not based on damage data as a reference, and in its implementation it is still not programmed with SOPs and special sections within the company that handle maintenance. These irregular maintenance activities lead to large breakdowns and downtime as well as high maintenance costs. This research will model the proposed machine maintenance that is able to minimize maintenance costs so that the company can minimize its production costs. The number of draw frame damage that occurred in the 2021 can be seen in table 1.

Table 1. Frequency of draw machine failure in 2021

Years	Month	Failure Frequency					
		A	B	C	D	E	F
2021	Januari	7	6	10	6	7	6
	Februari	6	5	4	6	9	5
	Maret	7	5	7	7	6	6
	April	6	3	16	9	5	4
	Mei	6	4	8	5	5	6
	Juni	7	5	7	7	7	5
	Juli	7	6	10	6	6	6
	Agustus	5	5	10	5	6	5
	September	3	6	9	6	5	5
	Oktober	4	4	12	5	7	3
	November	7	6	10	7	6	4
	Desember	7	5	8	7	5	5
TOTAL		72	60	111	76	74	60
AVERAGE		6	5	10	7	7	5

Based on the background that has been described, Then the problem can be formulated, namely, how to optimize the draw machine maintenance strategy by consider maintenance cost.

Research Methodology

After performing data collection techniques for research, the next step is to process the data. Among them:

a. Based on the historical data of the working time of each operator and employee contained in the maintenance and production department,
b. The most critical component damage data and the results of the analysis will be calculated by calculating Mean Time To Failure (MTTF) and Mean Time To Repair (MTTR) to determine the difference between the time the draw machine is repaired and the time of the next machine breakdown, and the calculation of the value availability of draw frames. The calculation of MTTR is obtained from the length of time the repair is done until the engine repair is completed. From the time the initial failure has been repaired until the next failure occurs while the machine is operating.
c. Repair strategy will consider by repair cost and breakdown machine.

Using the lingo 18 software to perform calculations of repair cost that PT. SPN must expand.

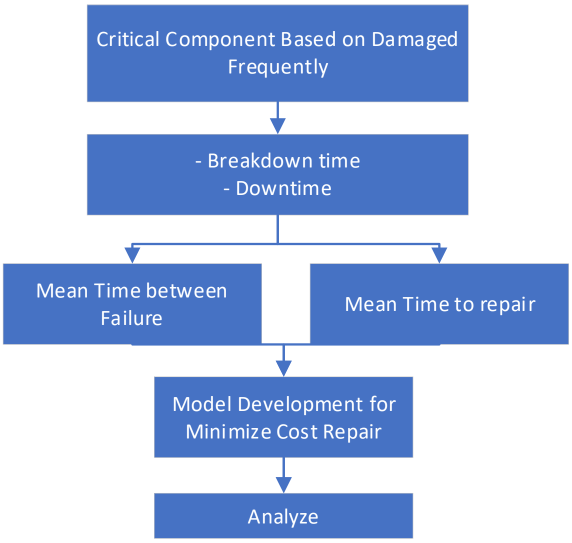

Figure 2. Research Model Framework

Literature Review

In various previous writings it is often assumed that maintenance activities are the repairable system is perfect so that it is able to make the system as if it came back new (good as new) so that it is identical to the model replacement [14]. Imperfect maintenance model assuming the treatment resulted in the system after being treated may be the same bad as not being cared for (bad as old), or in between (bad as old – good as new), or even worse than before (worse than old) [15].

Surveys of treatment models show a trend imperfect maintenance modeling due to the ideal

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conditions of perfect care difficult to achieve, one of which is the maintenance and replacement model.

Maintenance Definition

Maintenance is the likelihood that a damaged component or system will be repaired within a specified time frame when maintenance is performed in accordance with the proper procedure [8]. Maintenance is an activity to maintain or maintain factory facilities or equipment by making repairs, adjustments, or replacements needed in order to create a satisfactory production operational state in accordance with what has been planned [7].

The main maintenance objectives are to:

a. Increase the asset's life (i.e., every part of a workplace, building, and contents).This is especially important when there is a lack of resources for replacement.
b. Ensure the availability of equipment installed for production and get the maximum return on investment.
c. So that the equipment operation of all the necessary equipment is ready at all times, for example, backup units and other units.
d. Maintaining the ability of production equipment or facilities to meet needs in accordance with production targets and plans
e. Exceeding usage and storage limits and retaining capital invested in the company for a set period of time in accordance with company policy
f. Maintain product quality at the expected level in order to meet the needs of the product itself and keep production activities from being disrupted.
g. Pay attention to and avoid machine and equipment operating activities that can endanger work safety.
h. Achieving the lowest possible cost level by performing maintenance activities effectively and efficiently for the entire organization.

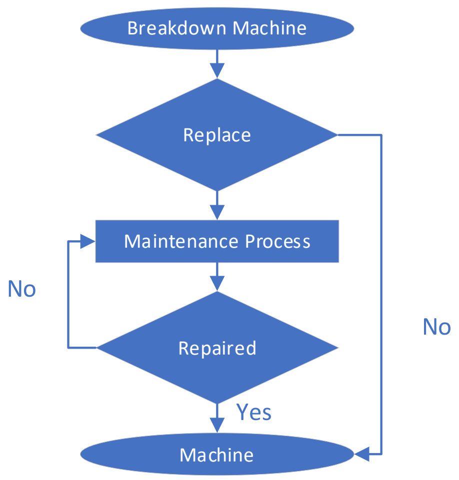

Figure 1. Maintenance Process Flowchart

Maintenance is an activity carried out to maintain the entire condition of the equipment so that it remains in good condition and can be expected to produce the appropriate output. The choice of maintenance program will affect the continuity of factory production productivity. Therefore, it is necessary to carefully consider the form of maintenance that will be used, especially with regard to production requirements, time, cost, reliability of maintenance personnel, and the condition of the equipment being worked on. Many difficulties were encountered in determining the treatment strategy, including [16], [17], [18]:

a. A skilled workforce;
b. Experienced technicians
c. very supportive instrumentation
d. Good cooperation between maintenance departments.
e. Factors influencing the choice of treatment strategy.
f. Age of production equipment/machinery
g. Machine usage capacity rate
h. Spare parts availability
i. Maintenance department's ability to work quickly
j. Market situation, readiness of funds, and other factors

To run a production program with minimum disruption, the time for maintenance work needs to be planned as well as possible [19]. The time of maintenance work is determined by the conditions when production activities are stopped due to maintenance needs and when the factory is not operating due to time schedules or working hours. The determination of factory operating hours depends on the size of the industry, type, and level of production. There are various systems for changing work time in the industry, so that the time available to carry out maintenance work can be determined when the plant is not operating [20], [21]. The sequence of planning the maintenance function includes [22] [23]:

a. The form of treatment to be determined.
b. Planning maintenance work to be done with future considerations
c. Controlling and documenting
d. A collection of all maintenance issues that can be resolved with a specific treatment.
e. Use of the selected treatment method

Mean Time to failure (MTTF)

The mean time to failure is the average time interval for failure of a damage distribution where the average time is the expected time for failure of identical units operating under normal conditions.

Mean Time to Repair (MTTR)

In calculating the average or determining the mean value of the probability function for the improvement time, it is very important to pay attention to the distribution of the improvement data. The determination for this test is carried out in the same way as previously described.

Maintenance Efficiency, Failure Cost and Preventive Cost Good maintenance will be carried out within a certain period of time and when the production process is not running [24] [25]. The more frequent maintenance of a machine, the higher the maintenance costs. In addition, if maintenance is not carried out, it will reduce the performance of how the machine works. Optimal maintenance/ maintenance patterns need to be sought so that between maintenance costs and damage costs can be balanced at the most minimal total cost [26] [27] [28].

Preventive costs (maintenance costs) are costs incurred due to scheduled machine maintenance. Meanwhile, the failure cost is the cost incurred due to unexpected damage that causes the production machine to stop while production is running [29] [30].

Result and Discussion

Model development is carried out to calculate the most probable repair cost. The following is a machine repair cost development model by considering repair costs.

Queue Model With Multi Chanel Simgle Phase [M/M/3] at Steady State Condition

The development of the improvement strategy model follows the queuing theory, which is one machine queue with several improvements. As the name suggests, this queuing system has several service facilities. Although it consists of several services, basically every service facility is the same. Therefore, when there is an empty repair, the machine will be directed to it.

In this system, before customers get service at an empty facility, they will queue up by forming a line. With this queuing system, customers will get service faster, so they don't have to wait too long.

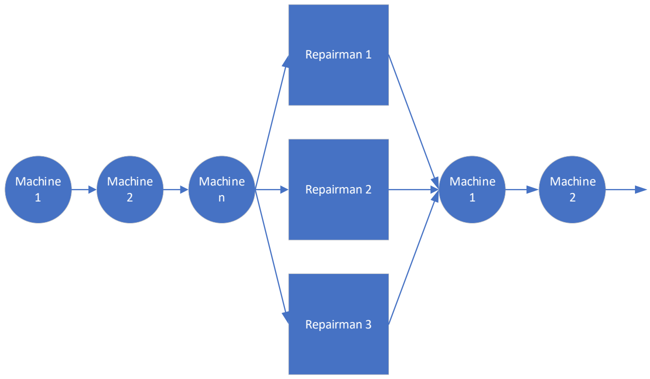

Figure 3. Repair Queue Model

In this study, it is assumed that the average time between machines being damaged must be greater than the average time the machine is repaired. This condition is called the steady-state condition. This condition must be met in a repair path so that the flow of the repair process does not stagnate. In this study, the steady-state assumption is met if MTTR < MTBF, where MTTR is the average amount of time required for the machine to be repaired following a Poisson distribution, while MTBF is the average time that regulates the engine time rate by repairmen following exponential distribution.

Model Notation

$NREP_i$	Possible Repairman available for repair at machine i
$MNDOWN_i$	Expected number of down machine i
$CPERHR_i$	Expected cost/hour of down machines i
$TCOST_i$	Total expected repair cost/hour at repairman i
$MOMTTR_i$	Monthly mean time to repair at machine i
$MOMTBF_i$	Monthly mean time between failure at machine i
NMACH	Number machines subject to breakdown
CR	Hourly cost of a repairman
CM	Hourly cost of a down machine

Objective Function

The objective function of model 1, calculates the most optimal machine repair costs for each occurrence of the probability of damage to the machine and handled by the repairman.

$$CPERHR_i = CM\ x \sum_{i \dots n}^{i} NDOWN \quad \forall\, i = 1 \dots k \quad (1)$$

Model 2, calculates the total cost of repairs each occurrence of the probability of damage. For each case of 1 - 3 repairmen calculate expected number of machines down, cost per hour of down machines, and total cost per hour of operations;

$$TCOST_i = \sum_{i..n}^{i} CPERHR_i + (CR\ x\ i) \quad \forall\ i = 1 \ldots k \ (2)$$

Repair Queue Function

Model 3, calculates the Probability in a Finite Source, in this case expected number of machines under repair.

$$MNDOWN_i = \sum_{k..n}^{i} \frac{NMACH\ x\ MOMTTR_i}{\rho} \quad \forall\ i = 1 \ldots k \ (3)$$

Model 4, is the queuing function of the engine repair strategy was developed using a single-phase Multi-channel model, taking into account the mean time between failure, and the mean time to repair.

$$\rho = \sum_{i..n}^{i} \frac{MTBF_i}{MTTR_i} \quad \forall\ i = 1 \ldots k \qquad (4)$$

Constraints

Model 5 is constraints for steady state asumptions. Mean time between failure must be greater than mean time to repair.

$$\text{MTTR} < \text{MTBF} \qquad (5)$$

Analysis

In this research, the author examines the time of damage to the draw frame machine. This machine is also the machine that is used the most and has the highest frequency of breakdowns. In this company, there are 6 draw machine operating. The role of this machine in the process production at PT. SNP is critical and important because of this engine is the beginning of all existing production processes. It is certain that if this machine is disturbed, the entire production process will be disrupted.

Table 2. Operation Time Data

Machine	Breakdown Frequency Average	Total Operation Time		Total Hours
		Loading	Breakdown	
A	6	200	9,05	190,55
B	5	200	9,33	190,27
C	10	200	12,05	187,55
D	7	200	10,08	189,52
E	7	200	10,02	189,58
F	5	200	9,25	190,35

The data processing required is Mean Time Between Failure (MTBF) data, Mean Time To Failure (MTTR) data, and availability values. For the calculation of the draw frame operation time, it can be seen in table 3.

Table 3. Performance Maintenance Results

Machine	MTBF (Hrs)	MTTR (Hrs)	Availability (%)
A	31,49	1,50	95,27
B	38,05	1,86	95,13
C	18,47	1,20	93,77
D	27,07	1,44	94,76
E	27,08	1,43	94,79
F	38,07	1,85	95,17
Average	30,04	1,55	94,82

Example of Performance Maintenance in Machine.

a. MTBF = 190,55/6
= 31.49 Hrs

b. MTTR = 9,05/6
= 1.50 Hrs

c. Availability = 190,55/200 x 100%
= 95.27%

From the data recording of damage to the draw frame machine, the results of MTBF and MTTR are obtained. When the MTBF of the two components is damaged, the machine cannot operate, resulting in production losses. While MTTR is the time needed to make improvements. From this discussion, it can be concluded that the MTBF and MTTR values are the basis for the company's policy to take action on engine maintenance, but for policies taken on this basis, it still needs consideration because many things make engine components do not operate according to their service life, but can also cause engine components to fail. affected by other conditions that cause the machine to not operate properly.

Another impact if there is damage to the machine then PT. SPN must spend a number of costs, namely the cost of repairs, and the cost of dead machines. From the information obtained, the cost of repair person is $30/hour, and the cost of down machine because the production line becomes stop is $350/hour.

Simulation Test

The results of the simulation using Lingo software to find out the Cost Repair that must be issued by the company are obtained as follows:

Table 4. Probability Repair and Cost Result

Repairman	MNDOWN	CPERHR ($)	TCOST ($)
A	0.3427630	119.9670	149.9670
B	0.2825311	98.88587	158.8859
C	0.3660397	128.1139	218.1139
Total Cost		346,96677	526,9658

The results of the modeling simulation result in each repairman calculating the number of machines that are expected to be damaged, the cost per hour of the machine down, and the total cost per hour of repair.

Conclusion

Based on the results of data processing and analysis that have been discussed in the previous chapter, the following conclusions can be drawn us the results of the calculation of average MTBF (Mean Time between Failure) is 30,04 hour and MTBF is 1,55 hour, with availibility 94,82%. By performing preventive maintenance, the level of machine reliability can be increased according to the target what the company wants.

Probability of machine repair by repairman A is 0,3427630, B is 0,2825311, and C is 0,3660397.

Total cost that PT. SPN must expand for repair the whole drawing machine is $529,9658.

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