Implementation of Preventive Maintenance on CNC Milling Tape Drill Machine at PT XYZ Using FMEA Method and Age Replacement

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Abstract

The Maintenance system is an important factor that can boost the productivity of a company, likewise for PT XYZ which is engaged in the jig and tool industry. In fulfilling the customer demand, work productivity is needed in the company, especially in the company's machine maintenance system. There are many machine problems that occur at PT XYZ, such as downtime due to the company's production machines. This can cause the production process to stop suddenly and can even cause losses due to maintenance that occurs due to the damage. The research was carried out on the CNC milling tape drill machine which has the most downtime frequency of 70 times with a time reaching 206.15 working hours during 2017 to 2019. This study provides a maintenance proposal at PT XYZ by implementing preventive maintenance with an age replacement method which then obtained a cost comparison between the maintenance model used by PT XYZ now and the proposal. From the Research results, there are 4 critical components because they have a Risk Priority Number value that is above the critical of RPN, where the four components are the solenoid valve with an RPN value of 180, a plarail chain of 150, a spindle motor of 140, and signal lamp of 180 where the critical value of RPN is 123.54. This study also obtained the optimal replacement time interval for 4 critical components where the optimal replacement is on the 41st day for solenoid valve, 38th day for plarail chain, 207th day for motor spindle, and 90th day for signal lamp. Then obtained the difference in maintenance costs is IDR 39.356.404 if PT XYZ implements preventive maintenance using the age replacement method.

Keywords: Maintenance System, Preventive, Risk, and Replacement.

1. Introduction

In the Industrial World, products are the main result of the production process. Products are the main income for a company. In an Increasingly advanced era, companies must compete in competition to produce products that are better than their competitors. This makes employees have to work even harder to produce quality products. Quality products are produced through quality machines. In order for the machine to maintain its quality, maintenance activities are needed for these production machines. The maintenance process is an important activity to do. According to Assauri (1999), Maintenance is defined as an activity to maintain factory needs so that a state of production operation is as planned (Assauri 1999). Maintenance of the components and machines used in the production process can be done, one of which is by the preventive maintenance method. According to Ebeling (2003) Preventive maintenance is maintenance that is carried out on a scheduled basis, periodically, during which a large number of inspections and repairs, replacement, activities, lubrication, and matching are carried out (Ebeling 2003). If preventive maintenance is implemented, the company can schedule regular maintenance of machines and components that support the production process. With the routine scheduling of machine component maintenance, the availability of machine components can be estimated. With that production process can be planned according to machine availability.

PT XYZ is a company engaged in the production of various kinds of jigs such as air insert jigs, auto insert jigs, panel welding jigs, insert nut jigs, and others. Apart from producing various kinds of jigs, PT XYZ also produces various kinds of work tables and chairs. In Carrying out production, PT XYZ has a machine in the process, namely the CNC Milling Machine FANUC Tape Drill (Type S). Where this machine is used in making parts that have surface shapes that are difficult to produce by manual machines such as lathes, milling machines, drilling, etc., and almost all the components that are formed must go through the drilling process. If the CNC Milling Tape Drill machine is interrupted, the production process at PT XYZ will stop and this will disrupt the product finishing process so that the product cannot be marketed before assembly is complete. Machine breakdown that occurs in machines is very detrimental to the company, therefore it is very important to maintain this FANUC Tape Drill CNC Milling machine in good condition.

The condition of the maintenance system at PT XYZ is still not classified as good which result in PT XYZ suffers a loss because the product the customer wants does not arrive within the specified time, so that the price of the product is reduced in accordance with the mutual fine if the product does not arrive at its destination on time. This is because PT XYZ only carries out maintenance when a machine component is damaged and the workforce used is not yet focused on machine maintenance. PT XYZ still uses the services of company employees who understand a little about machine damage but do not yet understand the machine in depth. This causes the machine to experience frequent breakdowns and takes a long time to maintain the machine. This incident not only affected the product processing time, but also caused losses to PT XYZ, where PT XYZ pays the employee costs for repairing the CNC Tape Drill machine of IDR 4,073,190 for 206.15 working hours, and also the losses caused by replacing components, materials and machine tools needed during maintenance are IDR 85,102,500, the total overall maintenance costs for PT XYZ amounted to IDR 89,175,690 in 2017 to 2019. In addition, during 2019 the breakdown of the CNC Tape Drill machine experienced by PT XYZ caused the product to not be delivered on time so this caused losses to PT XYZ due to the fine that must be borne by PT XYZ as compensation for late delivery of products. The total losses suffered by PT XYZ is IDR 64,875,350 to companies that order PT XYZ products.

Based on observations that have been made, PT XYZ. Does not yet have an integrated maintenance schedule, especially on the CNC Milling Tape Drill machine, so that the company does not have a period for machine maintenance or component replacement. This can be known from the large number of machines breakdown, reaching 70 breakdowns during 2017 to 2019 and also ineffective breakdown handling where maintenance can run for up to 5 hours in one hand so that it causes a lack of worker productivity due to wasted working hours on maintenance process that reached 206.15 working hours during 2017 to 2019. To solve this problem, the researcher tries to propose a maintenance for production machine of CNC milling FANUC by combining the failure mode and effect analysis method and the preventive maintenance method with the age replacement model. The proposal using the failure mode and effect analysis method aims to determine and classify between critical components and non-critical components on a CNC tape drill milling machine. Meanwhile, the researchers chose the age replacement model because it was based on interviews with PT XYZ, the source of engine components used by PT XYZ comes from outside Indonesia such as Japan, Korea and China, so this is why. Then this causes the component time to arrive at PT XYZ will take a long time. If PT XYZ applies the age replacement method, so PT XYZ can prepare a more mature stock of replacement components so there is waiting time caused by waiting times for ordering machine components. Besides that, the age replacement method can also prevent the replacement of new equipment, thereby saving maintenance costs for machines. Some studies related to FMEA and age replacement methods were conducted by (Abbas et al. 2009, Chang et al. 2013, Liang and Parlikad 2020, Mutiara et al. 1997, Puspitasari and Martanto 2014).

2. Literature Review

Failure mode and Effect analysis is an Engineering technique used to identify the existing or potential failures or problems in a design, process, or services structure of a system before they occur, to prevent undesirable incidents and protect employees from occupational accidents and disease by taking necessary measures (Mutlu and Altuntas 2019). FMEA is a reliable method in the field of risk management for guaranteeing product and system (design and operation) reliability and safety in various industries (Lo and Liou 2018). FMEA is a powerful analysis method for process safety. Since FMEA was first developed at Grumman Aircraft Corporation in the mid-19th century, it has been extensively utilized in many industries (Subriadi and Najwa 2020).

In implementation of FMEA, corrective actions are defined and implemented by identifying potential problems and calculating the risk to eliminate or reduce their occurrence possibility. In most studies in which FMEA method is used, risk identification and ranking are carried out based on traditional risk priority number (RPN) scores. This score is focused improvement effort on the risks that may have less severity with a higher RPN compared to other risks with lower RPN. Additionally, conventional FMEA considers only three indices of severity(S), occurrence(O), and detection (D) (RPN Determinant factors) in risk assessment which leads to inefficiency of traditional RPN score (Yousefi et al. 2018). The ranking result of failure modes mainly determined by the RPN is calculated by multiplying the evaluation result of S, O, and D in the application process of FMEA (Subriadi and Najwa 2020). Failure Mode and Effect Analysis (FMEA) is classified as the semi-quantitative method. The Risk Priority Number (RPN) in FMEA supports the quantitative analysis of risk events. This method not only finds the highest risk accurately and quickly but also overcomes the concerns about losing information. FMEA can evaluate the potential risk critically (Wang et al. 2020).

Most industrial systems become more complex and multiple-function, most organizations expend a great amount of cost associated with equipment failure and its subsequent repair and replacement (Lim et al. 2016). Regular maintenance is essential to keep equipment, machines, and the work environment safe and reliable. The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs. It is designed to preserve and enhance equipment reliability by replacing components before they actually fail (Safaei et al. 2020). The design of maintenance policies that extend the useful life of systems is crucial concern for the company (Badia et al. 2020)

Age replacement method is one of the most used maintenance policies based on preventive action in order to prevent the failure of a system. Age replacement means that a system is replaced at failure or at a specified replacement age, whichever occurs first. In current age replacement policies, the replacement age is identified without consideration of the effects from operating conditions. However, the lifetime of a system may be affected by various operating conditions, such as the surrounding environment and the operators (Jin and Yamamoto 2017).

3. Methods

The data processing stages in his study are as follows:

a. Determination of FMEA, LTA, and RCM II Decision Worksheet
   At this stage, FMEA is first determined to define the failure and the cause of each engine failure. Then a Logic Tree Analysis is carried out to add priority considerations from the FMEA table to determine the components or systems that are prioritized for maintenance, after which fill in the RCM II Decision Worksheet.
b. Determination of Critical Components
   At this stage, critical and non-critical components are determined to determine where the components of the CNC machine are frequently damaged and which are not frequently damaged.
c. Determination of Damage Distribution
   At this stage, the data on the time of damage to the existing machines then will be carried out to determine the distribution of the damage to determine the schedule for replacing these critical components.
d. MTTF Calculation
   After the stage of determining the distribution of component damage, the MTTF calculation is carried out to retrieve the parameter data required for the calculation of the research time, namely to show the average time the damage occurs.
e. Calculation of Cost of Failure and Cost of Preventive
   At this stage, the cost of damage and prevention is calculated which will be used as a parameter for calculating the age replacement method
f. Determination of Component Replacement Time Intervals
   After the parameters are obtained from several stages. The age replacement method can be used to determine the time interval for component replacement. The choice of age replacement method by researchers is based on the conditions that occur in companies where machines in the company vary so that it is not effective and efficient when the group replacement method is carried out. Various machines will make the required machine components different from one machine to another so that if you want to replace damaged components, it will be difficult to do it in a group.
g. Calculation of Actual Maintenance and Preventive Maintenance Costs
   After obtaining the required cost data, then it can determine the calculation of the total actual maintenance costs and preventive maintenance costs. Then you can see the difference in how much costs are reduced.

4. Data Collection

This study uses machine component data and component prices, time between faults and repairs time, maintenance cost data, product output data and company income, and questionnaires results data for operator/machine employee. The respondent for this study were 18 workers in the operator division

5. Results and Discussion

5.1 FMEA

Based on the FMEA data obtained, it is known that the risk priority number for each component is as follows:

Table 1. FMEA CNC milling tape drill

No	Components	RPN
1	Solenoid Valve	180
2	Plarail Chain	150
3	Spindle Motor	140
4	Crank Arm Tape Drill	120
5	Signal Lamp	180
6	Air Blow Compressor	108
7	Tool Switch Set	112
8	Working Lamps	64
9	Power Cable	120
10	Grease Pipe	105
11	Coolant Hose	80
RPN Critical Value		123,5455

Then it can be seen that there are 4 components that have an RPN value above the critical RPN value so that these components can be classified as critical components. Where these components are the solenoid valve, plarail chain, motor spindle, and signal lamp.

5.2 Determination of Components Replacement

Based on the calculation of the replacement interval obtained from the four critical components, it is found that the components replacement scheduled for the solenoid valve is 41 days, this indicates that the optimum replacement of the solenoid valve component is the 41st day after operation. For plarail chain components, the component replacement schedule is 38 days, which means that the optimum plarail chain component replacement schedule is 38 days after the component operates. Then for the motor spindle component is obtained on the 207th day, this means that the optimal replacement of the motor spindle component is the 207th day after the component is operated. As for the signal lamp component, the component replacement schedule is obtained on the 90th day, which means that the optimum replacement of the signal lamp component is on the 90th day after the component is used.

5.3 Calculation of Actual Maintenance Costs and Preventive Maintenance

Actual maintenance costs for PT XYZ CNC Milling Tape Drill machine are calculated using data which includes data on labor costs, component purchases and production loss costs. Meanwhile, the calculation of preventive maintenance costs is obtained using the age replacement method. Preventive maintenance costs consist of labor costs and component purchases. The following is the calculation result of maintenance costs for the CNC Milling Tape Drill machine.

Table 2. Critical component maintenance costs

Component	Actual Maintenance Cost			Preventive Maintenance Cost
	2017	2018	2019	
Solenoid Valve	IDR8.969.317	IDR6.406.655	IDR6.406.655	IDR4.924.791
Plarail Chain	IDR1.538.664	IDR1.153.998	IDR576.999	IDR822.582
Spindel Motor	IDR6.547.318	IDR13.094.636	IDR13.094.636	IDR849.516
Signal Lamp	IDR198.337	IDR793.348	IDR595.011	IDR76.168

Then it can be determined from the table that the difference between the actual maintenance costs and the preventive maintenance costs for the age replacement method obtained by PT XYZ the CNC Milling Tape Drill machine can be seen in table 3 as follows:

Table 3. Difference between actual maintenance and preventive maintenance costs

Component	Difference Cost (IDR)			Total Cost Difference (Rp)
	2017	2018	2019	
Solenoid Valve	IDR4.044.526	IDR1.481.864	IDR1.481.864	IDR7.008.255
Plarail Chain	IDR716.082	IDR331.416	-IDR245.583	IDR801.915
Spindel Motor	IDR5.697.802	IDR12.245.120	IDR12.245.120	IDR30.188.042
Signal Lamp	IDR122.169	IDR717.180	IDR518.843	IDR1.358.192
Total	IDR10.580.579	IDR14.775.580	IDR14.000.244	IDR39.356.404

The difference between the actual maintenance and preventive maintenance costs received by PT XYZ for the solenoid valve component is IDR 7,008,255, for the plarail chain component is IDR 801,915, for the motor spindle components is IDR 1,358,192 where if totaled from 2017 to 2019, the difference in costs received by PT XYZ when implementing company maintenance using the age replacement method is IDR 39,356,404.

6. Conclusion

The findings of this study are based on the processing FMEA, the critical components are the solenoid valve with an RPN value of 180, a plarail chain with an RPN value of 150, a spindle motor with value of 140, and a signal lamp with a value of 180. Where is the critical value of RPN is at a value of 123,54. While the non-critical components are crank arm tape drill with RPN value of 120, air blow compressor with RPN value of 108, tool switch with value 112, working lamps with RPN value 64, power cable with RPN 120, grease pipe with RPN value of 105, and coolant hose with RPN value of 80. Then from the critical component, the component replacement time interval is carried out using the age replacement method. Where the calculation for the solenoid valve component is 41 days, for the plarail chain component it is 38 days, for the spindle motor component it is 207 days and for the signal lamp component it is 90 days. This shows that the optimal replacement of solenoid valve component is 41 days after the component operates, for the plarail chain it is 38 days after operation, for the spindle motor it is 207 days after operation and for the signal lamp it is 90 days after the component operates. Then if the company implements a policy of replacing critical components using the age replacement method from 2017 to 2019, PT XYZ can reduce the losses used due to maintenance costs during that period. Where the solenoid valve component can minimize losses of IDR 7,008,255, for the plarail chain component of IDR 801,915, for the spindle motor component of IDR 30,188,042 for the signal lamp component of IDR 1,358,192, if the total loss due to not applying this method in the company's maintenance system is IDR 39,356,404.

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