Preventive Maintenance Policy to Improve the Effectiveness of XYZ Machine

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Abstract. PT ABC which is a manufacturing company that produces steel pipes. The last period there was an XYZ machine that often downtime and disrupted the production process. The breakdowns indicate the ineffectiveness of machine. It was necessary to identify and analyze the problems that occurred and the factors that caused the problem. Measurement of machine effectiveness dan it caused is carried out using the OEE method. To avoid the recurrence of machine ineffectiveness, machine maintenance is carried out in a preventive manner according to the spare parts classification (there are 3 classifications of spare parts based on price, namely A under Rp.250,000, B between Rp.250,000 - Rp.500,000 and C above Rp.500,000). The results obtained for the average value of OEE for 1 year is 68%, which shows a value below the ideal OEE standard (85%) and needs to be evaluated. From the calculation of the largest losses value is in the reduce speed losses factor of 67%, it is necessary to minimize the difference in ideal cycle time with actual time (operation time). The best scheduling results is using the preventive maintenance policy method with the schedule of maintenance are: for classification A spare parts the maintenance every 3 months, class B every 5 months, and class C every 6 months.

1 Background

The development of industry and technology in the current era of globalization is increasingly rapid, marked by the level of competition between companies that is increasing and tight. This situation causes the company to be able to compete to maintain the business it manages [1] and improve their productivity to sustain in competitive market [2]. One of the things that supports the smooth running of operational activities in a company is that production machinery must be in a ready-to-use condition to carry out its duties.

To keep the production machines able to operate or function properly, good machine maintenance is needed. Good machine maintenance is very important to achieve effective and efficient performance in a system. Machines and equipment that are maintained will be much more optimal in performance compared to machines that have never been maintained or maintained [3]. Preventive maintenance will be better than repair (breakdown maintenance) in terms of time and costs incurred by maintenance activities [4].

PT. ABC has four machines with different tasks to produce pipe products. The machines are pickling machine for coil washing, rolling machine for coil thinning, and annealing machine for coil coating. Another machine is the XYZ machine for forming and welding pipes that have been formed. The existing machine maintenance system in the company so far only repairs after the machine experiences problems/damage without any preventive efforts.

Of the existing machines in the company, the XYZ machine is the machine that experiences the most problems compared to other machines. The amount of downtime and machine productivity can be seen in Table 1.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Downtime (Hours)</th>
<th>Total Production (Tonnes)</th>
<th>Machine Capacity (Tonnes)</th>
<th>Total Production vs Capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickling</td>
<td>180</td>
<td>212300</td>
<td>230000</td>
<td>99</td>
</tr>
<tr>
<td>Rolling</td>
<td>182</td>
<td>212240</td>
<td>220000</td>
<td>99</td>
</tr>
<tr>
<td>Annealing</td>
<td>178</td>
<td>213000</td>
<td>225000</td>
<td>98</td>
</tr>
<tr>
<td>Welded Pipe</td>
<td>240</td>
<td>216310</td>
<td>245800</td>
<td>88</td>
</tr>
</tbody>
</table>

Based on the Table 1, it can be seen that the average existing machine has an effectiveness rate above 90%, only the welded pipe machine has an effectiveness rate below 90%. According to the OEE standard, if the
effectiveness of the machine is below 90%, it can be said that there is a problem with the machine.

According to [5]–[8], there are several methods for analyzing machine effectiveness including Overall Equipment Effectiveness (OEE), Net Equipment Effectiveness (NEE), and Total Effective Equipment Productivity (TEEP), researchers propose to use the OEE method because it can be more universally accepted and can show a more precise and detailed machine effectiveness value. According to [9] and [10], the preventive maintenance policy method is a method used to obtain an optimal repair and maintenance schedule. This preventive maintenance policy method will calculate the cost of machine maintenance and machine maintenance scheduling so that the best maintenance costs and the right maintenance time of the XYZ machine can be known with the aim of reducing the occurrence of machine downtime due to six big losses, increasing the effectiveness value of the XYZ machine and improving the maintenance of the XYZ machine.

According to [6], six big losses are six losses that must be avoided by every company because they can reduce the effectiveness of a machine, one of these six big losses is downtime, decreased machine speed, defective products/rejects that exceed the company's tolerance limit, decreased total production, the number of products produced does not match the capacity of the machine, and the number of normal products that decrease so that rework/rework needs to be done. Based on Table 1 the downtime that occurred on the pipe welding machine in April 2022-March 2023 caused the company to stop the production process for 270 hours on the pipe machine, this caused the company to experience losses in the form of the company's machinery payment costs on the pipe welding machine which could not be maximized with details of the use and payment of pipe welding machine electricity in the form of 270 hours with the calculation of kWh = (watt x hour) / 1000, kWh = (190,000 x 270) / 1000 = 513,000 kWh x Rp.1,699 = Rp.871,587,000, other losses in the form of products produced with 1 hour of workmanship can produce 3.75 tons of pipe, 270 hours = 3.75 x 270 = 1012.5 tons = 10,125,500 kg of pipe, for 1 pipe with JIS G 3444 Spec with a diameter of 10 cm weighs 57.4 kg/m so that the problem makes the company unable to produce pipes worth 10,125,500 kg: 57.4 kg = 176,642 pipes.

Based on these problems, it is necessary to make preventive efforts to reduce the occurrence of downtime. Based on one of these problems, researchers are trying to measure the effectiveness of the machine using the OEE method because it is to measure the effectiveness of the machine precisely before the next action is taken. Machines that have an OEE value \( \leq 85\% \) mean that the OEE value does not meet world class standards, the analysis of six big losses is used to determine the biggest losses that cause the effectiveness of the machine to decrease. The OEE value obtained is used to determine and evaluate the effectiveness of the use of pipe welding machines in the company, then evaluation efforts will be made by calculating maintenance costs and scheduling the best maintenance of pipe welding machines using the preventive maintenance policy method. According to [11], the preventive maintenance policy method is a method used to obtain an optimal repair and maintenance schedule. This preventive maintenance policy method will calculate the cost of machine maintenance and scheduling machine maintenance so that it can be known the best maintenance costs and the right maintenance time of the pipe welding machine with the aim of reducing the occurrence of machine downtime due to six big losses and increasing the effectiveness value of the pipe welding machine.

2 Research Methodology

2.1. Research Tools and Materials

This research using OEE methods and preventive maintenance policy tools. For collecting data, this research using primary data such as machine breakdown, set up time, etc.

2.2. Problem Identification

Identification of existing problems is on XYZ machines that often experience problems so that OEE calculations will be carried out. The OEE calculation is carried out to determine the effectiveness of the machine and the improvement efforts made to increase the effectiveness of the XYZ machine. The type of research is quantitative methods.

The types of data contained in this study are primary data and secondary data which will be explained as follows:

1. Primary data contained in this study include:
   a. Factors causing the failure of the XYZ machine.
   b. Production flow process.
   c. Cycle time, an example of cycle time such as the time for the welding process of one pipe.

2. Secondary data contained in this study include
   a. Company profile and organizational structure.
   b. Machine working time data
   c. Planned downtime data, XYZ machine maintenance time data.
   d. Set up and adjustment data for XYZ machine
   e. Failure and repair machine data
   f. Production quantity data for machine XYZ
   g. Data on the number of reject and rework products of XYZ machine.
   h. SOP (Standard Operational Procedure)

2.3. Data Retrieval Stage

The data collection stage carried out includes:
1. Field Study
2. Observation
3. Interview
4. Literature Study
5. Problem Identification

2.4. Procedure Stage and Research Data Processing

The research procedure stage analyzes the effectiveness of the XYZ machine using the OEE method:
1. Carry out field studies and search for literature studies on the object to be researched to solve
problems or propose improvements to problems found in the company, especially in the XYZ machine section.
2. Determine the formulation of problems contained in the XYZ machine production section.
3. Determine the purpose of the problem formulation that has been determined, measuring the effectiveness of the XYZ machine and providing strategies to improve the effectiveness of the XYZ machine.
4. Collecting the necessary data. The research data needed in the study include:
   a. Setup and adjustment data.
   b. Planned downtime data.
   c. Machine working time data.
   d. Failure and repair data.
   e. Production quantity data.
   f. Data on the number of reject and rework products.
5. Perform data processing with stages including:
   a) Calculating the OEE value
   b) Calculating the value of six big losses.
   c) Calculating maintenance policy (maintenance scheduling)
6. Make conclusions and suggestions in the research that has been done.

2.5. Data Analysis Stage
The data analysis stage is based on the results of the calculations along with the diagrams that have been displayed, among others:
1. Analysis of availability rate ≥ 90% which means that the availability rate value meets world class standards.
2. Analysis of performance rate ≥ 95% means that the performance rate value meets world class standards.
3. Analysis of quality rate ≥ 90% means that the quality rate value meets world class standards.
4. OEE analysis ≥ 85% means that the OEE value meets world class standards.
Proposed improvements to the company using analysis of the calculation of six big losses and scheduling maintenance policies that can increase machine effectiveness and reduce the occurrence of problems in the use of XYZ machines.
Conclusion as the purpose of the research and the proposed improvements given by the researcher and suggestions as a goal for improvement due to the shortcomings of the researcher so that it will make the next research even better.

2.6. Proposed Improvements
The proposed improvements made in the study. The initial stage the researchers measured the effectiveness of the XYZ machine using the OEE method. The next stage is to analyze the six big losses that can reduce the effectiveness of the XYZ machine. The next step after getting losses that result in the effectiveness of the XYZ machine being reduced, the calculation of machine maintenance costs and scheduling of machine maintenance using the maintenance policy method will be carried out so that the best maintenance costs and the right maintenance time of the XYZ machine can be known with the aim of reducing the occurrence of machine downtime due to six big losses and increasing the effectiveness value of the XYZ machine.

3. Results And Discussion

3.1. XYZ Machine Data Collection
This research used various data in April 2022-Maret 2023 such as working hours data in the XYZ machine production section, XYZ machine downtime data, and XYZ machine production.

Results of OEE (Overall Equipment Effectiveness) Calculation of XYZ Machine
The mathematical calculation in calculating the OEE value in April 2022 is:

\[ OEE = \frac{\text{Availability rate} \times \text{Performance rate} \times \text{Quality rate}}{100} \]

From Table 2 it showed that for a year production, XYZ machine was ineffective. Its indicated that the machine had problem to be analysed. Using six big losses analyse, caused of ineffective will be found.

3.2. Six Big Losses Calculation Results XYZ Machine
Recapitulation of data accumulated value of six big losses after calculation, among others showed in Table 3. Table 3 shows the recapitulation of accumulated data from the value of six big losses. Losses with the largest total time are in the value of reduce speed losses for 28466.342 minutes or about 67% of total losses. The second order with the largest percentage of losses is in setup and adjustment losses with 10%, the third order is equipment failure losses of 9%, the fourth order is idle and minor stoppage losses of 7%, the fifth is defect losses of 6%, and the last order is reduced yield of 1%. Based on this data, what should be evaluated first as the cause of the low OEE
value or machine ineffectiveness is related to reduce speed losses or losses due to a decrease in the speed of the XYZ machine. This problem can be solved by minimizing the difference between ideal cycle time and actual operation time.

The difference between the ideal cycle time and the actual time (operation time) is large, one of which occurs because the machine stops operating too often. One of the causes is that there is no scheduling of machine maintenance, the new machine is repaired if it is damaged. The next step is to schedule preventive maintenance and compare the cost between preventive maintenance and reactive maintenance.

Table 3. Recap of data accumulated six big losses

<table>
<thead>
<tr>
<th>No</th>
<th>Six Big Losses</th>
<th>Total Time (minutes)</th>
<th>Losses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment Failure Losses</td>
<td>3660</td>
<td>9%</td>
</tr>
<tr>
<td>2</td>
<td>Setup and Adjustment Losses</td>
<td>4300</td>
<td>10%</td>
</tr>
<tr>
<td>3</td>
<td>Idle and Minor Stoppage Losses</td>
<td>3000</td>
<td>7%</td>
</tr>
<tr>
<td>4</td>
<td>Reduce Speed Losses</td>
<td>28,466,342</td>
<td>67%</td>
</tr>
<tr>
<td>5</td>
<td>Defect Losses</td>
<td>3172,146</td>
<td>6%</td>
</tr>
<tr>
<td>6</td>
<td>Reduce Yield</td>
<td>0,13</td>
<td>1%</td>
</tr>
</tbody>
</table>

Total 42,598,618 100%

3.3. Determination of the Best Maintenance Scheduling Time for XYZ Machine Based on the Results of Preventive Maintenance Policy Calculation

Table 4. Determination of the best engine maintenance scheduling time and cost per month

<table>
<thead>
<tr>
<th>No</th>
<th>Brake down</th>
<th>Maintenance Cost</th>
<th>Best Machine Maintenance Scheduling Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Repair Policy</td>
<td>Preventive Maintenance Policy</td>
</tr>
<tr>
<td>1</td>
<td>Classification A</td>
<td>Rp. 8,899.730</td>
<td>Rp.2.271.150</td>
</tr>
<tr>
<td>2</td>
<td>Classification B</td>
<td>Rp. 9,702.450</td>
<td>Rp.2.423.376</td>
</tr>
<tr>
<td>3</td>
<td>Classification C</td>
<td>Rp.10,723.597</td>
<td>Rp.2.925.461</td>
</tr>
</tbody>
</table>

Table 4 shows the cost of engine maintenance using the reactive maintenance method and preventive maintenance policy along with the best time to schedule, the best engine maintenance and costs every month. Based on the results of calculations that have been carried out for class A damage types, engine maintenance scheduling is carried out every 3 months. The results of other calculations show that for class B damage types, the best machine maintenance scheduling is carried out every 5 months and for class C the best machine scheduling is carried out every 6 months.

Examples of preventive maintenance efforts based on Table 5 that can be done to prevent damage from Teflon heater spare parts such as tightening / replacing the bolts, nuts, and clamps. It is intended that when this Teflon heater will be used, every part of this Teflon heater can work properly and is not released when used. Another preventive effort is to check / replace the heater switch so that the switch can be used properly and avoid an electrical short circuit, the best time recommended for preventive maintenance is based on the average run time for 1-3 months.

4. Conclusions and Suggestions

4.1. Conclusion

The conclusions obtained from the research that has been done are:

1. All the results of the calculation of the known OEE value show a value that is below the ideal OEE value of 85%. For example, the lowest OEE value occurred in July 2022 with an OEE value of 68%, of course this low OEE value is caused by the three main factors in the form of availability rate, performance rate, and quality rate. The performance rate value which has a value below the other two factors also needs to be evaluated again, the performance rate value on the XYZ machine is 79% compared to the average percentage value of the availability rate of 93% and the quality rate of 96%. The low performance rate value is caused by the high value of performance losses, the value of performance losses itself is obtained from the summation of briefing time and material time so that it can be used as an evaluation to reduce/minimize the two times so that the value of performance losses is not too high and the performance rate value can increase so that the OEE value/machine effectiveness can also increase.

2. The results of the calculation of the six big losses carried out show that the largest percentage of losses is in reducing speed losses with a percentage of 67%. The second order with the largest percentage of losses is in setup and adjustment losses by 10%, the third order is equipment failure losses by 9%, the fourth order is idle
and minor stoppage losses by 7%, the fifth is defect losses by 6%, and the last order is reduce yield by 1%. Based on this data, what should be evaluated first as a cause of low OEE value or machine effectiveness is related to reduce speed losses or losses due to a decrease in machine speed, namely by minimizing the difference in ideal processing time (ideal cycle time) with actual time (operation time) so that the value of reduce speed losses can be lower and the OEE value / effectiveness of the XYZ machine can be better.

3. The results of the calculation of maintenance costs that have been carried out using both the repair policy method and the preventive maintenance policy method. Spare parts A classification require maintenance costs Rp.8,899,730/month using the repair policy method and Rp.2,271,150/month using the preventive maintenance policy method, with the best machine maintenance time every 3 months. Spare parts B classification, require maintenance costs Rp.9,702,450/month using the repair policy method and require Rp.2,423,376/month if using the preventive maintenance policy method, with the best machine maintenance time every 5 months. Spare parts C classification require maintenance costs Rp.10,723,597/month using the repair policy method and require Rp.2,925,461/month if using the preventive maintenance policy method, with the best machine maintenance time every 6 months. Based on the results, the company should use the preventive maintenance policy method because it requires a smaller cost than the repair policy method. The best machine scheduling time for each class of spare parts is expected to minimize the occurrence of damage to the XYZ machine so that the OEE/effectiveness value of the XYZ machine can increase. An example of preventive maintenance efforts for spare parts from the XYZ machine on the tool in the form of amine and nitrate liquid coating. This has the aim of protecting the surface of the tool so that it can be more resistant to rust. Other preventive efforts are the provision of soap, wetting agents, and chlorine with the aim of lubrication and reducing face tension, and germicide coatings to control bacterial growth, the best time recommended for preventive maintenance is based on the average run time for 1-3 months under normal circumstances.

4.2. Suggestions

Suggestions for further research are to add more specific ways to carry out maintenance both before damage occurs and after damage occurs to each class of machine constituent spare parts.

5. References


