Performance Acceleration on Production Machines Using the Overall Equipment Effectiveness (OEE) Approach

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Abstract. Mistakes during working can trigger a decrease in production level that may lead financial loss to the company. The factors that affect the mistakes are called losses, such as breakdown loss, set up/ adjustment loss, idling and minor stoppage loss, reduced speed loss, reduced yield loss, and rework loss. The objective of the research is to accelerate the performance of the JSW 330T machine in PT. YogyapresisiTehnikatamasIndustri. JSW 330T is a machine that has the highest downtime numbers. The method for measuring the effectiveness is using the Overall Equipment Effectiveness (OEE). The results of the research show that the JWQ 330T has average rate of the effectiveness (OEE) of 52.66%, availability ratio of 73.43%, performance efficiency rate of 83.58% and quality rate of 84.6%. From the six big losses calculation, the factor that affects the most on the low score of OEE is the breakdown loss which is 58.85% with total time loss of 929.65 hours in a year.

1. Introduction
One of the improvement efforts on manufacturing industries is enhancing the equipments’ utility as optimal as possible. Utilization of the existing equipments or machines in the manufacturing industries is good if at least it’s about half of the machine’s real capability [1]. Manufacturing companies must implement new technologies that aim to improve the plant performance. New technologies are often more complex to be maintained or repaired [2]. Therefore, the machines need to be preserved to maintain their function. It will certainly contribute in total production costs, by having the maintenance expense for the equipments and machines of the manufacturing industries, either directly or indirectly [3]. To minimize and overcome the machines’ impairment, the maintenance process should be done properly and regularly based on the predefined schedule. Maintenance is the conception of all the activities required to maintain the quality and performance of equipment and keep it functioning properly as in the previous condition to generate the desired products [4]. Therefore, we need a method that is capable to reveal maintenance problems clearly, in order to enhance the equipment performance optimally [5].

Overall Equipment Effectiveness (OEE) is a method used for implementing the Total Productive Maintenance (TPM) in order to keep the equipment in ideal condition by erasing its six big losses. Besides that, OEE is a quantitative metric that has been increasingly used in industry, not only for controlling and monitoring the productivity of production equipment, but also as an indicator and driver of process and performance improvements [6]. The OEE score is calculated by referring the existed concepts, that is determined the three main factors, i.e. the availability rate, performance rate,
and quality rate [7]. It is used to identify losses related to equipment for the purpose of increasing the total asset performance and reliability [8]. Failures identification from the most significant OEE score categories can affect the machines’ effectiveness; therefore it needs the six big losses analysis to find any kind of losses that may occur.

Six big losses is a calculation engine that raises productivity losses for companies are often caused by the use of machine/ equipment that are not effective and efficient. The six big losses can be categorized into three namely downtime (time reduction), Speed losses (decrease speed), and defects (defects) [9]. The six big losses not related to the actual performance of maintenance, but also directly related to the speed and quality [10]. Therefore, to eliminate the six big losses needed improvement activities designed to increase the efficiency of the equipment [11].

The objective of this research is analyzing one of the machines in PT. YogyaPresisiTehnikatamaIndustri (PT. YPTI), that is JSW 330T, using TPM as a maintenance process developed for improving productivity by making the processes more reliable and less wasteful. TPM also facilitates the organizations to achieve higher levels of productivity as well as improve the customer service, morale, and profits [12]. Therefore by using the OEE method, we can find the performance of the machine and the factors that contribute on the OEE score from the six big losses calculation. The purpose of OEE is to determine which of the six big losses that affect the decreasing effectiveness of the JSW 330T and the cost of losing for one year with the recommendation of using RCM [13].

2. Literature Review

2.1 Total Productive Maintenance (TPM)
Total Productive Maintenance was first defined in 1970s by Seiichi Nakajima from the Japan Institute of Plant Maintenance [1]. Maintenance is an activity to preserve and maintain the existing facilities as well as do the required reparation, adjustment, or replacement to get the ideal condition of production operation as planned. Total Productive Maintenance began from the idea of Preventive Maintenance and Production Maintenance, which came from America to Japan and developed into a typical Japanese new system and later it’s called as Total Productive Maintenance (TPM). TPM is a maintenance concept which involves all the employees to reach effectiveness of the production system through participation as well as productive, proactive, and well-planned maintenance activities [15]. According to [14], the comprehensive definition of TPM covering five elements as follows:

- Its objective is creating a preventive maintenance (PM) system to extend the machines’ or equipments’ useful life.
- Its objective is optimizing the overall effectiveness of machines or equipments.
- It can be applied in several departments such as engineering, production, and maintenance department.
- It involves all of the internal stakeholders, from the highest management to the employees/ operator in production department.
- It is the development of maintenance system based on PM through motivational management.

2.2 Overall Equipment Effectiveness (OEE)
Overall Equipment Effectiveness is a method used as measuring instrument in TPM implementation program, to maintain the equipment in ideal condition by erasing the six big losses. The measurement of OEE score are determined by these three main ratios:
2.1.1. **Availability Ratio**

It is a ratio that illustrates the use of the available time for the machines’ or equipments’ operations. Availability ratio also measures the overall time in which the system is not in operation because of the occurrence damage to the equipment, production preparation and adjustment. The formula to calculate this ratio is:

\[
\text{Availability Ratio} = \frac{\text{Operation Time}}{\text{Loading Time}} \times 100\%
\]

Loading Time = Total Planned Time – Planned Downtime

2.1.2. **Performance Efficiency**

It is a ratio that illustrates the machines’ capability in producing products. Performance ratio is also a ratio of the actual operating speed of the equipment with ideal speed based on design capacity. The formula to calculate this ratio is:

\[
\text{Performance Efficiency} = \frac{\text{Actual Product x Ideal cycle time}}{\text{Operation Time}} \times 100\%
\]

Data required in the performance efficiency of the company in the form of percentage of working hours and production machine parts per month.

2.1.3. **Rate of Quality**

It is a ratio that illustrates the products’ quality produced by the equipments in accordance with standards. Quality Ratio is intended on the loss quality of products such as of defects that occur related to equipment, for conversion into time with the intention of how much time equipment is consumed to produce the defective product. The formula to calculate this ratio is:

\[
\text{Rate of Quality} = \frac{\text{Good Products} - \text{Total Defect}}{\text{Gross Products}} \times 100\%
\]

Data required in the rate of quality of the company in the form of a product that results are good and defective products.

2.3 **Six Big Losses**

The objective of the Six Big Losses calculation is to determine the OEE score. The low productivity of the machine causing harm to the company is often caused by the use of machinery / equipment that are not effective and efficient.

3. **Methods**

The research was conducted by using primary and secondary data. The focus of this research is on the JSW330T machine, which has the highest downtime numbers. The primary data was used for measuring the production process time, observing the amount of defective products and idle time. As explained above that to calculate the OEE we need to calculate the availability ratio, performance efficiency, and the rate of quality first. The formula of OEE score is as follows:

\[
OEE \ (%) = \text{Availability Ratio} \ (%) \times \text{Performance Efficiency} \ (%) \times \text{Rate of Quality} \ (%)\]

After calculating the OEE score, the score can be compared with the standard of Japan Institute of Plant Management (JIPM) so the company’s position can be seen towards the world class companies. This research will also calculate the main factors in the production plant that lead the company’s financial loss, in order to conduct preventive actions for improvement in the future research.
4. Result and Discussion

4.1 Result

4.1.1 Production Data
Production and defect data from the Production Division of the PT. YPTI for one year starts on January to December 2014 is shown below:

| No | Months   | Part Production (unit) | Good Product (unit) | Scrap | Rework | Total |
|----|----------|------------------------|---------------------|-------|--------|-------|
| 1  | January  | 2901                   | 2474                | 427   | 0      | 427   |
| 2  | February | 7739                   | 7092                | 657   | 0      | 657   |
| 3  | March    | 17354                  | 16139              | 1232  | 0      | 1232  |
| 4  | April    | 4761                   | 3983                | 790   | 0      | 790   |
| 5  | May      | 18085                  | 16509              | 1598  | 0      | 1598  |
| 6  | June     | 23545                  | 21879              | 1697  | 0      | 1697  |
| 7  | July     | 8107                   | 7112               | 1008  | 0      | 1008  |
| 8  | August   | 3549                   | 2999               | 569   | 0      | 569   |
| 9  | September| 9074                   | 7459               | 1633  | 0      | 1633  |
| 10 | October  | 4425                   | 3448               | 990   | 0      | 990   |
| 11 | November | 10256                  | 8773               | 1511  | 0      | 1511  |
| 12 | December | 2253                   | 2004               | 252   | 0      | 252   |

4.1.2 OEE Score
The OEE of the JWS 330T machine in PT. YPTI during January to December 2014 are as follow:

| No | Months   | Availability Ratio (%) | Performance Efficiency (%) | Rate of Quality (%) | OEE (%) | JIPM (%) |
|----|----------|------------------------|----------------------------|---------------------|---------|----------|
| 1  | January  | 79.11                  | 78.59                      | 82.74               | 51.44   | 85       |
| 2  | February | 58.94                  | 88.91                      | 90.74               | 47.56   | 85       |
| 3  | March    | 86.35                  | 90.81                      | 92.37               | 72.43   | 85       |
| 4  | April    | 69.48                  | 78.80                      | 80.17               | 43.90   | 85       |
| 5  | May      | 72.76                  | 89.10                      | 90.32               | 58.55   | 85       |
| 6  | June     | 83.08                  | 90.51                      | 92.43               | 69.50   | 85       |
| 7  | July     | 83.13                  | 84.66                      | 85.83               | 60.40   | 85       |
| 8  | August   | 77.90                  | 79.16                      | 81.03               | 49.97   | 85       |
| 9  | September| 65.50                  | 80.08                      | 78.11               | 40.97   | 85       |
| 10 | October  | 50.87                  | 74.60                      | 71.29               | 27.05   | 85       |
| 11 | November | 69.59                  | 84.08                      | 82.78               | 48.44   | 85       |
| 12 | December | 84.44                  | 83.63                      | 87.43               | 61.74   | 85       |
4.1.3 Six Big Losses Identification on JSW 330T Machine

After calculating the six big losses percentage toward the effectiveness of the JSW 330T machine for one year, the average losses from January 2014 – December 2014 are as follow:

| No. | Six Big Losses              | Totals of Time Loss(hours) | Losses Percentage(%) |
|-----|-----------------------------|----------------------------|-----------------------|
| 1   | Breakdown Loss              | 929.65                     | 58.85                 |
|     | Set up and Adjustment       |                            |                       |
| 2   | Loss                        | 30.00                      | 1.90                  |
| 3   | Idling Minor Stoppages      | 21.50                      | 1.36                  |
| 4   | Reduced Speed Loss          | 343.39                     | 21.74                 |
| 5   | Rework Loss                 | 0.00                       | 0.00                  |
| 6   | Scrap / Yield Loss          | 255.08                     | 16.15                 |
| **Total** |                               | **1579.62**               |                       |

Table 4. Big Six Losses Percentage of the JSW 330T Machine

4.2 Discussions

From the result above, it can be seen that there were fluctuations in the availability time, it is because the down time machines tend to fluctuate due to frequent damage to the machine, which will directly affect the performance efficiency score. This company’s rate of quality (84.6%) is lower than the JIPM standard (99.9%), while the performance ratio is 83.5% (JIPM standard is 95%) and the availability ratio is 73.43% which is too far from the JIPM standard.

The average OEE score of the company is 52.66%, it is also far from the JIPM standard which is 85%, although the score is considered proper if it is compared with the OEE score of some industries across the world that have been surveyed by the JIPM.

Figure 1. OEE Score of PT. YPTI
From the instable scores above, it can be concluded that the company’s capability in conducting production process was not consistence. Therefore, it will be difficult for the company to get the guarantee assurance for its products as well as the production on time.

From the six big losses measurement, it shows that the machine experiences frequent breakdown, in which 929.65 hours or 116 days in a year. The reduced speed loss also often happens, in which 343 hours in 2014. It shows that the JSW 330T’s reliability is considered low. Therefore, we recommend the company to conduct a more intensive maintenance or consider purchasing a new machine to replace it.

5. Conclusion And Recommendation

5.1 Conclusion
Based on the research on JSW 330T machine during January 2014 – December 2014, it can be concluded that:

- From the average rate of the OEE calculation is 52.66%, means the effectiveness of the JSW 330T is far from the required standard based on JIPM that is 85%.
- The most dominant factor of the six big losses which cause the decreasing on the production effectiveness or gives the biggest contribution on the OEE score is the breakdown losses (58.85%) with total time loss of 929.65 hours.

5.2 Recommendation
From the research results, we recommend the company to pay more attention to routine repairs to components of the machine so as to minimize the damage. As for further research can further optimize the increased effectiveness of the machine to determine the time interval determination of replacement parts for all machine components resulting in frequent downtime and determine total cost of losses to the company for one year on the machine JSW 330T so that the results obtained are more specific and more leverage in improving the effectiveness of the machine by using RCM.

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