Performance Measurement Analysis of HTM 1004 100 Ton Hydraulic Press Machine using OEE

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Abstract
PT TGI, specializing in sound and communication devices, is a manufacturing company engaged in the electronics field. Due to the wide distribution of its customers, its production level has a high value. This makes the company often experience sudden and fluctuating demand. A sudden request from customers will surely increase the company's revenue. However, on the other side, it also increases the machine's workload. Hence, this study aims to measure the performance of a machine using the Overall Equipment Effectiveness (OEE) Method. The OEE result showed that the average value is equal to 63.2%. The value is much lower than the world-class standard value of 85%. Further study disclosed that the Six Big Losses that influence the low value of OEE is Reduced Speed Loss with a percentage of 77.51%. This study also recommends several solutions to improve the OEE values, focusing on Performance Efficiency.

Keywords: *Measure, Overall Equipment Effectiveness (OEE), Six Big Losses, Performance Efficiency*

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1. Introduction

Globalization currently has a significant impact on the sustainability of businesses in Indonesia. For instance, on the manufacturing industry. The industry has the most significant export contribution. In 2021 it achieved a national export value of USD 177.10 billion. The value reaches 76.49% of the total exports. PT TGI is a manufacturing company engaged in the electronics sector specializing in sound and communication. The company also participates in exporting its products.

The wide distribution of the target customers at PT TGI gives the company a high production level. It is common for the company experiencing sudden requests from customers. These sudden demands sometimes make the products produced by the company insufficient. Demand and production for February 22 to July 22 shown on Figure 1. The figure clearly shows that the demand could not be fulfilled in the month of March, April, and May. The lags are obvious, especially in May.

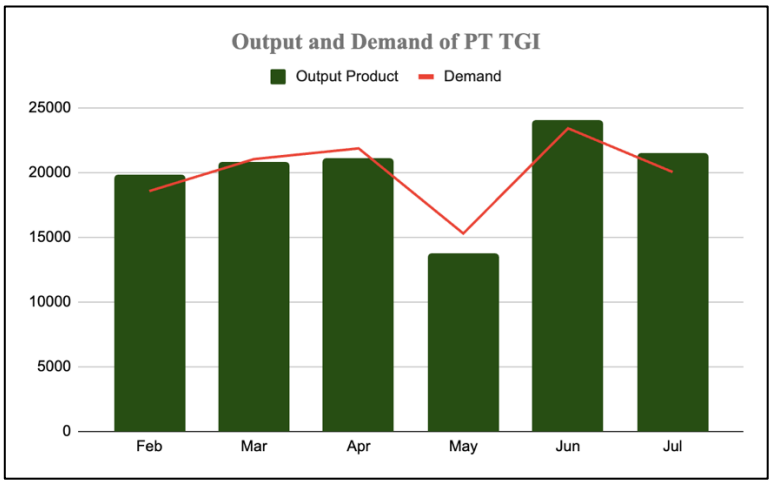

Figure 1. Demand and Production at PT TGI

To fulfill the demand, the company needs to have adequate capability not only in the aspect of manpower but also in the machineries used in the production process. Accepting a sudden request will increase the machine's workload. Efforts are needed to control the machine's condition on the production site. If the machine has an unreliable condition, it will significantly hamper the production process, which at the end impact the company's ability to meet customer demands. If this happens frequently, it will cause losses for the company.

These problems may also be caused by an inability to measure the actual performance of the machines inability to find solutions that can be applied to the problems encountered. Overall equipment effectiveness (OEE) is a method used to calculate the effectiveness and the performance a machine in a process. Example of this method utilization is given by Riadi and Anwar (2019). The method was used to calculate the performance and effectiveness of the HTM 1004 100 Ton Hydraulic Press machine at PT TGI. As addition to calculate the OEE, this study also calculated the Six Big Losses to find out the most significant losses and proposed some recommendations to solve the problems.

2. Methodology

Overall Equipment Effectiveness (OEE) metric is a method to calculate the effectiveness and performance of a machine in the production process. In the OEE calculation, three components are used to determine the productivity of the machine which comprises the availability of a machine, the performance rate or efficiency of production, and the quality rate to determine the quality of the output produced. According to Williamson (2006), losses can be identified from these three components. The findings can later be used as a basis for improvements in the production aspect.

Availability rate shows the use of available time for a machine or an equipment operating its activities. The rate is expressed in proportion (ratio). At this calculation stage, the Availability Ratio is obtained by dividing the Loading Time and Operation Time of the machine using Equation (1). Furthermore, Machine Loading Time is the difference between the Working Time and Planned Stop Time and Operation Time is the time the machine operated. The value is calculated by deducting the Loading Time by its Setup Time and Down Time..

$$Availability\ Rate = \frac{Operation\ Time}{Loading\ Time}\ x\ 100\% \quad (1)$$

Performance ratio is a measure to show the ability of equipment to produce products. Performance ratio is expressed in proportions. Equation (2) is used to find the performance efficiency of a machine. If Equation (2) ends up with a value more than 100%, it indicates that the time to produce one unit (ideal cycle time) is to high.

$$Performance\ Efficiency\ =\ Speed\ Operation\ Time\ x\ Net\ Operation\ Rate\ x\ 100\% \quad (2)$$

Net Operation Rate on Equation (2) is calculated through Equation (3).

$$Net\ Operation\ Rate = \frac{Actual\ Production}{operation\ Time}\ x\ Actual\ Cycle\ Time \quad (3)$$

The last component of OEE is the product quality rate. This component is a ratio to show the ability of the equipment to produce products according to standards. This measure is expressed in percentage. In this calculation, it is necessary to have data showing how much is produced under good and bad conditions, as well as the total production of the machine as a whole. The quality rate is calculated using Equation (4).

$$Quality\ Rate\ = \frac{Actual\ Production - Rejected\ Product}{Actual\ Production}\ x\ 100\% \quad (4)$$

After the three components obtained, then the OEE value is calculated to determine the performance of the machine under study using Equation (5).

$$OEE = Availability\ Rate\ x\ Performance\ Efficiency\ x\ Quality\ Rate\ x\ 100\% \quad (5)$$

Theoretically, based on the value of the OEE, a machine is categorized into 4 classes (Risyahadi et al., 2018). If the OEE value less or equal to 40%, the equipment is considered has low performance. A machine belongs to this class will have clear problem to solved. If the OEE is between 40 to 60%, the equipment belongs to medium performance. This type of machine should be improved so that its OEE reaches 85%. An equipment with OEE 85% is considered as world class performance. The machine has high competitiveness. The last OEE class is OEE with a value of 100%. An equipment with this OEE value may produce zero defect products within real time production with no downtime.

Since in many cases equipment falls to the first or second category, after calculating the OEE, the Six Big Losses is determined to find out the problem related to the equipment. Six Big Losses consists of equipment failure loss, setup & adjustment loss, idle & minor stoppage loss, reduced speed loss, defect loss, and reduced yield loss. This analysis is carried out based on the cumulative percentage of the total time loss calculation for each losses' factor. The results of the Six Big Losses Percentage calculation will later be processed using the Pareto Chart to find out which problems have higher priority to solve. After knowing the losses that cause 80% of the damage frequency, the causes of these losses are identified using the Fishbone Diagram. From this point, recommendations are proposed to overcome the causes or related losses.

3. Result

To calculate the OEE of the HTM 1004 100 Ton Hydraulic Press machine, 6 months' historical data were collected and recorded. The data includes Machine Working Time, Downtime, Set up and Adjust time, etc. Table 1 summarizes the data. Machine Working Time

is the time the machine utilized to make products in a month. Planned Stop Time is the time the machine spent for doing preventive maintenance. This time is anticipated time. Down Time is the time the machine stop to production due to the machine break down. Set up and adjust time are the time needed to prepare machine to shift producing a new product. Actual Production is the number of items produced per month. Rejected Output is the number of productions that do not meet the requirements.

Table I. Historical Data of 100 Ton HTM 1004 Hydraulic Press Machine

Month	Machine Working Time (min)	Downtime (min)	Set up & Adjust (min)	Planned Stop Time (min)	Theoretical Cycle Time (min)	Actual Production	Rejected Output
Feb-22	25,920	1,500	630	2,160	0.78	19,786	152
Mar-22	28,820	3,270	660	1,760	0.78	23,121	97
Apr-22	25,920	246	630	2,160	0.78	21,000	153
May-22	28,820	480	660	1,760	0.78	13,660	122
Jun-22	25,920	37	630	2,160	0.78	23,966	114
Jul-22	28,820	40	660	1,760	0.78	21,390	153

Availability Rate

Availability rate of the machine is calculated using Equation (1). Based on the calculation results, on average the Availability Rate of the hydraulic press machine, is 92.5%. Figure 2 clearly shows that the rate are above the ideal standard, with the ideal standard Availability Rate that has been set by JIPM for a machine being at a value of ≥ 90%. The only month the availability is less than the standard is in the month of March. The value is 85.5% which is not that far from the ideal one. The high values of Availability Rate of the machine show that the machine is ready to be used at any time.

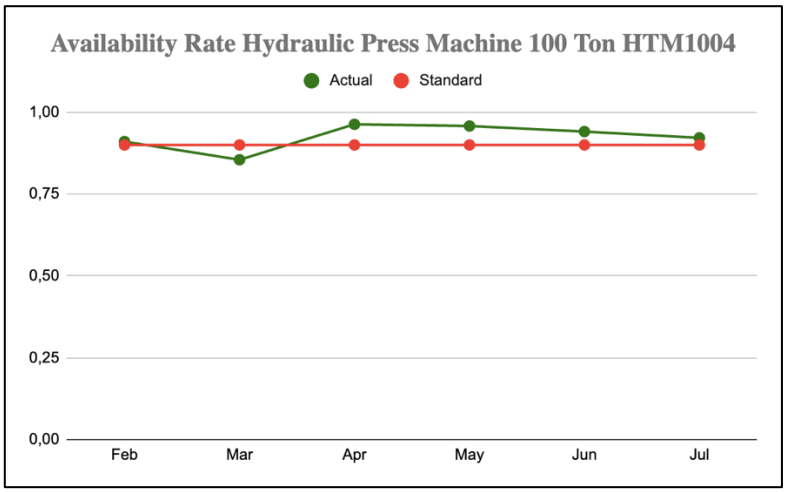

Figure 2. Availability Rate of the 100 Ton hydraulic machine

Performance Rate

Machine performance rate is calculated using Equation (2). Figure 3 shows that the performance rates of the machine are all below the standard. The values fluctuate with the average of 69%. The highest performance rate is 84% that reached on month of June. This figure indicates that the Performance Rate value is far away from the ideal standard of ≥ 95%. Even, the rate is so low at the month of May, i.e. 0.41. This shows that the level of production carried out by the machine is not in accordance with the working hours that have been set.

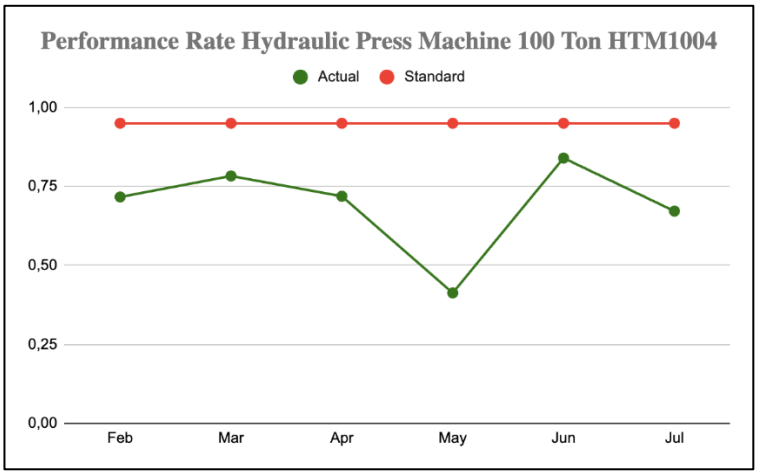

Figure 3. Performance Rate of a 100 Ton HTM 1004 Hydraulic Press Machine

Quality Rate

Machine quality rate is calculated using Equation (4) and the results are shown on Figure 4. The rates are good because they have an average quality value of 99.3%. They exceed the ideal standard of Quality Rate according to JIPM, which is 99%. This shows that the product produced by the 100 Ton Hydraulic Press machine has good quality.

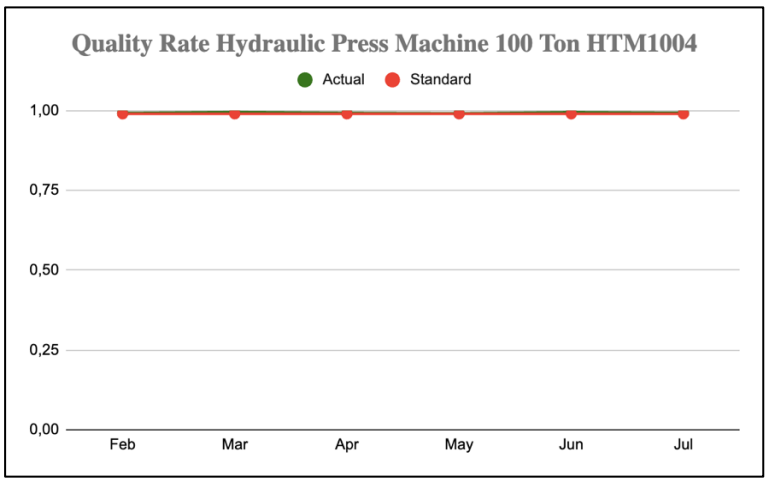

Figure 4. Quality Rate of 100 Ton HTM 1004 Hydraulic Press Machine

Overall Equipment Effectiveness

Multiplying values listed on Figures 2-4, the OEE is calculated using Equation (5), and the results shown in Figure 5. Based on the figure, it can be seen that the OEE values are fluctuated

from month to month with the average of 63.2%. Even though the value belongs to category 3, but it is much lower than the ideal standard OEE value set by JIPM, i.e. ≥85%.

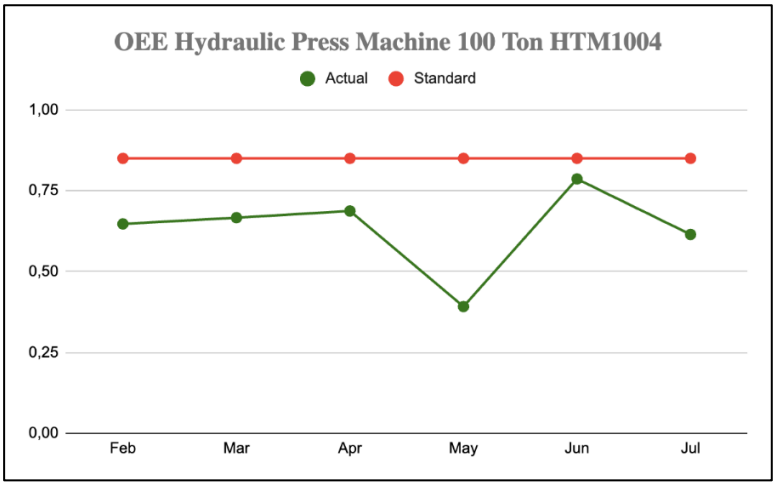

Figure 5. OEE of 100 Ton HTM 1004 Hydraulic Press Machine

Multiplying values listed on Figures 2-4, the OEE is calculated using Equation (5), and the results shown in Figure 5. Based on the figure, it can be seen that the OEE values are fluctuated from month to month with the average of 63.2%. Even though the value belongs to category 3, but it is much lower than the ideal standard OEE value set by JIPM, i.e. ≥85%.

To identify the problem that leads to the low value of OEE, the next step is calculating the Six Big Losses. The losses may exist at every production stage. For the purpose, breakdown related data for each loss were collected during the six months' period. Table 2 summarizes the data.

Table 2. Historical Data of 100 Ton HTM 1004 Hydraulic Press Machine Breakdown

Month	Breakdown Losses (%)	Set up & Adjustment Losses (%)	Idling and Minor Stoppages (%)	Reduced Speed Losses (%)	Defect Losses (%)	Reduced Yield Losses (%)
Feb-22	6.31	2.65	0	25.8	0.50	0.50
Mar-22	12.08	2.44	0	18.55	0.28	0.44
Apr-22	1.04	2.65	0	27.08	0.50	0.50
May-22	1.77	2.44	0	56.24	0.35	0.44
Jun-22	3.27	2.65	0	15.07	0.38	0.50
Jul-22	5.38	2.44	0	30.26	0.44	0.44
Average	4.975	2.545	0	28.833	0.408	0.470

Calculating the data on Table 2, Table 3 summarizes the finding while Figure 6 is the Pareto Chart for the values. Table 3 shows that the biggest loss is the Reduced Speed Losses with the value of 77.51%.

Table 3. Six Big Losses of 100 Ton HTM 1004 Hydraulic Press Machine

Six Big Losses	Total Time Losses (min)	Average Losses (%)	Cumulative Percentage (%)
Reduced Speed Losses	44,571	28.833	77,51
Breakdown Losses	7,729	4.975	90,95
Set up and Adjustment Loss	3,870	2.545	97,68
Reduced Yield Losses	714	0.470	98,92
Defect Losses	620	0.408	100,00
Idling and Minor Stoppages	0	0	100,00

Figure 6, the Pareto chart, is used to find out the Losses that most affect the effectiveness of the machine.

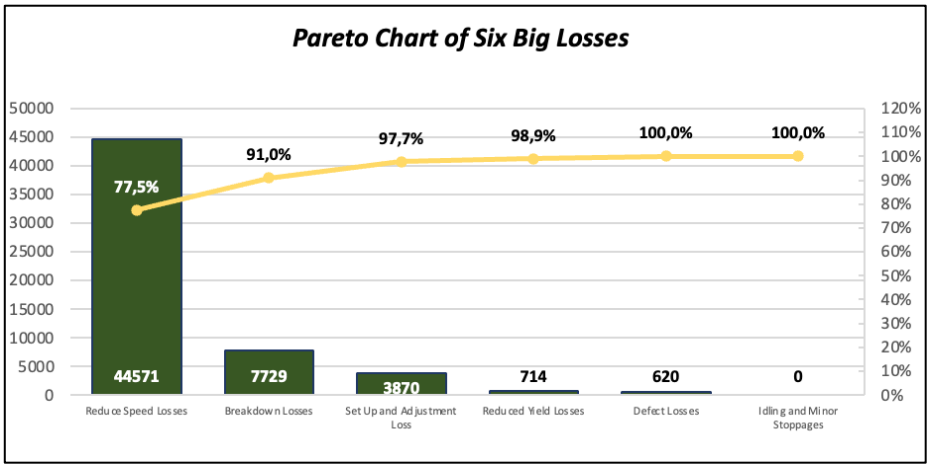

Figure 6. Pareto Chart of Six Big Losses

Based on the results of the Pareto, it is found that the factor that becomes Critical Down Time on the machine is Reduce Speed Losses. This finding is in line with the fact that the Performance Rate of the machine below the ideal standard (see Figure 3). Therefore, solution to the problem is focused on improving the Reduce Speed Losses factor. An analysis using Fishbone Diagram was carried out to determine the root cause of this factor. The result is displayed in Figure 7. Fishbone Diagram is basically identified the cause related to 5M and E aspects, i.e. Man, Machine, Material, Method, Money and Environment. Causes related to each aspect are attached to the diagram. From the six aspects, Money has not any issues. It is removed from the diagram. From the Man aspect, it is identified that the operator who run the machine is not fully follow the SOP. From the Machine aspect itself, the issue is the fuse and from the Environment, it is identified that the working space has lack of ventilation.

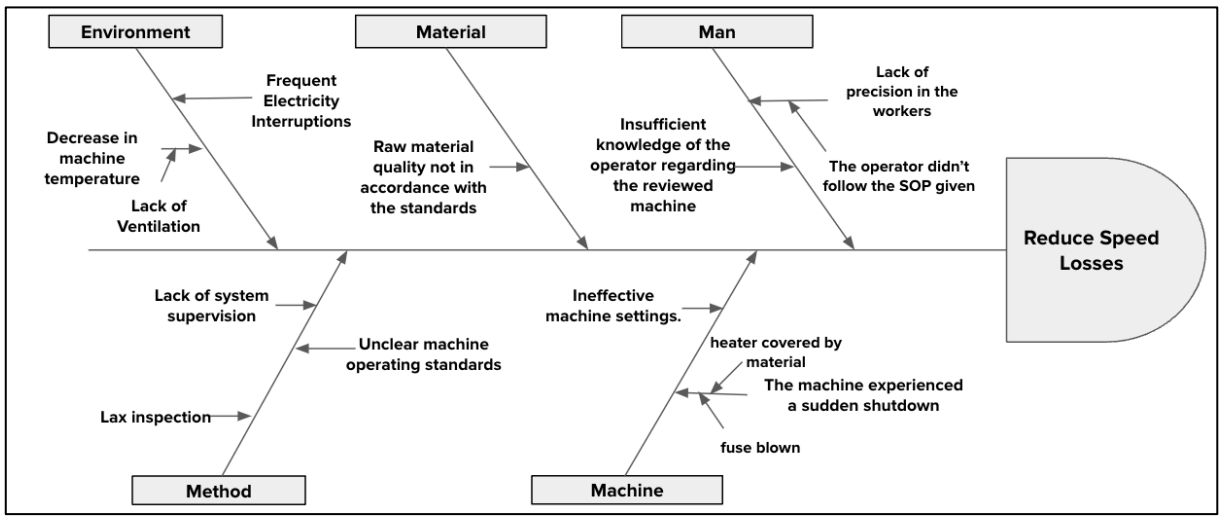

Figure 7. Cause and Effect Diagram of Reduced Losses Speed

Based on the root of the problem identified through the Fishbone Diagram, recommendations are proposed to handle the losses. List of recommendations is listed on Table 3.

Table 3. Recommendation to solve the causes identified

Potential Failure Mode	Root Cause	Recommendations
The amount of production produced can not meet customer demand	Operators do not follow SOP	**Checklist Periodic Review by Supervisor:** Periodic repairs are needed on a daily and weekly basis to maintain maintenance and repair of the machine. It is , carried out at set-up time duration. **Improve the Quality Control and Quality Assurance Systems:** To increase QC tightness, it is necessary to improve the Quality Control and Quality Assurance systems to ensure that the quality of the products produced is always in accordance with the provisions set by the company.
Limited Air Circulations	Lack of Ventilation	**Increasing the number of ventilation and improving room layout:** To avoid overheating, the company needs to increase the number of ventilation around the factory area so that it can help improve the performance of the operator in charge of operating the machine.

Machine Damage	Blown Fuse	**The addition of a generator is discussed with the ability of electric power:** A blown fuse will certainly cause the machine to stop suddenly thereby hampering production. This can be overcome by providing a generator that is in accordance with the electric power installed by PLN and in accordance with the needs of the machine.

4. Conclusion

Based on the study on the 100 Ton HTM 1004 Hydraulic Press machine, it was found that the average OEE value from the machine is below the OEE standard, with the average value equal to 69%. The component that greatly influences the low OEE value is performance efficiency, which aligns with the Six Big Losses factor that most influenced the low level of OEE is on Reduce Speed Loss. The cause of the problem of not achieving the ideal Performance Rate is that the machine often experiences obstacles in production due to fuses that often blow, lack of ventilation, and the operators do not follow SOPs. Suggestions for improvement that can be implemented by the company compries of periodic checklist reviews by supervisors, increasing ventilation, and improving room layout, as well as adding gensets to adjust to electrical power capability.

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