Journal of Mechanical, Civil and Industrial Engineering
ISSN: 2710-1436
DOI: 10.32996/jmcie
Journal Homepage: www.al-kindipublisher.com/index.php/jmcie

JMCIE
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Role of Total Productive Maintenance Application for Increasing the Efficiency of Timber Processing Production

Rasmi Sitohang[1] ✉, Bungaran Tambun[2] and Rahidun Simangungsong[3]
[12]Institut Sains Dan Teknologi TD Pardede, Medan, Indonesia
[3]Universitas Darma Agung, Medan, Indonesia
Corresponding Author: Rasmi Sitohang, **E-mail**: rasmisitohangistp@gmail.com

| ABSTRACT

The purpose of this research is to find out the Role of total productive maintenance application for increasing the efficiency of timber processing production. The method of research is using TPM and OEE. The highest OEE value on the Under Cut machine is 71.91%, Thicknesses = 76.93, Surface Planner = 75.06 %, Six Drill = 69.62 %, Double-end = 86.50 %, spindle Moulder 85.21%, single shaper 72.85%, and automatic Round Dowel machine = 80.63 %. If the eight machines have OEE, there are 2 machines that reach the optimum condition, namely OEE > 85 %. While others are under optimum conditions. The factors that contributed the most so that the ideal OEE value was not achieved during the period Mei-July 2020 and became the main priority for elimination by the company on the Under Cut machine were the Indling factor and Minor Stoppages Loss of 46.83%, reduced speed loss of 29.23% on the Thicknesser factor machine. The dominant ones are Idling and Minor Stoppages loss 44.63% reduced speed loss 17.12%, then meisn 40.11%, then Reduced Speed 71.72%.

| KEYWORDS

Production, total productive maintenance, processing, wood, efficiency

| ARTICLE DOI: 10.32996/jmcie.2022.3.1.7

1. Introduction

In today's increasingly flexible manufacturing system, where the workforce has been replaced by robots that can work 24/7 with automated systems, product quality is used to support production processes and production systems, also depending on the device. Production system management is also an important component in managing machine/equipment maintenance on the factory floor. To support the smooth production process, it is necessary to carry out maintenance and repair in case of damage to the machine or system used, to prevent damage to the machine, or at least reduce the type and time of damage. As a result, the damage so that the manufacturing process does not stop too much properly and reasonably so that the productivity and efficiency of the machine can be increased and losses due to machine damage can be overcome. All processing industries have machine/equipment maintenance problems, and wood processing industries have machine/equipment maintenance problems. Therefore, you need to follow the steps exactly. If there is a failure that is directly related to the automatic production process, it will directly cause a decrease in production efficiency. Therefore, effective and efficient steps are needed to be able to overcome and prevent problems that result in low productivity of the machine/equipment. Machine/equipment maintenance management are techniques and activities to maintain and maintain and improve product quality. This includes techniques and activities that are interrelated and integrated, involving all departments and everyone from top management to operators through small group activities. Improper handling and maintenance of machines/equipment can not only cause machine/equipment breakdowns. But it also results in other losses such as the length of setup/adjustment time, the machine producing defective products, the machine operating but does not produce the product, and often the machine stops suddenly (idling and minor stoppages), decreased machine production speed (reduced speed).

2. Literature Review

2.1 Maintenance

In the manufacturing industry, machines and equipment that are available and ready to be used are needed every time the production process begins. The function of the machines/equipment used in the production process will be damaged in line with the decreasing ability of the machine/equipment; however, its useful life can be extended by making continuous and periodic repairs through proper maintenance activities. The decline in the ability of machines/equipment according to The Japan Institute of Plant Maintenance, namely: Natural deterioration, namely the natural decline in the performance of machines/equipment due to the occurrence of rust/wear on the physical machines/equipment during usage time even though they are used correctly. Accelerated deterioration is a decrease in the performance of machines/equipment due to human error (human error) resulting in rust/wear on machines/equipment due to neglect of actions and treatment that should be carried out on machines/equipment. Damage that occurs to the machine/equipment can occur due to many reasons and occur at different times throughout the life of the machine is used. Therefore, in preventing and trying to eliminate the damage that may arise during the production process, it is necessary to have ways and methods to anticipate it by carrying out maintenance activities for machines and equipment. Maintenance is all technical and administrative actions taken to keep the machine/equipment in good condition and can perform its function properly, efficient and economical, according to specifications and capabilities with a high level of security. Meanwhile, according to Ansauri, stated that maintenance is an activity to maintain or maintain machinery/equipment and make repairs or adjustments/replacements needed so that there is a satisfactory production operating condition in accordance with what is planned. Basically, the expected results from maintenance activities for machines/equipment (equipment maintenance) include the following: Condition Maintenance, namely maintaining the condition of the machine/equipment to function properly so that the components contained in the machine can also function in accordance with its economic age.

2.2 Maintenance Types

2.2.1 Planned Maintenance (Planned Maintenance)

Planned maintenance (planned maintenance) is maintenance that is organized and carried out with the future in mind—control and record-keeping according to a predetermined plan. Therefore, the maintenance program to be carried out must be dynamic and require active supervision and control from the maintenance department through information from machine/equipment history records. The concept of planned maintenance is intended to overcome the problems faced by managers with the implementation of maintenance activities. This communication can be improved with an information system that can be provided with complete data to make decisions. The most important data in maintenance activities include maintenance request reports, inspection reports, repair reports and others.

1. *Preventive Maintenance* (Preventive Maintenance)
   Preventive Maintenance (preventive maintenance) are maintenance actions that are carried out when and as long as the machine/equipment is operating properly, before the machine/equipment is damaged, which aims to keep the machine/equipment from being damaged and detect symptoms of impending damage early, so that action can be taken to carry out repairs before the machine/equipment breaks down.

2. *Corrective Maintenance* (Repair Maintenance)
   Corrective maintenance (Repair maintenance) is a maintenance activity that is carried out after the occurrence of a malfunction or malfunction of the machine/equipment so that it cannot function properly.

3. *Predictive Maintenance*
   Predictive maintenance is maintenance actions that are carried out on a specified date based on the prediction of the results of the analysis and evaluation taken at certain time intervals. Recorded data taken to perform predictive maintenance can be in the form of data, vibration, temperature, vibration, flow rate and others.

4. Unplanned Maintenance (Unplanned Maintenance)
   Unplanned Maintenance is usually in the form of break downs-emergency maintenance. Breakdowns-emergence maintenance (emergency maintenance) is a maintenance action that will not be carried out on machines/equipment that is still operating until the machine/equipment is damaged and can no longer function.

Maintenance of the condition of machinery/equipment that supports the implementation of the production process is an important component in the implementation of maintenance of the production unit. The purpose of productive maintenance (productive maintenance) is to achieve what is called profitable PM, which means that we only try to prevent damage and defects that may occur in machines/production equipment but also carry out all maintenance actions efficiently and effectively.

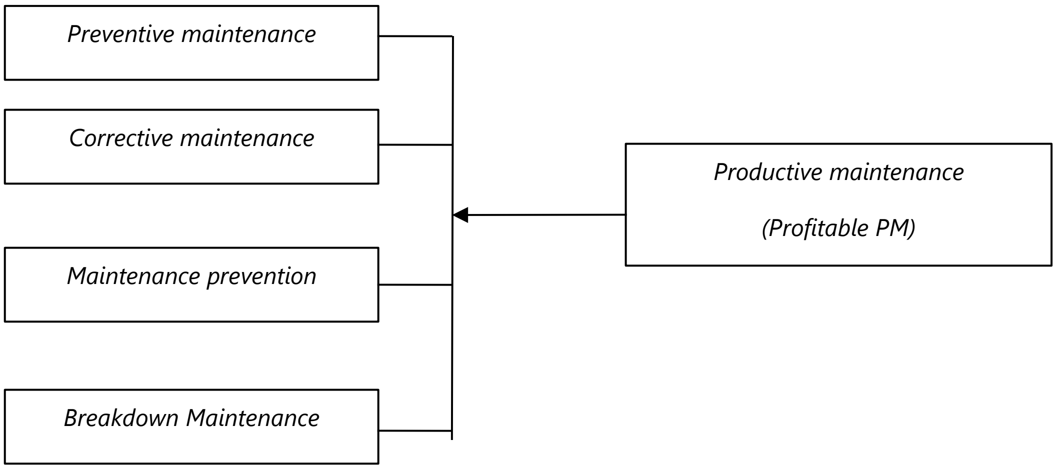

Figure 1. Profitable PM Diagram

And to achieve what is called profitable PM (productive maintenance), we must carry out maintenance actions which include the following activities:

1. *Preventive maintenance (*prevent damage).
2. Corrective maintenance (carry out development and modification on machines/equipment to prevent damage and make repair steps easier).
3. *maintenance prevention (*designing and creating tools that require little maintenance).
4. *Breakdown maintenance* (carry out repairs in case of damage).

2.3 Total Productive Maintenance

Total Productivity maintenance is a program to increase company productivity and efficiency in all fields involving all parties, all departments, and groups of people from top management to operators through small groups. Overall the definition of TPM includes the following five elements:

1. TPM aims to maximize the overall effectiveness of the machine/equipment.
2. TPM creates a PM system to extend the life of the machine/equipment.
3. TPM can be applied to various departments (such as engineering, production, maintenance).
4. TPM involves everyone from the highest levels of management to employees on the factory floor.
5. TPM is the development of a maintenance system based on PM through the management of motivation for autonomous small group activities.

2.3.1 OEE (Overall Equipment Efectivities)

Overall Equipment Effectives (OEE) is a comprehensive measure that indicates the level of productivity of the machine/equipment and its theoretical performance. This measurement is very important to know and can also show the area on the production line. OEE is also a measuring tool to evaluate and provide a way to ensure an increased productivity of the use of machines/equipment. The mathematical formula of Overall Equipment Effectives (OEE) is formulated as follows:

OEE = Availability x Performance Efficiency x Rate of Quality product x 100%

2.3.2 Availability

Availability is the ratio of the time to the loading time. So to be able to calculate machine availability, the values of:

1. *Operation time*
2. *Loading time*
3. *Downtime*

Availability value is calculated with the following formula:

$$Availability = \frac{\text{operationtime}}{\text{loadiingtime}} x100\%$$

Availability $=\frac{\text{loadingtime} - \text{Downtime}}{\text{loadiingtime}} x 100\%$

Loading time is the available time per day or month minus the planned downtime of the machine.

Loading time = total available time – Planned downtime

Planned downtime is the amount of downtime that has been planned in the production plan, including machine downtime for maintenance (schedule maintenance) or other activities. Operation time is the result of reducing loading time with machine downtime; in other words, operation time is the available operating time after machine downtime is removed from the planned total available time.

2.3.3 Performance Efficiency

Performance Efficiency is the result of multiplying the operation rate and the operating rate or the ratio of the quantity of product produced multiplied by the ideal cycle time to the time available for the production process (operation time). Operation speed rate is a comparison between the ideal engine speed based on the actual engine capacity (theoretical ideal cycle time) and the actual engine speed (actual cycle time). The mathematical equation is shown as follows:

Operation speed time $=\frac{\text{Ideal cycle time}}{\text{Actual cycle time}}$

Netoperating rate $=\frac{\text{Actual processin}g\text{ time}}{\text{operationtime}}$

Net operating rate is the ratio between the number of products processed multiplied by the actual cycle time and the operation time. %et operating time is useful for calculating losses caused by minor stoppages decreasing production speed. Three important factors are needed to calculate Performance efficiency:

1. *Ideal cycle time (*ideal cycle time/standard time).
2. *Processed amount (*number of products processed).
3. *Operation time*(machine operating time).

Performance efficiency =operating x operating speed rate

Performance efficiency $=\frac{\text{processed maount } x \text{ ideal cycletime}}{\text{operationtime}} x \frac{\text{idealcycletime}}{\text{actual cycletime}}$

Performance efficiency $=\frac{\text{processed maount } x \text{ ideal cycletime}}{\text{operationtime}} x 100\%$

2.4 Rate of Quality Product

Rate of Quality product is the ratio of the number of good products to the total number of products processed. So the Rate of Quality product is the result of calculations using the following two factors:

1. *Processed amount (*number of products processed)
2. *Defect amount*(number of defective products).

Rate of Quality product can be calculated as follows:

Rate of Quality product $=\frac{\text{processed maount } x \text{ ideal cycletime}}{\text{Processed amount}} x 100\%$

3. Research Methodology

3.1 Data collection technique

The data needed in this study were collected by recording the data from the company's documentation in the form of historical data obtained from the production unit and the company's maintenance unit and observation, namely the data obtained by observing and recording to complete the existing data. Previous The required data collection relates to Data from companies related to the components needed to measure the OEE of machines and equipment, namely: Availability includes data: operation time, loading time, downtime, and setup time. Performance Efficiency includes data; theoretical cycle time, ideal cycle time, processed amount, and operation time. Rate of quality includes data: Processed amount, defect amount. Type of machine used data type and time of breakdown.

3.2 Data analysis technique

The data from the components that make up the OEE ratio is the initial data that will be used as a basis for measuring the level of productivity and efficiency of the machines used in certain parts. This measurement is very important to find out what factors from the six big losses contribute to the largest losses on the machine/equipment that result in low productivity and machine efficiency—a good OEE percentage rate is85.

3.3 Determination of the Number of Observations

Determining the number of observations for a study is a prelude to the study where it is expected that the number of observations made can represent the characteristics of the population. So the more observations made, the better the expected results.

For example :
Xi = 1st observation
N= Number of observations
σ = Standard deviation of the population
σ_x = Standard deviation of the mean value of x

Then the standard deviation of the average value of the measured element is:

$$\bar{X} = \frac{\sum_{i=1}^{N} X_i}{N}$$

$$\sigma_x = \sqrt{\frac{\sum (X_1 - X)^2}{N}}$$

Xi= Price of the stopwatch reading of each observation
$\bar{X}$ = Average price of observations
N = Sum of the number of observations

By taking the value of the 95% confidence level and the 5% accuracy level, the number of observations required (N') is calculated:

$$N' = \left[\frac{20(\sqrt{N \sum X_1^2 - (\sum X_t)^2})}{\sum x_i}\right]^2$$

3.3.1 Level of Accuracy and Level of Confidence

The level of accuracy and confidence is a reflection of the level of certainty desired by the measurement after deciding not to take too many measurements.

The level of accuracy indicates the maximum deviation of the actual completion time measurement results. While the level of confidence indicates the level of confidence of the measurer that the results obtained to meet the requirements for accuracy. So the level of accuracy of 5% and the level of confidence 95% means that the deviation of the measurement results from the actual maximum allowable result is 5%, and the probability of succeeding in getting results in such a way is 95.5. In other words, if the measurer obtains a measurement result that deviates more than 5% from the actual one, then such a result is at most 5% of the total number of measurements.

3.3.2 Data Uniformity Test

During the measurement, the operator may get data that is not uniform. Since non-uniformity can go unnoticed, a show hart is needed. The principle is that each data is plotted in a control chart whose control limits have been determined, then note the data in the data, the upper control limit (BKA) and the lower control limit (BKB).

In determining the upper control limit and lower control limit, 3σoften used for :

BKA : x + 3σ

BKB : x- 3σ

Where :

BKA = Upper control limit

BKB = Lower control limit

X= the average price of the average x $_1$

3.3.3 Standard Time Calculation
To calculate the standard time, it is necessary to calculate the average cycle time, which is called the selected time, rating factor (adjustment factor), normal time and allowance (slack).

Wn = wt x Rf

Where :
Wn=time%normal
Wt= selected time
Rf = *rating factor*

Ws = Wn x (100/100-All)

Where :
Ws = standard time
All = *allowance*

3.3.4 Adjustments and Allowances
Rating is a factor obtained by comparing the work speed of a person with a normal speed according to the observer's concept.

4. Results and Discussion

4.1 Pareto Chart EEE Six Big Losses

This diagram will show the effectiveness of the lost machines due to inefficient use of time due to the influence of the six big losses on the machines. In figure 6.1. up to Figure 6.8 is a Pareto diagram that shows the greatest priority for the six big losses contained in the OEE six big losses during the period Mei-July 2020, then a Pareto diagram is made showing the factors that result in reduced effectiveness of the eight machines which will be the priority for improvement. .

Table 1. Percentage of Under Cut Machine Six Big Losses Factors for the May - July 2020 Period

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	35.4	46.83
2	Reduced Speed Loss	22.1	29.23
3	Set-up/Adjustment Loss	11.9	15.74
4	Break Down Loss	5.7	7.54
5	Yield/Absorb Loss	0.3	0.40
6	Rework Loss	0.2	0.26
Total		75.6	100

Source: Data Processing Results, 2020

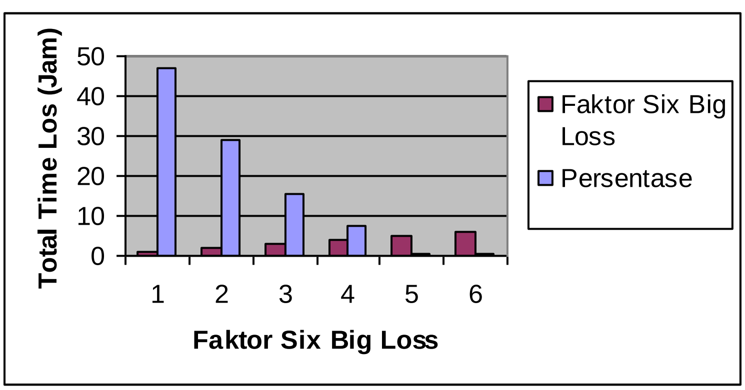

Figure 2. Pareto Six Big Losses Diagram for Under Cut Machines for the May - July 2020 Period

Table 2. Percentage of Factors Six Big Losses Thicknesser Machine Period May - July 2020

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	24.5	44.6266
2	Reduced Speed Loss	9.4	17,122
3	Set-up/Adjustment Loss	12.7	23,133
4	Break Down Loss	7.8	14.2077
5	Yield/Absorb Loss	0.3	0.54645
6	Rework Loss	0.2	0.3643
Total		54.9	100

Source: Data Processing Results, 2020

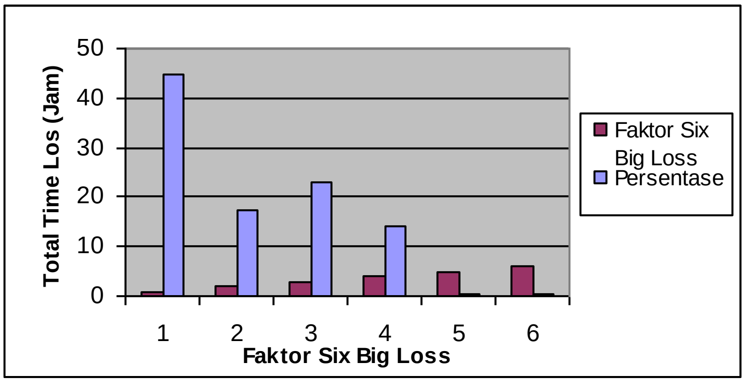

Figure 3. Pareto Six Big Losses Diagram for Thicknesser Machine May - July 2020

Table 3. Percentage of Six Big Losses Factors for Surface Planner Machines for the Period May - July 2020

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	31.6	40,1117
2	Reduced Speed Loss	24.9	31,607
3	Set-up/Adjustment Loss	15.4	19.5481
4	Break Down Loss	6.6	8,37776
5	Yield/Absorb Loss	0.12	0.15232
6	Rework Loss	0.16	0.2031
Total		78.78	100

Source: Data Processing Results, 2020

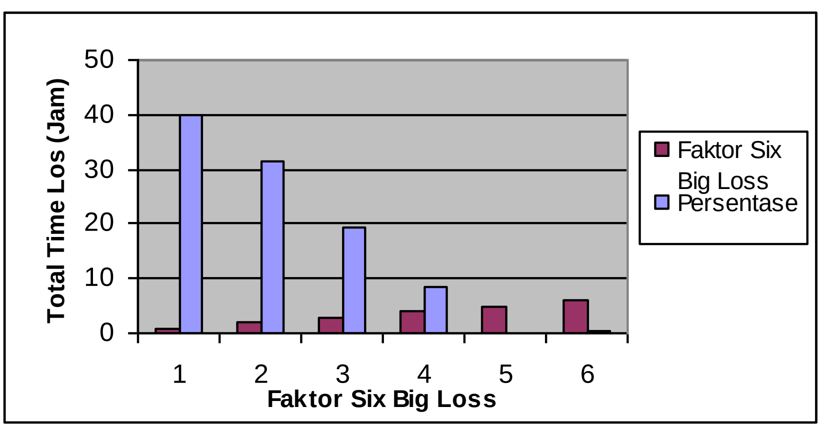

Figure 4. Pareto Six Big Losses Diagram for Surface Planner Machine May - July 2020

Table 4. Percentage of Six Big Losses Factors for Six Drilling Machines for the Period of May - July 2020

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	47.9	64.8173
2	Reduced Speed Loss	4.1	5.54804
3	Set-up/Adjustment Loss	14.4	19,4858
4	Break Down Loss	7.3	9.87821
5	Yield/Absorb Loss	0.1	0.13532
6	Rework Loss	0.1	0.13532
Total		73.9	100

Source: Data Processing Results, 2020

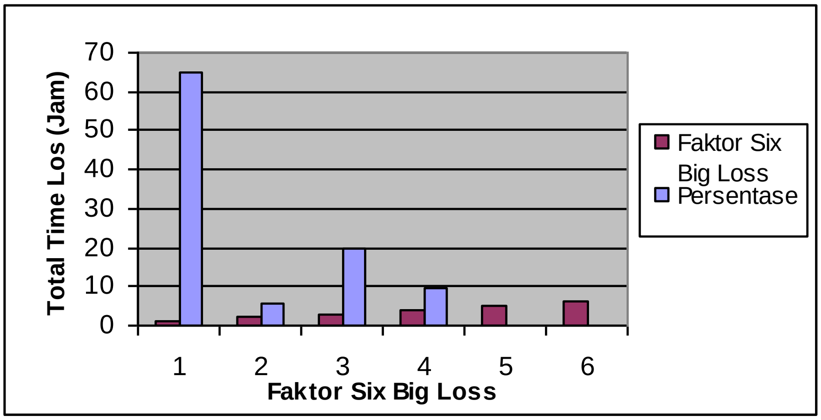

Figure 5. Pareto Six Big Losses Diagram for Six Drilling Machines May - July 2020

Table 5. Percentage of Six Big Losses Factors for Double End Machines for the May - July 2020 Period

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	10.6	26.1084
2	Reduced Speed Loss	10.7	26.3547
3	Set-up/Adjustment Loss	11.9	29.3103
4	Break Down Loss	6.4	15,7635
5	Yield/Absorb Loss	0.5	1.23153
6	Rework Loss	0.5	1.23153
Total		40.6	100

Source: Data Processing Results, 2020

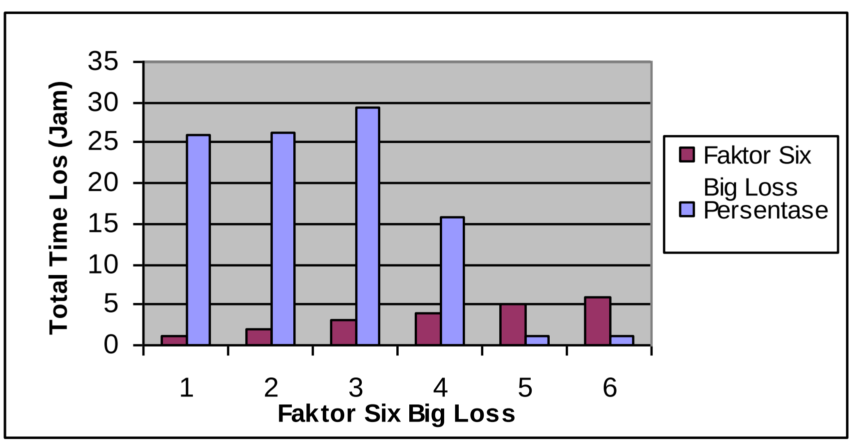

Figure 6. Pareto Six Big Losses Diagram for Double End Machine May - July 2020

Table 6. Percentage of Six Big Losses Factors for Spindle Molding Machines for the Period of May - July 2020

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	96.1	80.0833
2	Reduced Speed Loss	4.7	3.91667
3	Set-up/Adjustment Loss	12.9	10.75
4	Break Down Loss	5.7	4.75
5	Yield/Absorb Loss	0.4	0.33333
6	Rework Loss	0.2	0.16667
Total		120	100

Source: Data Processing Results, 2020

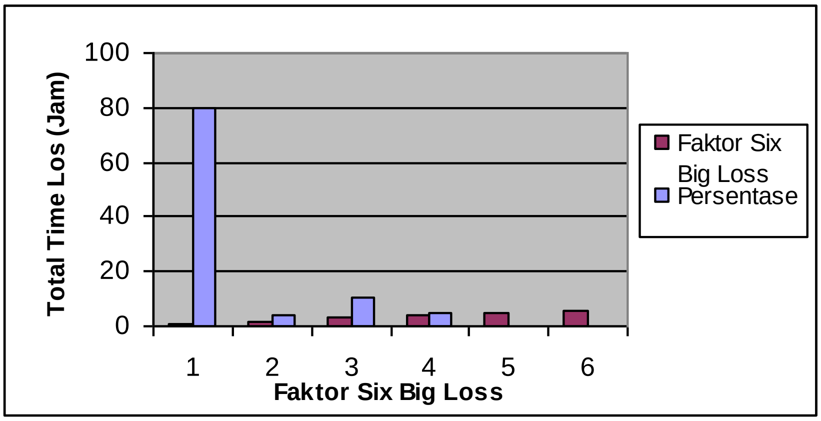

Figure 7. Pareto Six Big Losses Diagram for Spindle Molding Machine May - July 2020

Table 7. Percentage of Factors Six Big Losses Single Shapper Machine Period May - July 2020

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	35.5	46,7721
2	Reduced Speed Loss	21.4	28,195
3	Set-up/Adjustment Loss	11.5	15,1515
4	Break Down Loss	6.9	9.09091
5	Yield/Absorb Loss	0.3	0.39526
6	Rework Loss	0.3	0.39526
Total		75.9	100

Source: Data Processing Results, 2020

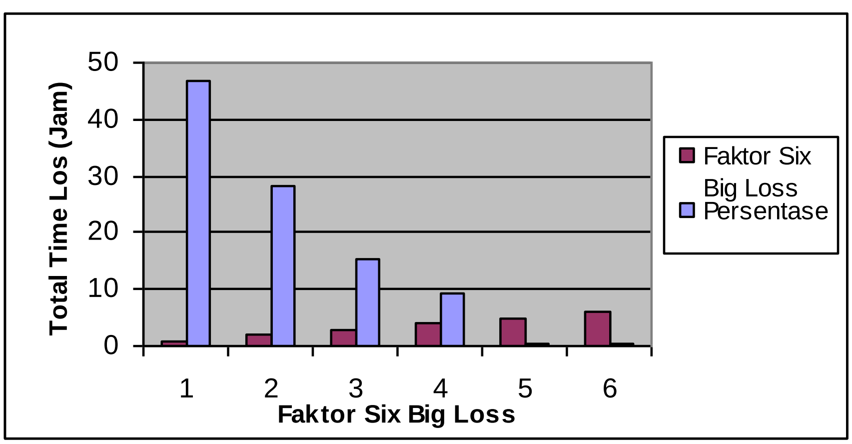

Figure 8. Pareto Six Big Losses Diagram for Single Shapper Machine May - July 2020

Table 8. Percentage of Six Big Losses Factors for Automatic Round Dowel Machines for the Period of May - July 2020

No	Six Big Losses	Inefficiency Time (Hours)	Percentage (%)
1	Idling and Minor Stoppages Loss	27.9	57.0552
2	Reduced Speed Loss	3.3	6,74847
3	Set-up/Adjustment Loss	10.8	22.0859
4	Break Down Loss	6.6	13.4969
5	Yield/Absorb Loss	0.2	0.409
6	Rework Loss	0.1	0.2045
Total		48.9	100

Source: Data Processing Results, 2020

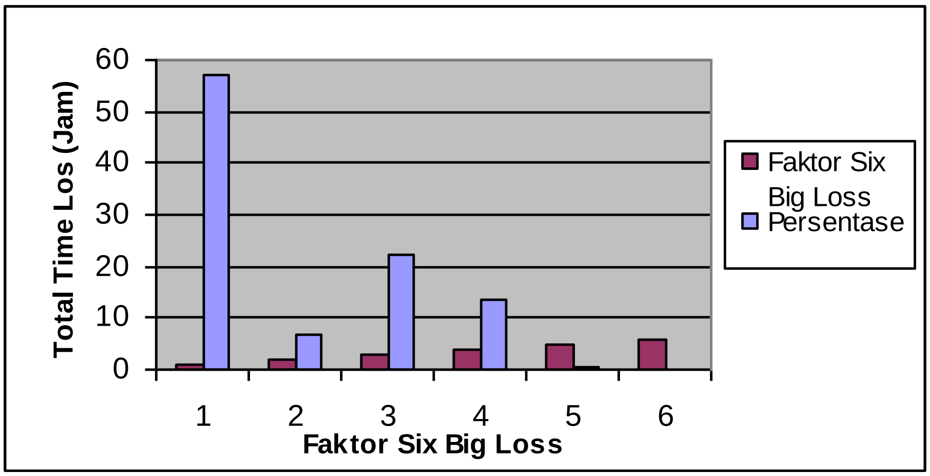

Figure 9. Pareto Six Big Losses Diagram for Automatic Round Dowel Machine May - July 2020

4.2 Overall Equipment Effectiveness (OEE) discussion

The analysis of the results of the OEE calculation was carried out to see the level of effectiveness of the use of the machines used by the company, which consisted of 8 machines during the period May - July 2020. This OEE measurement is a combination of time factors, production speed and quality of machine operation used. The magnitude of the OEE value indicates the level of effectiveness of the use of the eight machines observed. The highest OEE value of the extrusion machine occurred in the period of observation experiencing changes. The highest OEE value of the Under Leave machine was in the Mei 2020 period, which was 71.91%, and the lowest value was in the March period, 67.46%. . The highest OEE value in this period was influenced by the availability ratio of the machines used which reached 88.54% and the ratio rate of the quality product was 99.94%, while the performance efficiency was only 81.17%. So it can be concluded that the low value of OEE is influenced by low-performance efficiency for each period. Availability of 89.21%. Meanwhile, the low OEE value in July was caused by the ratio of the performance efficiency value of 97.16%. On the Spindle Molder machine, the highest OEE value is in the Mei period, and the lowest is in the March period. The high value of OEE in that period, which reached 54.38%, was influenced by the ratio of the rate of the quality product reaching 99.85%. While the low value of OEE in the March period reached a value of 54.38%, influenced by the ratio of the value of performance efficiency, which reached a value of 62.35%. On the Single Shapper machine, the highest OEE value was in the July period, and the lowest was in the March period. The highest OEE value in the July period was 72, 5% is influenced by the rate of quality product ratio reaching 99.87% and the availability value 88.98%. While the low OEE value in the March period was influenced by the availability value of 86.53%. Meanwhile, the low OEE value in the March period was influenced by the performance efficiency value reaching 81.08%. On the Automatic Round Dowel Machine, the highest OEE value was in the July period, while the lowest was in the March period. The OEE value in the July period was 80.63%. OEE in the July period is influenced by the ratio of the rate of the quality product reaching 99.94% and availability reaching 89.54%, while performance efficiency is reaching 90.20%. Based on the OEE analysis, it was concluded that the cause of the low OEE value of the eight machines observed by the performance efficiency factor was the factor that most influenced the low OEE value. From all OEE results, there is no value in achieving an OEE value of 85% as a reference for the ideal value according to the experience of companies that have successfully implemented TPM in their companies. The percentage change in the OEE value of the machines in the period from Mei to July can be assessed in table 9.

Table 9. Percentage Change in OEE Value of Machines for the Period May - July 2020

Machine name	Period	OEE (%)
Under Cut	May	71.91
	June	67.46
	July	71.82
Thicknesser	May	75.85
	June	73.32
	July	76.93
Surface Planner	May	67.62
	June	64.09
	July	75.06
Six Bor	May	69.62
	June	67.31
	July	69.07
Double End	May	84.23
	June	79.73
	July	86.50
Spindle Mold	May	85.21
	June	54.38
	July	55.97
Single Shaper	May	71.12
	June	67.17
	July	72.05
Automatic Round Dowel Machine	May	79.07
	June	77.91
	July	80.63

Source: Data Processing Results, 2020

On the Surface Planner machine, the factor of six big losses that result in low OEE is caused by Idling and Minor stoppages of around 40.11% and break down the loss of 8.37%—then followed by a reduced speed loss factor of 31.60%. The situation on the Surface Planner machine is the same as the Thicknesser machine; therefore, to analyze the causes of these losses are the same. On the Six Bor machine, the dominant factors forming the low OEE value are the idling and minor stoppages loss factor of 64.82% the setup/adjustment loss of 19.48 %. Then the Breakdown loss value is 9.90%%, but the reduced speed loss is only 5.54%. On the Double End machine, the dominant factor forming the low OEE value is the set-up/adjustment loss, which is 29.31%, the Reduced Speed Loss value is 26.35%, then the idling and minor stoppages loss is 26.11%, and the breakdown loss value is 15.76. %. On the Spindle Molder machine, the dominant factor that makes the OEE value low is the idling and minor stoppages loss factor, downtime and a large setup time loss value. On the Single Shapper machine, the dominant factor forming the low OEE value is the same as on the Single Shapper machine, namely that the Idling factor and minor stoppages loss, downtime loss and then a large setup time loss value. On the Automatic Round Dowel Machine, it can be seen that the Idling and minor stoppages value is 57.05 % and the setup/adjustment loss is 22.05 %, and the Breakdown loss value is 6.74%. On the Single Shapper machine, the dominant factor forming the low OEE value is the same as on the Single Shapper machine, namely that the Idling factor and minor stoppages loss, downtime loss and then a large setup time loss value. On the Automatic Round Dowel Machine, it can be seen that the Idling and minor stoppages value is 57.05 % and the setup/adjustment loss is 22.05 %, and the Breakdown loss value is 6.74%. On the Single Shapper machine, the dominant factor forming the low OEE value is the same as on the Single Shapper machine, namely that the Idling factor and minor stoppages loss, downtime loss and then a large setup time loss value. On the Automatic Round Dowel Machine, it can be seen that the Idling and minor stoppages value is 57.05 % and the setup/adjustment loss is 22.05 %, and the Breakdown loss value is 6.74%.

5. Conclusion

The conclusion from the results of this study is that the company only uses approximately 77% of the potential capacity of the engine, while the ideal value is 85 %. The low effectiveness of the machine used is due to the high contribution given by the six big losses, which also results in low productivity and efficiency of the machine in the company, namely the idling factor and minor stoppages loss and reduced speed loss. From the results of OEE calculations carried out on the highest Under Cut machine in the May period, 71.91%. The lowest OEE occurred in the period of June 67.64 %, on the Thicknesser machine, the highest was in the period of July 76.93%, and the lowest was in May 73.32%, on the Surface Planner machine, the highest was in the period of July

75.06%, and the lowest was in June 64.09 % on the Double End machine, the highest was in the period of July 86.50%, and the lowest was 79.73% in June,

References

[1] Asauri, S. (1980). *Production Management*. Third Edition, Publishing Institute, Faculty of Economics, University of Indonesia, Jakarta..

[2] Anthony, M. B., (2019), Analysis of Total Productive Maintenance (TPM) Application Using Overall Equipment Effectiveness (OEE) And Six Big Losses On Cold Leveller Machines PT. PPP. UNIK TEAK: *Scientific Journal of Industrial Engineering and Management, 2*(2), 94-103.

[3] Baumers, M., Dickens, P., Tuck, C., Hague, R.J.T.f & .Change, S., (2016), The cost of additive manufacturing: machine productivity, *economies of scale and technology-push: 102*:193-201.

[4] Cochran, D.S., Foley, J.T. and Bi, Z., (2017), Use of the manufacturing system design decomposition for comparative analysis and effective design of production systems. *International Journal of Production Research, 55*(3). 870-890.

[5] da Silva, R. F &,.de Souza, G. F. M., (2020), Asset management system (ISO 55001) and Total Productive Maintenance (TPM): a discussion of interfaces for maintenance management. Gepros: *Gestão da Produção, Operações e Sistemas, 15*(2), 288.

[6] Das B, Venkatadri U, Pandey P., (2014), Applying lean manufacturing system to improving the productivity of air conditioning coil manufacturing. *International Journal Advanced Manufacturing Technology, 71*(1):307–323.

[7] Díaz-Reza, J. R., García-Alcaraz, J. L & ,.Martínez-Loya, V., (2018), Impact Analysis of Total ProductiveMaintenance: *Critical Success Factors and Benefits. Springer*.

[8] Domingo, R & .Aguado, S.J.S., (2015), *Overall environmental equipment effectiveness as a metric of a lean and green manufacturing system. 7*(7):9031-9047.

[9] Ginder A, Robinson A, Robinson CJ, (1995), Implementing TPM: *The North American experience. Taylor & Francis.*https://doi.org/10.1007/s00170-013-5407-x

[10] Gellings, R. (2001). *Overall Equipment Effectiveness*. Ente Grate Inc, Birmingham, Alabama..

[11] Jasiulewicz-Kaczmarek M., (2016), SWOT analysis for planned maintenance strategy—a case study. *IFACPapers OnLine 49*(12):674–679. https://doi.org/10.1016/j.ifacol.2016.07.788.

[12] Gaspert, V. (1998) "*Total Production Management*". Gramedia, Jakarta.

[13] Katila, P, (2000). "*Appling Total Productive Maintenance-TPM Principles in the Flexible Manufacturing System*". Technical Report, Lulea Teknikka Universitet.

[14] Leflar J. A. (2001). *Practical TPM, Successfi II Equipment Management for Agilent Technologies*. Productivity Press, Portland, Oregon,

[15] Nakajima S. (1998). *Introduction to Total Productive Maintenance*, Chamberige, MA, Productivity Press, Inc..

[16] Nazir, M. (1988). Research Methods Publisher Ghalia Indonesia, Jakarta,

[17] Sutalaksana, I. Z, (1979). Working Procedures Engineering, Laboratory of Work Procedures & Ergonomics, Department of Industrial Engineering, ITB, Bandung,

[18] Shiroses, K. (1995). *TPM Team Guide*, Productivity Press. Inc., Portland, Oregon.

[19] Semiconductor Manufacturing Productivity. (1995). "Overall Equipment Effectiveness (OEE) Guidebook Revision 1.0, Technology Transfer, Sematech. Inc.

[20] The Japan Institute of Plant Maintenance (1996). TPM for Every Operator, Shopfoor Series, Productivity Press, Inc., Portland, Oregon.