Biolematik Machine Productivity Analysis Using Overall Equipment Effectiveness (OEE) Method: Case Study

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Abstract

Productivity is an activity in producing an item or product using the most effective and efficient way possible. To increase the productivity of machines/equipment, it is necessary to apply TPM. Section CV 6 has applied the TPM method, but it doesn't work consistently so there are still a lot of loss time. As a result of the loss time, the resulting production is not in accordance with the company's target. So the purpose of this research is to measure the productivity level of a biolematik machine by using the Overall Equipment Effectiveness (OEE) method and to minimize the Six Big Losses which are the cause of the decline in engine performance. Based on the results of the implementation of the method and discussion, the results of the calculation of the OEE value from 62.76% - 80.03%, it can be concluded that the biolematik machine still has an OEE value below the standard 85%. From the calculation of the six big losses, several factors were found that caused the low productivity of biolematik machines, namely the setup and adjustment, Equipment Failure, and Reduced Speed sections. This study also provides input for improvements in the setup and adjustment, Equipment Failure, and Reduced Speed sections after parsing existing problems using Fishbone diagrams.

Keywords : TPM, OEE, Six Big Losses, Fishbone Diagram

INTRODUCTION

In today's industrial world, companies are advancing and developing rapidly to compete with similar companies in maintaining the company existence. Increasingly fierce competition makes companies have to be more severe in carrying out changes to become winners in the competition.

With time, the condition of machines and equipment will experience a decrease in their ability to operate. In addition to the problem of engine age as an internal factor, several external factors affect the engine's ability to perform (Rifaldi, 2020). Several factors include errors in running the machine, inputting raw materials that are not as planned, and also other causes that result in the machine not being able to work as normal. To maintain the machine so that it is always optimal, it is necessary to take good care (Syahruddin, 2012). Every company must have problems with the machine because there is damage to the machine, which is called downtime. The occurrence of downtime is usually caused by poorly maintained machines, incorrect operation, and so on (Poniman et al., 2015). The company must immediately overcome the downtime problem that occurs in the production machine because if it is too frequent, it can have an impact on the machine, such as the machine will experience a breakdown, which of course, the company does not want it (Wahono & Sukmono, 2012).

To maintain the performance and condition of the machine so that it is always optimal during the production process, good and scheduled maintenance is needed and increases the effectiveness of the machine. Maintenance is an activity carried out to maintain a machine so that it can continue to work optimally as in its initial condition (Ardian, 2010).

PT. Indah Kiat Pulp & Paper (PT. IKPP) is a company engaged in the pulp & paper manufacturing industry. PT. IKPP has several production processes within the company's scope, such as making pulp, paper rolls, boxes, wrapping, and paper reams of various sizes. Of course, the machine's role is very large in achieving the maximum production target to help the company survive and even become the winner of business competition with other similar companies. One of the factors supporting the manufacturing industry's success is the smooth production process. So that if the production process is smooth, the use of effective

machinery and equipment will produce quality products, the right time for completion of manufacture, and low production costs (Hamid & Purnomo, 2018)

In the field observation with the FM (Finishing Maintenance) unit leader, the data obtained from lose time on biolematik machines is still high and affects machine productivity. Some of the causes of losing time on biolematik machines are damage to machine parts, and there are also some human errors, such as errors in entering machine setting parameters and raw material errors, it has an impact on machine productivity..

LITERATURE REVIEW

Productivity is an activity in producing an item or product using the most effective and efficient way possible. Productivity is very important in daily life to raise the standard of living.

To maintain machine productivity, proper and scheduled maintenance is needed. Maintenance is an activity to maintain or keep an object working according to its function and is carried out intentionally (consciously) on the part of the facility by making specific improvements to achieve results following the plan (Hamid & Purnomo, 2018)

To determine a machine's effectiveness level, it is necessary to calculate the OEE value. According to Nakajima in (Alvira et al., 2015) OEE is a method to measure the effectiveness of the use of equipment/machines by including various points of view in the calculation process.

OEE is a comprehensive measure that identifies the level of productivity of a machine or equipment and its theoretical performance. This measurement is essential to evaluate and improve the right way to ensure an increased productivity of using machines or equipment. This OEE measurement is based on the measurement of three main ratios: Availability Rate, Performance Rate, and Rate of Quality (Gelisman & Ginting, 2016).

The international standard for the OEE value is 90% for the Availability Rate value, 95% for the Performance Rate value, 99% for the Rate of Quality value, and the OEE value 85%. To determine the effectiveness of one machine, it is necessary to measure the effectiveness of a machine to reduce the amount of loss. The six big losses from Downtime losses are equipment failure (breakdown loss) and setup and adjustment loss. Speed losses are idling and minor stoppages and reduce speed loss. Defect losses, namely process defects loss, and reduced yield loss (Wibisono, 2021).

To determine the Losses factor that has the most influence on decreasing the effectiveness of the machine, a cumulative percentage calculation is carried out, and a Pareto diagram is made. A Pareto chart is a bar graph that shows problems in order of the number of failures. The problem that occurs the most is shown by the first bar graph, which is the highest and placed on the far left until the problem with the least number of problems is addressed by the last bar graph, which is the lowest on the far right.

METHODS

The research framework can be seen in Figure 1.The object of research in pulp and paper production companies. The data used in 2021, the data are loss time and production data.

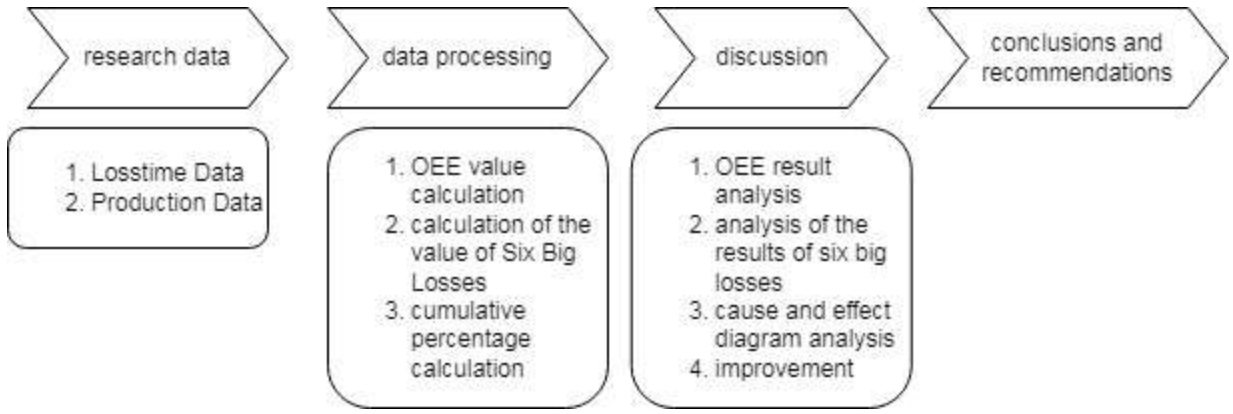

Figure 1. Research framework

RESULT AND DISCUSSION

The company carries out the production process 24 hours every day. Therefore smooth production is significant for the continuity of the production process. Downtime is the time that should be used for the production process, but due to damage, production must stop to make repairs. Downtime is a loss caused by the loss of production because the machine is damaged and makes the machine have to stop to make repairs. In table 1, the downtime data can be seen in the following table :

Table 1. Biolematik machine Losetime time data

Losetime Period 2021 (Minute)							
No	Month	Available Time	planned downtime	Break Down	Set & Adjustment	unschedule shutdown	Total Loss Time
1	January	44040	1050.95	2581.18	6558.65	2689.1	12879.88
2	February	40320	475.53	2216.35	6733.61	679.98	10105.47
3	March	44640	651.09	3958.6	6193.68	80	10883.37
4	April	41820.02	755.63	3230.15	7273.16	0	11258.94
5	May	38175.06	1579.04	2592.14	6429.45	35	10635.63
6	June	34080.14	305.04	2607.27	5224.12	30	8166.43
7	July	27710.29	355	1167.04	4191.13	135	5848.17
8	August	2640.56	0	80	236.47	0	316.47
9	September	19863.82	210.04	1478.49	3418.88	0	5107.41
10	October	18990.35	175	1380.05	2932.72	40	4527.77
11	November	38670.06	510.03	3074.43	6142.79	110	9837.25
12	December	40480.41	340.07	2063.11	5306.4	0	7709.58

The calculation of the OEE value is obtained from the multiplication of the availability rate, performance rate, and quality values. Before calculating the OEE value, it is necessary to calculate the three factors. After getting the results of the OEE value, it is continued by calculating the value of the losses that have the most significant effect on the failure.

Availability is a ratio that shows the available time for machine or equipment operating activities. The formula used to calculate the availability rate value is a:

$$\boldsymbol{Availability} = \frac{\boldsymbol{Operating\ Time}}{\boldsymbol{Loading\ Time}} \boldsymbol{x100\%}$$

Table 2. Availability Rate Value

Month	Operating time (minute)	Loading Time (minute)	Availability Rate
January	33849.22	42989.05	78%
February	30894.51	39844.47	77%
March	33836.63	43988.91	76%
April	30561.08	41064.39	74%
May	27574.43	36596.02	75%
June	25943.71	33775.1	76%
July	21997.12	27355.29	80%
August	2324.09	2640.56	88%
September	14756.41	19653.78	75%
October	14502.58	18815.35	77%
November	28942.81	38160.03	75%
December	32770.83	40140.34	81%

Performance ratio is a ratio that describes the ability ofequipment to produce goods. To calculate the performance rate, valu in table 3,the following formula :

$$\boldsymbol{Performance\ Efficiency} = \frac{\boldsymbol{Input\ x\ Ideal\ Cycle\ Time}}{\boldsymbol{Operation\ Time}} \boldsymbol{x\ 100\%}$$

P-ISSN 2722-8150
E-ISSN 2722-8142

Table 3. Performance Rate Value

Month	Production (Rim)	Cycle Time (Minute/Rim)	Operating time (Minute)	Performance Efficiency (%)
January	1793983.46	0.016	33849.22	84.79%
February	1662900.182	0.017	30894.51	91.50%
March	1904514.357	0.017	33836.63	95.68%
April	1514625.929	0.019	30561.08	94.16%
May	1384680.513	0.018	27574.43	90.38%
June	1590028.177	0.015	25943.71	91.93%
July	1174814.392	0.018	21997.12	96.13%
August	71497.74047	0.031	2324.09	95.36%
September	735540.5614	0.019	14756.41	94.70%
October	757615.6105	0.018	14502.58	94.03%
November	1428554.573	0.019	28942.81	93.77%
December	1960071.7	0.016	32770.83	95.69%

The rate of quality is a ratio that describes the number of better products to the total number of products processed, as seen in table 4. To calculate the rate of quality value, can use the following formula.

$$\boldsymbol{Rate\ of\ Quality} = \frac{\boldsymbol{Input - \ Quality\ Defect}}{\boldsymbol{Production\ Input}} \boldsymbol{x100}\%$$

Table 4. Rate of quality Value

Month	Production (Rim)	Reject Product (Rim)	Rate of Quality (%)
January	1793983.46	91508.10	94.90%
February	1662900.18	87627.02	94.73%
March	1904514.36	97034.51	94.91%
April	1514625.93	92721.60	93.88%
May	1384680.51	75105.99	94.58%
June	1590028.18	68419.05	95.70%
July	1174814.39	49031.48	95.83%
August	71497.74	3309.82	95.37%
September	735540.56	34337.93	95.33%
October	757615.61	34501.50	95.45%
November	1428554.57	73671.73	94.84%
December	1960071.70	84604.35	95.68%

The calculation of the OEE value is needed to determine whether the machine/equipment has been producing maximally or not; it can be seen in table 5. The mathematical formula of overall equipment effectiveness (OEE) is formulated as follows:

Table 5. OEE Value

Month	*Availability Rate*	*Performance Efficiency*	*Rate of Quality*	OEE
January	78%	84.79%	94.90%	62.76%
February	77%	91.50%	94.73%	66.74%
March	76%	95.68%	94.91%	69.02%
April	74%	94.16%	93.88%	65.41%
May	75%	90.38%	94.58%	64.11%
June	76%	91.93%	95.70%	66.86%
July	80%	96.13%	95.83%	73.70%
August	88%	95.36%	95.37%	80.03%
September	75%	94.70%	95.33%	67.71%
October	77%	94.03%	95.45%	69.11%
November	75%	93.77%	94.84%	66.70%
December	81%	95.69%	95.68%	74.16%

Six Big Losses

The key to the success of a production process is to minimize the six big losses. In an effort to increase the productivity of biolematik machines, it is necessary to minimize the six big losses factors as follows:

1. Equipment failure is a loss caused by damage to machinery/equipment. To calculate the value of equipment failure can be seen as follows:

$$Equipment\ Failure = \frac{Breakdown}{Loading\ Time} x100\%$$

$$Equipment\ Failure = \frac{2581.18}{42989.05} \text{x}100\%$$

$$Equipment\ Failure = 6\%$$

2. Set up and adjustment is a loss caused by the installation and adjustment of parts. The following can be seen the calculation of the value of set up and adjustment.

$$Setup\ and\ Adjustment = \frac{Setup\ and\ Adjustment\ losses}{Loading\ Time} \text{x}100\%$$

$$Setup\ and\ Adjustment = \frac{6558.65}{42989.05} \text{x}100\%$$

$$Setup\ and\ Adjustment = 15{,}25\%$$

3. Idling and minor stoppage are losses caused by the engine stopping momentarily or operating without producing a product. The calculation of idling and minor stoppage can be seen as follows.

$$Idling\ and\ minor\ stoppages = \frac{Non\ Productive\ Time}{Loading\ Time} \text{x}100\%$$

$$Idling\ and\ minor\ stoppages = \frac{2689{,}1}{42989{,}05} \text{x}100\%$$

$$Idling\ and\ minor\ stoppages = 6{,}26\%$$

4. Reduced speed is a loss caused by low operating speed, as seen in the following calculation.

$$Reduced\ Speed\ Losses = \frac{actual\ cycle\ time - (ideal\ cycle\ time\ x\ Product\ total)}{Loading\ Time} \text{x}100\%$$

$$Reduced\ Speed\ Losses = \frac{33849 - (0{,}016x\ 1793983)}{42989{,}05} \text{x}100\%$$

$$Reduced\ Speed\ Losses = 11{,}97\%$$

5. Defects in process are losses caused by product defects. The following is the calculation of defects in process

$$Defect\ Process = \frac{Ideal\ cycle\ time\ x\ Total\ Rework}{Loading\ Time} \text{x}100\%$$

P-ISSN 2722-8150
E-ISSN 2722-8142

$$Defect\ Process = \frac{0{,}016\ x\ 91508{,}10}{42989{,}05} \text{x}100\%$$
$$Defect\ Process = 3{,}41\%$$

6. Reduced yield is a loss caused by waiting for the production process to run stable from the start. The reduced yield calculation can be seen as follows.

$$Reduced\ Yield = \frac{Ideal\ cycle\ time\ x\ Total\ Yield}{Loading\ Time} \text{x}100\%$$
$$Reduced\ Yield = \frac{0{,}016\ x\ 46914{,}79}{42989{,}05} \text{x}100\%$$
$$Reduced\ Yield = 1{,}75\%$$

Pareto chart serves to determine the cumulative number of losses that occur, can see in figure 2. By knowing the cumulative amount, it can be determined which losses are the priority in future improvements. The following is the result of calculating the cumulative percentage can see in table 6.

Table 6. Cumulative Percentage

No	Failure Type	*Time Losses*	Percentage (%)	Cumulative Percentage(%)
1	*Set up and Adjustment*	60641.06	45.47%	45.47%
2	*Equipment Failure*	26428.81	19.82%	65.29%
3	*Reduced Speed Losses*	21571.95	16.18%	81.47%
4	Process Defect	13755.34	10.31%	91.78%
5	*Reduced Yield*	7163.03	5.37%	97.15%
6	*Idling and minor stoppages*	3799.08	2.85%	100.00%
	Total	133359.27	100.00%	

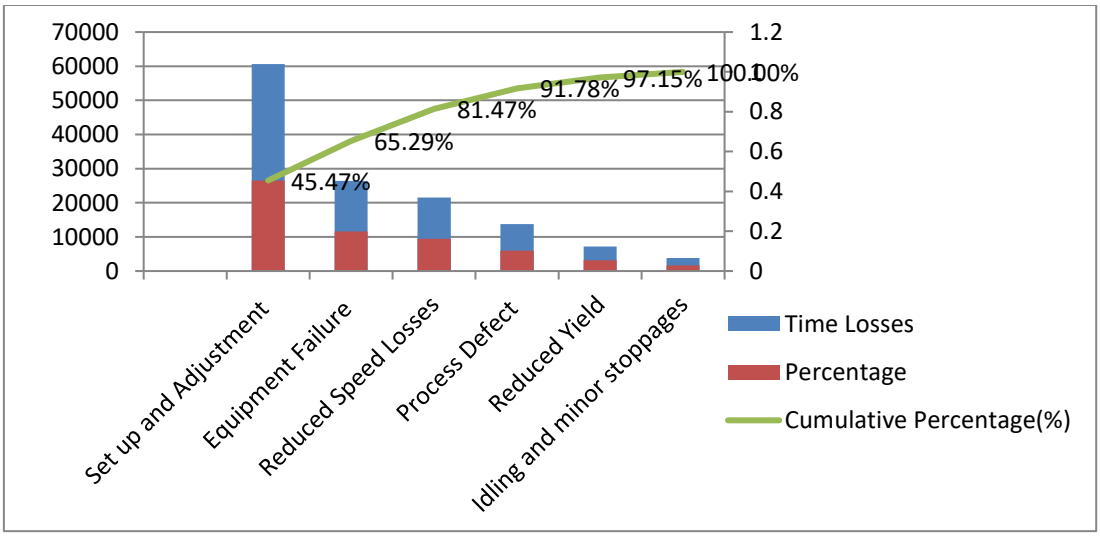

Figure2. Pareto Diagram

OEE is a product of TPM which aims to calculate the level of effectiveness of a machine in the production process. This study was carried out on a biolematik machine thatwas classified as still in a new condition compared to other machines that are decades old. This OEE calculation includes the production line's time, performance, and quality. The OEE value set according to the standard is 85%. The following is a graph of the results of calculating the OEE value of a biolematik machine.

P-ISSN 2722-8150
E-ISSN 2722-8142

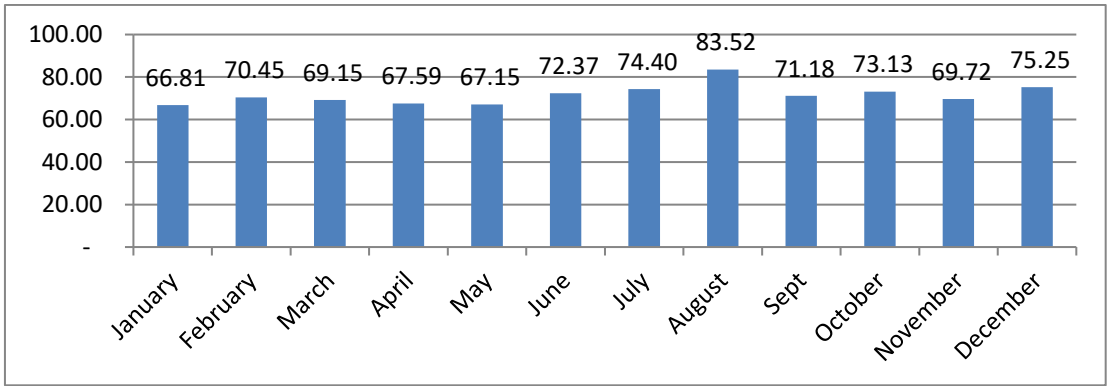

Figure 3. OEE value graphic

Six significant losses is a calculation to determine which factor has the most important influence on the productivity of a machine which can be seen in the measure of the OEE value. The following are the results of the analysis of the six big losses that have been carried out in table 7:

Table 7. Six Big Losses Cumulative value

No	Failure Type	Total Time Losses	Persentase (%)
1	Set up and Adjustment	60641.06	45.47%
2	Equipment Failure	26428.81	19.82%
3	Reduced Speed Losses	21571.95	16.18%
4	Process Defect	13755.34	10.31%
5	Reduced Yield	7163.03	5.37%
6	Idling and minor stoppages	3799.08	2.85%

From the Pareto diagram in figure 3, it can be seen that the losses that most affect the effectiveness of the biolematik machine are set up and adjusted with a time of 60641.06 minutes, Equipment Failure with a time of 26428.81 minutes, and Reduced Speed with a time of 21571.95 minutes. Set up and adjustment is the total loss caused by machine settings, order changes, consumptive part changes, Equipment Failure is Loss caused by damage to parts/equipment and Reduced Speed is failure due to a decrease in engine speed.

To find the cause of the decrease in the productivity of the biolematik machine caused by the setup and adjustment factor, Equipment Failure and Reduced Speed, an analysis is carried out using a causal diagram. Suggestions for improvement to minimize failures in the set up and adjustment factors, Equipment Failure and Reduced Speed Losses can be seen in the following table.

Table 8. ***Proposed improvements to Set Up and Adjustment Losses***

No	Problem factor	Source	Problem Solving
1	Man/Operator	Lack of Understanding of Machine Operation	1. Provide training to operators on a regular basis.
			2. Directly supervise the operator
		Operators out of focus	1. set the right break time.
			2. Hold a competition between shifts to increase the spirit of competition.

No	Problem factor	Source	Problem Solving
2	Machine	there is no schedule for changing consumptive parts	1. make a list of replacement parts and when they will be replaced next. 2. Check the availability of parts in the warehouse
		setting error	1. Make a standard size setting machine. 2. Always re-check after setting.
3	Environment	Dirty machine area	1. Do cleaning every new roll change. 2. Doing cleaning every shift change.
4	Material	high curling roll	1. check the quality of the roll to be cut.
		box material is too soft	1. check the quality of the box material before use.
5	Method	incomplete tools	1. complete the required tools 2. create a handover list of tools. 3. make supervisors as PIC tools
		parameter input error	1. Create standard parameters for each product order. 2. Each shift head must accompany the operator during the change of machine parameters.

Table 9. ***Proposed improvements Equipment Failure Losses***

No	Problem factor	Source	Problem Solving
1	Man/Operator	Skill Difference	provide the necessary training for field work.
		Limited Number of Personnel	Make a note of every damage and repairs made to make repairs easier
2	Machine	Less preventive	manage the division of labor personnel as effective and efficient as possible.
		Spare Part Limitations	establish a routine preventive schedule.
3	Environment	Dirty machine area	Make a list of parts to be replaced and make a schedule for part replacement during the shutdown.
4	Material	Part material is not good	make a list of available spare parts and not to make it easier to order.
		Part order process time	do cleaning after every preventive activity.
5	Method	Difficulty in analyzing problems	order original or fabricated parts using good materials.
		There is no fixed preventive schedule	create parts ordering categories, such as urgent parts, consumptive parts, and parts for stock.

Tabel 10. ***Proposed improvements Reduced Speed Losses***

No	Problem factor	Source	Problem Solving
1	Human/Operator	Operators are not responsive	provide training to improve teamwork in the field
2	Machine	High Vibration	provide direction regarding work responsibilities
3	Environment	no cleaning schedule	Perform preventive routine and scheduled
4	Raw material	base paper quality is not good	make a shutdown schedule to replace worn parts
		soft box material	carry out preventive cleaning of the machine
5	Method	belt installation is not the same length	do cleaning on the machine from the rest of the raw materials
		rough cut	check the quality of the base paper before cutting

REFERENCES

Alvira, D., Helianty, Y., & Prassetiyo, H. (2015). Usulan Peningkatan Overall Equipment Effectiveness (Oee) Pada Mesin Tapping Manual Dengan Meminimumkan Six Big Losses. *Jurnal Itenas Bandung*, *03*(03), 240–251.

Ardian, A. (2010). Perawatan dan Perbaikan Mesin. *Kementrian Pendidikan Nasional Universitas Yogyakarta Teknik Mesin*, *December*, 1–77.

Gelisman, J., & Ginting, E. (2016). *Implementasi Total Produktive Maintenance Dengan Metode Overall Equipment Effectiveneess (OEE) Untuk Menentukan Maintenance Strategi Pada Mesin Digester Plant (Studi Kasus PT. Toba Pulp Lestari, Tbk)*.

Hamid, A., & Purnomo, S. A. (2018). Analisa Efektivitas Kinerja Mesin Turning Star SB-16 Dengan Metode Total Productive Maintenance (TPM) di PT Mitsuba Indonesia Dosen Teknik Industri Universitas Pamulang. *Jitmi*, *1*(1), 50–63.

Poniman, P., Cundara, N., & Afma, V. M. (2015). Menurunkan Cost of Quality Pada Proses Cutting and Crimping Di Mesin Oprrs 6w Pada PT. Sumitomo Wiring System Batam Indonesia. *PROFICIENSI: The Journal of the Industrial Engineering Study Program*, *3*(2).

Rifaldi, M. R. (2020). Overall Equipment Effectiveness (OEE) Pada Mesin Tandem 03 Di PT. Supernova Flexible Packaging. *Jurnal Rekayasa Industri (Jri)*, *2*(2), 67–77. https://doi.org/10.37631/jri.v2i2.180

Syahruddin. (2012). Analisis Sistem Perawatan Mesin Menggunakan Metode Reliability Centered Maintenance (RCM)Sebagai Dasar Kebijakan Perawatan yang Optimal di PLTD "X." *Jurnal Tekhologi Terpadu*, *1*(7), 42–49.

Wahono, S., & Sukmono, T. (2012). *PENGUKURAN KINERJA MESIN PRODUKSI MENGGUNAKAN METODE OVERALL THROUGHPUT EFFECTIVENESS GUNA MENINGKATKAN HASIL PRODUKSI*. 199–210.

Wibisono, D. (2021). Analisis Overall Equipment Effectiveness (OEE) Dalam Meminimalisasi Six Big Losses Pada Mesin Bubut (Studi Kasus di Pabrik Parts PT XYZ). *Jurnal Optimasi Teknik Industri (JOTI)*, *3*(1), 7–13. https://doi.org/10.30998/joti.v3i1.6130