



Implementation of Total Productive Maintenance with Overall Equipment Effectiveness (Oee) Method to Determine Maintenance Strategy for Digester Plant Machines (Case Study of PT. Toba Pulp Lestari, Tbk)

Juna Gelisman Edward

Faculty of Engineering, University of North Sumatra, Indonesia

ARTICLE INFO

Article history:

Received September 17, 2021

Revised October 07, 2021

Accepted November 28, 2021

Keywords:

Digester Plant
Overall Equipment Effectiveness
Six Big Losses
Total Productive Maintenance (TPM)

ABSTRACT

This study analyzed the implementation of Total Productive Maintenance (TPM) on the machine Digester using Effectiveness Overall Equipment (OEE). Total Productive Maintenance (TPM) is to increase the productivity of the equipment and production equipment with an investment of treatments as necessary to prevent major losses occurred 6 (Six Big Losses). Six Big Losses are causing these losses are: Losses due to damage to the equipment (Breakdown Losses), losses due to the installation of equipment (Set-up and Adjustment losses), losses due to operate without load or paused (Idling and minor stoppages), losses due to the decline production speed (Speed Reduced losses), losses due to product defects in the process (Rework losses), the losses due to the low yield (Yield / Scrap losses). Based on the results of the calculation of OEE values in the machine Digester during the month of June 2015 - May 2015 obtained availability value = 97.6% meet the standard JIPM by 90%, performance efficiency = 95.22% meet the standard JIPM by 95%, quality of rate = 97.00% this condition is not JIPM meet the standards of 99%, and the yield value of OEE = 90.20% is considered a world-class production. This score is a score that is suitable to serve as a long-term goal. The factor that has the greatest percentage of factor six big losses are idling and minor losses amounted to 50.98%, reduce speed losses of 23.59%, yield/scrap losses 14.49% set up and adjustment of 10.20%, Breakdown losses amounted to 0.78%. and to increase the value of OEE replacement of genuine spare parts are used to replace the damaged spare parts.

This is an open access article under the [CC BY-NC](https://creativecommons.org/licenses/by-nc/4.0/) license.



Corresponding Author:

Juna Gelisman Edward
Faculty of Engineering
University of North Sumatra
Jln. Dr. T. Mansur No.9, Medan City, North Sumatra, 20222, Indonesia
Email: juna@gmail.com

1. INTRODUCTION

Maintenance is an activity to maintain or maintain facilities and machines/production equipment and make repairs or replacements needed so that (Anggoro, 2014) Satisfactory production operating conditions are obtained according to what has been planned (Titin & Chamidatul, 2015). Maintenance of machines or equipment in the industrial/manufacturing world is expected to operate optimally, one of which is by performing maintenance on these machines and equipment (Dewi &

Rinawati, 2015). The stoppage of a process on the production floor is often caused by a problem in the machine/production equipment, for example the machine stops suddenly (Hutahaeen, 2018), decreased production speed of the machine, the length of time for setup and adjustment, the machine produces a defective product and the machine operates but does not produce a product (Alvira et al., 2015). This will cause losses to the company because in addition to reducing the level of efficiency (Rahayu & Susilowibowo, 2014) and the effectiveness of the machine/equipment also results in costs incurred due to the damage. PT. Toba Pulp Lestari, Tbk is a company engaged in the production of wood processing into pulp (Sidabutar, 2019).

In its operation to produce pulp, a digester plant machine is used to cook wood chips to produce processed pulp products (Purnamasari, 2013), this is certainly inseparable from problems related to the effectiveness of the machine/equipment (Saiful et al., 2014). To ensure the continuity of the production process, the company certainly does not expect this to happen (Aangkut, n.d.) damage that can cause huge losses. Therefore, steps are needed to prevent or overcome these problems (Barimbing, 2020). Total productive maintenance (TPM) is the development of the idea of productive maintenance, which is a method of maintaining machinery and equipment (Hanggara, 2014). TPM evolved from a traditional maintenance system that involved all departments and everyone to participate and take responsibility for the (Hamid et al., 2018) maintenance of machinery/equipment. Steps to prevent or overcome these problems in an effort to increase production efficiency are carried out with TPM which uses the Overall Equipment Effectiveness (OEE) method as a tool used to measure and (Dewi & Rinawati, 2015) know the performance of the machine/equipment. This research was conducted to obtain an overview of the suitability of the factors that determine the need for total productive implementation (Fadlilah, 2016) maintenance with the condition of the company and see which of the six big losses is the dominant factor affecting the decrease in the effectiveness of the machine/equipment (Silalahi, 2020). Thus, this paper will provide suggestions for improving the effectiveness of machines/equipment in an effort to increase production efficiency in the company through the implementation of total productive maintenance (Angin et al., 2017).

The objectives of this study are: (1) This study aims to formulate the effectiveness and efficiency of the performance of the digester plant machine using the Overall Equipment Effectiveness (OEE) method (Tanjung et al., 2021). (2) To formulate the factors that give the greatest contribution to the OEE value of the six major losses (six big losses) in the digester plant machine at PT. Toba Pulp Lestari, Tbk (Kurniawan et al., 2021) (3) To find out the repair solutions that can be done by PT. Toba Pulp Lestari, Tbk (Sitompul & Rinawati, 2019).

2. RESEARCH METHOD

2.1 Research Design

The study was carried out according to the level of explanation, namely the level of explanation, the research intends to explain the position of the variables studied and the relationship between one variable and another variable (Darna & Herlina, 2018). Based on this research used is a comparative study. Comparative research is a research that compares (Darna & Herlina, 2018). The study was conducted for more than one sample, or at different times.

2.2 Object of Research

The object under study is the Digester machine located in the area of PT. Toba Pulp Lestari, Tbk. Includes production data, maintenance data, downtime data, Digester machine capacity, and any damage that occurs to the Digester machine and its handling.

2.3 Data Analysis and Troubleshooting

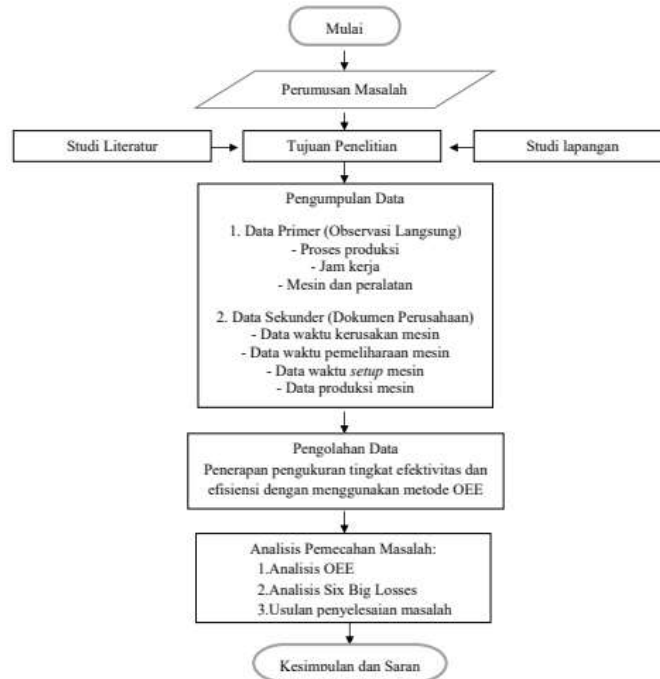


Figure 1. Research methodology

3. RESULTS AND DISCUSSION

3.1. Data Collection Meters

The object of this research is the Digester plant machine located at PT. Toba Pulp Lestari, Tbk. Digester plant machine is a wood chip cooking station to be processed into wood pulp (pulp). It is on this machine that the fiberline production process begins and ends after producing the pulp sheet. Therefore, when there is damage to this machine, it will result in disruption of the production process which has an impact on decreasing production capacity. This must have a bad impact on the company. At PT. Toba Pulp Lestari, Tbk has 15 Digester plant machines where only 13 Digesters (#1,#2,#3,#4,#5,#6,#8,#9,#10,#11,#13,#14 ,#15) which can be operated to cook chips into wood pulp, while 1 Digester machine (#12) is used as a reservoir and circulation of cooking liquid (black liquor) and 1 machine (#7) is not operated because it is damaged. Digester machine number 1 (Digester #1) was selected as the object of research. The purpose of implementing TPM is to minimize the six big losses contained in the Digester machine, so that the maximum effectiveness of the use of the machine in that area can be obtained. So first, measurements are taken to be able to determine the level of effectiveness of the machines/equipment currently used by using the OEE (overall equipment effectiveness) indicator. With the increase in OEE will result in increased efficiency and productivity on the Digester machine. To measure effectiveness using OEE on this machine, data from production reports is needed.

The data used are in the period June 2015 – May 2016, namely: (1) Digester machine downtime data, (2) Planned downtime for the Digester machine, (3) Digester machine setup time data (4) Digester machine production time data (5) Other supporting data in problem solving.

3.2. Data Processing

After all the data is collected, the next step is to process the data.

3.2.1. Availability Calculation

Availability, is the level of availability or readiness of the machine in good condition (in terms of the machine/equipment ready to use) when used at any time. A machine or production equipment with a high level of availability indicates that the machine or equipment is always in a ready-to-use condition if it is used at any time. Availability is the ratio of operation time to its loading time.

Table 1. #1 Digester Machine Availability in the Period June 2015 – May 2016
(Source: Data Processing)

No	Bulan	Loading Time(Jam)	Operating Time (Jam)	Downtime (Jam)	Availability (%)
1	Juni	676.58	666.34	10.24	98.49
2	Juli	647.50	645.15	2.35	99.64
3	Agustus	695.44	684.09	11.35	98.37
4	September	714.00	710.92	3.08	99.57
5	Oktober	744.00	742.50	1.50	99.80
6	Nopember	468.92	418.70	50.22	89.29
7	Desember	716.58	713.25	3.33	99.54
8	Januari	723.87	717.05	6.83	99.10
9	Februari	667.33	653.41	13.92	97.91
10	Maret	733.87	658.67	18.55	97.47
11	April	662.22	658.67	3.55	99.46
12	Mei	700.50	651.35	49.15	92.98
Rata-rata					97.63

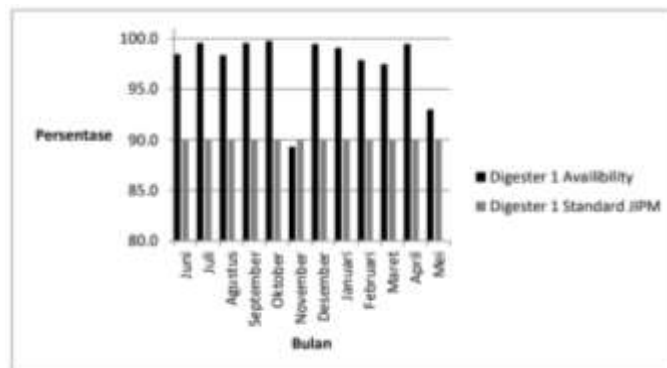


Figure 2. Digester #1 machine Availability Diagram PT. Toba Pulp Lestari, Tbk

From Figure 4.2 above, we can see the comparison between the Availability value of the Digester #1 machine every month against the standard set by JIPM, which is 90%. From the diagram, the November availability value remains the lowest at 89.29% and is below the JIPM standard value. This happens due to low operating time and high downtime. However, although the Availability value in November was low, it was covered because in other months it was relatively high, and the average Availability value for Digester #1 was 97.63%.

3.2.2. Defect Loss

Defect loss is the state of the machine when it does not produce products that comply with the specifications and product quality standards that have been set and scrap, namely losses that arise during the production process have not reached a stable production state when the production process begins until a stable process state occurs. Factors included in

Defect Loss is Rework Loss and Yield/Scrap Loss.

Table 2. Yield Losses calculation results for the period June 2015 – May 2016
Source: Data Processing

No	Bulan	Loading Time (Jam)	Ideal Cycle Time (Jam/Ton)	Reject (Ton)	Yield Losses (%)
1	Juni	676.58	0.567	32.36	2.71
2	Juli	647.50	0.567	32.64	2.86
3	Agustus	659.44	0.567	35.78	2.92
4	September	714.00	0.567	34.66	2.75
5	Oktober	744.00	0.567	36.84	2.81
6	Nopember	468.92	0.567	20.13	2.43
7	Desember	716.58	0.567	35.50	2.81
8	Januari	723.58	0.567	35.34	2.77
9	Februari	667.33	0.567	33.51	2.85
10	Maret	733.87	0.567	37.23	2.88
11	April	662.22	0.567	34.61	2.96
12	Mei	700.50	0.567	33.55	2.72

In table 4.14 it can be seen that the largest yield losses presentation occurred in April due to high reject products in that month with a presentation of 2.96%. While the lowest presentation occurred in November in line with the low number of reject products in that month.

3.3. Data Calculation Analysis

3.3.1. Overall Equipment Effectiveness (OEE) Calculation Analysis

The OEE calculation analysis was carried out to see the effectiveness of the use of the Digester #1 machine in the period June 2015 – May 2016. The OEE measurement of the Digester #1 machine is based on the time, speed and quality factors during the operation of the Digester machine.

Table 3. Digester Machine #1 Achievement Percentage Period June 2015 – May 2016.

No	Bulan	Availability Rate (%)	Performance Efficiency (%)	Rate of Quality (%)	Overall Equipment Effectiveness (%)
1	Juni	98.49	91.83	97.00	87.72
2	Juli	99.64	95.67	97.00	92.47
3	Agustus	98.37	98.90	97.00	94.36
4	September	99.57	92.18	97.00	89.03
5	Oktober	99.80	93.81	97.00	90.81
6	Nopember	89.29	90.89	97.00	78.72
7	Desember	99.54	94.10	97.00	90.86
8	Januari	99.10	93.20	97.00	89.59
9	Februari	97.91	96.97	97.00	92.10
10	Maret	97.47	98.42	97.00	93.06
11	April	99.46	99.35	97.00	95.85
12	Mei	92.98	97.39	97.00	87.84
	Rata-rata	97.63	95.23	97.00	90.02

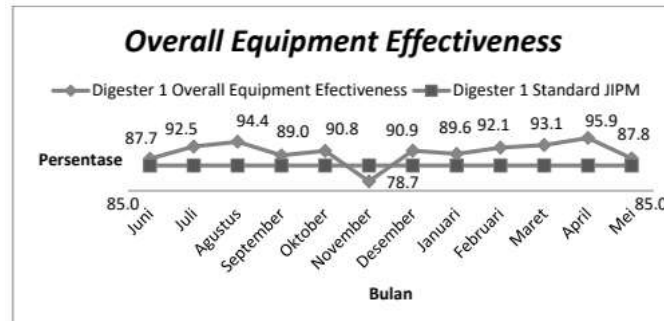


Figure 3. Comparison of the OEE value of Digester #1 for the period June 2015–May 2016 with the Standard JIPM (Japan Institute Of Plant Maintenance).

From the data in table 4.15 and the graph in Figure 4.6 above, we can see that the achievement of the OEE value from June to October was relatively at 85%-90% (satisfactory), and the highest achievement was in April of 95.85%. The achievement of the OEE value can be achieved in that month because the Performance Efficiency of the engine runs well and there are no sudden disturbances, and meets the JIPM (Japan Institute Of Plant Maintenance) standard. So the production is considered perfect working with fast performance and minimal downtime. The graph above also shows a sharp decline in November, namely 78.72%, this is the lowest achievement. And so on December–May was relatively stable again at 85%-90%.

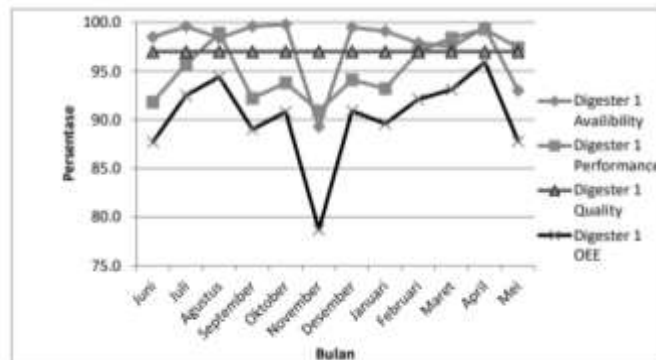


Figure 4. Graph of the Influence of Percentage Availability Rate, Performance Efficiency, Rate Of Qualityproduct, To Digester Machine OEE Value.

In Figure 4.7 above, it can be seen that the pattern shown by the availability value resembles the pattern in the performance efficiency value so that it forms an OEE pattern that is not much different. This shows that the large or small values of availability, performance, and rate of quality have a very good or bad impact on the OEE value. And it can also be seen that the pattern shown in Figure 4.7 is like a cycle where at the beginning (June 2015) the OEE value was at 87.72 and ended (May 2016) at 87.84.

3.4. OEE Six Big Losses Calculation Analysis

Table 4. Percentage of Factors Six Big Losses Digester Machine #1 Period June 2015 – May 2016

No.	Six Big Losses	Total Time Losses (Jam)	Persentase (%)	Persentase Kumulatif (%)
1.	Idling/Minor Stoppages Losses	807.25	50.98	50.98
2.	Reduce Speed Losses	373.59	23.59	74.57
3.	Yield/Scrap losses	228.90	14.49	89.03
4.	Setup and Adjustment Losses	161.44	10.20	99.22
5.	Breakdown Losses	12.33	0.78	100.00
6.	Rework Losses	0.00	0.00	100.00
Total		1583.51	100	100

Table 4.16 shows that the most dominant loss factor in the digester machine is speed losses where idling and minor stoppages losses dominate, namely 807.25 hours or 50.98% and followed by reduce speed losses of 373.59 hours or 23.59% so that speed losses have an impact of 74.57% on the total loss. The lowest losses are breakdown losses of 12.33 or 0.78%. While rework losses are confirmed does not have an impact on the loss of the Digester machine because there is no rework done. For more details can be seen in Figure 4.8 below.

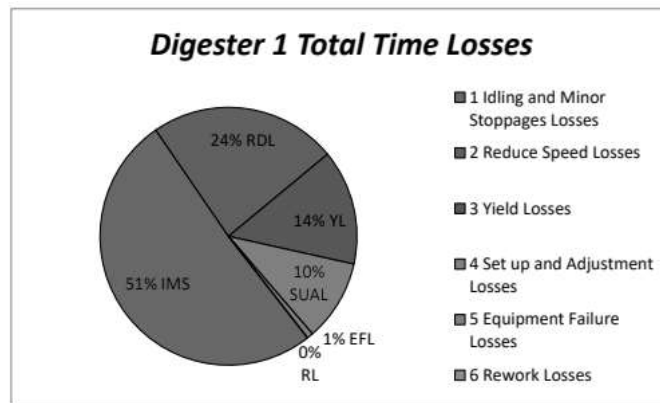


Figure 5. Pie Chart Percentage of Six Big Losses Digester Machine #1

3.5. Cause-and-effect diagram analysis (Fish Bone)

To get the problem handled as quickly as possible, it is necessary to do a cause-and-effect analysis of the factors that cause these problems. This cause-and-effect diagram is often referred to as a fishbone diagram. As shown in Figure 4.9. This analysis was carried out by direct observation in the field, interviews with operators, and also interviews with shift engineers at the factory. The results of these interviews, is one of the possible causes of the difficulty of achieving the expected OEE. Damage that often occurs in digester machines is leakage in the gasket (gasket) on the blow valve, check valve, manual valve, and digester engine pump. The damage that occurs greatly affects the amount of blow digester machine and the high downtime so that it reduces the effective time of machine operation. In the interviews obtained, the parameters that affect the occurrence of these losses are taken, namely: humans, materials, methods, and the environment.



Figure 6. Fishbone Diagram Causes Gasket Leakage Frequency Tall

Table 5. Proposed solution to the problem of Six Big Losses

No.	Faktor – Faktor	Penyelesaian masalah
1.	Manusia a. Penanganan kerusakan.	a. Dibuat pelatihan-pelatihan khusus terhadap teknisi sebagai asset perusahaan.
2.	Material a. Komponen berkualitas buruk. b. Ukuran komponen tidak tepat. c. Getaran tinggi pada <i>blow line</i> .	a. Komponen yang asli harus diusahakan untuk dipakai. b. Melakukan pengecekan persediaan komponen yang sering mengalami kerusakan. c. Menjaga kondisi <i>pipe support</i> dalam kondisi layak operasi.
3.	Metode a. Kerusakan tiba-tiba.	a. Melakukan pemeliharaan secara berkala atau ketika terjadi penurunan kualitas kinerja mesin untuk mencegah waktu <i>breakdown</i> yang tinggi.
4.	Lingkungan a. Kebersihan.	a. Menanamkan kesadaran kepada operator akan kebersihan di area mesin setelah siap melakukan perbaikan mesin.

4. CONCLUSION

Based on the results of the analysis and description of the measurement results of Overall Equipment Effectiveness (OEE) Digester Machine #1 PT. Toba Pulp Lestari, Tbk can be drawn several conclusions, namely: (1) Measuring the effectiveness of the machine using the Overall Equipment Effectiveness (OEE) method at PT. Toba Pulp Lestari, Tbk between June 2015 – May 2016 was 90.2%, this value meets JIPM standards and production is considered world class. Biggest percentage was in April at 95.85% and the lowest was in November at 78.72%. (2) The factors that have the largest percentage of the six big losses are idling and minor losses of 50.98%, reduce speed losses of 23.59%, yield/scrap losses of 14.49%, set up and adjustment of 10.20%, Breakdown losses of 0.78%. (3) The proposed solution to the problem of six big losses on the Digester machine is the original component used to replace the damaged component, this aims to extend the life time of the engine component and prevent sudden damage.

From this research, some suggestions can be given as follows: (1) The need for the provision of spare parts and spare parts for components in maintenance and term maintenance.

(2) The company should also apply TPM to other parts of the company to measure the effectiveness of the company's overall machinery/equipment. (3) Companies need to instill awareness in all employees to be able to take an active role in increasing efficiency and productivity for the company.

ACKNOWLEDGEMENTS

We would like to thank all those who have contributed to this research, so that the research can be carried out properly.

REFERENCES

- AANGKUT, A. E. B. P. A. (n.d.). *Mirsa Afriliya Linda Putri Pratama, 2022. Analisis Kebijakan Efisiensi Biaya Pemeliharaan Alat Angkut Batubara Pada PT. Goden Energy Cemerlang Lestari Di Angsana. Fakultas Ekonomi Universitas Islam Kalimantan Muhammad Arsyad Al Banjari Banjarmasin. Dibawa.*
- Alvira, D., Helianty, Y., & Prassetiyo, H. (2015). USULAN PENINGKATAN OVERALL EQUIPMENT EFFECTIVENESS (OEE) PADA MESINTAPPING MANUAL DENGAN MEMINIMUMKAN SIX BIG LOSSES. *Reka Integra*, 3(3).
- Anggoro, S. (2014). Pengembangan Sistem Manajemen Perawatan Forklift Dengan Pendekatan Reliability Centered Maintenance (Rcm) Berbasis Oracle Alert System (Studi pada PT Gajah Tunggal Tbk Tangerang). *Jurnal Operations Excellence: Journal of Applied Industrial Engineering*, 6(2), 268897.
- Angin, J. B. P., Manurung, E. D., & Siregar, A. H. (2017). Penerapan Total Productive Maintenance dengan menggunakan metode OEE pada turbin uap Type C5 DS II-GVS. *J. Energi Dan Manufaktur*, 10(1), 29–36.
- Barimbing, Y. T. P. S. (2020). *Langkah-Langkah Strategi Pemerintah Kecamatan Dalam Pencegahan Penyebaran Covid-19 Di Kecamatan Habinsaran Kabupaten Toba.*
- Darna, N., & Herlina, E. (2018). Memilih Metode Penelitian Yang Tepat: Bagi Penelitian Bidang Ilmu Manajemen. *Jurnal Ekologi Ilmu Manajemen*, 5(1), 287–292.
- Dewi, N. C., & Rinawati, D. I. (2015). Analisis Penerapan Total Productive Maintenance (Tpm) dengan Perhitungan Overall Equipment Effectiveness (Oee) dan Six Big Losses Mesin Cavitec PT. Essentra Surabaya (Studi Kasus PT. Essentra). *Industrial Engineering Online Journal*, 4(4).
- Fadlilah, P. (2016). *Perencanaan Total Productive Maintenance (TPM) Menggunakan Six Big Losses dan Overall Equipment Effectiveness (OEE) pada Lini Z di PT. Pindad Turen. Universitas Brawijaya.*
- Hamid, A. A., Sewaka, S., & Purnomo, A. (2018). JANALISA EFEKTIFITAS KINERJA MESIN TURNING STAR SB-16 DENGAN METODE TOTAL PRODUCTIVE MAINTENANCE (TPM) DI PT. MITSUBA INDONESIA. *JITMI (Jurnal Ilmiah Teknik Dan Manajemen Industri)*, 1(1), 50–62.
- Hanggara, M. S. (2014). *Pengukuran Efektivitas Mesin Dengan Penerapan Total Productive Maintenance Di PT Singa Perkasa Abadi Palembang. Sekolah Tinggi Teknik Musi.*
- Hutahaean, L. (2018). ANALISA PENERAPAN TOTAL PRODUCTIVE MAINTENANCE TERHADAP PRODUKTIFITAS MESIN DRYER TWIND MENGGUNAKAN METODE OVERALL EQUIPMENT EFFECTIVENESS DI PT. XYZ. *Ratih: Jurnal Rekayasa Teknologi Industri Hijau*, 1(1), 12.
- Kurniawan, M., Ramadhan, W. A. R., & Effendi, U. (2021). PENGUKURAN EFEKTIVITAS MESIN PRODUKSI GULA DI PG KREMBONG SIDOARJO. *Jurnal Teknologi Pertanian*, 22(1), 57–68.
- Purnamasari, R. (2013). *ANALISIS ACTIVITY BASED MANAJEMEN DALAM PENINGKATAN EFISIENSI BIAYA PRODUKSI PADA SEKSI PULP MAKING-9 PT. INDAH KIAT PULP AND PAPER PERAWANG. Universitas Islam Negeri Sultan Syarif Kasim Riau.*
- Rahayu, E. A., & Susilowibowo, J. (2014). Pengaruh perputaran kas, perputaran piutang dan perputaran persediaan terhadap profitabilitas perusahaan manufaktur. *Jurnal Ilmu Manajemen*, 2(4), 1444–1455.
- Saiful, S., Rapi, A., & Novawanda, O. (2014). Pengukuran Kinerja Mesin Defekator I dengan Menggunakan Metode Overall Equipment Effectiveness (Studi Kasus pada PT. Perkebunan XY). *Journal of Engineering and Management in Industrial System*, 2(2).
- Sidabutar, L. (2019). *EVALUASI SISTEM PENGENDALIAN INTERN PERSEDIAAN BAHAN BAKU PADA PT. TOAB PULP LESTARI Tbk PORSEA TOBASA.*
- Silalahi, R. R. (2020). *USULAN PENERAPAN TOTAL PRODUCTIVE MAINTENANCE (TPM) UNTUK MENINGKATKAN KINERJA MESIN UJI TARIK JTM-200HS HYDRAULIC DENGAN METODE OVERALL EQUIPMENT EFFECTIVENESS (OEE)(STUDI KASUS: BALAI BESAR TEKNOLOGI KEKUATAN STRUKTUR (B2TKS)-BPPT. Institut Teknologi Indonesia.*
- Sitompul, B. G., & Rinawati, D. I. (2019). ANALISIS OVERALL EQUIPMENT EFFECTIVENESS (OEE) PADA

- MESIN DIGESTER DAN PENDEKATAN 5 WHYS UNTUK PERBAIKAN PADA PT TOBA PULP LESTARI, Tbk.(Studi Kasus: PT TOBA PULP LESTARI, Tbk.). *Industrial Engineering Online Journal*, 8(1).
- Tanjung, F. A. A., Nasution, F. A. K., & Irwan, A. (2021). ANALISIS PENERAPAN PERAWATAN PADA MESIN DIGESTER DENGAN METODE OVERALL EQUIPMENT EFFECTIVENESS (OEE) PT. XYZ. *JiTEKH (Jurnal Ilmiah Teknologi Harapan)*, 9(2), 82–90.
- Titin, T., & Chamidatul, I. (2015). Analisa Peningkatan Mutu Pemeliharaan Mesin Terhadap Kelancaran Proses Produksi Pada Perusahaan Dolomite. *Jurnal Ekbis*, 13(1), 6-Halaman.