Available online at: http://publikasi.mercubuana.ac.id/index.php/ijiem

IJIEM (Indonesian Journal of Industrial Engineering & Management)

ISSN (Print) : 2614-7327 ISSN (Online) : 2745-9063

Effort to Improve Overall Equipment Effectiveness Performance with Six Big Losses Analysis in the Packaging Industry PT BMJ

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ARTICLE INFORMATION

Article history:

Received: 10 October 2021
Revised: 14 November 2021
Accepted: 21 December 2021

Category: Research paper

Keywords:
Overall equipment effectiveness
Six big losses
Productivity
Causal diagram

ABSTRACT

Increasing productivity is very important for companies to gain success in their business processes. This paper describes a case study of a manufacturing company that produces packaging products. PT BMJ is one of the companies engaged in the packaging industry. Low productivity and increased product demand for Offset machines becomes quite an important issue in the company, so that it becomes the objects of this research. Overall Equipment Effectiveness (OEE) is one of the methods that can measure machine effectiveness with three assessment factors, namely: availability, performance, and quality. Measurement of the OEE value and analysis of six big losses are carried out as an effort to increase the OEE value of machines and improve the production system in the company. The root cause of the problem is identified by using a causal diagram to be able to provide several suggestions for improvements. Based on the results comparison of OEE value before and after the implementation of improvement on the Offset machine, these improvements can increase the OEE value by 7.13% in two month implementation. Although the increase in OEE has not yet reached the criteria for World Class OEE, the proposed improvement has been able to reduce six big losses and increase the value of OEE.

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1. INTRODUCTION

Industry competition encourages companies to look for alternatives to increase company profits. One of the alternatives is to make efficiency and continuous improvement in the production system. Increasing productivity is very important for companies to gain success in their business processes. The main factors of production needed by an organization in order to operate optimally are man, machines, money, methods, materials and information known as 5M+I. In general, problems with production facilities that cause production to be interrupted or stop at all can be categorized into three factors, namely humans, machines, and the environment. These three things can affect one another (Triwardani et al., 2013). To increase productivity can be done by increasing the effectiveness of the machine. The effectiveness of a machine is a condition and the ability to succeed in a machine to produce products as desired. It is important to increase the effectiveness of the machine so that the machine can be used optimally.

PT BMJ is one of the companies in the packaging industry that produces packaging products. The high demand for products at PT BMJ is the main reason to increase productivity by using machines as effectively as possible and with high machine performance so that these demands can be fulfilled. In addition, the condition of the age of the machine that is no longer young can certainly result in a lack of effectiveness of machine performance. So, it is necessary to make some improvement efforts to improve machine performance so that the machine can operate optimally. Total Productive Maintenance is a planning system to increase the quantity and quality of production through the study of the effectiveness of machines, equipment, processes, and employees in a company (Nakajima, 1988).

One of the basic measurements related to TPM is Overall Equipment Effectiveness (OEE), which is a performance measurement that is appropriate for the overall effectiveness of equipment to increase productivity (Stamatis, 2010). The OEE method is used as an initial calculation to find out how much the value of the machine's effectiveness with using historical production data from the company (Tobe et al., 2017). OEE measurement is based on three main factors, namely: availability, performance, and quality. Referring to the global international standards issued by the JIPM (Japanese Institute of Plant Maintenance) for measurement OEE, the minimum value for the availability level is 90%, 95% for the performance level, and 99% for the quality level and the total percentage of OEE is 85% (Djunaidi & Natasya, 2013). The stages of the DMAIC pattern can be followed, generalized and applied in improving OEE and using lean tools at each of these stages (Chiarini, 2015).

Six Big Losses are six losses that must be avoided by any company that can reduce the effectiveness of a machine (Nakajima, 1988). Six Big Losses are usually categorized into three things, namely downtime, speed losses, and defects. Seeing this, we need a method that can solve the problem appropriately so that the effectiveness of tools and machines can be used optimally. One method that is widely used is OEE.

Based on the existing problems, a proposed solution is needed by conducting analysis and improvement efforts so that the predetermined targets are achieved. The use of the OEE measurement method and analysis of the six big losses that occur is expected to find the causes of productivity problems related to machine production performance. Thus, it is expected to reduce the incidence of losses in order to improve machine performance.

2. LITERATURE REVIEW

Overall Equipment Effectiveness is a method used to measure the effectiveness of a facility or machine condition in operation (Herwindo et al., 2013). Based on the literature study on OEE implementation that has been carried out (Atikno & Hardi Purba, 2021), from several journals that have been reviewed, it was found that OEE is mostly used in the manufacturing industry sector. Rahman and Perdana stated that the OEE value of 50% is an acceptable amount (Rahman & Perdana, 2019). However, in order to become a profitable company, it is recommended to have an OEE value of at least 85% with the composition of the OEE factor as in Table 1 below (Wijaya & Widyadana, 2015).

Table 1. OEE value standard

Factor	Score
Availability Rate (A)	≥90%
Performance Rate (P)	≥95%
Quality Rate (Q)	≥99%
OEE	≥85%

The calculation of the OEE value from Availability Rate, Performance Rate, Quality Rate, to the percentage of OEE is obtained from the formula below (Hermanto, 2016). The Overall Equipment Effectiveness (OEE) method is a total measurement of performance related to Availability, Performance, and Quality with the formula in Equation 1 below:

$$OEE = A \times P \times Q \quad (1)$$

where

A Availability Rate

P Performance Rate

Q Quality Rate

Availability is the amount of time available for each machine or equipment operating activity. Components that affect Availability are equipment failure, set-up, and adjustment losses. Equation 2 formula is the calculation of Availability rate, namely:

$$\text{Availability} = \frac{\text{Run Time}}{\text{Planned Production Time}} \times 100\% \quad (2)$$

Performance efficiency is a description of the ability of the equipment to produce products. Performance efficiency has two components, namely idling and minor stoppage losses and reduces speed. Equation 3 formula is the calculation of Performance efficiency, namely:

$$\text{Performance} = \frac{\text{Actual Speed}}{\text{Speed Mac Machine}} \times 100\% \quad (3)$$

Quality rate is supported by two components, namely defect in process and reduce yield. Equation formula 4 is a calculation to determine the Quality rate value, namely:

$$\text{Quality} = \frac{\text{Good Count}}{\text{Total Count}} \times 100\% \quad (4)$$

There are six major disadvantages that cause low performance of the equipment which causes low performance of equipment. These six losses are called the Six Big Losses, which consists of (Kameiswara et al., 2018):

1. Startup Loss

Startup loss categorized as quality loss due to scrap/reject during production startup caused by wrong machine setup, insufficient warm-up process, and so on.

2. Setup/Adjustment Loss

Setup/Adjustment loss categorized as downtime loss due to "stolen" time due to long setup time caused by several things, for example the machine is worn out, below the expected capacity, operator inefficiency, and so on.

3. Cycle Time Loss

Cycle time loss is categorized as speed loss due to a decrease in processing speed caused by several things, for example the machine is worn out, below the capacity written on the nameplate, below the expected capacity, operator inefficiency, and so on.

4. Chokotei Loss

Chokotei loss is categorized as speed loss as unplanned idling and minor stops. Chokotei is a Japanese term in industrial scoope which means small stoppage due to simple cases, not from a serious problem of equipments or machines, need no special handling or adjustment, generally the downtime that occurs less than 1 minute but high frequence. This is because the machine hangs so that it has to be reset, there is cleaning/checking, blocking of sensors, delivery, and so on.

5. Breakdown Loss

Breakdown loss categorized as a downtime loss due to damage to machines and equipment, unscheduled maintenance, and so on.

6. Defect Loss

Defect loss categorized as quality loss due to rejects during production.

Supporting methods are needed to determine appropriate corrective action targets after information on OEE is obtained. Referring to the literature study conducted by Atikno and Hardi Purba (2021), the most widely used method is Six big Losses. Six Big Losses are analyzed to determine the causes of the OEE performance of an equipment so that steps can be taken to improve the machine effectively. From the six losses above, it can be concluded that there are three types of losses related to the production process that must be anticipated, that is:

1. Downtime loss which affect the Availability Rate value
2. Speed loss which affect the Performance Rate value.
3. Quality loss which affect the Quality Rate value.

In previous research, OEE has an important role in determining the effectiveness of the production process in the manufacturing industry. OEE is proven to be able to identify the level of effectiveness of the machine in producing its products (Samad et al., 2011). In addition, the low value of OEE on production machines can be further analyzed using six big losses, so that effectiveness can be increased and can eliminate losses that exist in the company (Suryaprakash et al., 2021). PT BMJ have been calculated the OEE value every month, there is even a daily OEE calculation. However, the cause of the decline in the effectiveness of the machine in the company has not been analyzed further. Therefore, this study uses the analysis of six big losses with the aim of eliminating existing losses and increasing the effectiveness.

3. RESEARCH METHOD

In this study, the object of research is the Offset machine used in the packaging printing process, the company under study is located in Karawang. The observation method used in this research is to observe or directly observe the production process at the company. Furthermore, observations were made on the Offset machine data recording. In conducting this research, the framework used is shown in Fig. 1.

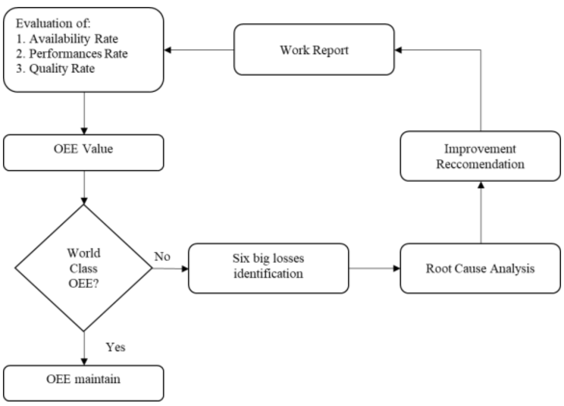

Fig. 1. Research framework

Based on description, in this study the OEE method is used based on three main components, namely Availability Rate, Performance Rate, and Quality Rate. The research was conducted by calculating the OEE value in the period January and February 2020, knowing the six big losses that occurred, making a fishbone diagram to look for problems, proposing improvement ideas then comparing the results before the repair was made and after the repair was made.

4. RESULT AND DISCUSSION

4.1 OEE Value Measurement

Data that will be used to calculate the OEE value of printing machine will be identified and analyzed starting from January to February 2020, the results of the data processing are shown in the form of a diagram in Fig. 2.

Based on Fig. 2, it can be seen that the highest percentage of OEE supporting factors
is found in the Quality rate, which is 95.27%. This shows that the product results from the machine process are of very good quality and the company should still maintain the quality of the product. Meanwhile, other supporting factors that are quite low are the Performance Rate with an average of 42.06% followed by the Availability Rate with an average of 42.39%. The value of these two factors has not reached the ideal standard value for measurement OEE.

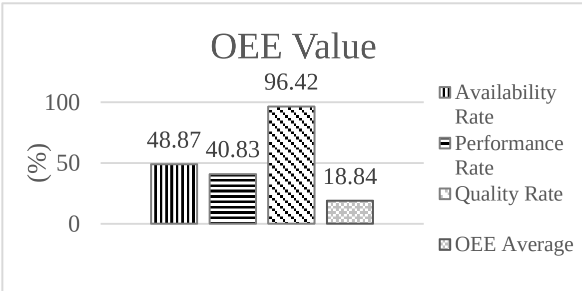

Fig. 2. Percentage of OEE value and factors performance in Jan. - Feb. 2020

The calculation of the OEE value is done by multiplying the Availability, Performance and Quality rate. Based on the calculation results, the OEE value is 16.98%, which is categorized as very low and is below the ideal global standard of 85% OEE. It can be said that the performance of the PT BMJ Offset machine has not been optimal. Therefore, it is necessary to make improvements to increase the value of these factors in order to increase the effectiveness of the machine to be better so that it is said to meet the OEE value standard.

4.2 Six Big Losses Identification and Root Cause Analysis

From the calculation of the results of the OEE value, problem has identified by interview and observe the location. The causes analysis was carried out using some fishbone cause and effect diagram to determine the cause of the low OEE value.

1) Availability Rate

The low Availability value indicates that there is excessive downtime loss on a machine. In this study, the Offset machine experienced 3 main causes of downtime loss, namely: high enough job changeover reaching 50 grades per month with an average time of 4 hours changeover job, electrical failure due to the large Mean Time Between Failure (MTBF) and Mean Time To Repair. (MTTR) to overcome it so that a lot of time is consumed, only for doing maintenance on the Offset machine, and cleaning blankets which is done manually. The value of MTTR and MTBF in January – February 2020 are shown Fig. 3.

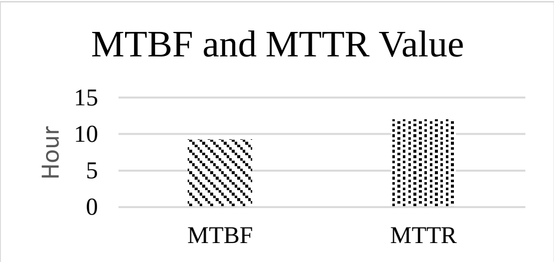

Fig. 3. MTTR and MTBF value in Jan. - Feb. 2020

2) Performance Rate

In January to February 2020, Offset machines can only achieve engine speed performance of 40% which indicates that the machine is less productive. There is flexibility over which to set the threshold between an equipment failure (Availability Loss) and a small stop (Performance Loss). In the above problems, it can be categorized as performance loss because this problem affects machine performance so that the OEE value in the performance rate aspect becomes low.

3) Quality Rate

During the research, the problem of the Offset machine in the quality rate aspect was the result of the production of products that did not meet the criteria. Products produced from the Offset machine often have defects in their production, including: scratch so that the product is categorized as a failed product, is bent at the edges so that the product falls into the reject product category and color defects can make the product with the defect enter the reject product.

Six big losses can be considered as the common factors that cause ineffectiveness on the machine. Based on the OEE value in the January - February 2020 period, it is necessary to evaluate the factors that cause the low OEE value, especially on availability and performance. Therefore, analysis of six big losses is carried out to determine the factors that affect the low value of Overall Equipment Effectiveness (OEE). From the results of the analysis, the factors causing the occurrence of six big losses are shown in Table 2 below.

From the Table 2, it can be known the causes of six big losses in every aspect of the OEE factor which causes the low OEE value. All of these problems, especially the cause of

Table 2. Six big losses identification

No.	Overall Equipment Effectiveness	Six Big Losses	Cause
1	Availability Loss	Breakdown Loss	Electrical Failure
		Set up/Adjustment Loss	Change Over Job Process take long time
			Cleaning Blanket had many troubles
2	Performance Loss	Chokotei Loss	Minor Stoppage occurs quite frequently
		Cycle Time Loss	Production speed engines only reaches 40% speed max
3	Quality Loss	Startup Loss	Mistakes when set-up machine and max water feed's less or more than 40%
		Defect Loss	Hickies, faded color, scumming,

availability loss and performance loss made this offset machine had a seriously real problem when operating. The factors that cause six big losses are caused by humans, machines, and the environment. Factors caused by humans are operators who do not understand and experience fatigue due to repeated activities and compacted production due to pursuing production targets so that their work performance decreases, and there is no visual management on the maintenance party.

Although electrical failure is one of the problem, but the time that had been took from change over process and the cleaning blanket makes many defects are the main problems. Factors caused by the machine are incomplete tools, clamp plate unit 5 often has problems, blankets that are cleaned manually are not completely clean, max water feed is less or more than 40%, and dry ink. Factors caused by the environment are the air conditioner in the room is not fully functional and the occurrence of electrical failure which causes the machine not to operate according to the production schedule. If all of this problems didn’t get improved, the loss of OEE value will continuously increase. Reffering to Chiarini A. (2015), the causes of these problems can be given improvement proposals to increase the OEE value of the machine.

4.3 Proposed Improvement

Some suggestion for improvement proposals in overcoming the causes of the problems that occurred were given to the company. After discussions with the internal company, several suggestions can be implemented in the production process on the related machine. Following are the proposals that have been received and can be reviewed again the results of the implemeplanationtation of the improvements shown in Table 3.

The proposed improvement was implemented in the Offset machine production process starting in early March 2020. For the changeover job, we proposed the single minute exchange of dies to help the process of changeover job get less more time. For electrical failure, we proposed to make visual management and the track records when doing maintenance. This will help the workers to maintain the maintenance schedule. For cleaning blanket, we proposed for changing method into automatic using tissue cleaning system for maximum cleaning. For cycle time loss, we proposed to improve the feeder setting for all factors because the old setting did not worked well. For chokotei loss, we proposed to increase material capacity and make some improvements for the machine rolls. For startup loss, we proposed to simply do regular check on the water feed consistently and making a simple display that the workers understand. This will help the workers to keep maintain the amount of water in the water feed. And for the defect loss, we proposed to do periodic cleaning for the molleton roller and printed ink so all part of the machine was clean and minimize the cause of defect. Comparison of the OEE value before (January - February) and after (March - April) the improvement can be seen in Fig. 4.

Table 3. Proposed improvements to increase OEE value

Root Cause	Proposed Improvement
Changeover Job	Single Minute Exchange of Dies
Electrical Failure	Visual Management Maintenance Records
Cleaning Blanket	Replacement of manual processes to automatic using a tissue cleaning system
Cycle Time Loss	Changes in method improvements in Feeder Settings both indicators in machines, humans, materials and work methods
Chokotei Loss	Increases in material capacity and improvements to machine rolls
Startup Loss	Regular check of water feed consistently and simple display
Defect Loss	Periodic cleaning of the molleton roller and printed ink on the machine

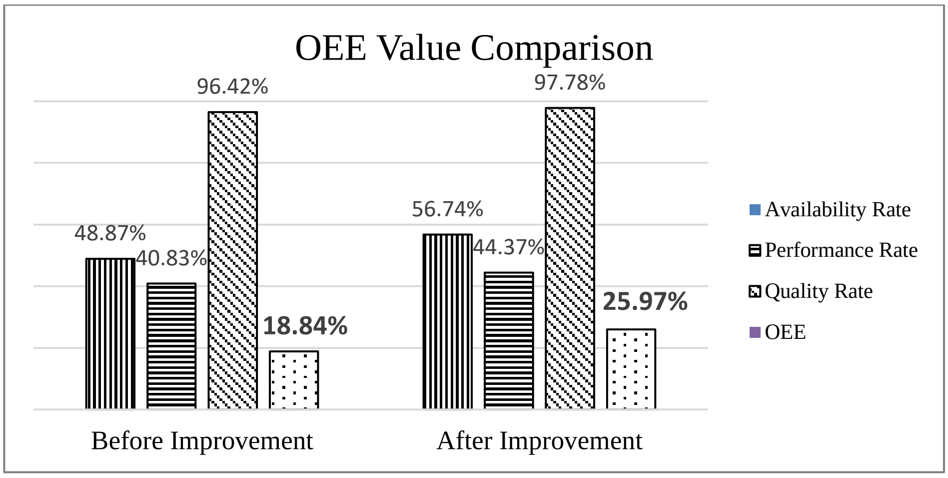

Fig. 4. OEE value comparison

Fig. 4 shows that there was an increase in the value of Availability Rate, Performance Rate, and Quality Rate before and after the implementation of the proposed improvement in the production process on the Offset machine. The result has been able to increase the OEE value by 7.13% from before the repair which was valued at 18.84% to 25.97%. The proposed improvements have been implemented for two months.

5. CONCLUSION

Based on the calculations and analysis carried out, the six big losses identified were breakdown loss caused by electrical failure in the machine, set up / adjustment loss caused by the job changeover process that was too long and cleaning blankets carried out manually experienced many problems, chokotei loss which is caused by minor stoppage quite often, cycle time loss caused by machine production speed only reaches 40% of its maximum speed, startup loss caused by incorrect machine setup including unstable water feed and defect loss caused by defect faded colour, hickies, and scumming. Before repairs were made, the OEE value was 18.84%. In these conditions, the factors that make the OEE value low are the Availability factor of 48.87% and the Performance Rate factor of 40.83%. The results after improvements to increase the OEE value were that the Availability value increased by 7.87%, Performance Rate by 3.54%, Quality Rate by 1.36%, and OEE value by 7.13%. This shows that the improvement efforts made can increase the OEE value on the Offset machine. Suggestions that can be given from the result of research that had been carried out are: continue to monitor and give more efforts to increase the Overall Equipment Effectiveness value on each machine and always provide training to each company so that the improvement are more optimal than before. This is because the company must pay more attention to the condition of the company machine or equipment that have been used by estimating the time of the occurrence of damage through the calculation of the operating life. In addition, what can be done for further research is to be able to calculate OEE on the entire machine so that the optimization of the production process is increasingly identified and can calculate the costs incurred based on the OEE conditions.

REFERENCES

Atikno, W., & Hardi Purba, H. (2021). Sistematika Tinjauan Literature Mengenai Overall Equipment Effectiveness (OEE) pada Industri Manufaktur dan Jasa. *Journal of Industrial and Engineering System*, *2*(1), 29–39. https://doi.org/https://doi.org/10.31599/jies.v2i1.401

Cahyadi, D., Rahmita, I., & Yusuf, Y. (2018). Analisis Perhitungan Overall Equipment Effectiveness (OEE) pada Mesin Rolling Stand 3 (Section Mill) Untuk Meningkatkan Efektivitas Mesin Di PT. Krakatau Wajatama. *Flywheel: Jurnal Teknik Mesin UNTIRTA*, *IV*(2), 82–87. http://dx.doi.org/10.36055/fwl.v2i1.4105

Chiarini, A. (2015). Improvement of OEE performance using a Lean Six Sigma approach: An Italian manufacturing case study. *International Journal of Productivity and Quality Management*, *16*(4), 416–433. https://doi.org/10.1504/IJPQM.2015.072414

Djunaidi, M., & Natasya, R. (2013). Pengukuran Produktivitas Mesin dengan Over-All Equipment Effectiveness (OEE) di PT. Sinar Sosro KPB. Cakung. *Simposium Nasional Teknologi Terapan*, *I*, 33–40. https://doi.org/http://hdl.handle.net/11617/4113

Ekawati, A. Y., & Husni, P. (2018). Analisis Overall Equipment Effectiveness (OEE) pada Proses Pengemasan Primer di Industri Farmasi. *Farmaka*, *16*(1), 27–32. https://doi.org/10.24198/jf.v16i1.16749

Hafiz, K., & Martianis, E. (2019). Analisis Overall Equipment Effectiveness (OEE) pada Mesin Caterpillar Type 3512B di PT. PLN (PERSERO) ULPLTD bagan besar PLTD Bengkalis. *SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin*, *13*(2), 87–96. https://doi.org/10.24853/sintek.13.2.87-96

Hasrul, H., Shofa, M. J., & Winarno, H. (2017). Analisa Kinerja Mesin Roughing Stand dengan Menggunakan Metode Overall Equipment Effectiveness(OEE) dan Failure Mode Effect Analysis (FMEA). *Jurnal INTECH Teknik Industri Universitas Serang Raya*, *3*(2), 55–60. https://doi.org/10.30656/intech.v3i2.879

Hermanto, H. (2016). Pengukuran Nilai Overall Equipment Effectiveness pada Divisi Painting di PT. AIM. *Jurnal Metris*, *17*(2), 97–106. http://ojs.atmajaya.ac.id/index.php/metris/article/view/473

Herwindo, Rahman, A., & Yuniarti, R. (2013). Pengukuran Overall Equipment Effectiveness (OEE) sebagai Upaya Meningkatkan Nilai Efektivitas Mesin Carding (Studi Kasus PT. XYZ). *Jurnal Teknik Industri Universitas Brawijaya*, *2*(5), 919–928. http://jrmsi.studentjournal.ub.ac.id/index.php/jrmsi/article/view/138

Indriawanti, V., & Bernik, M. (2020). Analisis Penerapan Total Productive Maintanance (TPM) dengan Menggunakan Metode Overall Equipment Effectiveness (OEE) pada Mesin Printing. *Jurnal Teknik Industri*, *10*(1), 42–52. http://dx.doi.org/10.25105/jti.v10i1.8388

Kameiswara, R. A., Sulistyo, A. B., & Gunawan, W. (2018). Analisa Overall Equipment Effectiveness (OEE) dalam Mengurangi Six Big Losses pada Cooling Pumpblower Plant PT Pabrik Baja Terpadu. *Jurnal Intent: Jurnal Industri Dan Teknologi Terpadu*, *1*(1), 67–78. https://doi.org/10.47080/intent.v1i1.260

Latif, A., & Ervil, R. (2016). Perbandingan Nilai Overall Equipment Effectiveness (OEE) Mesin Packer Lama dan Mesin Packer Baru pada Packing Plant Indarung (PPI) PT. Semen Padang. *Jurnal Sains Dan Teknologi Keilmuan Dan Aplikasi Teknologi*, *16*(2), 119–186. http://dx.doi.org/10.36275/stsp.v16i2.39

Magdalena, R., & Ginting, A. P. (2019). Analisis Produktivitas Mesin Sheating 3 dengan Metode Overall Equipment Effectiveness (OEE) pada Produksi Fiber Optic PT. Voksel Electric Tbk. *Jurnal Ilmiah Teknik Industri: Jurnal Keilmuan Teknik Dan Manajemen Industri*, *7*(2), 120–127. https://doi.org/10.24912/jitiuntar.v7i2.5935

Maknunah, L. U., Achmadi, F., & Astuti, R. (2016). Penerapan Overall Equipment Effectiveness (OEE) untuk Mengevaluasi Kinerja Mesin-Mesin di Stasiun Giling Pabrik Gula Krebet II Malang. *Jurnal Teknologi Industri Pertanian*, *26*(2), 189–198. https://doi.org/10.24961/j.tek.ind.pert.2016.26.2.189

Maknunah, L. U., Astuti, R., & Effendi, M. (2014). Perancangan Aplikasi Pengukuran Overall Equipment Effectiveness (OEE): Studi Kasus di PG Krebet Baru II. *Jurnal Teknologi Pertanian*, *15*(1), 7–14. https://jtp.ub.ac.id/index.php/jtp/article/view/427

Nakajima, S. (1988). *Introduction to TPM: Total Productive Maintenance*. Productivity Press.

Rachman, T., & Nugraha, A. W. (2018). Pengukuran Overall Equipment Effectiveness (OEE) Untuk Perbaikan Proses Manufaktur Mesin Bead Grommet. *Jurnal Inovisi*, *14*(1), 1–11. https://ejurnal.esaunggul.ac.id/index.php/inovisi/article/view/3583

Rahman, A., & Perdana, S. (2019). Analisis Produktivitas Mesin Percetakan Perfect Binding dengan Metode OEE dan FMEA. *Jurnal Ilmiah Teknik Industri*, *7*(1), 34–42. http://dx.doi.org/10.24912/jitiuntar.v7i1.5034

Ridwansyah, M., Nusraningrum, D., & Sutawijaya, A. H. (2019). Analisis Overall Equipment Effectiveness Untuk Mengendalikan Six Big Losses Pada Mesin Pembuatan Nugget. *INDIKATOR: Jurnal Ilmiah Manajemen & Bisnis*, *3*(1), 38–51. http://dx.doi.org/10.22441/indikator.v3i1.5166

Samad, M. A., Hossain, M. R., & Asrafuzzaman, M. (2011). Analysis of Performance by Overall Equipment Effectiveness of the CNC Cutting Section of a Shipyard. *Journal of Science and Technology*, *2*(11), 1091–1096. https://www.researchgate.net/publication/328629423_Analysis_of_Performance_by_Overall_Equipment_Effectiveness_of_the_CNC_Cutting_Section_of_a_Shipyard

Setiawan, L. (2021). Literature Review of the Implementation of Total Productive Maintenance (TPM) in various Industries in Indonesia. *IJIEM: Indonesian Journal of Industrial Engineering & Management*, *2*(1), 16–34. http://dx.doi.org/10.22441/ijiem.v2i1.10591

Stamatis, D. (2010). *The OEE Primer Understanding Overall Equipment Effectiveness, Reliability, and Maintainability*. Taylor & Francis Group. https://doi.org/10.1201/EBK1439814062

Suliantoro, H., Susanto, N., Prastawa, H., Sihombing, I., & Mustikasari, A. (2017). Penerapan Metode Overall Equipment Effectiveness (Oee) Dan Fault Tree Analysis (Fta) Untuk Mengukur Efektifitas Mesin Reng. *J@ti Undip : Jurnal Teknik Industri*, *12*(2), 105. https://doi.org/10.14710/jati.12.2.105-118

Sundana, S., & Al Qodri, M. T. (2019). Analisis Penyebab Rendahnya Nilai OEE Pada Mesin Heading Di PT DRA Component Persada. *Journal Industrial Servicess*, *5*(1). https://doi.org/10.36055/jiss.v5i1.6505

Suryaprakash, M., Gomathi Prabha, M., Yuvaraja, M., & Rishi Revant, R. V. (2021). Improvement of Overall Equipment Effectiveness of Machining Centre Using TPM. *Materials Today: Proceedings*, *46*(19), 9348–9353. https://doi.org/https://doi.org/10.1016/j.matpr.2020.02.820

Susetyo, A. E. (2017). Analisis Overall Equipment Effectiveness (OEE) untuk Menentukan Efektivitas Mesin Sonna Web. *Jurnal Science Tech*, *3*(2), 93–102. https://doi.org/10.30738/jst.v3i2.1622

Tobe, A. Y., Widhiyanuriyawan, D., & Yuliati, L. (2017). The Integration of Overall Equipment Effectiveness (OEE) Method and Lean Manufacturing Concept to Improve Production Performance (Case Study: Fertilizer Producer). *Journal of Engineering and Managment Industrial System*, *5*(2), 102–108. https://doi.org/10.21776/ub.jemis.2017.005.02.7

Triwardani, D. H., Rahman, A., & Tantrika, C. F. M. (2013). Analisis Overall Equipment Effectiveness (OEE) dalam Meminimalisir Six Big Losses pada Mesin Produksi Dual Filters DD07. *Jurnal Rekayasa Dan Manajemen Sistem Industri*, *1*(2), 379–391. http://jrmsi.studentjournal.ub.ac.id/index.php/jrmsi/article/view/44

Wijaya, C. Y., & Widyadana, I. G. A. (2015). Pengukuran Overall Equipment Effectiveness (OEE) di PT Astra Otoparts Tbk. Divisi Adiwira Plastik. *Jurnal Titra*, *3*(1), 41–48. http://studentjournal.petra.ac.id/index.php/teknik-industri/article/download/2981/2686