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Case study article

Improving press machine efficiency using a TPM approach and Six Big Losses analysis

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ABSTRACT

This study aims to improve the efficiency of press machines in the food manufacturing industry by implementing the Total Productive Maintenance (TPM) method and analyzing the Six Big Losses. The main issues identified include high downtime, excessive vibrations, and machine component failures, all of which negatively impact production efficiency. This research measures Overall Equipment Effectiveness (OEE) based on three key parameters: availability, performance, and quality. The results indicate that the average OEE is 84%, which falls below the 85% standard recommended by the Japan Institute of Plant Maintenance (JIPM). The primary causes of low efficiency are idling and minor stoppages (48%) and equipment failures (28%), both of which are influenced by a lack of preventive maintenance and errors in machine settings. A fishbone diagram analysis identifies the key factors contributing to inefficiency. To enhance machine effectiveness and reduce waste, a more optimized TPM implementation is recommended, focusing on Autonomous Maintenance and Preventive Maintenance. This study confirms that applying TPM and OEE can optimize production performance and improve the competitiveness of the manufacturing industry through enhanced maintenance systems and machine efficiency.

1. Introduction

A manufacturing company in the food support industry is facing recurring operational challenges. After several years of operation, its machines have experienced performance declines due to high levels of waste, low quality ratios, and other indicators exceeding standard limits. Waste refers to any work activity that does not add value or incurs excess costs for the company. Observations and interviews revealed that waste levels have reached up to 40%, significantly impacting the company's profits. Common issues include machine deterioration caused by a lack of maintenance, such as dirt accumulation, missing or worn components, leaks, abnormal machine noises, excessive vibrations, and other arising problems. To address these issues, a systematic approach is required to establish an improved system for production processes, maintenance, and machine repairs. Therefore, TPM activities must be conducted in order to solve the problem.

TPM is a maintenance system that involves all levels of an organization, from top management to frontline employees, including operators, developers, marketing, and administration. Operators are responsible not only for operating machines but also for maintaining them. TPM is an innovative approach to maintenance that optimizes equipment effectiveness, minimizes sudden breakdowns, and promotes autonomous maintenance by operators. It enhances product accessibility while reducing investment needs [1].

Additionally, TPM facilitates manufacturing companies in implementing Total Quality Management (TQM) practices, enabling them to compete in the global market [2]. It improves company efficiency, product quality, job satisfaction, and safety performance by involving both management and employees [3]. A key principle of TPM is autonomous maintenance, where operators are required to perform basic maintenance and repairs to keep machinery in optimal condition. TPM and the Six Big Losses framework are widely used in waste management and lean manufacturing processes [4].

OEE and FMEA have been applied to analyze the effectiveness of SAG Mill machines in mining, revealing that OEE falls below the JIPM 85% standard, with

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downtime and idling as the primary factors. Recommended improvements include adding equipment to extend machine lifespan, reducing downtime, and increasing production efficiency [5]. Similarly, a study conducted at a steel company in Jordan found low equipment effectiveness, with OEE at only 42%. Analysis using TPM, OEE, and the Six Big Losses framework showed a high-quality rate of 99%, but availability was only 49%, and performance was 84%. Recommended improvements included the implementation of SMED, CMMS, and enhanced production planning [6].

A literature review on the implementation of Total Productive Maintenance (TPM) to improve Overall Equipment Effectiveness (OEE) in the manufacturing industry highlights that the primary issue is low equipment effectiveness due to suboptimal maintenance. Analyzing studies on TPM and OEE reveals that implementing TPM enhances OEE by reducing downtime, improving performance, and increasing production quality [7].

A study conducted at a folding carton packaging company found that the effectiveness of printing machines was low, with an OEE of only 56%. The key factors contributing to this low OEE were excessive downtime, poor performance, and high product defect rates. Recommended improvements include predictive maintenance and operator training to enhance machine efficiency and production quality [8].

Similarly, a manufacturing company in Indonesia reported low machine effectiveness, with an OEE of 68.63%, which falls below the JIPM 85% standard. The study applied OEE, Six Big Losses, a fishbone diagram, and the Overall Equipment Cost Loss (OECL) approach to analyze the issue and identify key factors affecting machine performance [9].

In automotive component companies, the implementation of Autonomous Maintenance has improved OEE values from 65.8% to 80.4%, though this remains below the company's target [10]. To further align OEE values with business goals, several recommendations have been proposed, including reviewing other pillars of Total Productive Maintenance (TPM). A key aspect of OEE is Overall Equipment Cost Loss (OECL), which quantifies cost losses due to availability, performance, and quality issues [11].

Six Big Losses is a framework used to identify and reduce six major categories of losses that affect machine performance. These categories include:

- Breakdown Losses – Occur due to sudden machine failures, causing the machine to stop operating.
- Setup and Adjustment Losses – Represent the time lost during machine setup or when adjusting operational parameters.
- Idling and Minor Stoppage Losses – Happen when the machine briefly stops or operates without load due to minor disruptions.
- Reduced Speed Losses – Arise when the machine operates below its optimal speed.
- Quality Defect and Rework Losses – Result from defective products that require repair or replacement. Low-quality ratios affect machine efficiency and require further analysis through TPM with OEE to eliminate these losses [12].
- Startup Losses – Occur during the machine startup period until it reaches stable operating conditions.

An automotive component company analyzed machine effectiveness using OEE and Six Big Losses, revealing an average effectiveness of 75.9%–80.6%, which is below the 85% standard. The primary cause of low OEE was Setup and Adjustment Losses (40.3%). To improve production efficiency, predictive maintenance and operator training are recommended [13].

Machine effectiveness in the automotive industry was also analyzed to identify factors contributing to efficiency decline. The implementation of TPM led to an OEE improvement of 74.3%, demonstrating its effectiveness in optimizing machine performance and production processes [14].

OEE can be applied across various industries. In Indonesia's pulp and paper industry, machine effectiveness was analyzed using OEE and Six Big Losses, showing an average effectiveness of 74.01%, which is below the 85% standard. The primary cause was Reduced Speed Losses (27.6%). Recommended improvements include maintaining operating speed and reducing component wear to enhance efficiency [15].

In Indonesia's cement industry, OEE and FMEA were used to evaluate the effectiveness of packer machines, revealing that effectiveness remained below the 85% standard. The main causes were Reduced Speed Losses, Idling and Minor Stoppages, and Equipment Failures. Suggested improvements include preventive maintenance and regular cleaning to enhance machine performance [16].

OEE is one of the most used methods for evaluating manufacturing process performance, helping to identify and eliminate production failures. The OEE parameters encompass various types of losses, known as the Six Big Losses, which include downtime (equipment failure), setup and adjustment, idling and minor stoppages, reduced speed, defects in process, and yield and rework. These factors significantly impact machine performance and overall production efficiency [17].

This study is crucial as it highlights existing losses, identifies OEE indicators, and assesses their impact on production efficiency. The primary objective is to optimize resource utilization to minimize equipment losses, thereby improving overall equipment effectiveness and reducing production losses [18]. Additionally, the effective implementation of Total Productive Maintenance (TPM) in the manufacturing industry can enhance company performance [19].

The success of TPM is measured by overall equipment efficiency (OEE). Previous research indicates that measuring OEE and assessing losses significantly contribute to helping organizations start

TPM improvement steps to enhance overall company efficiency [14]. Improvement steps begin with identifying and initiating corrective actions and implementing them to track changes from the initial analysis [20].

This study uses the Overall Equipment Effectiveness (OEE) method to tackle the company's issues. OEE measures machine performance by evaluating three parameters: availability, performance, and quality. Overall availability can be improved through comprehensive Total Productive Maintenance (TPM) implementation within the organization [21]. Performance is related to productivity and linked to quality [22]. OEE is a key performance indicator (KPI) crucial for assessing TPM implementation. Performance indicators can effectively validate cleaning, inspection, lubrication standards, and autonomous maintenance activities, allowing for reduced waste and contamination [23]. OEE and KPI were used to measure performance and analyze low machine effectiveness, revealing an average OEE of only 49.40%, far below the 85% standard. As a solution, the implementation of Total Productive Maintenance (TPM) is recommended to enhance machine efficiency and overall productivity [24], [25].

The OEE results were then compared with defect analysis using statistical process control to determine the proportion of defects in product packaging. To identify root causes, a fishbone diagram was used to analyze inefficiencies and efficiencies in packaging machines. Combining TPM with Total Quality Management (TQM) has significant potential to enhance manufacturing performance compared to implementing them separately [26]. Additionally, the 5S methodology is part of TPM that contributes to performance improvements in manufacturing companies [27], [28]. TPM aims to keep machines and equipment in optimal condition at all times, requiring periodic preventive maintenance.

Research findings indicate that TPM methodologies, including scheduled preventive and autonomous maintenance, can significantly reduce machine damage, with reductions of 23% for Lathe machines and 38% for CNC machines [29]. There is no existing research analyzing Press machines in the food industry. This study will examine the causes of the Six Big Losses to improve Press machine efficiency using the OEE approach. The study aims to identify parameters for calculating OEE, determine OEE values for each Press machine in the production area, assess defect percentages in product packaging, identify root causes of issues, and propose solutions or improvement ideas. Applying TPM principles can minimize machine damage.

Although this study discusses TPM and OEE as tools to improve manufacturing efficiency, it lacks an in-depth exploration of how these approaches integrate with lean manufacturing, particularly in waste elimination. The study focuses more on OEE calculations and loss identification without addressing the economic impact of TPM implementation, such as cost reduction, profitability improvement, or its effect on new equipment investment. It emphasizes the technical aspects (OEE, TPM, and Six Big Losses) but does not discuss how human factors influence TPM effectiveness

This study maps the relationship between OEE values and the Six Big Losses in manufacturing, helping companies identify root causes and areas for improvement. It confirms that comprehensive TPM implementation, including autonomous maintenance and preventive maintenance, can reduce machine failures and improve OEE performance. By combining OEE with the fishbone diagram method, this study provides a systematic approach to analyzing the main causes of inefficiency and poor product quality while offering recommendations to enhance OEE for manufacturing companies.

2. Material and method

2.1. *Type of research*

This research uses both quantitative and qualitative methods. Quantitative research is a method for testing specific theories by examining the relationships between variables. These variables are typically measured using research tools, and statistical methods can be employed to analyze numerical data. Quantitative methods are based on positivist philosophy and are used to study research samples and populations. Sampling techniques are carried out randomly or through random sampling. On the other hand, qualitative methods focus on a deep understanding of an issue rather than generalizing problems. The aim is to identify factors to enhance the operational effectiveness of the Press machine with the potential to reduce Six Big Losses.

2.2. *Data sources*

The data used in this research includes primary data obtained directly through observations and interviews. The data, in terms of its nature, is quantitative and consists of numerical values.

2.3. *Data collection*

This research requires several types of data to identify and find solutions to the problems being studied. The data needed includes primary data, secondary data, and other supporting information. Primary data is collected directly by the researcher through interviews and distribution of questionnaires to relevant personnel in the company. Secondary data is obtained from production reports documented by the company. Data collection involves field research, direct examination of the research objects, including machine maintenance data related to Six Big Losses, maintenance, and component replacement, as well as working hours and days. Additionally, data collected includes production process results, non-standard production process data (product defects), and production capacity data. Literature review is conducted by reading and studying books or previous research to obtain secondary data related to this study.

2.4. Data processing and analysis

Data processing involves calculating OEE and Six Big Losses by determining performance, availability, and quality ratios, setting repair priorities, identifying dominant causes using cause-and-effect diagrams, and making recommendations for maintenance improvements. The final stage involves writing a report on the analysis results of the research conducted. To assess the performance of the machine, it is necessary to determine its OEE. The OEE level is influenced by availability, machine performance, and the quality of the products produced.

3. Results and discussions

This research is conducted on the Toyo Line (Machine 4B), which consists of four lines: V, W, X, and Y. The selection of this study is based on historical data, where Machine 4B has the lowest OEE value compared to the others.

3.1. Productivity and reliability indicators

To improve the OEE of Machine 4B, productivity and reliability indicators are calculated. The data is presented in Table 1.

3.2. Analysis

Availability is the ratio between the actual operating time and the planned machine operating time. It reflects how much of the available loading time is utilized, excluding losses due to downtime. The standard availability value is 90%. The highest availability percentage for the Toyo V machine occurred in February at 91.8%, as the machine usage was relatively optimal during that period. Conversely, the lowest availability percentage was recorded in January at 84.3% due to significant downtime and setup processes, primarily caused by scheduled maintenance and machine failures. The low availability value is mainly attributed to high downtime, particularly delays in machine setup due to the replacement of Autonik Pack Machinery, which required extended breakdown times.

The Performance Ratio describes the ability of equipment to produce goods. It considers factors that cause a decrease in production speed compared to the machine's actual capacity. The standard performance value is 95%. The Performance Ratio decreased to 83.5%. This low value occurred because production volume was low that month, while the available production time or operating time was reduced due to a high number of downtimes. The quality ratio is a comparison between products that pass quality control and total production. In this company, a product is considered good if the sheet meets the standards for weight, color, and maturity level. The company has set a target of 97% for products classified as good, while the international standard for the quality ratio is 99%. The highest quality ratio achieved is 99.2%, which exceeds international standards. The lowest value, recorded in January, was 99%, still aligning with international standards. Therefore, it can be concluded that the quality ratio produced by the Toyo machine consistently meets international standards.

To assess machine effectiveness using the Overall Equipment Effectiveness (OEE) method, supporting data is required, including the company’s production capacity, machine delay time, breakdown time, and planned downtime [30]. Research measuring the OEE value by identifying the six big losses can offer improvement recommendations. With these enhancements, the average machine availability reaches 84.40%, the performance level is 93.23%, the quality rate improves to 98.59%, and the OEE value achieves 77.53% [31]. In this study, the OEE calculation aims to evaluate the effectiveness of Line 4B, which has the lowest OEE value compared to other lines. Overall Equipment Effectiveness considers the time, quality, and performance of the production line.

Table 1.
Productivity and reliability indicators of machine 4B

No	Indicator	Line V	Line W	Line X	Line Y
1	Loading time (minute)	31590	31590	31590	31590
2	Downtime (minute)	3357	2133	1967	1977
3	Availability (%)	88.7%	93.0%	93.7%	93.3%
4	Output (unit)	139937	146160	147007	146907
5	Cycle time (minute)	31590	31590	31590	31590
6	Performance (%)	0.20	0.20	0.20	0.20
7	Reject (unit)	1230	1123	1110	1160
8	Quality (%)	99.0%	99.1%	99.0%	99.0%
9	Avaibility	88.7%	93.0%	93.7%	93.3%
10	Performance	88.0%	92.3%	93.0%	93.0%
11	OEE	77.2%	85.0%	86.2%	85.9%
12	Equipment failure (%)	24%	24%	24%	24%
13	Setup time (%)	14%	14%	14%	14%
14	Reduced speed losses (%)	2.5%	2.5%	2.5%	2.5%
15	Stopages losses (%)	38%	38%	38%	38%
16	Defect losses (%)	0.8%	0.8%	0.8%	0.8%

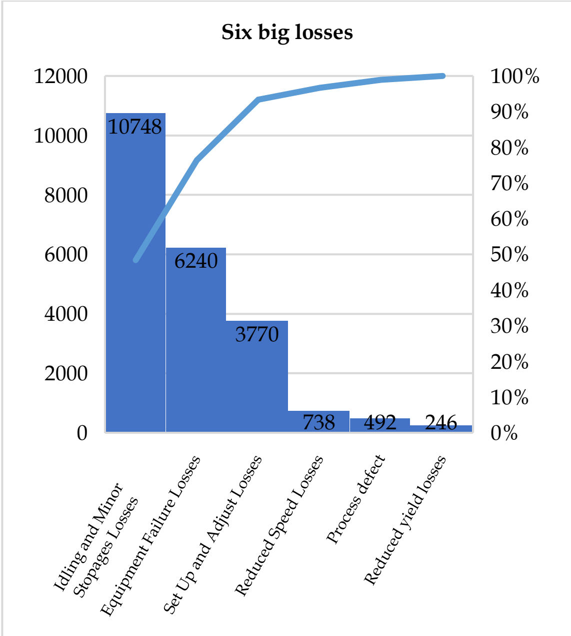

Figure 1. Pareto diagram of Six Big Losses

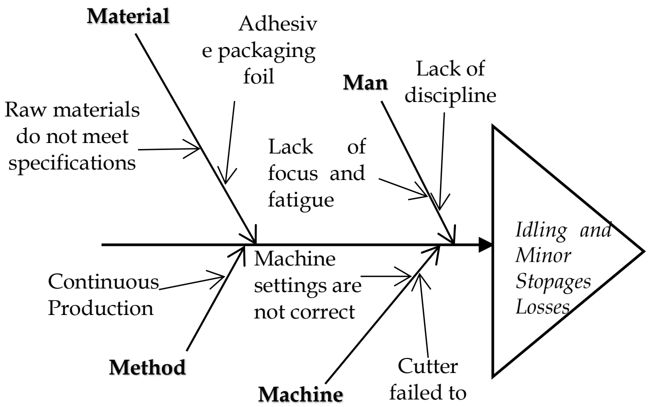

Figure 2. Fishbone diagram

After calculating the losses, the next step is to analyze the losses that have the most significant impact on the company. The research conducted shows that the Six Big Losses can be used to identify the causes of low OEE values in the paving machine production process [32]. The analysis results are depicted in a pie chart, which can be seen in Fig. 1. Based on Fig. 1, the largest loss occurs in Idling and Minor Stoppages Losses, accounting for 48%, followed by Equipment Failure Losses at 28%. The high value of Idling and Minor Stoppages Losses results from brief machine stoppages, machine jams, and idle machine time. These losses typically consume only a short amount of time and do not require maintenance personnel, as the machine stops only briefly. Meanwhile, the high Equipment Failure Losses are due to machine replacement processes and maintenance activities, which take time to set up the machine, preventing it from carrying out the production process.

The next step is to determine the root cause of the low OEE on machine 5B. This root cause analysis is conducted through brainstorming sessions with stakeholders on the production floor. The results of the root cause identification are presented in Fig. 2.

3.3. *Managerial implications*

This study achieved an average OEE of 84%, with the highest values recorded for availability (92.3%), performance (91.3%), and quality (99.2%). These results align with study [31], which also achieved an OEE of 84.4% in the food industry, demonstrating that the OEE method is effective in evaluating production efficiency in this sector. However, compared to study [33] in the automotive industry, the OEE improvement in this research is higher, possibly due to better machine conditions and maintenance systems.

This study focuses on press machines in the food industry, differing from study [32], which examined paving printing machines, and study [34], which analyzed CNC and lathe machines. This indicates that TPM and OEE implementation can be applied across various industries, although their effectiveness depends on the type of machine and operational conditions. In this study, Idling and Minor Stoppages Losses (48%) and Equipment Failure Losses (28%) were identified as the main causes of low OEE. Unlike study [32], where Set Up and Adjustment Losses were the primary issue, this research highlights that the main causes of Six Big Losses can vary depending on the machine type and production system.

This study integrates OEE, TPM, and Six Big Losses to enhance machine effectiveness. Study [33] emphasizes Autonomous Maintenance as a key approach to improving OEE, demonstrating the crucial role of operators in self-maintenance. Meanwhile, study [19] shows that Preventive Maintenance significantly reduces breakdowns, which could serve as an important addition to this research.

The implementation of TPM and OEE in the food industry has proven effective; however, there are opportunities to further optimize maintenance strategies, such as integrating Autonomous Maintenance or Preventive Maintenance, as suggested in Musa's research [10]. Additionally, study [34] states that the primary causes of Six Big Losses vary across industries, emphasizing the need for a more specific analysis for each machine type. This study could further enrich its discussion by making a more in-depth comparison with previous research, particularly concerning the effectiveness of TPM implementation and additional methods that could be applied.

4. Conclusions

The average OEE value of all machines reached 84%, with the main factors influencing effectiveness being availability (92.3%), performance (91.3%), and quality (99.2%). Machine V had the lowest OEE value of 77.6%, primarily due to the high levels of Idling and Minor Stoppages Losses and Equipment Failure Losses. Idling and Minor Stoppages Losses were the biggest contributors to production inefficiency, accounting for 48%, while Equipment Failure Losses accounted for 28% of total production losses, mostly caused by a lack of preventive maintenance and errors in machine setup.

A weekly evaluation of operator performance is necessary to identify and address the root causes of downtime. A more optimal implementation of TPM, including Autonomous Maintenance and Preventive Maintenance, can enhance machine effectiveness and reduce equipment failure rates. Improvements in machine program settings and the simplification of the expiry date replacement process can significantly reduce machine downtime.

Overall, the implementation of TPM and Six Big Losses analysis in OEE measurement has proven effective in identifying and overcoming the main sources of production inefficiency. By implementing the right improvement strategies, companies can enhance production equipment effectiveness and reduce waste, ultimately leading to increased productivity and profitability.

Declaration statement

Supriyati: Conceptualization, Methodology, Writing-Original Draft. Muhamad Hamsari: Collecting data. Tri Ngudi W: Writing-Review & Editing.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

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Generative AI was used to improve the clarity and readability of certain sections of this manuscript. The authors have carefully reviewed and refined all AI-generated materials to ensure accuracy and suitability for research purposes. Full responsibility for the scientific content, conclusions and integrity of the manuscript remains with the author; and the author discloses the use of AI to ensure transparency and compliance with publisher guidelines.

References

[1] R. Thorat and G. T. Mahesha, "Improvement in productivity through TPM Implementation," *Mater. Today Proc.*, vol. 24, pp. 1508–1517, 2020, doi: 10.1016/j.matpr.2020.04.470.

[2] M. F. Ahmad, S. F. Zamri, Y. Ngadiman, S. W. Chan, N. Zakuan, A. H. Nor Aziati, dan Y. Baba, "The impact of Total Productive Maintenance (TPM) as mediator between Total Quality Management (TQM) and business performance," *International Journal of Supply Chain Management*, vol. 8, no. 1, pp. 1033-1042, 2019.

[3] V. Shankul dan Y. Buke, "Relationship of 5S, TPM and SMS to enhance safety performance of manufacturing industry," *Journal of Industrial Safety Engineering*, vol. 6, no. 2, pp. 1-13, 2019.

[4] I. Leksic, N. Stefanic, dan I. Veza, "The impact of using different lean manufacturing tools on waste reduction," *Advances in Production Engineering & Management*, vol. 15, no. 1, pp. 81-92, 2020, doi: 10.14743/apem2020.1.351.

[5] S. L. Fuadiya and E. P. Widjajati, "Analysis of sag mill machine performance using overall equipment effectiveness and failure model and effects analysis method," *Int. J. Ind. Optim.*, vol. 3, no. 2, pp. 141–153, 2022, doi: 10.12928/ijio.v3i2.6701.

[6] J. Biswas, "Total Productive Maintenance: An In-depth Review with a Focus on Overall Equipment Effectiveness Measurement," *Int. J. Res. Ind. Eng.*, vol. 13, no. 4, pp. 376–383, 2024, doi: 10.22105/riej.2024.453380.1436.

[7] D. N. Gandhi and V. Deshpande, "a Review of Tpm To Implement Oee Technique in Manufacturing Industry," *Ind. Eng. J.*, vol. 11, no. 6, 2018, doi: 10.26488/iej.11.6.1073.

[8] R. H. Pratama, A. S. Pratama, dan D. Sari, "Implementation of overall equipment effectiveness (OEE) in improving production efficiency: a case study in manufacturing industry," *IOP Conference Series: Materials Science and Engineering*, vol. 1096, no. 1, pp. 012069, 2021, doi: 10.1088/1757-899X/1096/1/012069.

[9] S. Dewi, J. Alhilman, and F. T. D. Atmaji, "Evaluation of Effectiveness and Cost of Machine Losses using Overall Equipment Effectiveness (OEE) and Overall Equipment Cost Loss (OECL) Methods, a case study on Toshiba CNC Machine," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 847, no. 1, 2020, doi: 10.1088/1757-899X/847/1/012020.

[10] M. A. Musa, N. I. Kasim, A. R. Razali, Mahadzir, and W. A. N. Wan Saidin, "Improvement of Overall Equipment Effectiveness (OEE) through Implementation of Autonomous Maintenance in Crankcase Line," *Appl. Mech. Mater.*, vol. 761, pp. 165–169, May 2015, doi: 10.4028/www.scientific.net/AMM.761.165.

[11] I. A. Mahmoud, M. Fahmyaly, A. Mohib, and I. H. Afefy, "Integration of benchmarking with overall Equipment Cost Loss for industrial process improvement," *Jordan J. Mech. Ind. Eng.*, vol. 13, no. 1, pp. 49–59, 2019.

[12] R. F. Prabowo, H. Hariyono, and E. Rimawan, "Total Productive Maintenance (TPM) pada Perawatan Mesin Grinding Menggunakan Metode Overall Equipment Effectiveness (OEE)," *J. Ind. Serv.*, vol. 5, no. 2, 2020, doi: 10.36055/jiss.v5i2.8001.

[13] A. Sutoni, W. Setyawan, and T. Munandar, "Total Productive Maintenance (TPM) Analysis on Lathe Machines using the Overall Equipment Effectiveness Method and Six Big Losses," *J. Phys. Conf. Ser.*, vol. 1179, no. 1, p. 012089, Jul. 2019, doi: 10.1088/1742-6596/1179/1/012089.

[14] R. Sharma, "Overall equipment effectiveness measurement of TPM manager model machines in flexible manufacturing environment : a case study of automobile sector Richa Sharma," *Int. J. Product. Qual. Manag.*, vol. 26, no. 2, pp. 206–222, 2019.

[15] M. Sayuti, Juliananda, Syarifuddin, and Fatimah, "Analysis of the Overall Equipment Effectiveness (OEE) to Minimize Six Big Losses of Pulp machine: A Case Study in Pulp and Paper Industries," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 536, no. 1, 2019, doi: 10.1088/1757-899X/536/1/012136.

[16] I. S. Muthalib, M. Rusman, and G. L. Griseldis, "Overall Equipment Effectiveness (OEE) analysis and Failure Mode and Effect Analysis (FMEA) on Packer Machines for minimizing the Six Big Losses-A cement industry case," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 885, no. 1, 2020, doi: 10.1088/1757-899X/885/1/012061.

[17] Z. T. Xiang and C. J. Feng, "Implementing total productive maintenance in a manufacturing small or medium-sized enterprise," *J. Ind. Eng. Manag.*, vol. 14, no. 2, pp. 152–175, 2021, doi: 10.3926/jiem.3286.

[18] L. Hassani, "Ladan Hassani the impact of Overall Equipment Effectiveness on production losses in Moghan Cable & Wire," vol. 9, no. 4, pp. 565–576, 2004.

[19] E. Y. T. Adesta, H. A. Prabowo, and D. Agusman, "Evaluating 8 pillars of Total Productive Maintenance (TPM) implementation and their contribution to manufacturing performance," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 290, no. 1, 2018, doi: 10.1088/1757-899X/290/1/012024.

[20] M. D. O. dos Reis, R. Godina, C. Pimentel, F. J. G. Silva, and J. C. O. Matias, "A TPM strategy implementation in an automotive production line through loss reduction," *Procedia Manuf.*, vol. 38, no. 2019, pp. 908–915, 2019, doi: 10.1016/j.promfg.2020.01.173.

[21] I. M. Ribeiro, R. Godina, C. Pimentel, F. J. G. Silva, and J. C. O. Matias, "Implementing TPM supported by 5S to improve the availability of an automotive production line," *Procedia Manuf.*, vol. 38, no. 2019, pp. 1574–1581, 2019, doi: 10.1016/j.promfg.2020.01.128.

[22] E. Gidey, B. Beshah, and D. Kitaw, "Review on the evolving relationship between quality and productivity," *Int. J. Qual. Res.*, vol. 8, no. 1, pp. 47–60, 2014.

[23] E. E. Blanco, E. N. F. Solano, dan G. G. Moreno, "Implementation of the autonomous maintenance pillar based on the TPM philosophy," *DYNA (Colombia)*, vol. 87, no. 212, pp. 74-81, 2020, doi: 10.15446/dyna.v87n212.83211.

[24] R. CG, R. MJ, and Y. Krishna, "A Case Study to Determine OEE-A KPI Representing the Overall Productivity of a Machine.," *J. Mines, Met. Fuels*, vol. 71, no. 3, pp. 359–366, 2023, doi: 10.18311/jmmf/2023/33720.

[25] N. Gwangwava, G. A. Baile, P. Dikgale, and K. Kefhilwe, "Framework for Total Productive Maintenance for an Sme," *J. Eng. Technol. Ind. Appl.*, vol. 7, no. 29, pp. 52–61, 2021, doi: 10.5935/jetia.v7i29.740.

[26] S. Sahoo and S. Yadav, "Influences of TPM and TQM Practices on Performance of Engineering Product and Component Manufacturers," *Procedia Manuf.*, vol. 43, pp. 728–735, 2020, doi: 10.1016/j.promfg.2020.02.111.

[27] A. Singh and I. S. Ahuja, "Review of 5S methodology and its contributions towards manufacturing performance," *Int. J. Process Manag. Benchmarking*, vol. 5, no. 4, p. 408, 2015, doi: 10.1504/IJPMB.2015.072320.

[28] M. Dieste, R. Panizzolo, and J. A. Garza-Reyes, "Evaluating the impact of lean practices on environmental performance: evidence from five manufacturing companies," *Prod. Plan. Control*, vol. 31, no. 9, pp. 739–756, Jul. 2020, doi: 10.1080/09537287.2019.1681535.

[29] Pinto G., Silva F.J.G., Fernandes N.O., Casais R., Baptista A., and Carvalho C., "Implementing a maintenance strategic plan using TPM methodology," *Int. J. Ind. Eng. Manag.*, vol. 11, no. 3, pp. 192–204, 2020, [Online].

[30] F. Gunawan, A. Setiawan, dan H. Humaedi, “Pengukuran nilai efektivitas mesin reaktor A700,” *Jurnal Teknik Mesin Untirta*, vol. 4, no. 1, pp. 2-9, 2018.

[31] E. Febianti, K. D. Safitri, K. Kulsum, B. Kurniawan, P. F. Ferdinant, and H. Setiawan, “Measurement of effectiveness of food processing machine through overall equipment effectiveness (OEE),” *J. Ind. Serv.*, vol. 8, no. 1, p. 46, 2022, doi: 10.36055/jiss.v8i1.14076.

[32] I. K. Wardani, F. T. Dwi Atmaji, and J. Alhilman, “Pengukuran dan analisa efektivitas mesin pencetak paving menggunakan metode overall equipment effectiveness (OEE),” *J. Ind. Serv.*, vol. 7, no. 1, p. 125, 2021, doi: 10.36055/jiss.v7i1.12336.

[33] I. Leksic, N. Stefanic, and I. Veza, “The impact of using different lean manufacturing tools on waste reduction,” *Adv. Prod. Eng. Manag.*, vol. 15, no. 1, pp. 81–92, 2020, doi: 10.14743/APEM2020.1.351.

[34] Supriyati, Wiyatno Tri Ngudi, and Darmawan Heru, “Peningkatan produksi plastik injection dengan analisis Overall Equipment Effectiveness dan Single Minute Exchange of Dies (Increase of plastic injection production using Overall Equipment Effectiveness and Single Minute Exchange of Dies Analysis),” *Oper. Excell. J. Appl. Ind. Eng.*, vol. 2021, no. 3, pp. 394–406, 2021.