

Reducing Downtime on Injection Molding Machines Using the Overall Equipment Effectiveness (OEE) Method at PT Mah Sing Indonesia

David Rakes^{1*}, Hasyrani Windyatri², Suhendra³

Fakultas Teknologi Industri Universitas Pelita Bangsa, Indonesia^{1*23}

Email: davidrakes98@gmail.com^{1*}

ABSTRACT

In today's increasingly globalized industrial competition and rapid technological advancements, manufacturing companies strive to improve the quality and quantity of their products. However, intensive use and occasional overloading of machines can lead to decreased performance, shortened lifespan, and component failures. Machine failures not only cause costly downtime but also pose safety risks to workers. This study focuses on PT. Mah Sing Indonesia's efforts to optimize the injection molding process by addressing machine downtime through effective preventive maintenance strategies and comprehensive management approaches. Data collected over the course of 2023 highlights the application of Overall Equipment Effectiveness (OEE) metrics to evaluate machine performance and identify key areas for improvement. The findings underscore the significance of integrating human resources, technology, management practices, and environmental factors to enhance operational efficiency and productivity in injection molding processes.

Keywords: Preventive maintenance, Overall Equipment Effectiveness (OEE), machine downtime, injection molding, manufacturing efficiency

INTRODUCTION

In an era of increasingly global industrial competition and rapid technological advances, companies continue to strive to improve the quality and quantity of their products (Morrar et al., 2017; Schwab, 2017; Shrivastava, 2018; Xu et al., 2018; Zhong et al., 2017). This demands increased efficiency and effectiveness in the production process (Chowdhury et al., 2018; Fragapane et al., 2022; Zheng et al., 2018). The manufacturing industry often relies on machines as the main component of its operations (Black & Kohser, 2017; Esmailian et al., 2016; Kozlowski et al., 2012; Ouyang et al., 2020; Shan et al., 2020). However, intensive use and sometimes exceeding capacity can cause a decrease in engine performance, reduced engine life, and even damage to engine components (Bergthorson & Thomson, 2015; Kalghatgi, 2018; Noor et al., 2018). Machine failure not only causes costly downtime, but also requires additional costs for repairs or component replacement (Lee et al., 2020).

Therefore, the main challenge for manufacturing companies is to run the production process effectively and efficiently, while minimizing disruption due to machine breakdowns (Bojana et al., 2017; Zheng et al., 2018). Machine failures can be caused

by various factors, including the condition of the machine itself, human intervention, and environmental factors such as temperature, humidity, and workplace cleanliness (Uppal et al., 2021). To overcome this challenge, companies need to implement effective preventive maintenance strategies, improve training for machine operators, and pay attention to environmental factors that can affect machine performance (Siringoringo et al., 2021).

This shows that machine maintenance problems not only affect the company's operational and financial efficiency, but also the safety of individuals involved in the production process (Belekoukias et al., 2014; Holgado et al., 2020). This statement highlights PT. Mah Sing Indonesia in maintaining the effectiveness of their injection molding machine production process. Although the company has nine injection molding machines, they often experience unexpected downtime, which can disrupt smooth production. To overcome this problem, a multidisciplinary approach is needed involving various aspects, such as human resources, technology, management and capital. By involving all these elements in an integrated manner, companies can increase the effectiveness of the injection molding process at PT. Mah Sing Indonesia, reduce downtime, and increase overall productivity.

This study builds upon existing research by focusing on PT. Mah Sing Indonesia, which operates nine injection molding machines that frequently experience unexpected downtime. The goal of this research is to apply the Overall Equipment Effectiveness (OEE) method to evaluate and improve the performance of these machines. By analyzing data from 2023, this study aims to identify patterns of machine failures and develop more effective maintenance schedules. The primary objectives are to reduce downtime, enhance machine performance, and increase overall productivity.

The significance of this research lies in its potential benefits for both the manufacturing industry and the broader field of industrial engineering. For PT. Mah Sing Indonesia, improving machine uptime will lead to increased production efficiency and reduced operational costs. More broadly, the insights gained from this study can inform best practices for other manufacturers facing similar challenges. Additionally, the implications of this research extend to enhancing workplace safety by minimizing machine-related hazards and ensuring smoother production processes.

By adopting a comprehensive approach that integrates technological, managerial, and human factors, this research contributes to the ongoing efforts to optimize manufacturing operations and achieve greater industrial competitiveness.

RESEARCH METHODS

Places and Research Objects

This research was conducted at PT. Mah Sing Indonesia which is located in Parungmulya, Ciampel District, Karawang, West Java 41363, during the period January 2023 to December 2023.

Data collection

Data collection aims to obtain the information needed to achieve research objectives. The data collected is divided into primary and secondary data, which includes:

1. Primary data

Primary data is information obtained directly from the source. Primary data collection was carried out through field observations and interviews with sources who have expertise in their fields.

2. Secondary Data

Secondary data is information obtained from indirect sources such as literature studies, references and company documents. This secondary data is used to support primary data.

Data collected from primary and secondary sources includes:

1. Shift duration.
2. Downtime in the molding process.
3. Total products produced.
4. Products that require rework.
5. Delay in the molding process.
6. Planned downtime.
7. Molding damage criteria.

Data Collection Methods: Data was collected through the following three methods:

1. Observation

Observation is a method of collecting data by observing directly in the company.

2. Interview

Interviews are a method of collecting data through direct conversations with parties related to the problem being studied, with the aim of obtaining information from the company.

3. Study of literature

Literature study is a literature study that aims to provide a rationale for research and solve the problems that have been formulated. This study was conducted to obtain references in the form of theories or methods that are relevant to the research topic and used as a theoretical basis and basic assumptions in preparing research.

RESULTS AND DISCUSSION

Availability Rate Calculation

Availability Rate is a comparison between Operating Time and Processing Time. The formula for calculating Availability Level is as follows:

$$\text{Reate Availability} = \frac{\text{Operating Time}}{\text{Loading Time}} \times 100\%$$

The following is a calculation of availability levels for March.

$$\text{Availability Rate} = \frac{\text{Operation Time}}{\text{Loading Time}} \times 100\%$$

$$= \frac{140934}{208020} \times 100\%$$

$$= 68\%$$

The Availability Level which has been calculated from January to December 2023 can be seen as follows:

Table 1. Availability Rate Injection Molding from March 2023 – February 2024

Month	Operation Time (minutes)	Loading Time (minutes)	Availability Rate (%)
March	140934	208020	68%
April	143789	210840	68%
May	139876	233340	60%
June	114780	200523	57%
July	106387	194220	55%
August	118632	174840	68%
September	101153	196860	51%
October	129630	191760	68%
November	148200	215034	69%
December	130085	200950	65%
January	129500	200150	65%
February	163500	239000	68%

Data Processing Sources 2024

Performance Calculations

Performance Rate is a measure of the reliability or ability of a machine or equipment to produce output, which is calculated based on gross product, operating time and ideal cycle time. The formula for Performance Rate according to Hasriyono (2009) is:

$$Performance\ Rate = \frac{actual\ product}{Standart\ Product} \times 100\%$$

Table 2. Performance Rate from March 2023 – February 2024

Month	Product Actual	Product Standards	Performance (%)
March	41103	44154	93%
April	30521	39500	77%
May	35335	43765	81%
June	14021	15987	88%
July	36400	41231	88%
August	22824	22943	99%

Month	Product Actual	Product Standards	Performance (%)
September	34054	37242	91%
October	20811	21607	96%
November	28809	30632	94%
December	23103	24610	94%
January	21086	22698	93%
February	21756	23412	93%

Data Processing Sources 2024

Quality Rate Calculation

Quality Rate is the machine's ability to produce goods that comply with company standards based on final results, good products and rejected products. Rejected products are goods that are damaged.

Below is the calculation *Quality Rate* for March:

$$\begin{aligned}
 \text{Quality Rate} &= \frac{\text{Gross Product} - \text{Total Reject}}{\text{Gross Product}} \times 100\% \\
 &= \frac{224258 - 6645}{224258} \times 100\% \\
 &= 97\%
 \end{aligned}$$

The results of calculating *the Quality Rate values* from January to December 2023 can be found in the following table:

Table 3. Quality Rate from March 2023 to February 2024

Month	Gross Product (units)	Total Reject	Quality Rate (%)
March	224211	6642	97%
April	185198	5041	97%
May	209200	4930	98%
June	115654	3428	97%
July	181311	4545	97%
August	154102	3872	97%
September	180001	3811	98%
October	174220	4358	97%
November	176450	3500	98%
December	171522	3582	98%
January	169533	3981	98%
February	136387	3840	97%

Data Processing Sources 2024

Calculation of Overall Equipment Effectiveness (OEE) Value

Based on the calculation of the three key factors in OEE, we can calculate the Overall Equipment Effectiveness (OEE) value. The formula used to estimate OEE is as described by Nakajima (1998):

$$OEE (\%) = Availability Rate (\%) \times Performance Rate (\%) \times Quality Rate (\%)$$

Below is the calculation of the OEE value for March 2024:

$$\begin{aligned} OEE (\%) &= Availability Rate (\%) \times Performance Rate (\%) \times Quality Rate (\%) \\ &= 68\% \times 93\% \times 97\% \\ &= 61\% \end{aligned}$$

regarding Overall Equipment Effectiveness (OEE) from January to December 2023 is contained in Table 4, which lists the results of OEE calculations during that period.

Table 4. Overall Equipment Effectiveness Value from March 2023 – February 2024

Month	Availability Rate (%)	Performance (%)	Quality Rate (%)	OEE
March	68%	93%	97%	61%
April	68%	77%	97%	51%
May	60%	81%	98%	48%
June	57%	88%	97%	49%
July	55%	88%	97%	47%
August	68%	99%	97%	65%
September	51%	91%	98%	45%
October	68%	96%	97%	63%
November	69%	94%	98%	64%
December	65%	94%	98%	60%
January	65%	93%	98%	59%
February	68%	93%	97%	61%

Data Processing Sources 2024

Calculation of Six Big Losses

Six Big Losses are six types of losses that arise due to low efficiency of the machine.

1. Losses due to damage is a comparison between the total damage time and the loading time of a machine. This formula was introduced by Hasriyono in 2009.

$$Breakdown Losses = \frac{Total\ Breakdown\ time}{Loading\ Time} \times 100\%$$

This is the calculation of Losses Incurring Due to Technical Disturbances for March 2023:

$$\begin{aligned} \text{Breakdown Losses} &= \frac{17210}{208010} \times 100\% \\ &= 8.27\% \end{aligned}$$

"Data regarding *Breakdown Losses* in March 2023 to February 2024 is in the following table:"

Table 5 . Breakdown Losses from March 2023 – February 2024

Month	Total Breakdown Time	Loading Time	Breakdown Losses
March	17210	208010	8.27%
April	19930	210810	9.45%
May	23270	233320	9.97%
June	14150	135830	10.42%
July	18600	194290	9.57%
August	19720	174880	11.28%
September	18110	196870	9.20%
October	19890	191720	10.37%
November	19500	192510	10.13%
December	18640	182270	10.23%
January	19740	153620	12.85%
February	18100	150090	12.06%
Total	192030	2224020	8.63%

Data Processing Sources 2024

1. Calculation of *Set-up and Adjustment Losses*

The method used to calculate Losses Due to Adjustments and Preparations is (Hasriyono, 2009):

$$\text{Set-up and Adjustment Losses} = \frac{\text{Total Set-up and Adjustment}}{\text{Loading Time}} \times 100\%$$

The following is the calculation of Losses Due to Adjustments and Preparations for March:

$$\text{Setup and Adjustment losses} = \frac{\text{Total Setup and Adjustment}}{\text{loading time}} \times 100\%$$

$$\begin{aligned} \text{Set-up and Adjustment Losses} &= \frac{12190}{208020} \\ &= 5.86\% \end{aligned}$$

The following are the results of calculating Losses Due to Adjustments and Preparations from March 2023 to February 2024:

Table 6. Set-up and Adjustment Losses for March 2023 – February 2024

Month	Set-up Machine	Schedule Shutdown	Total Set-up and Adjustment	Loading Time	Set-up and Adjustment Losses (%)
January	10121	2000	12121	208010	5.83%
February	10912	2000	12912	210810	6.12%
March	10431	2000	12431	233320	5.33%
April	8311	2000	10311	135830	7.59%
May	8821	2000	10821	194290	5.57%
June	9410	2000	11410	174880	6.52%
July	11450	2000	13450	196870	6.83%
August	8025	2000	10025	191720	5.23%
September	7916	2000	9916	192510	5.15%
October	8134	2000	10134	182270	5.56%
November	8571	2000	10571	153620	6.88%
December	11810	2000	13810	150090	9.20%

Source Data processing 2024

Pareto Chart

By using a Pareto diagram, the main problem can be divided into smaller components, allowing for a more effective focus on improvement. The Pareto diagram shows that of the six main losses (Six Big Losses), Breakdown Losses (losses due to damage) are the most significant factor. The following are the results of the Pareto analysis:

Table 7. Pareto Breakdown Losses Diagram from March 2023 – February 2024

Month	Total Breakdown Time	Breakdown Losses	Cumulative
March	17210	7.59%	7.59%
April	19930	8.79%	16.38%
May	23270	10.26%	26.63%
June	14150	6.24%	32.87%
July	18600	8.20%	41.07%
August	19720	8.69%	49.76%
September	18110	7.98%	57.74%
October	19890	8.77%	66.51%
November	19500	8.60%	75.11%

December	18640	8.22%	83.32%
January	19740	8.70%	92.03%
February	18100	7.98%	100.00%
Total	226860	100.00%	

Data Processing Sources 2024

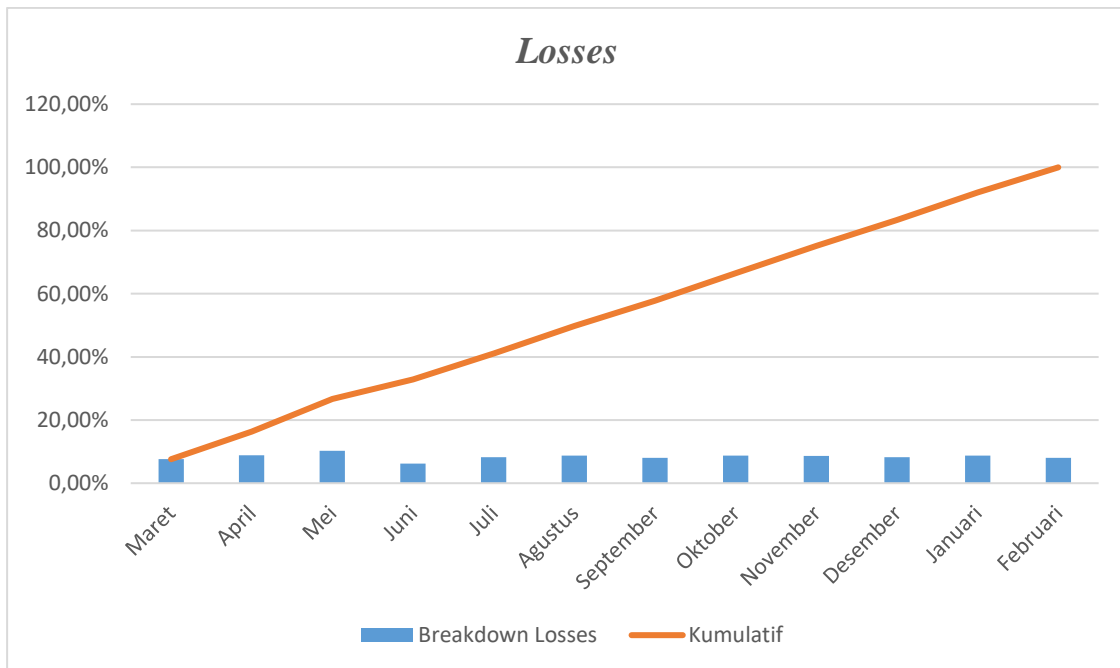


Figure 1. Pareto *Breakdown Losses Diagram*

Source: Data Processing 2024

Fishphone Diagram

By utilizing the fishbone diagram, we can find the root of the existing problem. Based on the previous Pareto diagram, the most dominant factor is losses arising from damage. Therefore, further analysis needs to be carried out to understand the causes of these high losses. Below is a fishbone diagram that highlights the losses incurred due to damage.

Table 8. Fishbone diagram

No	Factors (Main Goals)	Machine	Method	Material	Man	Environment
1	Improve inspections on equipment before starting the production phase.	Improve machine maintenance criteria.	Strengthen supervision to maintain the quality of raw materials.	Improve accuracy during tasks.	Increase the level of alertness while carrying out work.	Improve the cleanliness of equipment and production areas.
2	So that the machine does not experience damage while operating (such as jammed ejector, flashing, or hose leaks).	So that maintenance activities are carried out in accordance with established provisions.	So that engine components are not damaged.	So that employees are more careful when working.	So that employees are more alert when working.	So that production machines remain clean and dirt does not interfere with their performance.
3	Operator Section	Maintenance Department	QC and Operator Section	Operator and Maintenance Section	Operator and Maintenance Section	Operator and Maintenance Section
4	Before starting production process.	Before and after the production process.	Before starting the production process	Before and after the production process	Before and after the production process	Before and after the production process
5	Operator department	Maintenance Department	QC and Operator Department	Operator and Maintenance Department	Operator and Maintenance Department	Operator and Maintenance Department
6	Provide instructions on correct	Provide instructions on correct machine	Provide training and guidance on maintenance	Provide direction regarding raw	Provide pre-work direction and training	Provide direction regarding the

No	Factors (Main Goals)	Machine	Method	Material	Man	Environment
	machine operation at the start of the production process.	operation at the start of the production process.	in accordance with provisions.	materials that meet established criteria.	to increase responsibility and discipline at work.	significance of maintaining cleanliness

Comparison Before *Preventive Scheduling* and After *Preventive Maintenance Scheduling*

The following is a comparative illustration before and after implementing the preventive maintenance schedule on the injection molding machine as follows:

Table 9. Comparison before and after *preventive maintenance*

Before <i>Preventive Maintenance</i>			After <i>Preventive Maintenance</i>	
Machine Downtime	Percentage	Working hours	Machine Downtime	Percentage
23540	11%	209219	2064	0.99%

Source: Data Processing 2024

Before carrying out Preventive Maintenance, the machine experienced significant downtime (23,540 hours or 11% of total working hours). After carrying out Preventive Maintenance, machine downtime was successfully reduced to 2,064 (minutes) (0.99 % of total working hours), showing the effectiveness of the preventive measures taken to improve performance and reduce machine downtime.

CONCLUSION

The research results show that the average OEE value per month is still below the set standards, namely less than 85%. The main cause of low machine efficiency, far below the world class standard of 85%, is low availability levels which result in high machine downtime. However, after running the preventive maintenance schedule, there was a significant change in machine downtime. Initially, machine downtime reached 23,540 minutes (11%), but after corrective action, it fell to only 2,064 minutes (0.99%). To further improve performance, companies are advised to regularly schedule preventive maintenance for molds and machines to ensure injection molding performance remains optimal. In addition, it is necessary to arrange preventive maintenance schedules so that they are carried out on time and optimally, as well as carry out regular training to increase employee motivation and skills. Lastly, maintaining a clean work environment by regularly cleaning the production floor and molds is also highly recommended for employees.

REFERENCES

- Belekoukias, I., Garza-Reyes, J. A., & Kumar, V. (2014). The impact of lean methods and tools on the operational performance of manufacturing organisations. *International Journal of Production Research*, *52*(18), 5346–5366.
- Bergthorson, J. M., & Thomson, M. J. (2015). A review of the combustion and emissions properties of advanced transportation biofuels and their impact on existing and future engines. *Renewable and Sustainable Energy Reviews*, *42*, 1393–1417.
- Black, J. T., & Kohser, R. A. (2017). *DeGarmo's materials and processes in manufacturing*. John Wiley & Sons.
- Bojana, N., Jelena, I., Suzic, N., Branislav, S., & Aleksandar, R. (2017). Predictive manufacturing systems in industry 4.0: Trends, benefits and challenges. *Proceedings of 28th DAAAM International Symposium on Intelligent Manufacturing and Automation*, 796–802.
- Chowdhury, J. I., Hu, Y., Haltas, I., Balta-Ozkan, N., & Varga, L. (2018). Reducing industrial energy demand in the UK: A review of energy efficiency technologies and energy saving potential in selected sectors. *Renewable and Sustainable Energy Reviews*, *94*, 1153–1178.
- Esmailian, B., Behdad, S., & Wang, B. (2016). The evolution and future of manufacturing: A review. *Journal of Manufacturing Systems*, *39*, 79–100.
- Fragapane, G., Ivanov, D., Peron, M., Sgarbossa, F., & Strandhagen, J. O. (2022). Increasing flexibility and productivity in Industry 4.0 production networks with autonomous mobile robots and smart intralogistics. *Annals of Operations Research*, *308*(1), 125–143.
- Holgado, M., Macchi, M., & Evans, S. (2020). Exploring the impacts and contributions of maintenance function for sustainable manufacturing. *International Journal of Production Research*, *58*(23), 7292–7310.
- Kalghatgi, G. (2018). Is it really the end of internal combustion engines and petroleum in transport? *Applied Energy*, *225*, 965–974.
- Kozlowski, A., Bardecki, M., & Searcy, C. (2012). Environmental impacts in the fashion industry: A life-cycle and stakeholder framework. *Journal of Corporate Citizenship*, *45*, 17–36.
- Lee, J., Ni, J., Singh, J., Jiang, B., Azamfar, M., & Feng, J. (2020). Intelligent maintenance systems and predictive manufacturing. *Journal of Manufacturing Science and Engineering*, *142*(11), 110805.
- Morrar, R., Arman, H., & Mousa, S. (2017). The fourth industrial revolution (Industry 4.0): A social innovation perspective. *Technology Innovation Management Review*, *7*(11), 12–20.
- Noor, C. W. M., Noor, M. M., & Mamat, R. (2018). Biodiesel as alternative fuel for marine diesel engine applications: A review. *Renewable and Sustainable Energy Reviews*, *94*, 127–142.
- Ouyang, J., Ji, X., Zhang, X., Feng, C., Tang, Z., Kong, N., & Xie, A. (2020). *In situ sprayed NIR-responsive, analgesic black phosphorus-based gel for diabetic ulcer treatment*. *23*, 1–11. <https://doi.org/10.1073/pnas.2016268117>

- Schwab, K. (2017). *The fourth industrial revolution*. Crown Currency.
- Shan, S., Wen, X., Wei, Y., Wang, Z., & Chen, Y. (2020). Intelligent manufacturing in industry 4.0: A case study of Sany heavy industry. *Systems Research and Behavioral Science*, 37(4), 679–690.
- Shrivastava, P. (2018). Environmental technologies and competitive advantage. In *Business Ethics and Strategy, Volumes I and II* (pp. 317–334). Routledge.
- Siringoringo, D. M., Wangchuk, S., & Fujino, Y. (2021). Noncontact operational modal analysis of light poles by vision-based motion-magnification method. *Engineering Structures*, 244, 112728.
- Uppal, M., Gupta, D., Juneja, S., Dhiman, G., & Kautish, S. (2021). Cloud-based fault prediction using IoT in office automation for improvisation of health of employees. *Journal of Healthcare Engineering*, 2021(1), 8106467.
- Xu, L. Da, Xu, E. L., & Li, L. (2018). Industry 4.0: state of the art and future trends. *International Journal of Production Research*, 56(8), 2941–2962.
- Zheng, P., Wang, H., Sang, Z., Zhong, R. Y., Liu, Y., Liu, C., Mubarak, K., Yu, S., & Xu, X. (2018). Smart manufacturing systems for Industry 4.0: Conceptual framework, scenarios, and future perspectives. *Frontiers of Mechanical Engineering*, 13, 137–150.
- Zhong, R. Y., Xu, X., Klotz, E., & Newman, S. T. (2017). Intelligent manufacturing in the context of industry 4.0: a review. *Engineering*, 3(5), 616–630.

Copyright holder:

David Rakes, Hasyrani Windyatri, Suhendra (2023)

First publication right:

Journal of Social Science

This article is licensed under:

