

Optimizing the Performance of the Sinohara 60T Engine through the Implementation of Total Productive Maintenance (TPM) with the Overall Equipment Effectiveness (OEE) Method at PT Cipta Unggul Karya Abadi

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ABSTRACT

This study was conducted to analyze the effectiveness of the Sinohara 60T press machine at PT Ciptaunggul Karya Abadi using the Overall Equipment Effectiveness (OEE) method as part of the implementation of Total Productive Maintenance (TPM). The research problem arose due to high downtime, frequent breakdowns, and decreased machine performance affecting production productivity. This study aimed to determine the OEE value, identify the factors causing low machine effectiveness, and provide improvement recommendations. The research method used quantitative and qualitative approaches through observation, interviews, and processing production and maintenance data from November 2023 to March 2024. The results showed an availability rate of 94%, performance rate of 88%, quality rate of 97%, and an OEE value of 80%, which is still below the world-class standard of 85%. The dominant factors causing the low OEE value were setup and adjustment losses as well as idling and minor stoppages losses.



1. Introduction

In the manufacturing sector, the effectiveness and efficiency of the production process are important factors in increasing the competitiveness of companies [1]. The success of the production process is influenced by three main elements, namely input, process, and output, where machines have a very vital role because they are directly related to the smooth operation, product quality, and productivity of the company [2]. The high frequency of machine breakdowns and downtime can lead to decreased productivity, increased operational costs, and decreased quality of production results. Therefore, an evaluation of the effectiveness of the machine needs to be carried out to determine the level of machine performance in supporting the production process optimally. PT Ciptaunggul Karya Abadi is a manufacturing company engaged in the production of dies, jigs, and press parts. One of the main machines used in the production process is the Sinohara 60T press machine. Based on the results of field observations, the engine experienced problems in the form of high downtime, increased breakdown frequency, and decreased engine performance due to the suboptimal maintenance system implemented. This condition causes the production process to be less effective and has the potential to increase the number of defective products. Therefore, a maintenance method is needed that can increase the effectiveness of the machine and minimize production losses.

Research on the effectiveness of machines using the Overall Equipment Effectiveness (OEE) and Total Productive Maintenance (TPM) methods has been carried out before [3]. Other research shows that the effectiveness value of the engine using the OEE method is still below the world class standard of 85% due to the dominance of reduced speed loss and idling losses. The study only focused on measuring the effectiveness of machines without providing recommendations for comprehensive maintenance implementation. One of the researchers using the OEE method

and Failure Mode and Effect Analysis (FMEA) found that high engine downtime was caused by delays in the supply of spare parts and high frequency of breakdowns [4]. However, the study focuses more on component failure analysis and has not integrated the application of TPM as a whole in machine maintenance activities [5]. Another study conducted by research shows that the low effectiveness of the engine is influenced by high setup and adjustment losses and reduced speed losses [6]. The study recommends the implementation of TPM, but has not examined the relationship between availability, performance, and quality in an integrated manner in improving the effectiveness of production machinery.

Based on the previous research, it can be seen that most of the research only focuses on measuring the OEE value or identifying six big losses without providing a more integrated repair approach to the machine maintenance system [7]. Therefore, this study uses a Total Productive Maintenance (TPM) approach with the Overall Equipment Effectiveness (OEE) method to thoroughly analyze the effectiveness of the Sinohara 60T press machine based on three main components, namely availability, performance, and quality. The novelty of this research lies in the application of TPM which is not only used to measure engine effectiveness, but also to provide repair recommendations based on preventive maintenance and operator involvement in maintaining optimal engine condition [8]. With the application of this method, it is hoped that the company will be able to reduce downtime, increase machine productivity, and reduce the number of rejected products so that the effectiveness of the production process can increase according to OEE world class standards. This study aims to determine the OEE value of the Sinohara 60T press machine, identify the factors causing the decline in machine effectiveness, and provide suggestions for improvements through the implementation of TPM to improve the performance of production machines at PT Ciptaunggul Karya Abadi. The results of this

research are expected to be a reference for companies in developing a more effective, structured, and sustainable machine maintenance system.

2. Research Methods

This research was carried out at PT Ciptaunggul Karya Abadi, Karawang Regency, with the object of research in the form of a Sinohara 60T press machine in the period November 2023 to March 2024. The research was conducted to analyze the effectiveness of the machine through the Total Productive Maintenance (TPM) approach using the Overall Equipment Effectiveness (OEE) method [9]. The OEE method is used to measure the level of machine effectiveness based on three main components, namely availability, performance, and quality, so that the level of machine operational efficiency and the factors that cause a decrease in production performance can be known [10]. The TPM approach was chosen because it is able to support the improvement of machine reliability through preventive maintenance activities and operator involvement in maintaining the condition of production equipment [11].

This research uses quantitative and qualitative approaches. Qualitative data was obtained through unstructured observations and interviews with parties involved in the machine maintenance process, while quantitative data was obtained from the company's historical data related to the production and maintenance activities of the Sinohara 60T press machine. The data collected included the number of working days, running time, planned downtime, operation time, number of production, machine downtime, and number of rejected products during the observation period. In addition, the research is also supported by literature studies from journals, books, and previous research related to TPM, OEE, and six big losses as the basis for research analysis .

The research stage begins with the identification of problems through field observation and literature studies to find out the actual condition of production machines. Furthermore, the necessary data collection is carried out for the process of measuring the effectiveness of the machine. The data that has been obtained is then processed by calculating availability rate, performance rate, and quality rate as the main components in the OEE method. The OEE value is obtained from the results of multiplying the three components to determine the level of effectiveness of the Sinohara 60T press machine. After that, an analysis of six big losses was carried out to identify the dominant factors that caused the low effectiveness of the production machine [12].

The results of data processing are then analyzed descriptively to determine the main causes of downtime and decreased engine performance. Based on the results of the analysis, this study provides recommendations for improvement through the implementation of Total Productive Maintenance (TPM) to increase machine effectiveness, reduce downtime, and increase the productivity of the production process at PT Ciptaunggul Karya Abadi.

3. Results and Discussions

a. Data Collection

Data collection was carried out using historical operational data of the Sinohara 60T press machine at PT Ciptaunggul Karya Abadi during the period November 2023 to March 2024. The data is used as a basis for measuring the effectiveness of the machine using the Overall Equipment Effectiveness (OEE) method [13]. The data collected includes the number of working days, working hours per day, the number of productions, setup time, downtime, the number of rejected products, and the running time of the machine [14]. Details of the data on the use of the Sinohara 60T press machine during the study period can be seen in Table 1.

Table 1. Sinohara 60T Press Machine Usage Data for the Period November 2023 – March 2024

No	Moon	Number of Days	Working Hours/Day (Hours)	Production Quantity	Setup Time (Minutes)	Downtime (Minutes)	Reject	Running Time (Minutes)
1	Nov-23	22	8	11.950	25	210	500	176
2	Dec-23	16	8	12.310	25	150	420	128
3	Jan-24	22	8	11.600	25	1.930	197	176
4	Feb-24	20	8	15.567	25	480	520	160
5	Mar-24	19	8	9.100	25	125	390	152

Based on Table 1, the production amount of the Sinohara 60T press machine fluctuated during the study period. The highest production occurred in February 2024 at 15,567 units, while the lowest production occurred in March 2024 at 9,100 units. In addition, the highest downtime occurred in January 2024 of 1,930 minutes, which shows that there is a significant disruption in machine operations compared to other months. This high downtime has an impact on decreasing machine effectiveness and has the potential to hinder the achievement of the company's production targets [15].

Product reject data also shows unstable conditions during the observation period. The highest number of reject products occurred in February 2024 as many as 520 units, while the lowest number of rejects occurred in January 2024 as many as 197 units. This condition indicates that the performance of the Sinohara 60T press machine has not been running

optimally, so further analysis using the OEE method is needed to determine the level of machine effectiveness based on availability, performance, and quality aspects.

b. Calculation Availability Rate

The availability rate calculation is carried out to determine the availability level of the Sinohara 60T press machine during the production process. The initial stage in calculating the availability rate is to determine the loading time value. Loading time is the time available for the production process after deducting the planned downtime that has been scheduled by the company [16]. Planned downtime includes planned engine downtime and shutdown during working hours. The results of the calculation of the loading time of the Sinohara 60T press machine can be seen in Table 2.

Table 2. Calculation Results of Loading Time of Sinohara 60T Press Machine

No	Moon	Number of Days	Working Hours/Day (Hours)	Running Time (Minutes)	Planned Downtime/Day (Minutes)	Planned Downtime/ Month (Minutes)	Loading Time (Minutes)
1	Nov-23	22	480	10.559,8	80	1.760	10.480
2	Dec-23	16	480	7.679,8	80	1.280	7.600
3	Jan-24	22	480	10.559,8	80	1.760	10.480
4	Feb-24	20	480	9.599,8	80	1.600	9.520
5	Mar-24	19	480	9.119,8	80	1.520	9.040

Based on Table 2, it is known that the highest loading time occurred in November 2023 and January 2024 of 10,480 minutes. The high loading time is influenced by the number of working days compared to other months. During the research period, the machine operated for 8 working hours per day, starting at 08.00–12.00 WIB and continued at 13.00–17.00

WIB. The planned downtime used in this study is 80 minutes per day, so the value of monthly planned downtime is obtained from the result of multiplying the daily planned downtime and the number of working days each month.

Once the loading time value is obtained, the next step is to calculate the operation time. Operation time is the actual time the machine

operates after deducting unplanned downtime. The results of the operation time calculation of the Sinohara 60T press machine are presented in Table 3.

Table 3. Calculation Results of Operation Time of Sinohara 60T Press Machine

No	Moon	Loading Time (Minutes)	Downtime (Minutes)	Operation Time (Minutes)
1	Nov-23	10.480	210	10.269,8
2	Dec-23	7.600	150	7.449,8
3	Jan-24	10.480	1.930	8.549,8
4	Feb-24	9.520	480	9.039,8
5	Mar-24	9.040	125	8.914,8

Based on Table 3, the lowest operation time occurred in January 2024 at 8,549.8 minutes. This condition was influenced by the high engine downtime which reached 1,930 minutes. High downtime indicates that the production process experiences significant operational disruptions, reducing the effective time of the machine in carrying out production activities.

The next stage is to calculate the availability rate using the previously obtained loading time and operation time data. Availability rate is used to measure the level of readiness of the machine in carrying out the production process. The results of the Sinohara 60T press machine availability calculation can be seen in Table 4.

Based on Table 4, an average availability rate of 94% was obtained. The highest availability value occurred in March 2024 at 99%, while the lowest value occurred in January 2024 at 82%. The decrease in availability rate in

January 2024 was caused by high downtime due to engine breakdowns and the implementation of a maintenance system that is still breakdown maintenance. This condition shows that maintenance activities have not been carried out optimally through preventive and predictive approaches. The higher the availability rate, the higher the level of machine readiness in supporting the smooth production process.

Table 4. Results of Calculation of Availability Rate of Sinohara 60T Press Machine

No	Moon	Loading Time (Minutes)	Downtime (Minutes)	Availability Rate
1	Nov-23	10.480	210	98%
2	Dec-23	7.600	150	98%
3	Jan-24	10.480	1.930	82%
4	Feb-24	9.520	480	95%
5	Mar-24	9.040	125	99%
Average				94%

Performance rate is used to measure the level of a machine's ability to produce production output compared to the ideal capacity that should be achieved during operating time. In calculating performance rates, the data used includes the number of productions, the ideal production cycle time, and the operation time of the machine. Ideal cycle time is the time it takes for a machine to produce a single unit of product under optimal conditions. The results of the calculation of the performance rate of the Sinohara 60T press machine can be seen in Table 5.

Table 5. Performance Rate Calculation Results of Sinohara 60T Press Machine

No	Moon	Production Quantity	Cycle Time 1 pcs (Minutes)	Production Quantity × Cycle Time	Operation Time (Minutes)	Performance Rate
1	Nov-23	11.950	0,63	7.568	10.269,8	74%
2	Dec-23	12.310	0,63	7.796	7.449,8	105%
3	Jan-24	11.600	0,63	7.347	8.549,8	86%
4	Feb-24	15.567	0,63	9.859	9.039,8	109%
5	Mar-24	9.100	0,63	5.763	8.914,8	65%
Average						88%

Based on Table 5, it is known that the ideal cycle time to produce a single unit of product is 38 seconds or equivalent to 0.63 minutes per unit. The performance rate value is obtained from the result of multiplying the production amount with the ideal cycle time which is then divided by the machine's operation time. The

calculation results show that the average performance rate of the Sinohara 60T press machine is 88%, which means that the value is close to the OEE world class standard for the performance category.

The highest performance rate occurred in February 2024 at 109%, while the lowest value

occurred in March 2024 at 65%. The low performance rate in March 2024 shows that the machine's ability to produce production output has not been running optimally. These conditions can be influenced by several factors, such as decreased stability of machine performance, delays in the production process, and operator factors that cause the production speed to not reach the ideal capacity of the machine. The higher the performance rate value, the more optimal the machine's ability to produce products according to the production target that has been determined by the company.

c. Quality Rate Calculation

Quality rate is used to measure the ability of machines to produce products according to the quality standards that have been set by the company. The calculation of the quality rate was carried out by comparing the number of good products to the total production during the observation period. The data used in this calculation includes the number of production and the number of rejected products every month. The results of the calculation of the quality rate of the Sinohara 60T press machine can be seen in Table 6.

Table 6. Sinohara 60T Press Machine Quality Rate Calculation Results

No	Month	Production Quantity (pcs)	Reject	Good Products	Quality Rate
1	Nov-23	11.950	500	11.450	96%
2	Dec-23	12.310	420	11.890	97%
3	Jan-24	11.600	197	11.403	98%
4	Feb-24	15.567	520	15.047	97%
5	Mar-24	9.100	390	8.710	96%
Average					97%

Based on Table 6, an average quality rate of 97% was obtained, which shows that most of the products produced by the Sinohara 60T press machine have met the company's quality standards. The highest quality rate value occurred in January 2024 at 98%, while the lowest value occurred in November 2023 and March 2024 at 96%.

The decline in quality rate in several periods shows that there are still defective products (reject) produced during the production process. This condition is allegedly influenced by the sub-optimal calibration process of the engine and the condition of the engine components that experience a decrease in performance, resulting in an impact on the discrepancy in dimensions and the quality of production results. In addition to the engine factor, the operator's accuracy in the machine operation process also affects the quality of the products produced. The higher the quality rate, the better the machine's ability to produce products according to the quality standards set by the company and the smaller the level of loss due to rejected products.

d. Calculation Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is used to measure the overall effectiveness level of the machine based on three main components, namely availability rate, performance rate, and quality rate. The calculation of OEE is carried out by multiplying the three components so that the actual effectiveness value of the machine during the production process is obtained. This method was used to evaluate the success rate of the implementation of Total Productive Maintenance (TPM) on the Sinohara 60T press machine. The results of the OEE calculation for the period November 2023 to March 2024 can be seen in Table 7.

Based on Table 7, an average Overall Equipment Effectiveness (OEE) score of 80% was obtained. This value shows that the effectiveness of the Sinohara 60T press machine is still below the world class OEE standard of 85%, so there are still opportunities for improvement to improve the performance of the production machine.

Table 7. OEE Calculation Results of Sinohara 60T Press Machine

No	Moon	Availability Rate	Performance Rate	Quality Rate	OEE
1	Nov-23	98%	74%	96%	69%
2	Dec-23	98%	105%	97%	99%
3	Jan-24	82%	86%	98%	69%
4	Feb-24	95%	109%	97%	100%
5	Mar-24	99%	65%	96%	61%
Average					80%

The highest OEE value occurred in February 2024 at 100%, while the lowest value occurred in March 2024 at 61%.

The results of the analysis show that the availability rate and quality rate components have met world class standards with an average of 94% and 97%, respectively. This shows that the level of machine readiness and the quality of the products produced are quite good. However, the performance rate component is still unstable and is the main factor that causes the OEE value to not reach the optimal standard. The low performance rate indicates that the machine is not able to operate optimally according to the ideal production capacity, which is influenced by the factors of production speed, engine condition, and the effectiveness of the operator in carrying out the production process.

Based on the results of the OEE calculations, the recommended improvement efforts are focused on increasing the performance rate through the implementation of Total Productive Maintenance (TPM). The implementation of TPM can be done by increasing preventive maintenance activities, conducting routine checks on engine conditions, and increasing operator involvement in maintaining engine performance during the production process. With these improvements, it is hoped that the effectiveness of the Sinohara 60T press machine can increase and be able to achieve world class OEE standards in a sustainable manner.

e. Six Big Losses Analysis

The Six Big Losses analysis was conducted to identify the losses that affect the effectiveness of the Sinohara 60T press machine within the Total Productive Maintenance (TPM) framework. The analysis

consists of six categories: Setup and Adjustment Losses, Equipment Failure Losses, Idling and Minor Stoppages Losses, Reduced Speed Losses, Reduced Yield Losses, and Process Defect Losses. Each loss was calculated based on the relevant production and machine operating data. To ensure consistency, the calculation used the same time basis and production records applied in the OEE calculation.

1) Setup and Adjustment Losses

Setup and adjustment losses refer to time losses incurred during machine preparation, setting, and adjustment before or during production. The loss was calculated by comparing the recorded setup time with the machine Loading Time using the following formula:

$$\text{Setup and Adjustment Loss (\%)} = \frac{\text{Setup Time}}{\text{Loading Time}} \times 100 \quad (1)$$

The calculation results are presented in Table 8.

Table 8. Setup and Adjustment Losses Calculation Results

No	Moon	Setup Time	Loading Time	Setup & Adjustment Losses
1	Nov-23	25	10.480	24%
2	Dec-23	25	7.600	33%
3	Jan-24	25	10.480	24%
4	Feb-24	25	9.520	26%
5	Mar-24	25	9.040	28%
Average				27%

Based on Table 8, the average Setup and Adjustment Loss was 0.27%. The highest value occurred in December 2023 at 0.33%, followed by March 2024 at 0.28%. These results indicate that setup and adjustment activities contributed a relatively small proportion of the total Loading Time. Therefore, Setup and

Adjustment Loss should not be interpreted as the dominant loss solely based on the original percentage values reported in the manuscript.

2) Equipment Failure Losses

Equipment Failure Losses are losses caused by machine damage or equipment malfunction during production. The calculation was performed by comparing the recorded downtime with the Loading Time using the following formula:

$$\text{Equipment Failure Loss (\%)} = \frac{\text{Equipment Failure Time}}{\text{Loading Time}} \times 100 \quad (2)$$

The results are presented in Table 9.

Table 9. Equipment Failure Losses Calculation Results

No	Moon	Loading Time	Downtime	Equipment Failure Losses
1	Nov-23	10.480	210	2,00%
2	Dec-23	7.600	150	1,97%
3	Jan-24	10.480	1.930	18,42%
4	Feb-24	9.520	480	5,04%
5	Mar-24	9.040	125	1,38%
Average				5,76%

Based on Table 9, the highest Equipment Failure Loss occurred in January 2024 at 18.42%. This result corresponds to the highest recorded downtime during the observation period. The finding indicates that machine downtime was an important contributor to the reduction in machine availability, particularly in January 2024.

3) Idling and Minor Stoppages Losses

Idling and Minor Stoppages refer to short interruptions or periods in which the machine is temporarily stopped during the production process. This loss must be calculated using the actual recorded duration of idling and minor stoppages rather than planned downtime.

The calculation is performed using the following formula:

$$\text{Idling and Minor Stoppages Loss (\%)} = \frac{\text{Actual Idling and Minor Stoppage Time}}{\text{Loading Time}} \times 100 \quad (3)$$

Table 10. Idling and Minor Stoppages Losses Calculation Results

No	Moon	Number of Days	Loading Time	Non Productive Time	Idling and Minor Stoppages Losses
1	Nov-23	22	10.480	1.760	17%
2	Dec-23	16	7.600	1.280	17%
3	Jan-24	22	10.480	1.760	17%
4	Feb-24	20	9.520	1.600	17%
5	Mar-24	19	9.040	1.520	17%
Average					17%

Based on the available data, the values of 1,760 minutes in November 2023, 1,280 minutes in December 2023, 1,760 minutes in January 2024, 1,600 minutes in February 2024, and 1,520 minutes in March 2024 are obtained from 80 minutes of planned downtime per working day. Therefore, these values represent planned downtime and cannot be directly classified as Idling and Minor Stoppages without supporting records identifying them as actual minor stoppages.

Consequently, the original 17% values reported for Idling and Minor Stoppages are not used as final results. Actual Idling and Minor Stoppages Losses should only be calculated after the company records provide the duration of short stoppages or machine idling separately from planned downtime..

4) Reduced Speed Losses

Reduced Speed Losses occur when the machine operates at a speed lower than its specified or ideal operating speed. The calculation must use a validated Ideal Cycle Time, Total Production, and Operating Time. The formula used is:

$$\text{Reduced Speed Loss (\%)} = \frac{[(\text{Operating Time} - (\text{Ideal Cycle Time} \times \text{Total Production}))]}{\text{Loading Time}} \times 10 \quad (4)$$

Table 11. Reduced Speed Losses Calculation Results

No	Moon	Operation Time	Loading Time	Production Quantity	Cycle Time	Reduced Speed Losses
1	Nov-23	10.270	10.480	11.950	0,63	26%
2	Dec-23	7.450	9.060	12.310	0,63	-4%
3	Jan-24	8.550	9.540	11.600	0,63	13%
4	Feb-24	9.040	10.500	15.567	0,63	-8%
5	Mar-24	8.915	6.180	9.100	0,63	51%
Average						16%

BasThe original calculation in Table 11 produced negative values for December 2023 and February 2024. A negative loss percentage is not appropriate for reporting a physical production loss. Therefore, these values indicate an inconsistency between the Ideal Cycle Time, Production Quantity, Operating Time, or Loading Time used in the calculation.

For this reason, the Reduced Speed Loss values are not presented as final results until the Ideal Cycle Time of 0.63 minute/unit and the corresponding production and operating-time records have been validated against the original

company records. The calculation should be repeated after the data have been verified to prevent negative or otherwise inconsistent loss percentages..

5) Reduced Yield Losses

Reduced Yield Losses refer to losses occurring during the early stage of production, particularly defective products that cannot be recovered as normal production. The calculation should use the actual production-loss records and the validated production data. The results are presented in Table 12.

Table 12. Reduced Yield Losses Calculation Results

No	Moon	Number of Days	Reject	Ideal Cycle Time	Scrap	Reduced Yield
1	Nov-23	22	500	0,63	100	1%
2	Dec-23	16	420	0,63	85	1%
3	Jan-24	22	197	0,63	75	0%
4	Feb-24	20	520	0,63	250	2%
5	Mar-24	19	390	0,63	30	0%
Average						1%

Based on Table 12, the reported average Reduced Yield Loss is 1%. This indicates that the recorded reduced-yield loss was relatively small compared with the other measurable loss categories. However, the calculation remains dependent on the validity of the production and scrap records.

6) Process Defect Losses

Process Defect Losses refer to losses caused by products that do not meet quality standards during the production process and therefore require rework or become scrap. The calculation is based on the number of rejected products, Ideal Cycle Time, and Loading Time.

The calculation can be expressed as:

$$\text{Process Defect Loss (\%)} = (\text{Reject} \times \text{Ideal Cycle Time} / \text{Loading Time}) \times 100 \quad (5)$$

The results are presented in Table 13..

Table 13. Calculation Results of Process Defect Losses

No	Moon	Reject	Ideal Cycle Time	Loading Time	Process Defect
1	Nov-23	500	0.63	10,480	3
2	Dec-23	420	0.63	7,600	3.48
3	Jan-24	197	0.63	10,480	1.18
4	Feb-24	520	0.63	9,520	3.44
5	Mar-24	390	0.63	9,040	2.72
Rata-rata					2,76%

Based on the results of the Six Big Losses analysis, the loss categories should be interpreted based on the validity and consistency of the underlying data. The original calculation reported Setup and Adjustment Losses of 27%, Idling and Minor Stoppages Losses of 17%, and Reduced Speed Losses of 16%. However, the Setup and Adjustment

Losses value is mathematically inconsistent with the recorded setup time of 25 minutes and the reported Loading Time, because 25 minutes represents only approximately 0.24%–0.33% of the monthly Loading Time. In addition, the Idling and Minor Stoppages values of 17% were derived from planned downtime of 80 minutes per working day and therefore cannot be directly classified as actual minor stoppages without supporting records. The Reduced Speed Losses also require further validation because the original calculation produces negative values in December 2023 and February 2024. Therefore, the original ranking of Idling and Minor Stoppages as the dominant loss, followed by Reduced Speed Losses, cannot be retained as a validated conclusion. Based on the currently available and calculable data, Equipment Failure Losses represent the most clearly measurable time-based loss, with the highest value occurring in January 2024 at 18.42%. Further identification of actual minor stoppages and reduced-speed losses requires separate machine records to ensure that the Six Big Losses analysis is accurate, consistent, and reproducible.

f. Fishbone Diagram Analysis

Based on the results of the Overall Equipment Effectiveness (OEE) calculation, the

average OEE value of the Sinohara 60T press machine was 80% during the period from November 2023 to March 2024. This value is below the commonly referenced world-class OEE benchmark of 85%, indicating that there is still room for improvement in the effectiveness of the press machine. However, based on the verification of the Six Big Losses calculations, the previously identified dominant losses require further validation. The setup and adjustment loss was found to be approximately 0.27% on average when calculated using the setup time divided by loading time, while the previously reported idling and minor stoppage loss was based on planned downtime data and therefore cannot yet be confirmed as an actual idling and minor stoppage loss. In contrast, equipment failure loss can be directly calculated from the available downtime data and resulted in an average loss of 5.76%, with the highest value occurring in January 2024 at 18.42%.

To identify the potential root causes affecting the effectiveness of the Sinohara 60T press machine, a fishbone diagram analysis was conducted based on three main aspects, namely people, machines, and methods. The analysis was focused on the problems supported by the available observation and machine downtime data. The results of the fishbone analysis are presented in Figure 1.

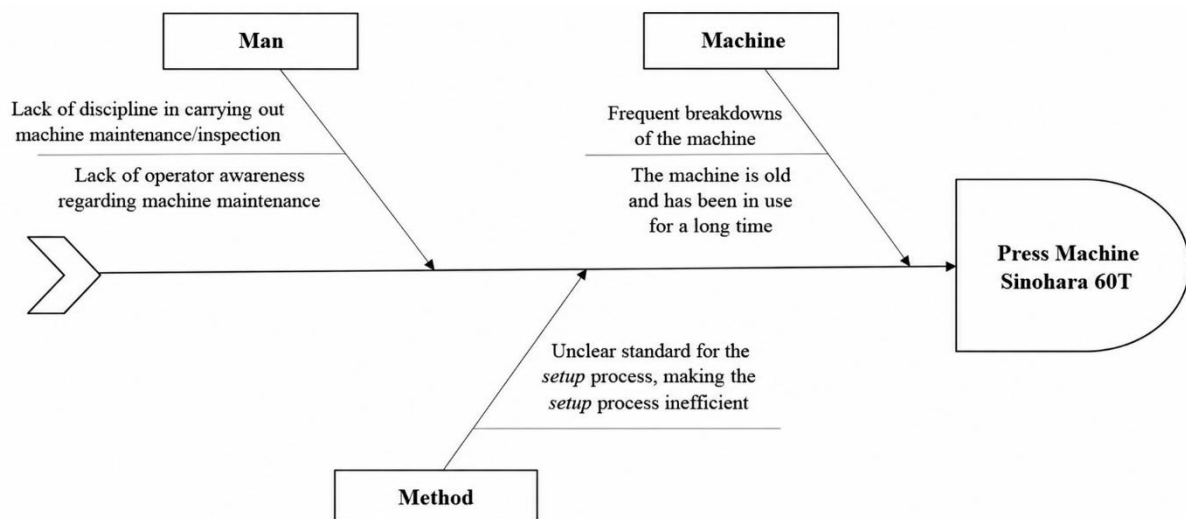


Figure 1. Fishbone Diagram of the Low Effectiveness of the Sinohara 60T Press Machine

Based on the fishbone diagram analysis, the people factor indicates that operator discipline

in conducting routine inspection and maintenance requires improvement. Operators'

awareness of machine conditions also needs to be strengthened so that potential abnormalities can be identified at an early stage. Insufficient attention to machine conditions may increase the risk of unexpected interruptions during the production process and contribute to equipment downtime.

In the machine factor, the potential causes are related to the long service life of the press machine and its relatively high workload during production activities. These conditions may increase the possibility of component wear and machine breakdown. This finding is consistent with the equipment failure loss calculation, which shows that equipment failure is a measurable source of production time loss, particularly in January 2024, when the equipment failure loss reached 18.42%. Therefore, machine condition monitoring and preventive maintenance are important aspects that need to be strengthened.

Meanwhile, in the method factor, the machine setup and adjustment process requires clearer and more standardized procedures. Although the calculated setup and adjustment loss is relatively small, standardized setup procedures remain important for maintaining process consistency and preventing unnecessary time consumption during machine preparation. The analysis also indicates that the previously reported idling and minor stoppage loss cannot yet be confirmed because the available data represent planned downtime rather than separately recorded actual minor stoppage time. Therefore, more detailed recording of downtime categories is required to distinguish planned downtime, equipment failure, idling, and minor stoppages accurately.

Based on the fishbone analysis, the proposed improvement efforts include strengthening operator discipline through training and supervision, implementing routine preventive maintenance, monitoring the condition of critical machine components, and developing standardized operating procedures for machine setup and adjustment. In addition, the company should improve downtime recording by classifying each interruption according to its actual cause. These improvements are expected to provide a more reliable basis for identifying the major sources of production losses and

supporting future OEE improvement efforts for the Sinohara 60T press machine.

g. Analysis and Discussion

Based on Table 7, the OEE results of the Sinohara 60T press machine varied during the observation period from November 2023 to March 2024. The monthly OEE values were 69% in November 2023, 99% in December 2023, 69% in January 2024, 100% in February 2024, and 61% in March 2024, with an average OEE of 80%. The considerable variation indicates that machine effectiveness was not consistent throughout the observation period. This fluctuation suggests that the machine did not experience the same level of operational performance in each month, which may be related to differences in downtime, operating conditions, production workload, and production speed. Therefore, the OEE value should be interpreted not only as an overall measure of effectiveness but also through the contribution of its Availability, Performance, and Quality components.

The Availability Rate ranged from 82% to 99%, with the lowest value occurring in January 2024. The lower availability in this period is associated with the relatively high downtime recorded during the month, indicating that machine interruptions reduced the proportion of planned production time that could be used for operation. This finding emphasizes that machine readiness is strongly influenced by the duration of unplanned interruptions. Similar findings have been reported by Aryanti et al. [3], who obtained an availability value of 80.4% on a Toshiba 650-ton injection molding machine and associated the low availability with high downtime. The similarity indicates that downtime remains an important factor in machine effectiveness across different manufacturing equipment, although the magnitude and causes of downtime may differ according to machine condition and production characteristics.

Meanwhile, the Performance Rate varied from 65% to 109%. The substantial variation indicates that the press machine did not consistently operate at its ideal production speed. Lower performance may be associated with reduced operating speed, interruptions

during operation, machine condition, production workload, and operator activities. Previous research by Aryanti et al. [3] also demonstrated that OEE performance should be interpreted together with the machine's ability to produce according to its ideal cycle time. Therefore, the variation in Performance Rate in this study indicates that improving machine effectiveness requires attention not only to downtime but also to the consistency of production speed. Performance values exceeding 100%, however, require validation of the production quantity, operating time, and ideal cycle time used in the calculation and should not be interpreted as actual performance above theoretical capacity..

The Quality Rate ranged from 96% to 98%, indicating relatively small variation in product quality during the observation period. The relatively stable quality performance suggests that rejected products contributed less variation to the monthly OEE results than the Availability and Performance components. Consequently, the substantial fluctuation in OEE was more closely associated with changes in machine availability and production performance. This condition differs from situations in which quality losses become the primary constraint of machine effectiveness. Aryanti et al. [3], for example, reported a quality rate of 94.9% on an injection molding machine and identified machine condition and operator skills during machine adjustment as factors affecting quality. In the present study, the higher and relatively

stable Quality Rate indicates that improvement priorities should be directed more carefully toward the components and loss categories supported by the available operational data rather than assuming that product quality is the main source of OEE reduction.

The average OEE of 80% is below the commonly used world-class benchmark of 85%. However, the gap from the benchmark should not be interpreted simply as a need to increase the OEE percentage. The results indicate that improvement should be directed toward the specific factors contributing to the variation in Availability and Performance. Previous research has also shown that OEE values below the benchmark can be associated with specific equipment losses and maintenance conditions. Suryadi et al. [4], for example, used OEE and Six Big Losses to identify factors contributing to machine ineffectiveness and reported that operator consistency, field supervision, and workplace conditions were among the factors affecting machine performance. Therefore, the present findings support the use of OEE not merely as a benchmark indicator but as a diagnostic starting point for identifying the operational conditions that require improvement.

To identify the factors that cause the low OEE value and determine appropriate corrective steps, problem analysis is carried out based on machine, human, and methodological factors. The results of the problem analysis and proposed solutions can be seen in Table 15.

Table 15. Results of Problem Analysis and Solutions

No	Problem	Causes	Solution	Faktor
1	Average low performance rate (not yet reached world class standards)	High breakdown frequency due to component wear and aging machine condition	Establish a regular preventive maintenance schedule and create machine maintenance checksheets	Machine
		Excessive machine workload	Arrange machine operating schedules and develop machine operation SOPs	Machine
		Lack of operator awareness regarding machine maintenance	Conduct training for operators related to machine maintenance	Human
2	High setup and adjustment losses	Unclear setup process standards causing inefficient setup activities	Develop SOPs for machine setup procedures	Method

No	Problem	Causes	Solution	Faktor
		Operators frequently perform activities outside the production process	Arrange break schedules and shift changes according to production time	Human
3	High idling and minor stoppages losses	Wear and tear on machine components	Perform regular preventive maintenance and replace damaged components	Machine
		Machine waits too long for readjustment after repair	Set maximum downtime limits during machine readjustment processes	Method

Based on Table 15, machine-related conditions represent an important potential contributor to the effectiveness problems of the Sinohara 60T press machine. The long service life of the machine, component wear, and production workload may increase the possibility of machine interruptions and affect operating performance. This interpretation is supported by the equipment failure loss calculation, which shows that downtime-related losses were particularly high in January 2024. However, these conditions should be interpreted as potential contributing factors identified through observation and fishbone analysis rather than as independently verified causal relationships. The findings therefore indicate the importance of strengthening preventive maintenance and monitoring critical machine conditions to reduce the possibility of unexpected interruptions.

The people factor indicates that operator involvement in routine inspection and machine maintenance is an important operational consideration. Limited attention to machine condition may delay the identification of abnormal conditions and potentially increase the duration of machine interruptions. This interpretation is consistent with Suryadi et al. [4], who identified operator consistency and field supervision as factors associated with machine ineffectiveness. However, the present study does not quantify the individual contribution of operator behavior to OEE; therefore, this factor is interpreted as a potential contributor based on the qualitative analysis.

The method factor indicates that machine setup and adjustment activities require clearer and more standardized procedures. Standardized procedures can help reduce

variation in how operators prepare and adjust the machine. Nevertheless, the corrected setup and adjustment calculation shows that this loss should not be described as a dominant loss in the present study. Instead, the finding indicates an opportunity to improve process consistency and ensure that setup activities are performed according to a defined procedure. This distinction is important because improvement priorities should be based on validated loss calculations rather than on qualitative observations alone.

Based on the integrated findings, the practical improvement implications for PT Ciptaunggul Karya Abadi include strengthening scheduled preventive maintenance, conducting routine inspections of critical machine components, improving operator awareness and maintenance involvement, and developing standardized procedures for machine operation and setup. In addition, the company should improve the recording and classification of downtime so that planned downtime, equipment failure, idling and minor stoppages, and other production interruptions can be distinguished accurately. These actions are expected to provide a stronger basis for controlling production losses and improving machine effectiveness. Rather than assuming that a single loss category is responsible for the OEE reduction, the improvement program should prioritize the loss categories that are supported by validated operational records.

From a theoretical perspective, this study reinforces the role of OEE as an integrated indicator of machine effectiveness by demonstrating that the interpretation of OEE requires examination of its individual components and associated production losses.

The findings also show that quantitative indicators should be interpreted together with qualitative analysis to understand potential operational causes. The integration of OEE, Six Big Losses, and fishbone analysis therefore provides a structured framework for connecting machine performance measurement with potential causes and improvement recommendations. This approach is consistent with previous studies applying OEE and Six Big Losses to diagnose machine ineffectiveness, while the present study applies the framework to the specific operating conditions of the Sinohara 60T press machine.

4. Conclusions and Recommendations

Based on the results of the study using the Overall Equipment Effectiveness (OEE) method on the Sinohara 60T press machine at PT Ciptaunggul Karya Abadi, an average availability rate of 94%, a performance rate of 88%, and a quality rate of 97% were obtained. These results show that the availability and quality components have met world class standards, while the performance rate is still below the ideal standard. The average OEE value obtained is 80%, so the effectiveness of the machine has not reached the Japan Institute of Plant Maintenance (JIPM) standard of 85%. The low OEE value is influenced by high downtime, excessive machine workload, and a setup process that has not run optimally. Based on the analysis of the six big losses, the dominant factors that cause low engine effectiveness are setup and adjustment losses and idling and minor stoppages losses. In addition, the results of the fishbone analysis show that machine, human, and method factors are the main causes of the decline in production machine performance.

To increase engine effectiveness, companies are advised to implement preventive maintenance on a scheduled basis, prepare standard operating procedures (SOPs) for machine use and setup, and improve operator competence through machine maintenance training. In addition, companies need to increase supervision of non-productive activities of operators and conduct periodic evaluations of machine conditions to minimize

downtime and increase production productivity in a sustainable manner. Further research is also recommended to develop analysis using other methods, such as Overall Resource Effectiveness (ORE) or Pareto diagrams, so that the results of the evaluation of machine effectiveness can be obtained more comprehensively.

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