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Implementation of Total Productive Maintenance (TPM) on Mitsui Seiki Compressors to Reduce Production Downtime

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Abstract:

This study investigates the application of Total Productive Maintenance (TPM) to improve the performance of the Mitsui Seiki Inverter screw compressor at PT SEI. The research focuses on evaluating the compressor's Overall Equipment Effectiveness (OEE), which combines availability, performance, and quality metrics to assess the effectiveness of the equipment. Data collection involved primary data from observations and interviews with maintenance staff, along with secondary data from production records. The analysis employed TPM techniques, specifically focusing on reducing downtime and improving machine performance by addressing key issues such as nozzle blockages, cooling system failures, and fluctuating speed losses. The results revealed that the average OEE for 2025 was below the ideal standard of 85%, mainly due to performance losses and recurring breakdowns. The study highlights the importance of consistent maintenance, operational parameter control, and enhanced quality control practices. Recommendations include more frequent nozzle cleaning, regular checks of the cooling system, and implementing regular OEE monitoring as a Key Performance Indicator (KPI). The findings provide valuable insights into optimizing the maintenance of industrial compressors and improving overall production efficiency.

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Introduction

The global competition in the automotive manufacturing industry is continuously increasing due to advancements in technology and market demands for higher efficiency and reliability in production processes. According to Sudrajat (2011), to maintain competitiveness, companies must sustain productivity through optimal machine and equipment availability. One strategic approach widely adopted by industries to improve equipment effectiveness is Total Productive Maintenance (TPM), a system aimed at achieving zero breakdowns, zero defects, and zero accidents by involving all elements of the company (Nakajima, 1988).

TPM consists of eight key pillars, which serve as the foundation for managing machine maintenance. However, three pillars are often emphasized in the initial evaluation of equipment maintenance: (1) Autonomous Maintenance, where basic maintenance tasks such as cleaning, lubrication, simple inspections, and abnormality detection are carried out by operators. This pillar ensures that operators gain a better understanding of machine conditions. (2) Planned Maintenance, where maintenance activities are scheduled based on operating hours, machine conditions, or historical failure data. This helps reduce unexpected downtime. (3) Education and Training, aimed at improving the technical competence of operators and technicians so that they can perform maintenance procedures, troubleshooting, and operate machinery effectively (Wireman, 2005).

PT SEI, a manufacturer of automotive components, particularly disc brakes for motorcycles, relies heavily on air compressors as a vital source of pneumatic energy for various machines. Any disruption in the compressor system can potentially halt the entire production process, making compressor maintenance crucial for smooth operations (Naufal & Saifudin, 2024).

One of the compressors used at PT SEI is the Mitsui Seiki Inverter Screw Compressor. Based on field observations, the compressor often experiences downtime due to issues such as nozzle return back blockage and temperature spikes beyond normal operating limits, triggering alarms for intake and discharge temperature (Boyce, 2009). These disruptions not only hinder production but also lead to increased maintenance costs and reduced equipment effectiveness.

This study focuses on implementing TPM for the Mitsui Seiki compressor to reduce machine downtime at PT SEI. The expected outcome is to provide a basis for evaluating maintenance effectiveness and offer recommendations to improve equipment performance, ensuring more efficient and reliable production. As initial support for the analysis, compressor performance data from May to July 2025 is presented in Table 1.

Table 1. OEE Data for May, June, and July 2025

Month	May 2025	June 2025	July 2025	Average
Availability (A)	81.5%	82.8%	83.9%	82.7%
Performance (P)	92.5%	98.1%	96.3%	95.6%
Quality (Q)	99.5%	98.1%	97.3%	98.3%
OEE (AxPxQ)	75.0%	79.7%	78.6%	77.8%

Previous studies have shown the effectiveness of TPM in enhancing machine reliability and reducing downtime. However, there is limited research that specifically addresses the application of TPM to screw compressors in automotive manufacturing settings. Most studies focus on general machinery or other industries, making the current research relevant for closing this gap by applying TPM principles to a specific type of compressor at PT SEI.

The increasing demand for higher operational efficiency in manufacturing requires timely and effective maintenance strategies. The disruption caused by compressor downtime leads to significant losses in production and increased maintenance costs. Implementing TPM offers a promising solution to mitigate these issues, but its impact on specific equipment like the Mitsui Seiki screw compressor needs further investigation.

This research is urgent as it directly addresses these operational challenges, aiming to enhance the reliability and efficiency of compressors at PT SEI.

Several studies have examined the application of TPM and OEE in various industrial settings. For instance, Wireman (2005) and Nakajima (1988) discussed the implementation of TPM to improve operational efficiency by focusing on equipment reliability and maintenance. Other studies, such as those by Bilianto and Ekawati (2016), highlighted the use of OEE as a tool for measuring equipment effectiveness, which aligns with the current research's methodology. Additionally, studies by Krisnaningsih (2015) and Rahmanadi and Yuamita (2022) further support the effectiveness of TPM in enhancing equipment performance, although most were focused on different machine types and industries.

The novelty of this research lies in its application of TPM specifically to the Mitsui Seiki screw compressor at PT SEI, which has not been widely explored in existing literature. This study integrates OEE with TPM, offering a comprehensive approach to evaluate and enhance compressor performance. By focusing on this specific equipment, the research provides valuable insights into improving operational efficiency and reducing downtime in automotive manufacturing environments.

The objectives of this study are to assess the achievement of Overall Equipment Effectiveness (OEE) for the Mitsui Seiki screw compressor before implementing TPM improvements, to identify the primary causes of losses (Six Big Losses) on the Mitsui Seiki screw compressor that lead to production downtime, and to implement the Total Productive Maintenance (TPM) methodology on the Mitsui Seiki screw compressor to achieve the desired OEE improvements.

The significance of this study is threefold. For students, it provides a practical application of machine maintenance theories and OEE analysis methods in real industrial settings, expands knowledge on machine maintenance management, and the application of TPM in manufacturing environments, while also offering hands-on experience in identifying, measuring, and analyzing industrial equipment efficiency. For universities, this study contributes academically by providing a reference for research in the field of machine maintenance management, demonstrates the relevance of theoretical learning and its implementation in industrial contexts, and serves as a basis for evaluating and improving the curriculum in Industrial Engineering to be more practical. For companies, the study provides technical recommendations regarding the effectiveness of compressor maintenance based on OEE analysis, helps identify the root causes of downtime and develop efficient corrective strategies, and supports the structured implementation of Total Productive Maintenance (TPM) to maintain machine reliability and production efficiency.

Methods

The methodology of this research is a systematic approach that outlines the steps and procedures involved in conducting the study from the beginning to the end. According to Sahban et al. (2025), research methodology is a systematic approach that includes a series of scientific steps and procedures, which guide the research from start to finish. This methodology not only explains how to collect and analyze data but also addresses ethical considerations, instrument design, and variable analysis. The purpose of the research methodology is to provide a clear and structured framework that ensures the research proceeds in an organized, objective, and accountable manner. It represents the stages of problem-solving, offering a framework for conducting research that leads to clearer and more directed execution.

This research adopts a quantitative research design, which is an approach used to gain knowledge through the collection and analysis of numerical data, as defined by Sugiyono (2019). This method allows researchers to assess, measure, and compare phenomena objectively, providing a clear representation of the variables being studied. The study applies Total Productive Maintenance (TPM) with Overall Equipment Effectiveness (OEE) as the primary measurement tool to assess the effectiveness of production equipment. The goal of this research is to evaluate the current state of machine maintenance practices, assess whether the existing maintenance system is optimal, and provide alternative solutions and recommendations for improving machine performance. The data collected in this study include maintenance records, failure frequencies, and operational disruptions in the production line. These data are then analyzed quantitatively to draw accurate conclusions.

This research was conducted at PT. SEI, located in the MM2100 industrial area in Cikarang, Bekasi. The research was carried out over a period of one month, starting from September 1, 2025, to December 12, 2025. This timeline covers the stages of observation, data collection, analysis, and report writing.

The research object in this study is the Mitsui Seiki Inverter screw compressor, which plays a crucial role as one of the main equipment units in the compressed air supply system to support the production process. The focus of the study is on machine maintenance activities, particularly applying TPM pillars such as Autonomous Maintenance (Jishu Hozen), Planned Maintenance, and Education & Training, and analyzing their impact on reducing downtime.

Primary data refers to original data collected directly from the source or research object, ensuring high accuracy and relevance to the research objectives. According to Wulandari and Bangun (2022), primary data is original because it is collected directly by the researcher using systematic methods to answer research problems. In this study, primary data was gathered using several techniques, including interviews and observations. Interviews were conducted with maintenance experts and management at PT SEI to obtain data regarding maintenance procedures, policies, and issues encountered during machine maintenance. Additional interviews were conducted with maintenance staff to gain further insights into on-site practices. This method provided deeper, more detailed, and contextual information. Observations were performed by directly monitoring production processes, machine maintenance activities, operational procedures, and employee interactions. This approach helped gather objective and real data, minimizing biases that could arise from verbal reports or documents.

Secondary data refers to data obtained from existing sources, such as literature, books, journals, official documents, and other previously collected data. This data is used to support the research and provide additional context. According to Sani et al. (2020), secondary data is vital as it strengthens the theoretical foundation, helps compare findings with previous studies, and provides a broader context for research analysis.

The collected data will be processed using TPM and OEE calculations. The processing steps include collecting data through Check Sheets, calculating TPM and OEE values, determining research priorities, identifying dominant causes of trouble, and developing recommendations to improve production outcomes.

The research follows several stages to achieve its objectives. The first stage is a literature study, followed by a company survey. Based on the survey results, problem formulation, research objectives, and scope are defined. The next stage involves data collection, which includes both primary data (interviews and observations) and secondary data from company records. After gathering the data, OEE calculations, Six Big Losses identification, and the creation of Pareto and Fishbone diagrams are performed. Following data processing, the analysis is conducted, and finally, conclusions and recommendations are drawn.

In the literature study phase, the researcher explores theories and concepts related to the research topic from various sources, including books, journals, and online resources. This stage also involves reviewing previous research to support the current study. During the company survey phase, the researcher conducts a survey at PT SEI. The problem formulation phase involves defining the research problem based on the identified issues. In this study, the focus is on assessing the current state of maintenance management at PT SEI and finding appropriate solutions to improve these practices. In the objective and scope definition phase, the researcher clarifies the goals of the research, focusing on understanding the maintenance management system at PT SEI and providing recommendations for improvement. The scope of the study is also defined to ensure that the research remains focused and relevant to PT SEI's operations.

In the data collection phase, the researcher gathers data through interviews, observations, and secondary data sources, including running time, downtime, production process sequences, production capacity, balancing, machine repair data, and maintenance schedules. Afterward, the data is processed to calculate key TPM elements such as availability, performance, quality, Overall Equipment Effectiveness (OEE), Six Big Losses, Pareto Diagram, and Fishbone Diagram.

Data analysis follows, where the researcher assesses the state of maintenance management at PT SEI. The analysis involves analyzing results before and after the improvement, evaluating the implementation of TPM, and comparing the results before and after TPM implementation. Finally, conclusions are drawn, and recommendations are provided based on the findings of the research. These recommendations are intended to guide PT SEI in improving its operations and will serve as a basis for future studies.

Results

This section presents the results and discussions on the effectiveness of the Mitsui Seiki Inverter compressor, focusing on the application of Total Productive Maintenance (TPM) and the evaluation of Overall Equipment Effectiveness (OEE). The data collected include key performance indicators such as machine availability, performance, and quality, which were analyzed before and after the TPM implementation to assess the impact of the maintenance strategies.

Sub 1 Data Collection and Processing

The data collected for the study primarily involved measuring Overall Equipment Effectiveness (OEE) for the Mitsui Seiki Inverter compressor. The key parameters included the number of units processed, operating time, downtime, and ideal cycle time. These data points were collected over the course of one month, from September 1–30, 2025, offering a comprehensive view of the compressor's operation.

Primary Data: The primary data for the study were gathered directly from the compressor, involving both observational data and interview data. Field observations assessed the compressor’s operational conditions, including maintenance routines, inspections, and performance parameters like temperature and pressure.

Secondary Data: Secondary data, such as production records, downtime logs, and historical defect data, were provided by the company. These helped to support the quantitative calculations of machine performance.

Sub 2 Availability Analysis

The Availability component of OEE measures the readiness of the equipment to operate, taking into account the planned production time minus downtime. As shown in Table 2., the availability rate for 2025 averaged 98.14%, meeting the Japanese Institute of Plant Maintenance (JIPM) standard of ≥90%. This indicates that the compressor was largely available for production as planned, with minimal downtime. However, issues such as nozzle blockages and temperature-related alarms contributed to intermittent machine shutdowns, which slightly reduced overall availability.

Table 2. Availability Rate Calculation

Month	Operating Hours (hrs)	Loading Hours (hrs)	Availability (%)
January	350	358	97.77
February	317	323	98.14
	Average		98.14

Figure 1. Availability Rate

The figure above shows the availability rate of the compressor across two months in 2025, highlighting a consistent high level of machine availability.

Sub 3 Performance Analysis

Performance measures the actual production speed versus the ideal speed. As indicated by Table 3., the performance rate for 2025 showed considerable variation, with an average of 84.78%, which is below the JIPM standard of ≥95%. The fluctuation in performance was mainly due to high speed losses, particularly during the months of July and August, where performance fell below 70%. These speed losses indicate the compressor operated at suboptimal speeds, possibly due to equipment wear or cooling inefficiencies.

Table 3. Performance Rate Calculation

Month	Input Quant ity (pcs)	Ideal Cycle Time (sec/pcs)	Operating Hours (hrs)	Performance (%)
January	498,641	0.000585	350	83.35
February	502,100	0.000585	317	92.69
		Average		84.78

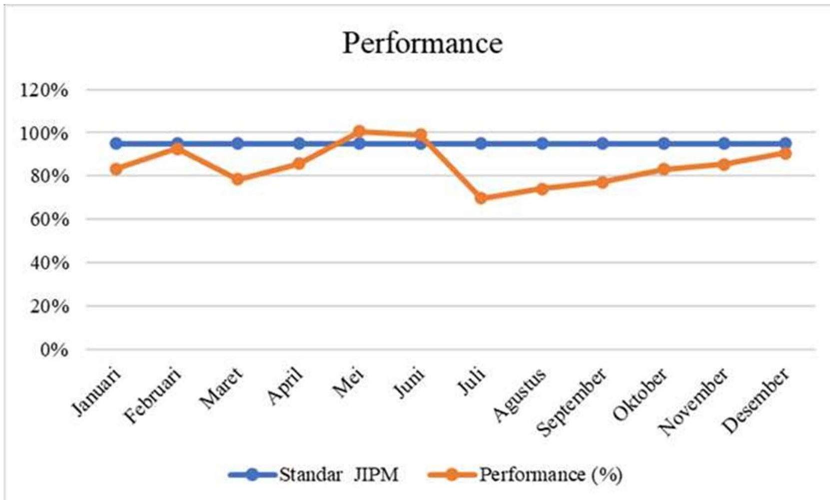

Figure 2. Performance Rate

The figure above displays the performance rate for two months, showing how fluctuations in performance impact the overall OEE of the compressor.

Sub 4 Quality Analysis

The Quality component measures the proportion of good products to total output. Table 4. shows that the average quality rate for 2025 was calculated at 98.98%, which is slightly below the JIPM standard of ≥99%. While the quality rate remained stable, higher defect rates were observed during months of heavy production, such as May and August. These defects are likely due to production overloads and insufficient initial quality checks by operators.

Table 4. Quality Rate Calculation

Month	Input Quantity (pcs)	Defects (pcs)	Quality (%)
January	498,641	5,984	98.80
February	502,100	3,918	99.22
	Average		98.98

Sub 5 OEE Analysis

Overall Equipment Effectiveness (OEE) combines the Availability, Performance, and Quality components. As shown in Table 5., the average OEE for 2025 was 82.65%, which is below the JIPM threshold of ≥85%. While availability and quality rates met the standards, the significant fluctuations in performance—especially during the high-demand months—led to a lower overall OEE. Addressing performance-related losses would have the largest impact on improving OEE.

Table 5. OEE Calculation

Month	Availability (%)	Performance (%)	Quality (%)	OEE (%)
January	97.77	83.35	98.80	80.51
February	98.14	92.69	99.22	90.26
Average	98.14	84.78	98.98	82.65

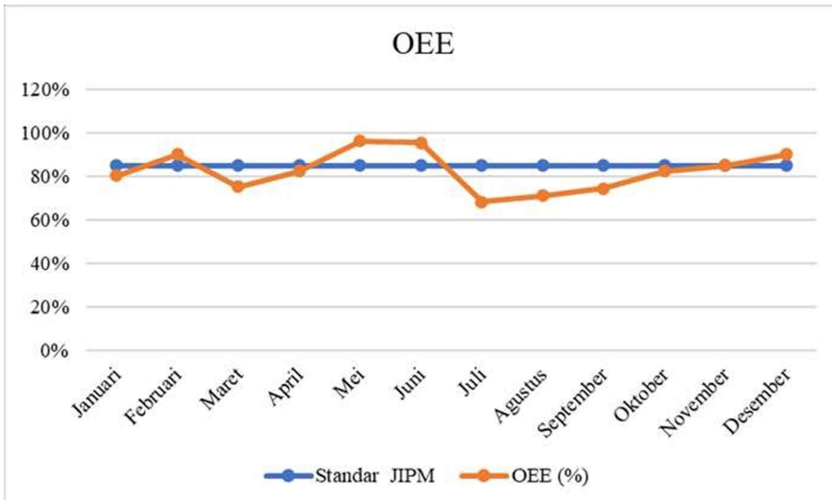

Figure 3. OEE Rate

The figure above illustrates the OEE rate, which remained below the JIPM standard, primarily due to performance issues.

Sub 5 Six Big Losses Analysis

The analysis of the Six Big Losses reveals that Reduced Speed Losses were the primary contributor to inefficiency, accounting for the largest portion of time loss in the production process. Table 6. summarizes the classification of Six Big Losses, with Reduced Speed Losses being the most significant, followed by Breakdown Losses.

Table 6. Six Big Losses Classification

Category	Type of Loss	Impact on OEE
Availability Losses	Breakdown Losses	Reduced machine operating time
Performance Losses	Idling/Minor Stoppages	Reduced production speed
Quality Losses	Defect Losses	Non-compliant products

The data suggests that focusing on reducing speed losses will have the most substantial impact on improving overall equipment effectiveness.

The results from this study indicate that the Mitsui Seiki Inverter compressor performs well in terms of availability and quality, with both parameters meeting JIPM standards. However, the performance rate remains the critical area for improvement, primarily due to reduced operational speed. The analysis of Six Big Losses further emphasizes the need for better control over machine speed and more effective maintenance practices.

Future improvements should focus on enhancing machine performance, particularly by addressing the causes of speed losses, improving preventive maintenance, and optimizing the compressor's cooling efficiency. By addressing these key areas, PT SEI can significantly improve its operational efficiency and align more closely with industry standards.

Conclusion

The analysis of the Mitsui Seiki Inverter compressor's performance revealed several key insights. First, the Overall Equipment Effectiveness (OEE) for 2025 was found to be below the JIPM standard of ≥85%. This shortcoming was primarily attributed to low performance rates, recurring downtime, and fluctuations in product quality. The average performance rate was 84.78%, which is significantly lower than the recommended threshold of >95%. This indicates that the compressor was not operating at its ideal speed, leading to high speed losses, particularly in the months of July and August, where losses exceeded 25%. Another major factor contributing to reduced efficiency was the frequent breakdowns, especially due to nozzle blockages, which were the leading cause of downtime. These breakdowns, along with alarms triggered by air intake and discharge temperature issues, resulted in machine availability fluctuating each month. Despite generally acceptable quality, some months showed a quality rate below 99%, which was caused by product rejections, indicating that quality control was not consistently maintained. Upon further analysis, it was identified that the root causes of these issues stemmed from dirty or clogged components, unstable machine operating parameters, and inconsistent maintenance practices, all of which led to recurring breakdowns and diminished machine performance.

Recommendations

Based on the findings, several recommendations are proposed to improve the compressor's performance. Firstly, to address the frequent nozzle blockages, it is crucial for the company to implement a more frequent cleaning schedule and ensure that maintenance practices are consistently followed, with proper documentation. In addition, the company should focus on improving the control of operational parameters, particularly by conducting routine checks on filters, the cooling system, and ensuring adequate airflow in the compressor room to prevent alarms related to air intake and discharge temperature. Given the significant speed losses observed in the performance analysis, it is recommended that the company investigates the causes of these speed reductions, such as internal compressor conditions, unstable operating pressures, or inappropriate operating methods. Strengthening the quality control processes is also essential, particularly in areas where product rejection rates are higher, to maintain a consistent quality rate above 99%. Moreover, regular OEE monitoring should be established as a key performance indicator (KPI) to enable the company to track trends in machine performance and address any significant declines promptly. Finally, further research on machine reliability, particularly focusing on metrics like Mean Time Between Failures (MTBF) and Mean Time to Repair (MTTR), should be conducted to assess the compressor's reliability more accurately and inform more effective maintenance policies.

Original Article

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