

Improvements to Increase OEE in the Molding Area Using 5S, SMED and TPM at a Company in the Metallurgical Sector

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Abstract

Continuous improvement in industries is essential to maintain optimal profitability and remain competitive in the market. Lean tools are techniques that help the metallurgical industry improve production and grow in a highly competitive environment. The following study is based on a company that manufactures cast and machined parts for the cement industry. Through diagnostic assessments to identify improvements to implement, it was found that the company has a very low OEE compared to the sector. Thus, using the VSM diagnostic tool, it was determined that the molding area has long mold setup times and low performance, in addition to low machine utilization. Lean tools such as 5S were employed to ensure everything is easily assessable and to establish a systematic order, SMED to reduce mold changeover time, and TPM, which helped increase machine availability and thereby improve overall machine performance. Improvements have been achieved following the successful implementation, such as increasing machine availability from 89.96% to 96.66% and yield from 80.86% to 83.18%, resulting in a 7.79% improvement in OEE.

Keywords

OEE, SMED, TPM, 5S, Productivity, Simulation.

1. Introduction

The metallurgical sector faces significant challenges related to low efficiency in its production processes, which affects both its productivity and competitiveness. Among the main problems are long setup times, unscheduled machine downtime, and inefficient use of resources. These deficiencies result in significant economic losses for companies in the sector (IEEE, 2024). According to INEI, in Peru, this sector is showing a slow recovery of 5.1% in 2022, still far from pre-pandemic levels (Sociedad Nacional de Industrias [SNI], 2022). In this context, improving the OEE indicator is essential to optimize operational efficiency, reduce costs, and increase the sector's production capacity.

The global standard for OEE in the industry is 85% (Canahua Apaza, 2021) , considered a level of excellence that guarantees a highly efficient and competitive operation. However, many companies in the metallurgical sector, especially in developing countries, operate at significantly lower levels, reflecting opportunities for improvement in critical processes. This has led to the adoption of continuous improvement tools, such as SMED, TPM, and 5S, which have proven effective in various international studies.

The literature highlights the implementation of SMED, which enabled a reduction in operating times, while the use of TPM contributed to a significant decrease in unscheduled failures, improving machine availability (Nicolik et al., 2023). Furthermore, it was found that SMED can reduce downtime during changeover processes by up to 48%, thereby increasing the overall performance of the production area (Ahmad & Soberi, 2017). Likewise, the application of 5S and TPM in metallurgical companies led to a reduction in waste, an increase in product quality, and a 10% rise in productivity (ScienceDirect, 2022). These strategies not only optimize resources but also promote operational sustainability.

The scientific article presented consists of six parts: Introduction, state of the art, methodology, results and discussion, conclusions, and references.

1.1 Objectives

The main objective of this research is to propose an improvement aimed at increasing the Overall Equipment Effectiveness (OEE) in the molding area of a metallurgical company through the implementation of Lean Manufacturing tools, specifically 5S, SMED (Single-Minute Exchange of Die), and TPM (Total Productive Maintenance).

To achieve this objective, the study will first develop the background and state-of-the-art review related to the identified problem, providing a solid theoretical foundation for the research. Subsequently, an analysis and diagnosis of the current situation in the molding area will be conducted using Lean Manufacturing tools to identify the main factors affecting operational performance and OEE levels.

Based on the findings, improvement proposals will be designed and developed through the application of 5S, SMED, and TPM methodologies, with the aim of optimizing processes, reducing operational losses, and enhancing equipment efficiency. Finally, the proposed solution will be validated by assessing its economic feasibility and evaluating its impact on the relevant stakeholders, thereby determining its contribution to the company's operational performance and competitiveness.

2. Literature Review

Management Model in the Metallurgical Sector

Given the context of a constantly changing market, operations and production management must necessarily adapt to ensure the company's continued existence. The metallurgical sector is a company with a wide range of manufactured products; it is a mixed production line, so decision-making regarding the improvements to be implemented will now also focus on the groups involved in product manufacturing, as a good relationship among them will have positive impacts. This leads managers to consider the relationship not only with a specific group but with all participants, enabling them to make decisions focused on an optimal connection.

Previous literature reviews present specific models that help implement improvements in the metallurgical industry; although these are partial and incomplete, it is necessary to generate contributions in this sector. While the improvement model brings about an improvement in service levels, cost reduction, and greater efficiency, it is also necessary for it to be a model that is not only sustainable—reducing the impact on the environment—but also provides economic, environmental, and social benefits.

OEE Indicator in Metallurgy

The OEE indicator is a key metric used in industry to measure the efficiency of equipment and production processes. It is an essential tool for evaluating the overall performance of operations, helping to identify areas for improvement and maximize productivity (Jonsson & Lesshammar, 1999). OEE combines three main factors: availability, performance, and quality (Garza-Reyes et al., 2010).

Implementation of Lean Tools

The Lean methodology seeks to optimize a company's processes through the implementation of tools, including SMED, 5S, and TPM. This approach was employed following a VSM analysis, which helps identify areas with the most problems or the greatest opportunity for improvement (Marques et al., 2022). Furthermore, it is important to identify critical points in order to tailor a more personalized response and successfully implement Lean tools. Thus, by implementing these tools within the company, one observes improved productivity, reduced costs, better service delivery, and ultimately greater competitiveness in the market (Dora et al., 2013).

3. Methods

Based on the review of the collected articles, the use of the following engineering tools was proposed: SMED to differentiate external tasks from internal ones and convert some internal tasks into external ones, thereby reducing setup times in the molding area; TPM to improve availability and reduce unscheduled failures through autonomous maintenance; and 5S to optimize order, cleanliness, and organization in the work area, creating a more efficient and safer environment. Table 1 presents the authors who have made the greatest contributions to identifying the tools according to the problem.

Table 1. Order Demand by Construction Project

Authors \ Causes	High mold preparation time	Unscheduled machine downtime	Unproductive time due to tool search
Bataineh O., Al-Hawari T., Alshraideh H & Dalalah D. (2019)		TPM	Six Sigma & Kaizen
Canahua N. (2019).		TPM	
Aucasime P. et al. (2020)		TPM & Kaisen	
Bhade S. & Hedge S. (2020)	SMED		
Senthilkumar C. & Nallusamy S. (2021)		TPM & Six Sigma	
Monteiro C. et al. (2019)	SMED		
Shahriar M. et al (2022)			5S
Ramírez A. et al. (2023)			5S
Proposal	SMED	TPM	5S

3.1 Model components

The model is divided into three components, which are described below:

Component 1: Analysis and diagnosis of the current situation. In this phase, a detailed analysis of the current state in the molding area was conducted using diagnostic tools such as VSM, Ishikawa diagrams, and Pareto charts. These tools enabled the identification of the root causes of inefficiencies, such as downtime, long setup times, and unscheduled failures of the mixing machine. See Figure 1.

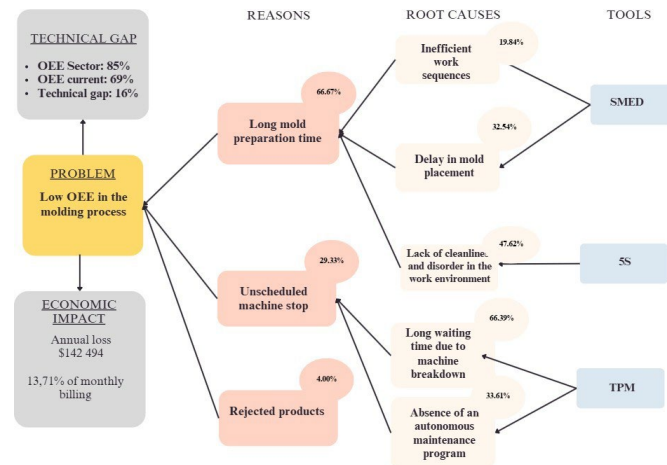


Figure 1. Problem tree

Component 2: Design of the improvement model. The improvement model will focus on eliminating processes that cause longer mold setup times and on reducing machine failures through the implementation of Lean Manufacturing tools. First, using the 5S methodology, the order, cleanliness, and organization of the work area will be improved. Waste segregation points will be established, tools and materials will be sorted and organized through the acquisition of new shelving, and a weekly cleaning schedule will be implemented. Second, using SMED, internal and external activities will be identified, transforming the former into external ones whenever possible. Subsequently, a parallel work sequence will be designed for operators, with the goal of eliminating downtime and optimizing the use of the mixing machine. Finally, Autonomous TPM will be implemented, training operators in basic maintenance tasks. This will allow them to resolve minor faults immediately, which will reduce unscheduled downtime and alleviate the burden on the technical team, ensuring greater machine availability and more efficient operation (Figure 2).

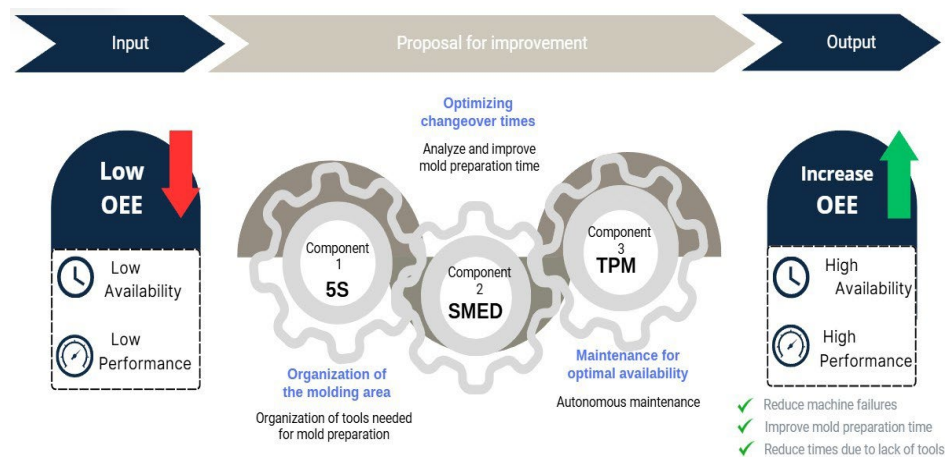


Figure 2. Model design

Component 3: Implementation and validation. To validate the model, a simulation will be developed in Arena software based on the parameters obtained during the diagnosis, and supplementary information about the company will be collected. The model will then be built in the software based on our proposal, and tests will be conducted to evaluate its effectiveness in a simulated environment. The results obtained will be compared with the initial objectives to determine to what extent the model will be able to close the identified gaps and increase OEE to the desired standard.

4. Data Collection

To collect data for the research, scientific articles and academic sources related to the topic. In addition, visits were made to the company directly to observe the process and extract data from there. Key performance indicators were also analyzed.

5. Results and Discussion

5.1 Numerical Results

Development of the 5S Tool

In the molding area, issues related to disorganization, inadequate cleanliness, and non-compliance with safety measures—identified in an initial audit with a compliance rate of 40.91%—were addressed. Actions were implemented, such as sorting tools and materials into usable, damaged, and obsolete categories, and eliminating unnecessary items. Additionally, changes to tool racks and labeling systems were proposed to organize tools, which reduced search time by 65%. Cleaning stations were established, and waste segregation was implemented in accordance with standard NTP 900.058, improving environmental management and cleanliness. Clear work procedures were also defined, and signs were posted to maintain order and safety.

Development of the SMED Tool

The objective was to reduce mold setup time on the mixing machine. To achieve this, the following steps were taken: Classification of internal and external activities, conversion of internal activities into external ones, and reduction of activity time through operators working in parallel. The activities were divided into 17 internal tasks and 4 external tasks. Internal activities accounted for 81% of the total time (26.49 minutes), while external activities accounted for 19%, or 9.86 minutes. By converting internal activities into external ones, such as reorganizing molds and materials, the time for internal activities was reduced to 19 minutes, achieving a 28% improvement. Likewise, the introduction of parallel workflows further reduced setup time. The total time for mold changes decreased from 32.5 minutes to 15.2 minutes, reducing downtime by 53%.

Development of the Autonomous TPM Tool

As part of the development of autonomous TPM in the molding area, a training program was implemented for the three operators, providing them with basic knowledge of mechanical and electrical maintenance. This training enabled them to perform essential tasks such as cleaning, lubrication, greasing, tightening screws, inspecting valves, and checking seals and bearings. The systems addressed included mechanical components (bearings, shafts, vanes), pneumatic components (gate pistons), and electrical components (motors, resin and lime pumps). This approach not only improved the operators' familiarity with the machine but also significantly reduced simple failures in the mixing machine, such as adjustment and wear issues, thereby minimizing downtime and maximizing operational availability. Additionally, autonomous maintenance lightened the workload of the technical team, allowing them to focus on preventive maintenance tasks for other machines throughout the production plant.

reduction. Similarly, the times for material location and preparation approached the proposed targets, with a notable decrease to 3.4593 and 5.7549 minutes, respectively. These efficiencies led to an increase in the Service Level, reaching 88.04%, which reflects substantial progress toward the 90% target. The results presented in Table 1 highlight the effectiveness of the implemented strategies in optimizing warehouse processes, although there is still room for continuous improvement.

5.2 Validation

To validate the design, the root causes of the low OEE in the molding process were identified using a problem tree. An initial diagnosis was also conducted, yielding key indicators: an OEE of 69%, 50 minutes of setup time per mold, 30% mixer utilization, and 25% of total time spent on non-productive activities. After obtaining these values, the model was built in Arena, taking into account the current situation in the molding area.

The simulation was based on production orders for the hammer line (See Figure 3). A production order arrives at the molding area and is completed in one shift per day. The number of hammers in an order varies according to a UNIF distribution (72,80), based on the weekly casting schedule.

Three operators are involved in the process. After implementing the improvement, it was determined that the operators should perform their activities in parallel to reduce downtime, thereby reducing mold setup time. Furthermore, the

contribution of autonomous TPM helped reduce the number of failures and repair time, resulting in a reduction in the frequency of unscheduled downtime by an average of 5 failures per month, primarily focused on cleaning and lubricating equipment components. The model was simulated over a one-year period, yielding the following metrics: average number of hammers produced, average mixing machine downtime, average time per production order, and average setup time.

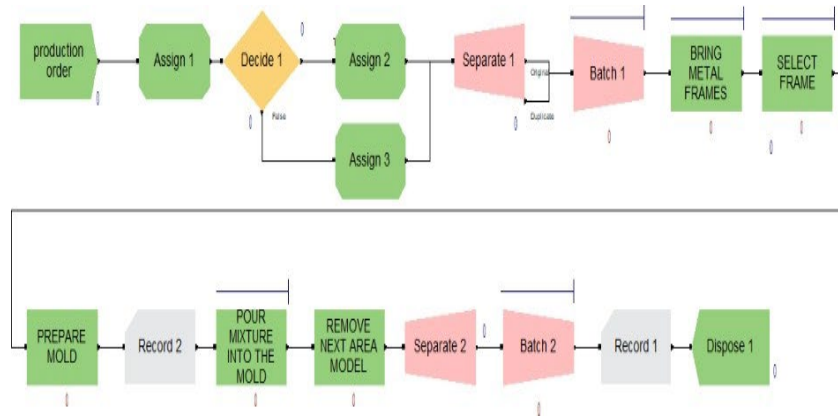


Figure 3. Simulation of improved molding area process

The simulation results (See Figure 4), show significant improvements in OEE, particularly in the Performance and Availability indicators. Performance increased from 80.86% to 83.18%, thanks to the reduction in setup time and failures. Availability improved from 89.96% to 96.66%, driven by an improvement in MTBF from 20.68 to 27.92 hours, indicating a longer time between failures, while MTTR was reduced from 2.31 to 0.96 hours, reflecting faster repairs. These improvements demonstrate that strategies such as SMED and Autonomous TPM are effective in optimizing downtime, thereby increasing the system's operational efficiency.

Based on the results presented, it can be concluded that by applying the proposed improvement tools (TPM, SMED, and 5S) focused on root causes, the technical gap associated with low OEE was significantly reduced. OEE increased from 69.40% to 77.19%, representing an improvement of 7.79%.

Problem	As is	To be	Improvement	Cause	Tools	Indicators	Actual	Objective	Improved
Low OEE	69.40%	77.19%	7.79% 	Unscheduled machine stop	TPM	MTBF	20.68 hrs	> 25 hrs	27.92 hrs
						MTTR	2.31 hrs	< 1 hr	0.96 hrs
						Availability	89.96%	> 95%	96.66%
				High mold preparation time	SMED	Performance	80.86%	> 85%	83.18%
					5S		96%	> 95%	96%

Figure 4. Dashboard of Results

6. Conclusion

The project presented has successfully demonstrated the effectiveness of Lean Manufacturing tools, such as SMED, TPM, and 5S, in increasing OEE in the molding area of a company in the metallurgical sector. Through a detailed analysis of the current situation and the simulated implementation of improvements, OEE increased from 69% to 77.19%, reflecting an improvement of 7.79%. This demonstrates the positive impact on availability, performance, and quality—fundamental aspects for operational competitiveness. Additionally, the company was able to produce 8 additional production orders, each including approximately 70 hammers with a unit price of S/ 500, which increased the company's revenue by S/ 274,400 in one month. This result highlights the direct economic benefit associated with

the improvement actions. However, the process was not without challenges. The main limitations included employee resistance to change, limited space in the molding area, and variability in demand during different periods of the year. The application of structured methodologies and validation through simulations made it possible to resolve the root causes of the problem, improving both productivity and efficiency. This also helped strengthen the company's revenue and overall operations.

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Biographies

Ana Patricia Romani-Navarro is a Bachelor of Industrial Engineering from the University of Lima (top third of the class), with 2 years of experience in SSOMA (Health, Safety, and Environment), Productivity, and Analytical Management. He is knowledgeable in SSOMA Management in Mining, Integrated Management Systems (ISO 9001, ISO 14001, ISO 45001), and people-centered continuous improvement through Lean Management tools. He is proficient in digital tools for tracking and monitoring performance indicators (Power BI, Power Apps, Power Automate). He is a proactive, analytical, committed, and adaptable professional, capable of taking on diverse challenges in the workplace. He has solid intermediate-level knowledge of Microsoft Office and holds an A-I driver's license. He is interested in joining companies seeking to elevate their Safety Culture standards through continuous improvement.

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*Proceedings of the 16th International Conference on Industrial Engineering and Operations Management
Ankara, Türkiye, June 23-25, 2026*

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