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Productivity Improvement Using the Lean Technique in the Pottery Industry

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Abstract

This research aims to apply Lean techniques to reduce waste in the production process of a pottery company to below 10%, enabling the company to meet increasing customer demands and shorten production times. Through a case study, Lean tools were utilized to improve process planning and control, employing the Deming Cycle for continuous enhancement. The research was conducted in five phases, beginning with data collection that revealed a 23% waste rate in the firing process over four months. Subsequent analysis identified key issues using Pareto diagrams and Fishbone Diagrams. Implementing targeted improvements, including temperature control in the firing process, reduced waste by 10-15%, ultimately lowering the overall waste rate to below 10%. This demonstrates the effectiveness of Lean techniques in optimizing production efficiency and reducing waste in the pottery industry.

Keywords
Lean Tools, Why -why Analysis, Pottery production, the Fishbone diagram

1. Introduction

The pottery industry, characterized by its traditional production methods, often faces significant challenges related to waste in the manufacturing process. A lack of structured production planning and quality control measures frequently leads to inefficiencies, resulting in various issues such as increased costs, compromised product quality, and extended production times. Addressing these challenges is critical for maintaining competitiveness in the market, both domestically and internationally (Shah & Patel 2020; Kabir et al. 2020). Many industrial sectors have adopted lean techniques to improve efficiency and reduce waste. These methodologies help streamline production by identifying and addressing the root causes of waste, enabling the production of high-quality products with minimal costs and shorter production times. Lean tools, such as the 7 Wastes, 7 QC Tools, 5S, the Deming Cycle (PDCA), and Why-Why Analysis, are particularly effective in enhancing production processes and meeting customer demands (Rao et al. 2019; Swarna & Mia 2020).

The case study company in this research is involved in pottery, specifically producing plant pots for domestic and international markets. The company's production process is divided between gas-fired and wood-fired kilns. Preliminary analysis revealed that significant waste is generated when using wood-fired kilns, primarily due to the challenges in controlling firing temperatures. This study aims to reduce waste in the production process by employing Lean techniques to analyze the causes of inefficiencies, develop solutions, and establish production standards. By implementing these techniques, the company seeks to improve production efficiency and better meet the growing demands of its customers (Ziarati 2019).

1.1 Objectives
This research was therefore conducted to analyze, find causes, and provide solutions to waste and increase efficiency in the production process by relying on lean techniques and related quality tools. It was done by studying the production of wood-fired kilns.

2. Literature Review
The Deming Cycle (PDCA) is a widely recognized quality management framework that consists of four stages: Plan, Do, Check, and Act. This systematic process is designed to improve organizational performance through continuous development. The cycle's primary goals are to address issues, foster ongoing development, facilitate informed decision-making, and mitigate management risks. Ishikawa (2018) expanded upon the original PDCA cycle by integrating the establishment of specific goals, targets, and methods for achieving these objectives within the planning phase. He further emphasized the necessity of training and education to support implementation during the execution phase. Additionally, Dr. Ishikawa underscored the importance of continuously revising standards to incorporate consumer feedback, complaints, and evolving requirements, ensuring the process remains dynamic and responsive.

The concept of the 7 Wastes, as outlined by Shah and Patel (2020), is central to Lean manufacturing principles. These wastes—Overproduction, Defects, Inventory, Transportation, Waiting/Delay, Motion, and Processing—are common inefficiencies that Lean techniques aim to minimize. Overproduction occurs when production exceeds demand, often due to oversized or excessively rapid production processes, leading to a lack of accountability for labor or raw materials. Defects result from waste generation during production, increasing raw materials and rework costs. Excess Inventory arises from ordering larger quantities of raw materials than necessary, while unnecessary Transportation within the production process leads to increased labor, time, and fuel costs. Waiting/Delay happens when labor or machinery is idle, causing production interruptions. Inefficient Motion is often due to poor workstation layout, and Excessive Processing leads to complexity and waste within the production process.

Previous studies have applied Lean techniques across various industries to enhance efficiency and reduce waste. For instance, Kabir et al. (2020) demonstrated how Six Sigma, a methodology related to Lean, was used in the leather industry to improve productivity by systematically identifying and eliminating defects. Similarly, Rao et al. (2019) explored the application of different Lean approaches in medium-scale manufacturing industries, highlighting the significant reduction in waste and improvement in production levels achieved through these techniques. However, while Lean techniques have been extensively studied and applied in manufacturing sectors, their application in traditional industries, such as pottery, remains relatively underexplored. The novelty of this research lies in its focus on the pottery industry, where traditional production methods often lack the structured processes and quality control measures found in more modern industries. By applying Lean techniques such as the Deming Cycle (PDCA), 7 QC Tools, and Why-Why Analysis, this study addresses the unique challenges of waste reduction in pottery production, particularly in wood-fired kilns where temperature control is less precise.

As emphasized by Ziarati (2019), Pareto Analysis is another critical tool in Lean methodologies. Following the Pareto principle, this technique helps identify and prioritize the most significant problems, focusing on the few causes that account for most issues. In this research context, Pareto Analysis targets the key sources of waste in the pottery production process, allowing for more efficient allocation of resources and more impactful improvements. Finally, using cause-and-effect diagrams, also known as Ishikawa or Fishbone diagrams, is a standard practice in Lean projects. These diagrams facilitate the identification of root causes by systematically considering every possible factor (Rao & Nallusamy 2019). This tool is particularly valuable in complex processes, such as pottery production, where multiple variables can contribute to waste. By employing this method, the study aims to uncover the underlying causes of inefficiencies and develop targeted solutions.

In summary, this literature review highlights the application of Lean techniques in various industries while underscoring the novelty of applying these methods to the traditional pottery industry. Integrating Lean tools in this sector offers a unique opportunity to enhance production efficiency and reduce waste, contributing to the broader field of Lean manufacturing.

3. Methods

The methodology uses the Deming Cycle to control and plan process improvements to solve waste problems in the production process, as shown in Figure 1.

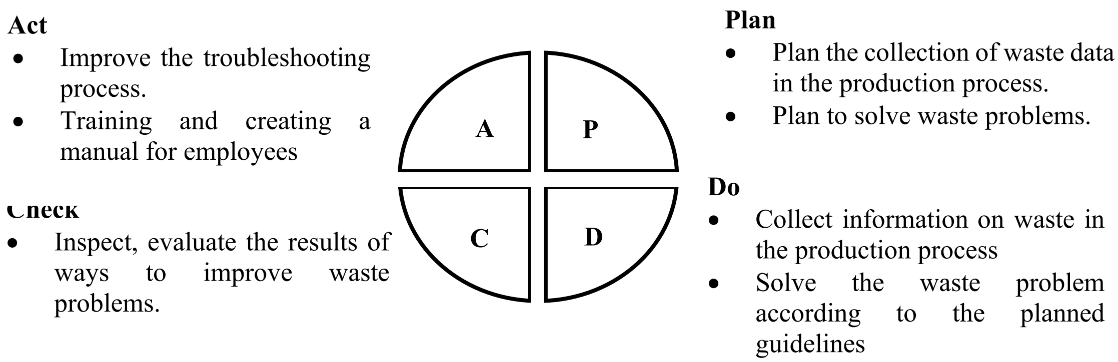


Figure 1. Deming Cycle

This study employs the Deming Cycle (PDCA) as the primary framework for controlling and improving the production process to reduce waste in a pottery manufacturing company. The methodology is divided into several distinct phases, each outlined below.

Step-1: Data collection. Use a check sheet to collect waste data at each step of the production process and analyze the results.
Step 2: Data analysis. Data analysis by prioritizing problems using a Pareto diagram and why-why analysis. And fishbone diagrams to find the root cause of the problem.
Step 3: Production improvement planning.
Step-4: Improvement production. Improvement production These improvements do not affect current production capacity. and guarantee ease of use for employees.
Step 5: Prevent problems. Train and create a manual for employees to increase their understanding and decision-making on waste problems.

3.1 Data collection and analysis

The researcher divided waste data collection into three main parts: Waste in the workpiece forming process, the drying process, and the firing process. The data is collected at the 3rd and 4th production sites, which are the main production capacity of the company. Data will be collected in various production sections using check sheets to collect information on the percentage of waste in each process, as shown in Figure 2 and Figure 3.

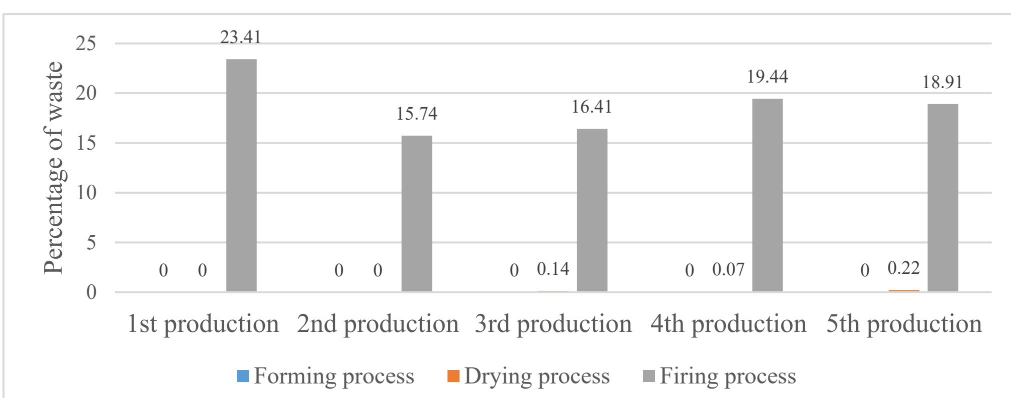


Figure 2. Waste that occurs in the production process of the 3rd production site

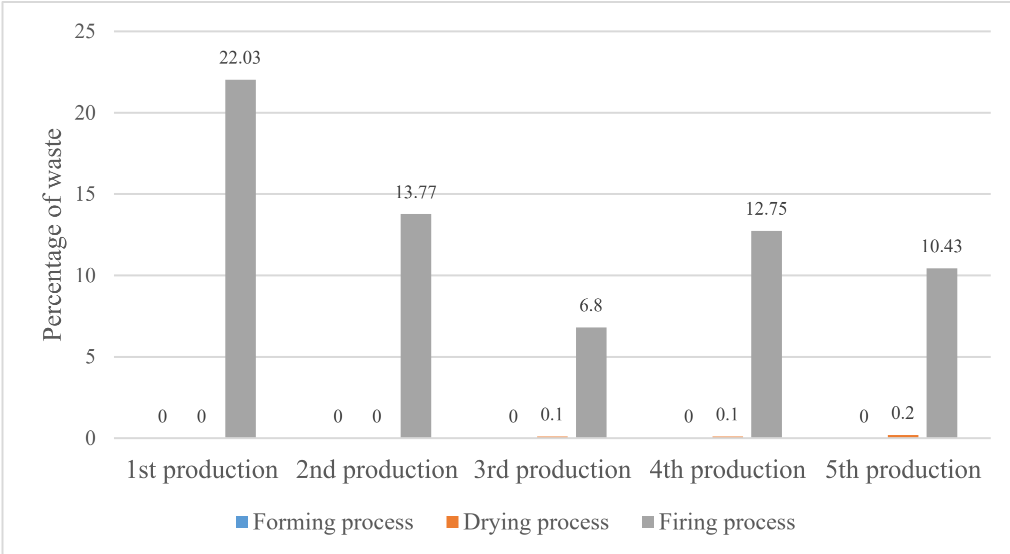


Figure 3. Waste that occurs in the production process of the 4th production site

From collecting the data, the researcher classified the defects resulting from the three processes into four types: crack, firing (Workpiece is distorted.), under firing, and microcrack. It was found that most of the defects occur in the firing process, as shown in Table 1 and Table 2.

Table 1. Percentage of defects for each type of 3rd production site.

Production site	**Production**	**Process**	**Defect (% percentage)**			
			Crack	**Over firing**	**Under firing**	**Micro crack**
3rd production site	1st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.00	0.00	0.00	0.00
		Firing process	11.38	11.67	0.00	0.36
	2st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.00	0.00	0.00	0.00
		Firing process	7.94	7.79	0.00	0.00
	3st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.14	0.00	0.00	0.00
		Firing process	5.58	10.56	0.00	0.00
	4st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.07	0.00	0.00	0.00
		Firing process	7.39	2.68	1.20	8.17
	5st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.22	0.00	0.00	0.00
		Firing process	11.88	7.03	0.00	0.00

Table 2. Percentage of defects for each type of 4th production site

Production site	Production	Process	Defect (% percentage)			
			Crack	Over firing	Under firing	Micro crack
4th production site	1st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.16	0.00	0.00	0.00
		Firing process	11.38	11.67	0.00	0.00
	2st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.00	0.00	0.00	0.00
		Firing process	7.10	6.67	0.00	0.00
	3st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.16	0.00	0.00	0.00
		Firing process	3.36	3.44	0.00	0.00
	4st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.07	0.00	0.00	0.00
		Firing process	2.46	10.29	0.00	0.00
	5st production	Forming process	0.00	0.00	0.00	0.00
		Drying process	0.21	0.00	0.00	0.00
		Firing process	4.64	5.79	0.00	0.00

3.2 Analysis Technique

Analysis of the collected data results and waste classification in Table 1 and Table 2 Most waste generated in the production process comes from the incineration section. From prioritizing the four defects that occur in the firing process using the Pareto chart, The trend of waste that occurs in the firing process is caused by cracks and overfiring in Figures 4. and 5.

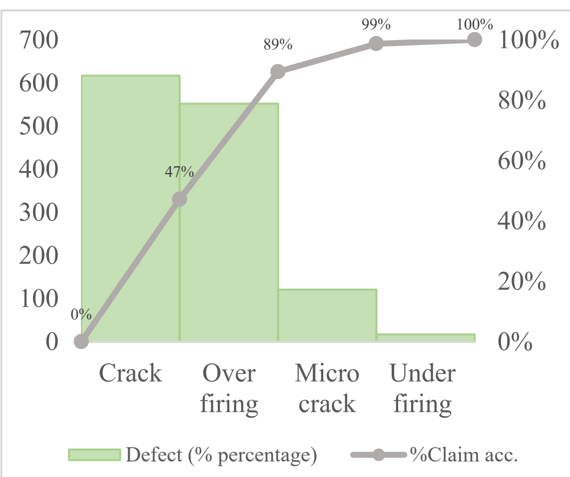


Figure 4. Pareto chart of 3rd production site.

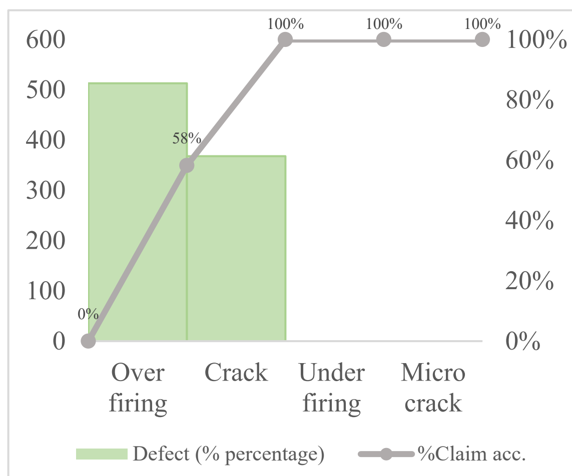


Figure 5. Pareto chart of 4th production site.

According to the Pareto chart analysis, two types of flaw problems occur in the firing process: crack and over-firing temperature. Analyzes were conducted to find the root causes of both problems using cause-effect diagrams and why-why analysis techniques to Analyze to find the root cause of the problem that causes the defect and from the results shown in Figure 6. and Figure 7. , both problems have a common point in causing defects in the workpiece. The company's employees do not have standards for the incineration temperature to use as a reference in their work, which results in various problems. Including waste in the production process

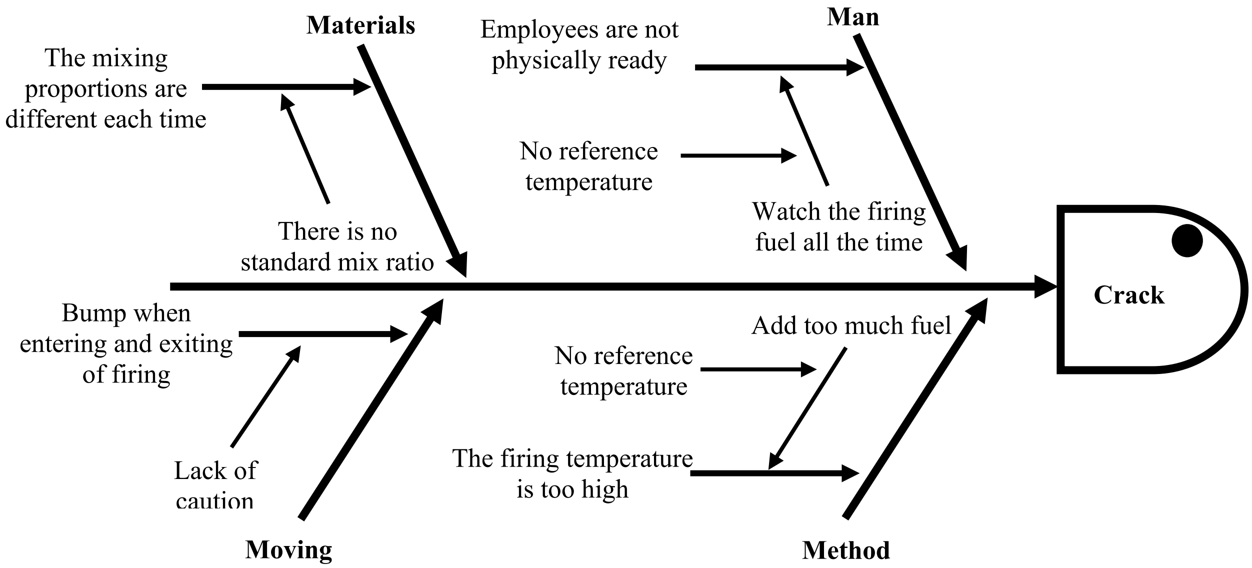


Figure 6. Cause-effect diagrams of crack defect

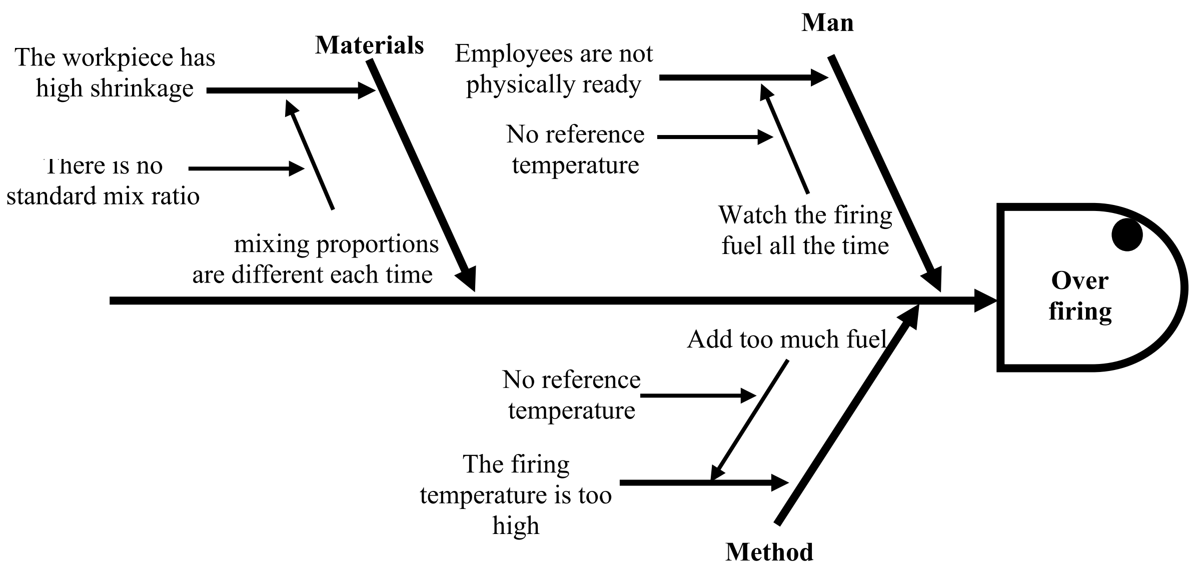
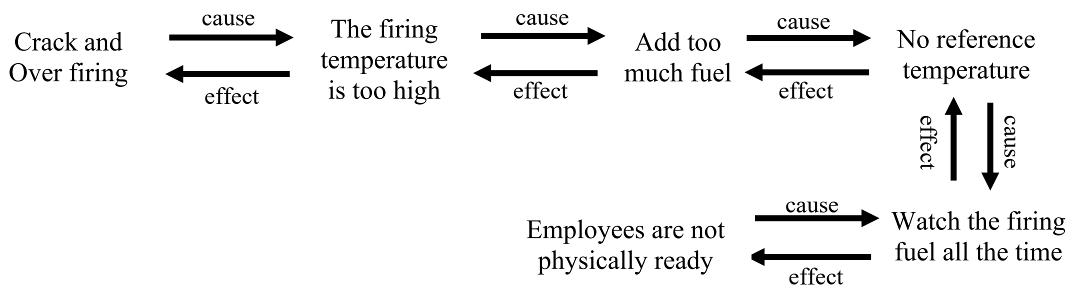


Figure 7. Cause-effect diagrams of overfiring defect

The analysis results are used to find the cause of defects in the workpiece that occurred. There was a common cause of both defects that occurred, which the researcher analyzed and concluded was caused by the employees in the incineration process lacking the temperature used to reference the incineration. It also results in employees having to keep an eye on the fuel being burned all the time, resulting in employees not getting enough rest.



The researcher has studied and installed a thermocouple, as shown in Figure 8. and Figure 9. for use in measuring the sintering temperature and creating a temperature standard for the sintering of the workpiece by dividing the steps into three steps.
Step 1:Collect the firing temperature data.
Step 2:Analyze/Improve firing temperature
Step 3:Try using the improved temperature.

Figure 8. Thermocouple

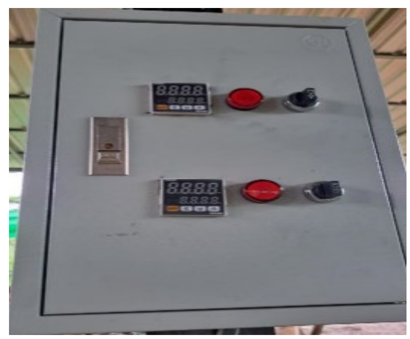


Figure 9. Temperature controller

4. Results and Discussion

From the reasons analyzed, the researcher adjusted the work method and collected data by using a thermocouple inside the furnace to standardize the temperature for firing the workpieces to reduce waste that occurs in the firing process of the 3 rd and 4 th production sites by adapting temperature measurement tools and improving combustion simultaneously. The first phase of the renovation is experimental incineration 1-4 (period of 1 month), as shown in Figure 10. and Figure 11, waste in the production process tends to decrease.

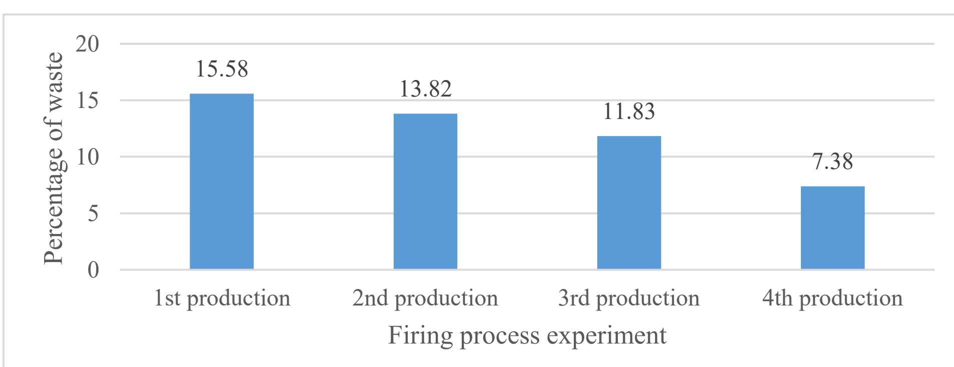


Figure 10. Percentage of production waste 1-4 of 3rd production site

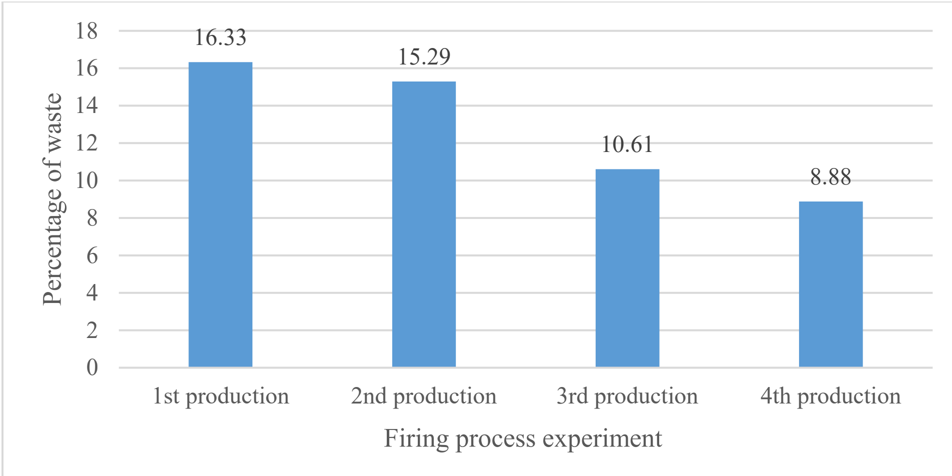


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Figure 11. Percentage of production waste 1-4 of 4th production site

Firing experiment using a thermocouple to help in the firing process. The researcher is continually improving the process of reducing waste in incineration. The researcher has used the improved production from the 1st-4th burning to test the 5th-8th burning. It can be seen that the process can be improved and the waste in the production process reduced to less than 10%, as shown in Figure 12. and Figure 13.

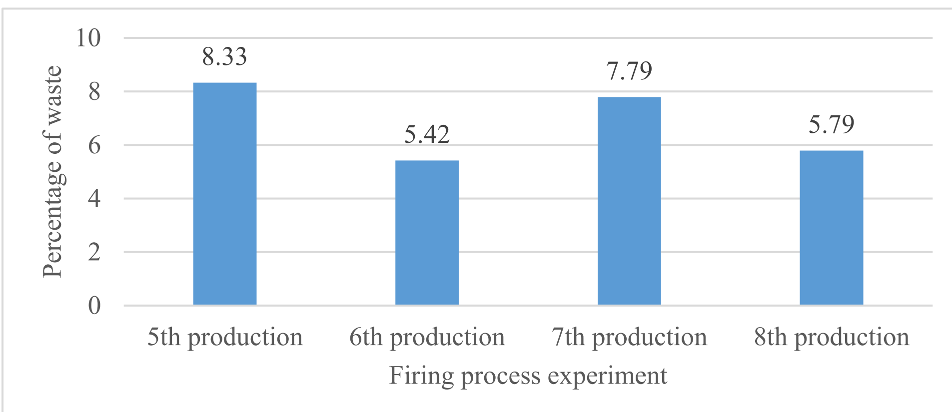

Figure 12. Percentage of production waste 5-8 of 3rd production site

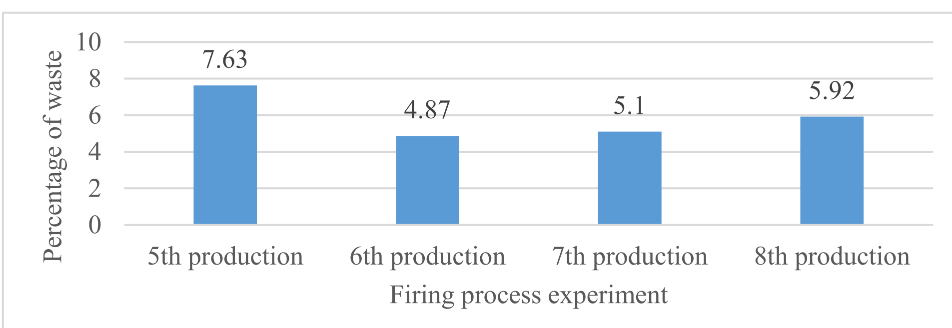

Figure 13. Percentage of production waste 5-8 of 4th production site

5. Conclusion

This study investigated waste problems in a pottery factory, focusing on applying Lean techniques to analyze the root causes of inefficiencies and develop targeted solutions. The analysis revealed that most waste issues were concentrated in incineration, where defects such as cracks and over-firing were prevalent. The root cause of these defects was identified as the lack of a standardized temperature reference for firing. To address this, a thermocouple was implemented to collect data and establish temperature standards for the firing process. Implementing these standards resulted in a significant waste reduction, lowering the defect rate in the production process to below 10%, with a final waste rate of 4.87%. This improvement reduced production costs and enhanced the company's ability to effectively meet customer demands.

While the results of this study demonstrate the effectiveness of Lean techniques in reducing waste in the pottery industry, there are opportunities for further research. Future studies could explore the long-term sustainability of these improvements and examine the impact of Lean techniques on other aspects of production, such as energy efficiency and resource management. Additionally, research could investigate the integration of more advanced technologies, such as automation and real-time monitoring systems, to further enhance process control and reduce variability in production.These potential areas for improvement and further exploration underscore the ongoing value of Lean techniques in the pottery industry and highlight the need for continuous innovation to maintain competitive advantage in a rapidly evolving market.

Acknowledgment

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Biographies

Thanathip Khaewkhong graduated from Suranaree University of Technology with a degree in Ceramic Engineering. Currently studying at the master's level in System Engineering, His research applies lean techniques to solve the waste problem in the pottery industry.

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