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Research Article

An Empirical Study on the Integration of Lean Manufacturing and Kaizen to Increase Manufacturing Productivity in Indonesia

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ABSTRACT

Introduction: The phenomenon experienced by several industries is due to a decrease in customer demand, unbalanced workstations, over capacity from what is needed, and too many activities that do not add value.

Objectives: This study aims to enhance process flow by reducing process waste and minimizing time in the assembly area, thereby increasing overall efficiency and productivity.

Methods: To achieve this, the research adopts a combination of the Lean Manufacturing approach and the Kaizen concept. Lean Manufacturing provides a systematic framework for eliminating waste. Meanwhile, Kaizen instills a continuous improvement mindset that ensures lean systems don't remain a one-time project. Combining these two methods allows for systematic productivity improvements through Focus Group Discussions (FGD). FGD with experts are used to guide the implementation of Fishbone Analysis and FMEA because they integrate cross-functional expert judgment, enhance content validity, and generate credible consensus in identifying root causes and process failure risks.

Results: The results demonstrate significant improvements in manufacturing performance. The process time was reduced by 45.2%, manpower requirements decreased by 33.3%, and daily production output increased from 50 units to 55 units, reflecting a 10% improvement. These findings highlight not only the benefits of reducing unnecessary processes and motion but also the impact on cost efficiency and workforce optimization. Moreover, the study addresses delivery delays that previously resulted from low productivity, indicating inherent limitations within the current process. Recognizing these challenges provides valuable insights for developing strategies to overcome them. In terms of broader implications, the research suggests that the integration of Lean Manufacturing and Kaizen in the Indonesian manufacturing context holds potential for scalability and wider adoption across the industry. This research has a level of originality that lies in the development and integration of a continuous productivity improvement model that combines Lean Manufacturing approaches, Kaizen Thinking, and expert-based risk and root cause analysis.

Conclusions: Overall, the results of a 45.2% reduction in process time provide a scientific contribution in the form of a practical, adaptive, continuous productivity improvement model, while simultaneously expanding the understanding of how the integration of Lean Manufacturing and Kaizen can be effectively operationalized to support the long-term competitiveness of the manufacturing industry.

Keywords: Assembling Line, Continous Improvement, Increasing Productivity, Kaizen, Lean Manufacturing.

INTRODUCTION

Following the global COVID-19 pandemic in 2020, Indonesia's manufacturing sector has shown positive signs of recovery and expansion. In 2022, the national manufacturing industry was valued at approximately US$240 billion, placing Indonesia as the 12th-largest manufacturing producer in the world. Furthermore, in 2023, the manufacturing industry recorded growth of 4.64% and contributed approximately 20% to Indonesia's total Gross Domestic Product (GDP), which was valued at US$1.371 trillion [1]. The development of industry in the world has increased rapidly, so that increasing competitiveness is a priority for all industrial sectors in the world market. The manufacturing industry is one of the important sectors that greatly influences the economic growth of a country [2]. Industrial growth in this era of globalization requires companies to implement various improvements to save operational costs and must be able to improve performance and competitiveness in order to excel in competition in the global market. This will certainly trigger competition among industry players to increase productivity and quality in the long term [3][4]. The phenomenon experienced by several industries is due to a decrease in customer demand, unbalanced workstations, over capacity from what is needed, and too many activities that do not add value [5]–[7]. A must if a company wants to compete effectively in the world market is to produce products that are tailored to the needs of individual customers and be as flexible as possible in responding to changes in product design that are adjusted to customer demand [8]. One way for industry to exist in global competition is to improve production processes in order to increase the response to increasing demand [9]. Another way to realize sustainable development is that every company is required to pay attention to recycling and reusing waste products [10]. Many industries that follow the principles of Lean Thinking will have a continuous improvement mindset so that it is useful to maintain acceptable and acceptable productivity levels and must do this for all assembly lines [6]. Manufacturing industries around the world are under pressure to lower their prices to be more competitive. To maintain profitability, they adopt Lean Manufacturing to reduce waste of time, process and cost [11][12]. In addition, the manufacturing industry must be able to reduce production costs through increased automation, thereby increasing overall manufacturing productivity, the handling process needs to be improved in terms of non-conformity [13][14]. To encourage the manufacturing industry to reduce waste of motion and waiting, improvements in identifying waste using Lean Manufacturing. To implement improvements using Kaizen focus on reducing motion and waiting time [15]. This method is combined with the Kanban tool, a substantial impact on inventory reduction is achieved [16]. Kaizen which means continuous improvement according to the principle of excellence is a lean management model that envisions the participation of all managers and employees in the business [17]. Lean-Kaizen is an effective and reliable improvement technique that helps overcome all types of hidden inefficiencies in the organization, after implementing the Kaizen concept, it gets reduced inventory levels, reduced cycle time, elimination of rework, increased productivity, and improved product quality [18].

The principle of lean manufacturing is one of the successful concepts with improvements that have been applied to eliminate waste and non-value-added activities that occur in many companies and increase work efficiency [19], [20]. The application of Lean Manufacturing in the manufacturing industry aims to minimize waste on the production floor with Flow mapping as a tool to identify waste by separating value-added and non-value-added activities in the production process, while improvements are made using the 5W + 1H technique and the Eliminate, Combine, Rearrange, Simplify (ECRS) principle [2]. Implementation of the Lean-Kaizen concept using VSM to overcome all types of inefficiencies and waste in the process [21].

Line Balancing Problem in the metalworking industry can be overcome by implementing The Grouping Evolution Strategy algorithms and discrete events simulation dynamically [22]. Lean and Green Value Stream Mapping are able to identify and reduce waste that occurs and increase green productivity [23]. A set of lean tools combined with line balancing, standard work and standard layout aims to increase performance productivity that can be identified with a mix of labor-intensive processes and flexible equipment [24], [25]. Lean can be implemented quickly and easily understood by workers which has an impact on increasing machine occupancy and decreasing defects and production costs, so that added value increases [26].

Lean Manufacturing can increase process time efficiency by 17.18%, which means the output ratio will increase the process by around 17.18% [7]. Lean is able to reduce production waste, waste of work time and increase the Overall Equipment Efficiency (OEE) value so that the productivity of production machine equipment increases [27]. Another approach that is combined with Lean is the DMAIC approach that has enabled better structuring of the entire project, choosing the right improvement solution with the right choice of Lean tools and several advantages that do not apply to other frameworks [28]. Lean Manufacturing practices must be combined with considering individual motivations in the use of technology and considering the Industry 4.0 approach to increase communication levels, reduce waste and increase work productivity [29]–[31]. Toyota, having created the Lean approach, describes its philosophy as a chart to define the basis of Lean project construction and the pillars that strengthen its rigidity (can be seen in Figure 1). Each part of the chart allows to define the objectives of the methodology with the elements in which it is necessary to act and the tools to be used. During the improvement step, this study used a Focus Group Discussion (FGD) with 5 expert members so that improvements are expected to be more focused, structured and conceptual. While the improvement concept (Kaizen) uses several Kaizen tools including Fishbone diagrams, why-why analysis and Failure Mode and Impact Analysis (FMEA). Other studies also use the Kaizen tool to analyze root causes using the Fishbone diagram combined with why why analysis and improvement plans are used using the 5W + 1H method [32].

Kaizen is a strategic instrument used to achieve and overcome company goals that provide tools to adapt to global competition by eliminating waste in the production process, changing corporate culture and encouraging cross-functionality [33]. Kaizen is an approach to improvement stages such as process analysis, time observation, waste identification, standard documents at work stations and all forms of quality improvement [34]. The implementation of Kaizen properly can result in improved quality, reduced cycle time and Work In Process (WIP) and increased productivity. Increasing management awareness to continue to make continuous improvements both in the field of process governance and in the field of human resource development [35].

OBJECTIVES

There is limited research linking Lean–Kaizen to the manufacturing context in developing countries, particularly Indonesia, which is characterized by a labor-intensive workforce, varying levels of human resource readiness, and limited technological resources. However, few studies have demonstrated the integrated application of Lean and Kaizen tools, facilitated by a structured FGD with industry experts, within the specific operational constraints of the Indonesian assembly sector, so this creates a gap in this research. The purpose of this study is to improve the process flow by reducing process waste and time in the assembly area so that efficiency and productivity can be increased.

METHODS

This research is a mixed-methods study, combining quantitative and qualitative research. Quantitative data is used as a baseline to identify the most significant problem areas, such as process time inefficiencies, workload imbalances, and production target achievement. These quantitative findings are then further deepened through a qualitative approach to understand the underlying causes behind the figures, including human factors, work methods, and process conditions. The combination of these two approaches allows for a more comprehensive analysis, with quantitative data pinpointing where problems occur, while qualitative exploration explains why they arise and how improvements can be effectively designed. The quantitative research used primary data from direct observation of the cycle time process, FGD results with five expert opinions, and FMEA. The qualitative research used secondary data from monthly report documents. This data was then analyzed through cause-and-effect analysis using Fishbone diagrams and why-why analysis.The procedure used FGD. The framework of this research can be seen in Figure 1.

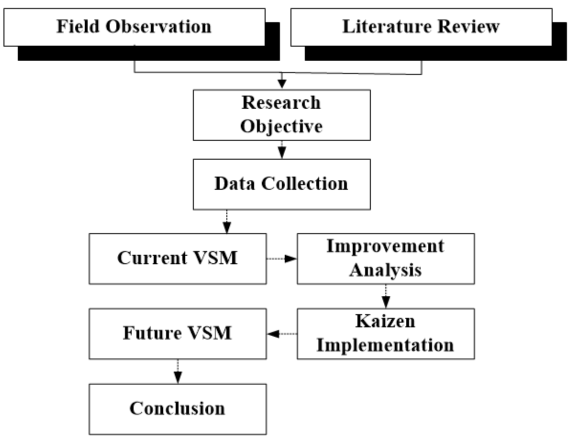

Figure 1. Research Framework

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Figure 1 shows the flow process of the research framework of this paper which begins with field observation and literature review as initial data to find out the phenomena that have occurred so far. The next step is to determine the objectives, goals and targets of the research so that this research will be directed and conceptualized in terms of collecting data and information related to data collection before improvement. The next step was for the research team to collaborate with the company's improvement team to identify the root cause and plan improvements. These results were based on FGD.

RESULTS

Current Condition

The initial stage in this study is to explain the problems that occur in the assembly production system. Based on initial observations on the production floor, it is known that the assembly process has several types of problems. The problem in the Assembly process is a decrease in productivity. Many factors cause this problem to arise. One of them is the ineffective process flow factor, which requires a lot of manpower. In addition, the daily production output does not reach the target. The assembly process flow in the current condition can be seen in Figure 2.

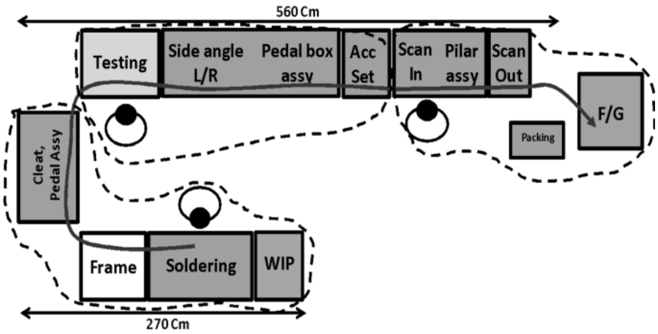

Figure 2. Current Process

Figure 2 shows that the number of operators is 3 people with an uneven distribution of workload. Operator 1 carries out the process from soldering to pedal assy. Operator 2 carries out the testing process to the accessory set and Operator 3 carries out the scan-in process to packing. As a result of these conditions, production capacity cannot be optimally utilized, resulting in production results that fall short of established targets. In addition to lowering productivity, this workforce imbalance also has the potential to increase operator fatigue at certain workstations and reduce the stability of the overall assembly process. Therefore, a systematic improvement approach is needed to balance the workload between operators, reduce wasted time, and increase assembly process efficiency so that production targets can be achieved sustainably. The following is the distribution of workload in the assembly process before the improvement an be seen in Figure 3.

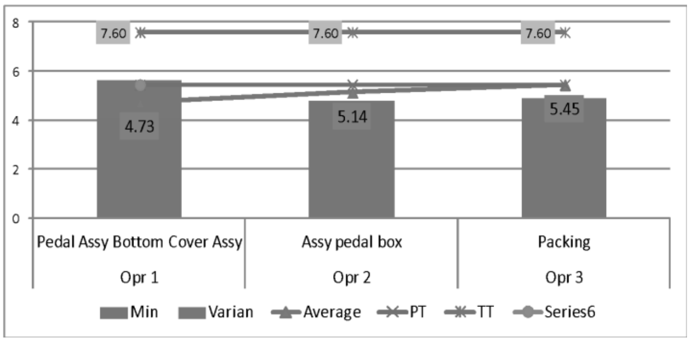

Figure 3. Man Power Loading Actual

Figure 3 shows that the workload of the assembly process is uneven. The average current operator requirement is 2.7 people so that workers in the assembly process are able to complete the work for 7 working hours with an output of

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50 units/day. While the normal working time is 8 working hours per day. This is one of the problems that needs to be analyzed for causal factors.

Improvement Analyze

Analysis of the causal factors of the problem is carried out by mapping the causal factors to the fishbone diagram and then conducting further analysis with why why analysis. This section analyzes the causes of the problem of decreased productivity in the Assembly section. Based on initial observations, the decrease in productivity was caused by an ineffective production layout, making line balancing ineffective. The factors causing the problem are known based on 5M through the Fishbone diagram which aims to find the main cause of the problem of decreased productivity. The following are the results of the analysis with the Fishbone Diagram which can be seen in Figure 4.

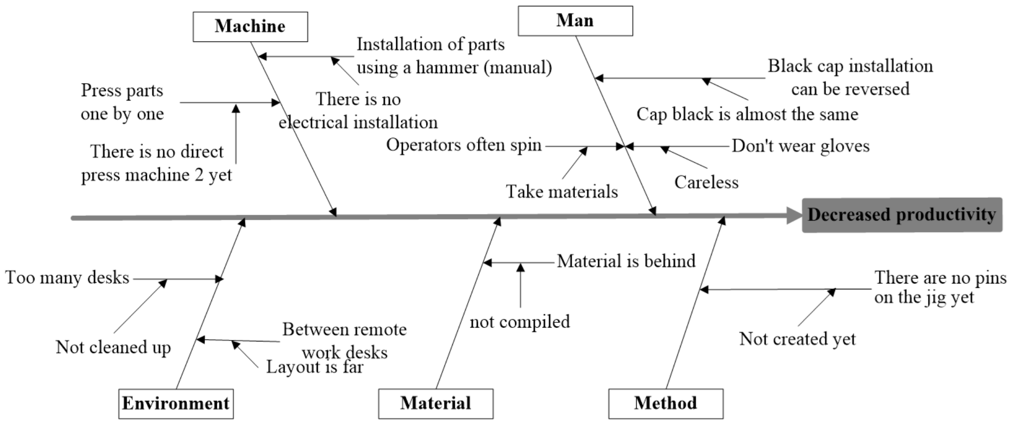

Figure 4. Fishbone Diagram of Productivity Decrease

After the Fishbone diagram is formulated, the next step is to define the why-why analysis to find out the root cause of the problem from the five factors that influence it. The results of the why-why analysis can be seen in Table 1.

Table 1. Why-why Analysis of Productivity Decrease in Assembling Section

Factor	Why 1	Why 2	Why 3	Why 4
Machine	Intstalation of parts using a hammer.	There is no electrical instalation	Haven't submitted a budget yet	Haven't made an application yet
	Press part one by one	There is no direct press machine 2 yet	Tool not ready	Haven't thought about the model yet
Material	Black cap installation can be reversed	Cap black is almost the same	Faint hole position	From supplier
	Operator opten spin	Take materials	Production supply	Production schedule
	Don't wear gloves	Careless	Hurry up	Pursue improvement targets
Method	There are no pins on the jig yet	Not created yet	Haven't thought of the system yet	No idea
Environ ment	Too many desks	Not cleaned up	No schedule	Haven't made a schedule yet
	Between remote work desks	Layout is far	Derivative from before	

Table 1 shows the existence of problem derivatives to the root cause of the problem, but not all of them are made important points in taking corrective actions. For this reason, FGD plays a role in determining the root cause points of the problem that are considered the most priority or most dominant to increase productivity in the Assembly section. The results of the FMEA analysis through FGD can be seen in Table 2.

Table 2. The Table of FMEA Results

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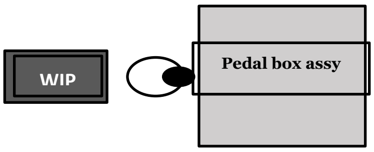
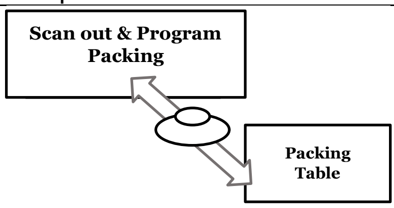
Potential Failure Mode	Sev	Potential Failure Effects	Occ	Potential Cause of Failure	Det	RPN	Rank
Press part one by one	7	Low productivity	7	Intstalation of parts using a hammer (manual)	6	294	4
Operator opten spin	8	Loss time	6	Distance of work desk and wipe away	7	336	2
Too many desks	5	Wasting process and time	8	Layout too long	8	320	3
Cap black is almost the same	6	Loss production	7	Black cap installation can be reversed	5	210	6
There are no pins on the jig yet	6	Loss time	6	Confused in setting standards	6	216	5
Long assembly process and time	7	Wasting process and time	8	VSM too much movement	9	504	1

Table 2 shows that the FMEA results obtained four main causal factors. Therefore, the improvement project team can decide that any RPN above 200 poses an unacceptable risk and must be corrected. In this study, FMEA analysis was conducted by an experienced improvement team during FGD. The results of the FGD indicated that the RPN value was in the medium to high risk category, thus declaring it feasible and a priority for corrective action. The experts' considerations were based on the potential impact on process performance and product quality, as well as the significant risk of failure if no further controls are implemented.

Kaizen Implementation

This study produced several Kaizen ideas carried out by the project team. Based on the results of the FMEA analysis as a reference for work priorities, Table 3 is the Kaizen implementation action carried out based on the problems.

Table 3. Improvements to the Assembling Section

No	Before Improvement	After Improvement	Correlation Improvement
1	 The WIP area is located behind the operator so the operator must turn around to take the material. **Before:** 0.06 minutes X 40 units = 2.4 minutes	 Modification of the table for material placement right in front of the operator. The effect can eliminate WIP table / space saving and eliminate motion **After:** 0.03 minutes X 40 units = 1.3 minutes	This modification embodies the Lean principle of point-of-use storage, which eliminates non-value-added motion and transport waste, thereby reducing the operator's cycle time per unit.
2	 The layout is too long so there is a lot of motion waste **Before:** 0.06 minutes X 10 BNS steps X 40 units = 26 minutes	 Reduce motiont by combining tables so that 2 tables can be eliminated **After:** 0.03 minutes X 10 BNS steps X 40 units = 13.3 minutes	This modification embodies the Kaizen principle of layout optimization to streamline the production process.

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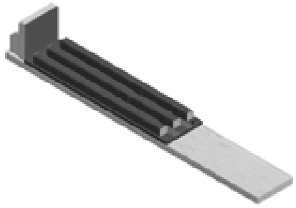
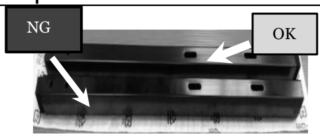
3	 When performing the part installation process using a hammer (manual). **Before:** 0.35 minutes X 40 units = 14 minutes	 The process using jig press so that the operator is faster in doing the process (one process produces 2 pcs) **After:** 0.21 minutes X 40 units = 8.6 minutes	This modification embodies the Kaizen principle of continuous improvement of work systems by modifying ergonomic work tools.
4	 Reverse stamp installation The black cap can be installed in reverse because both sides can be fitted with a black cap. There is no pokyoke	 Pin installation on the jig. Its effect is to prevent it from being reversed when installing the cap.	This modification embodies the Kaizen principle of continuous improvement of work systems by modifying ergonomic work tools.

Future Process

The final stage in this research is to analyze future conditions so that an effective and efficient production system is obtained. One of them is the production flow factor that has been streamlined so that it can reduce the number of manpower from 3 people to 2 people. The effect is to make the workload evenly distributed in one assembly process. The production process flow after improvement can be seen in Figure 5.

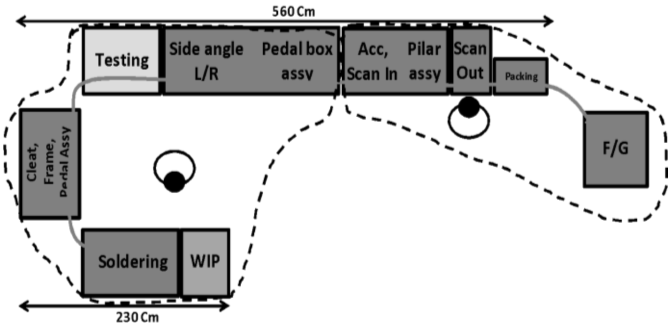


Figure 5. Future Process

Figure 5 shows that the change in factory layout has a significant impact on the assembly process. The workload is evenly distributed with the reduction in the number of operators to 2 people. Operator 1 carries out the process from soldering to pedal assembling, Operator 2 carries out accessories scan in to packing. The following is the distribution of workload in the assembly process after the improvements can be seen in Figure 6.

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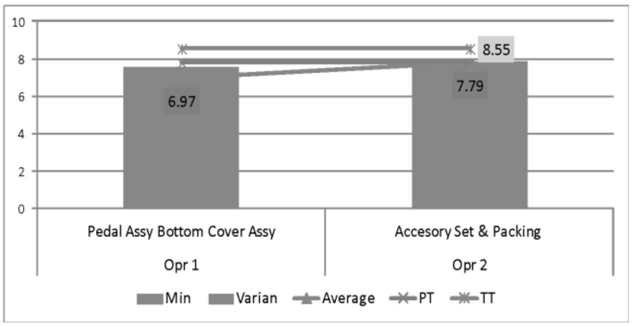

Figure 6. Man Power Loading After Improvement

Improvements in factory layout and line balancing have resulted in increased productivity. This result is seen during one day the process can produce output of 55 units/day with 2 operators.

DISCUSSION

Research Contribution

In principle, this research has provided many benefits and advantages for the industry related to reducing the number of manpower, increasing the results of the process per day and changing the layout of the efficient factory. For similar manufacturing industries, this research can be a suggestion and input for practitioners or related parties in improving manufacturing performance in order to remain competitive in the global market. The implementation of Line balancing combined with the Kaizen concept can provide significant results, namely improving manufacturing performance by reducing processes and movements, increasing productivity, reducing the number of workers and saving operational costs. The improvements made in this study can be a model or good example to be applied, developed especially in the manufacturing industry in the Assembling field. Finally, improvements can support sustainable business companies to become world leaders in manufacturing.

Comparison with Previous Research

Increasing productivity on the production line can be achieved by using the Lean manufacturing method in the form of a VSM tool in streamlining the process, reducing waste of time, processes and movements. The Lean Manufacturing method can be combined with the Kaizen concept in order to create increased productivity and savings in the number of workers. This is in line with previous research by Setiawan (Kumar et al., 2018) (Choomlucksana et al., 2015). This is in line with creating a lean production system, reducing waste, increasing production process efficiency, reducing lead time, reducing cycle time, eliminating rework, increasing productivity, and improving product quality are achieved. There is a difference in the analysis of improvements in this study, namely making improvements by integrating Lean Manufacturing with the Kaizen concept which consists of several improvement tools including fishbone diagrams, why-why analysis and FMEA. The novelty in the study used FGD with five expert members so that improvements were expected to be more focused, structured and conceptual.

In addition to theoretical and practical contributions, this research also provides methodological contributions through the development of an integrated approach to Lean Manufacturing and Kaizen that is systematically structured, so that it can be used as an operational framework to identify waste, design process improvements, and evaluate their impacts measurably in the context of the manufacturing industry.

Although this study shows positive results, there are several limitations that need to be considered. First, the study was conducted on a single process and in a specific industrial context, so generalizing the results to other manufacturing sectors requires in-depth research. Second, the evaluation of productivity improvements was conducted over a relatively limited period, so the long-term impact of Lean Manufacturing and Kaizen implementation on process stability and sustainable performance cannot yet be fully observed. Third, this study did not utilize modern technology, so further research is recommended to incorporate 4.0 technology.

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CONCLUSION

The research results show that the implementation of the improvement method significantly improved operational performance. This study produced several conclusions including, a decrease in process time during 1 shift from 42.4 minutes to 23.2 minutes or 45.2%, while the number of manpower used decreased from 3 people to 2 people during 1 shift production or 33.3%. The results of manpower productivity increased from 50 units/day to 55 units/day or an increase in productivity of 10%. Overall, these results demonstrate that the applied improvement approach is effective in increasing productivity while optimizing sustainable resource utilization. These findings reinforce the understanding that productivity improvements are achieved not only through technology investment but also through effective process and human resource management. These results can serve as a practical reference for other manufacturing companies in designing efficient and sustainable productivity improvement strategies. Furthermore, this research contributes by offering an applicable and easily replicable improvement model, particularly for manufacturing industries with labor-intensive characteristics and resource constraints. This model can be adapted by various manufacturing sectors as a guide for implementing process improvements to achieve operational excellence and long-term competitiveness. Based on this research, future work could explore the integration of Industry 4.0 technologies, such as IoT sensors for real-time data collection, to automate the monitoring of cycle times and further enhance the Lean-Kaizen continuous improvement cycle.

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