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Impact of Lean Principles on the Productivity of Bottling Line Process at XYZ Manufacturing Company

Leylee B. Alora

Graduate School, Management Engineering, University of Perpetual Help System Laguna, Philippines

Corresponding Author Email: aloraleylee@gmail.com

Flocerfida L. Amaya

University of Perpetual Help System Laguna, Philippines

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Abstract

This study aimed to examine the impact of Lean Principles on the productivity of XYZ Manufacturing Company. The company strives to provide quality products and uphold Filipino excellence on a global scale. To remain competitive, it must eliminate waste and enhance efficiency. However, research on Lean's application in the bottling industry, particularly in finished pack inspection, remains limited. There is also a gap in understanding how Lean contributes to bottling line productivity. A descriptive developmental approach was employed, incorporating observations and data collection to evaluate the current state of the finished pack inspection process, focusing on cycle time and output. Descriptive and inferential statistics were utilized to analyze performance trends and pinpoint inefficiencies. The study identified three major wastes—motion, transportation, and overprocessing—all of which contributed to extended cycle times and lower productivity. By implementing Lean-driven improvements, significant reductions in cycle time and increases in output were observed, with a p-value below 0.05, confirming Lean's effectiveness. These findings underscore the potential of Lean strategies in optimizing bottling line operations. The study offers valuable insights for industry practitioners and future research, demonstrating how waste reduction enhances efficiency and productivity in manufacturing.

Keywords: Lean Manufacturing, Lean Principles, Productivity, Non-Value Added Activities, Value Added Activities

Introduction

The manufacturing industry plays a key role in driving economic progress, needing continuous improvements in productivity, cost-effectiveness, and product quality. In the bottling industry, achieving seamless operations is critical to delivering products that meet

consumer expectations. However, bottling line processes are often plagued by waste or non-value-added activity, such as waiting time, defective work and rework, inspection delays, unnecessary motion, and improper transportation. These activities do not contribute value to the product from the customer's perspective and inflate operational costs. In contrast, value-added activities are those that enhance the product and are recognized and paid for by the customer. Lean principles, designed to identify and eliminate non-value-added activities, provide a structured approach to improving productivity, reducing manufacturing costs, and boosting market competitiveness (Dagne, 2022).

In the context of an increasingly competitive market setting, manufacturers are facing the growing challenge of meeting higher customer expectations while simultaneously reducing costs. To respond to these pressures, industries are adopting advanced manufacturing strategies that emphasize value creation, operational efficiency, and waste reduction. Among these strategies, Lean Manufacturing has emerged as a powerful approach for improving productivity and quality through the systematic elimination of non-value-added activities.

In the Philippine context, Gonzales (2023) explored highlighted how applying Lean tools like 5S, Kaizen, and Value Stream Mapping significantly reduced waste, improved operational efficiency, and fostered sustainable practices. Although these studies confirm the broader applicability of Lean methodologies, there remains a lack of focused research on their impact on bottling line processes, particularly in addressing waste and enhancing productivity in Philippine manufacturing.

This study aimed to address this gap by analyzing the impact of Lean principles on the finished pack inspection in a bottling line of XYZ Manufacturing Company. This research highlights the importance of minimizing non-value-added activity to improve productivity. By adopting Lean principles, XYZ Manufacturing Company can achieve enhanced productivity and greater market competitiveness. The purpose of this research is to analyze the impact of Lean principles on the bottling line productivity of XYZ Manufacturing Company specifically in the inspector’s workflow at finished pack inspection, focusing on identifying and addressing waste. By doing so, the study aimed to propose actionable Lean-based interventions that optimize operations and enhance value-added activity.

Literature Review

Lean Manufacturing

In the 21st century, lean manufacturing tools are essential for helping companies perform at their best. These tools are important for making sure that all parts of production and manufacturing work efficiently (Poswa et. al,2022). Furthermore, it seeks to propose improvements for each major waste identified using value stream mapping tools. (Yorke et al., 2020). Implementing Lean production enables manufacturers to achieve the same level of output while utilizing less human effort, financial resources, space, and equipment. (Rifqi et. al., 2021). The objective of Lean is to implement processes that enhance quality, safety, and worker morale while simultaneously reducing costs and shortening lead times (Kumar et al., 2022). Implementing lean manufacturing principles and process optimization techniques offers numerous benefits, including increased efficiency, cost reduction, improved quality,

shorter lead times, enhanced flexibility, better resource utilization, and improved employee engagement (Dutha, 2024).

The Impact of Lean Principles in the Productivity

Productivity is at the core of Lean Manufacturing practices, as they focus on reducing lead times, improving inventory management, and enhancing overall operational efficiency (Utami et. al., 2023). One effective method for eliminating waste and boosting productivity is through the implementation of the Toyota Production System. This approach focuses on streamlining processes and improving overall operational performance (Haekal, 2021). Lean Principles directly enhances productivity by streamlining processes, reducing waste, and optimizing workflow. Its implementation minimizes delays, accelerates production cycles, and ensures faster order fulfillment, leading to higher efficiency and improved output (Bouazza, 2021). By optimizing workflows and eliminating bottlenecks, Lean Manufacturing significantly enhances productivity by reducing inefficiencies and streamlining operations (Antonio, 2024). Lean Manufacturing directly improves productivity by reducing waste, standardizing cycle times, and streamlining processes. In today's fast-paced global economy, businesses use Lean to cut inefficiencies, lower costs, drive innovation, and speed up production (Rahman et. al., 2023). Implementing Lean Principles, such as the 5S system and a Kaizen culture, has proven effective in enhancing productivity (Queirolo et. al., 2024). Lean Manufacturing drives manufacturers to enhance productivity by eliminating waste and minimizing production losses. As a philosophy focused on efficiency, Lean enables organizations to optimize processes, streamline operations, and improve resource utilization (Irfan, 2025).

Methodology of Research

Research Design

The researcher used descriptive developmental research design to explore the impact of Lean Principles on the productivity in bottling industry. Descriptive developmental research aimed to document, describe and analyze the conditions of the data provided (Kosie, 2022). The foundation of this study was rooted in its focus on identifying current trends and addressing the existing conditions in the production line. The findings of this research were derived from the analysis of actual data from the bottling industry.

Sources of Data

The sources of data primarily came from observations and time studies conducted by the researcher inside the production area. The time study specifically focused on recording the time taken for each step in the process, enabling the identification of areas for improvement and the establishment of performance benchmarks. These activities helped identify the study's objectives through the use of various Lean tools, such as flow process charts, process activity mapping and root cause analysis. Furthermore, informal interviews with inspectors were conducted to validate and supplement the findings from the primary data sources. For the secondary sources documents and literature was also utilized. These include books, academic journals, and previous research studies.

Data Gathering Procedure

The researcher conducted observations within the production area to verify actual productivity, using Lean principles as a guide to identify non-value-added activity in the current process. A time study was performed, and with the help of a stopwatch, the cycle

time and flow of the finished pack inspection was measured. This enabled the researcher to distinguish activities that contributed directly to value creation from those that do not. After collecting the data, a statistical tool was used to compare the before and after the implementation of Lean Principles on the finished pack inspection on the production line.

Statistical Treatment of Data

The gathered data were subjected to the following statistical tool:

1. Percentage was utilized to determine the a) analysis of cycle time b) analysis of output c) comparison of activities before and after implementation of Lean Principles.
2. T-test Paired two sample for means was utilized to determine the significant difference on the finished pack inspection cycle time and output before and after the implementation of Lean Principles and the finished pack inspection output before and after the implementation of Lean Principles.

Results

The Current Status of the Finished Pack Inspection in Terms of

Cycle Time

Based on the time study, the finished pack inspection has a cycle time of 352.24 seconds. The process flow begins with collecting the finished pack, which takes 34.32 seconds, followed by transporting it to the inspection area, adding 45.62 seconds. The visual inspection, which is the longest step, takes 92.41 seconds, followed by recording the inspection result, consuming 32.00 seconds. Once inspected, the pack is sealed in 13.21 seconds before being transferred to the stacking area, which takes another 43.50 seconds. The process also includes getting the tag which took 35.32 seconds and writing details on tag which takes 18.65 seconds, then returning to the stacking area with 34.07 seconds and finally attaching the tag to the finished pack, which takes 3.13 seconds. It was observed that the current cycle time contains inefficiencies. The process involves manual handling, redundant inspection steps and other lean wastes, such as unnecessary motion and excessive transportation, all of which negatively impact efficiency and productivity.

Output

the output of the finished pack inspection before the implementation of Lean Principles. The analysis of the 30-day data revealed an average daily output of 110 pallets, indicating the impact of the current cycle time on overall productivity. The prolonged cycle time limits the number of pallets processed per day. Primarily due to non-value added activities such as manual handling, redundant steps, excessive movement, and unnecessary transportation. These inefficiencies slow down the workflow and reduce the workflow's ability to achieve higher output levels.

The Non-Value Activities Present in Finished Pack Inspection

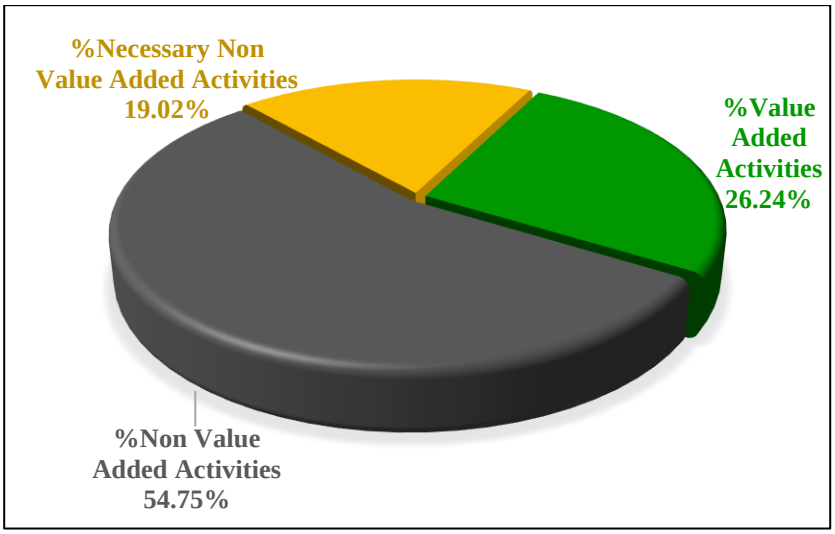

Figure 1. Result of Process Activity Mapping of Finished Pack Inspection

As shown on the figure above, in the whole process of finished pack inspection contained 26.24% of time spent on value-added activities, 19.02% of time spent on necessary non-value-added activities but most of the time spent on non-value-added activities with 54.75%. These NNVAs and NVAs accounted for approximately 73.77% of the total process time, highlighting the need for process optimization and streamlining. The separation of work areas and reliance on repetitive handling and documentation significantly hampered productivity, emphasizing the importance of optimizing the workflow to eliminate these wastes and improve productivity. The excessive time spent on NVAs, primarily due to work area separation, repetitive handling, and excessive documentation, significantly impacts productivity. This highlights the urgent need for workflow optimization, waste elimination, and streamlining processes to enhance efficiency and improve overall productivity.

The Causes of Non-Value-Added Activities

Table 1

Identified Non-Value Added Activities Causes and Recommendation for Improvement

Waste	Causes	Secondary Causes	Recommendation Improvement
Transportation	Inefficient workflow	Separate locations for inspection area, sealing and stacking	Relocate the inspection area directly on-line
	Lack of space optimization	Workstations are far apart	
Overprocessing	Non-standardized process flow	Lack of integration between inspection area and bottling line	Combine related inspection tasks and improve process flow. Give awareness for inspectors regarding the streamlined process.
	Lack of multitasking	inspectors are not aware of streamlined process	
Motion	Poor workstation layout	Equipment/tools positioning creates unnecessary motion	Preparation and printing of tag details before the production run starts. Use a tag rack or dispenser near the workstation to ensure that prepared tags are readily available.
	Unavailability of prepared tags	Inspector manually write the details on the tag	

Significant portions of the finished pack inspection process were consumed by non-value-added activities, such as excessive transportation, motion and overprocessing. These activities increased cycle time per unit and reduce the overall output of the process. As each unit took longer to process, fewer units were inspected within a given timeframe, leading to decreased productivity.

The Strategies for Improvement Used to the Finished Pack Inspection

Kaizen Improvement 1: Layout Optimization

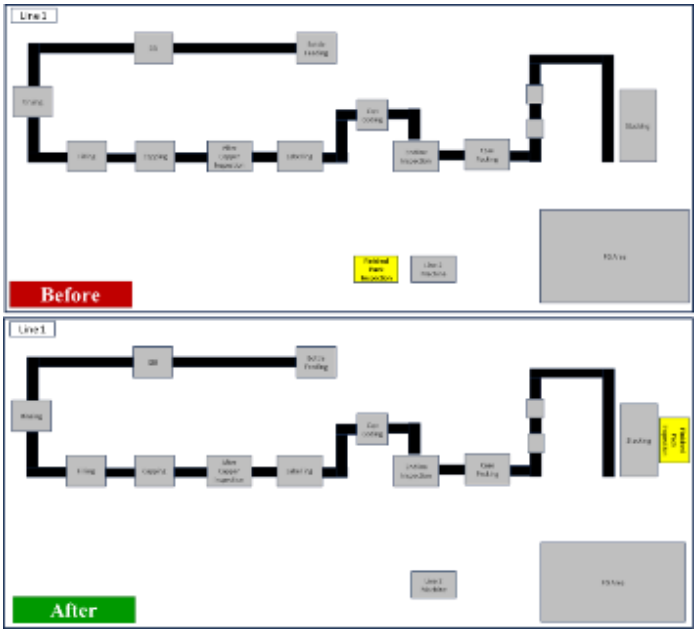

Figure 2. Before and After Bottling Line Layout

Relocating the finished pack inspection area to an on-line setup has improved productivity by reducing the time, motion, and transportation required for inspectors to conduct inspections. As shown in Figure 7, the previous arrangement demonstrated inefficiencies, as inspectors had to travel back and forth to the inspection area, leading to excessive travel time and a certain level of waste during inspection activities. By relocating the finished pack inspection area on-line, the need for transportation by inspectors has been minimize.

Kaizen Improvement 2: Streamlining the Finished Pack Inspection Process on the Bottling Line

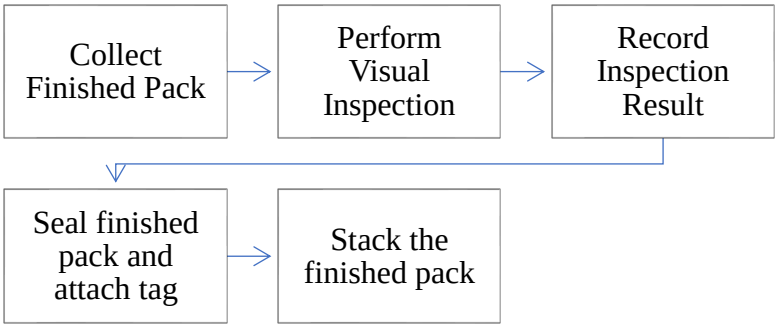

Figure 3. Process flow of the Proposed Finished Pack Inspection

Based on the figure above, streamlining the workflow ensured that the inspectors can focus on value-added activities and improving productivity. As a result, the workflow became leaner and more efficient, and enhancing productivity. The improved process was able to reduce the non-value-added activities which were the transportation and motion waste at finished pack inspection. By integrating the inspection step directly into the production line rather than moving finished products to a separate area, inspectors performed quality checks right where the products were made.

Kaizen Improvement 3: Automation of Tag Preparation

Before the Kaizen improvement, inspectors manually wrote the details on the approved tags for each finished pack, including the product name, production date, plant, quantity, line number, and pallet number. This manual process was time-consuming, prone to human error, and added unnecessary workload to the inspectors. Additionally, the time spent writing tags added to the overall process time. After the Kaizen improvement, all approved tags are pre-printed with the required details before the production run. Inspectors no longer need to write information manually; instead, they only attach the pre-prepared/pre-printed tags to the finished packs. The pallet numbers are also assigned in a continuous sequence, improving tracking and organization.

The status of the finished pack inspection after implementation of the Lean Principles

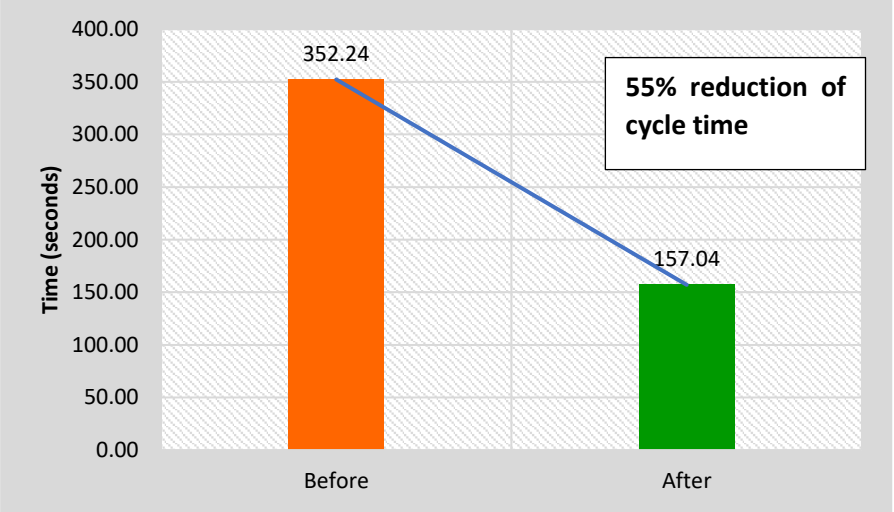

Figure 4. Analysis of Cycle Time

The results were analyzed by referring to the obtained data from before and after Kaizen improvement to measure the effectiveness of the Lean principles. Some benefits of Kaizen were observed in the form of reduction of non-value-added activity and improvement in productivity. Figure 9 shows that the cycle time of the inspector is decreased from 352.24 seconds to 157.04 seconds. Percentage improvement observed is 55 percent reduction of cycle time. This shows that non-value-added activity in the process were reduced since the Kaizen technique was utilized.

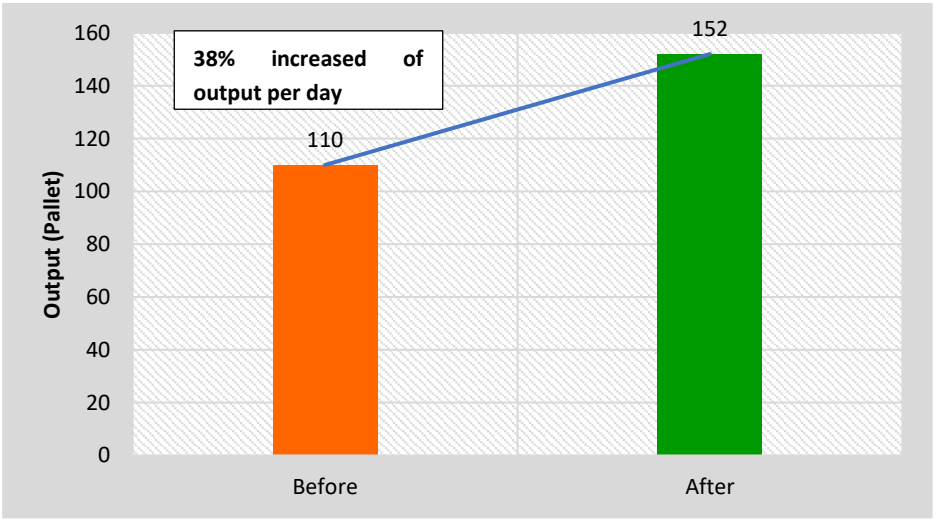

Figure 5. Analysis of Output per Day

As shown in Figure 5, the number of pallets before was 110 then it increased to 152 pallets after the Kaizen improvement. Percentage improvement observed was 38 percent increase. This shows that the Kaizen technique is very significant to resolve the problem, but also it validates that the reduction in cycle time has an impact in the increase of output per day and the productivity of inspectors in the finished pack inspection process.

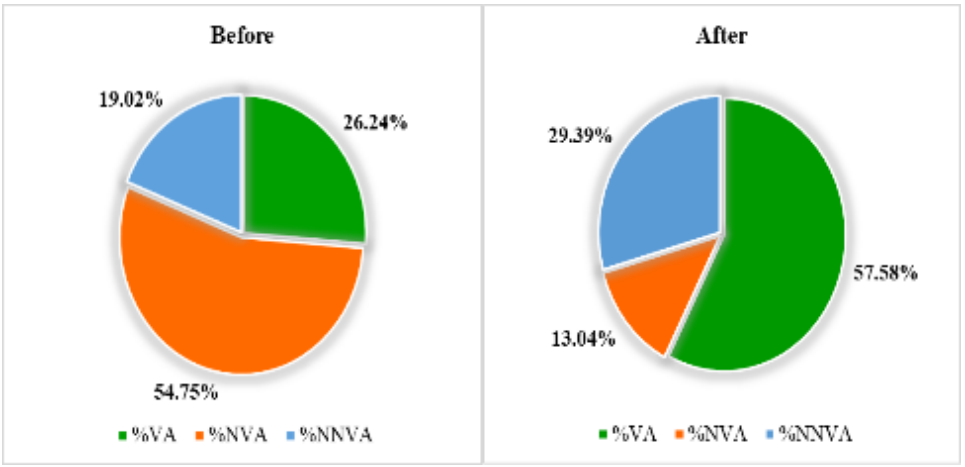

Figure 6. Comparison of Activity Before and After Implementation of Lean Principles

In Figure 6, the time was utilized properly by reducing non-value-added activity. Also, it indicates that streamlining the process through relocating and developing a standardized process in the workflow improved value-added activity and reduced time of inspectors for completing the task. Thus, the number of non-value-added activity has significantly reduced in the finished pack inspection process by 41.71%. The percentage of necessary non-value added activity increased slightly by 10.37%. While this is a minor increase, it's important to note that these activities are necessary for the operation.

The significant difference in finished pack inspection cycle time before and after implementation of Lean principles.

The before state has a mean of 352.24, while the after state, the mean was 157.02. The t-test was 304.160 while p-value 0.000*, which was lower than the significance level of 0.05. This means that the null hypothesis was rejected as there was a significant difference between the cycle time to process the finished pack inspection before and after the implementation of the Lean Principles.

The significant difference in finished pack inspection output before and after implementation of Lean principles.

The before state has a mean of 110.03, while the after state, the mean was 152.02. The t-test was -42.702 while p-value 0.000*, which was lower than the significance level of 0.05. This means that the null hypothesis was rejected as there was a significant difference between the output of the finished pack inspection before and after the implementation of the Lean Principles.

Action Plan to Implement Lean Principles in Finished Pack Inspection of all Bottling Lines of XYZ Manufacturing Company

Table 2
Action Plan to Implement Lean Principles in Finished Pack Inspection of all Bottling Lines of XYZ Manufacturing Company

Area of Concern	Program	Responsible Person(s)	Timeframe	Expected Outcome
Finished Pack Inspection	Implementation of Lean Principles in finished pack inspection in all bottling line	Quality Assurance Supervisor & Operational Excellence Team	Q3-Q4 2025	100% implementation of the Lean Principles in all bottling line's finished pack inspection.
Finished Pack Inspection	Kaizen	Operational Excellence Team, Quality Team and Production Team	Semi-annual	Increased efficiency, productivity and optimized workflows of XYZ Manufacturing Company.

Deploying lean leads to various positive outcomes, such as reduced lead times by eliminating obstacles through cross-departmental collaboration, improved quality through embedded learning cycles, enhanced innovation by empowering frontline authority, and more effective deliverables that meet end-user needs. By prioritizing lean principles, project management enhances responsiveness to the dynamic nature of modern marketplaces. Lean techniques significantly reduce waste, add value to customers, streamline processes, minimize rework, and optimize project delivery (Adegbite, 2024).

Discussion

1. The finished pack inspection at the bottling line of XYZ Manufacturing Company before implementation of Lean Principles has a cycle time of 352.24 seconds and has a 110 pallets output per day. It showed several inefficiencies that hinder operational efficiency and productivity. The current Among the process steps, visual inspection is the longest and most time-consuming activity, taking 92.41 seconds. Other major contributors to the total cycle time include transporting the finished pack to the inspection area 45.62 seconds), collecting the finished pack (34.32 seconds), and returning to the stacking area (34.07 seconds). These steps, along with additional tasks such as sealing (13.21 seconds), tagging (18.65 seconds), and writing details on the tag (3.13 seconds), add unnecessary time to the overall process. Several inefficiencies were identified in the inspection workflow, including excessive motion and transportation, redundant manual handling, and a lack of standardization in inspection procedures. These factors contributed to prolong the cycle time and reduce productivity. The presence of overprocessing, unnecessary movement, and excessive transportation aligns with common Lean wastes, which negatively impact operational performance.
2. Through using time study and process activity mapping this study was able to identify the non-value added activities or wastes in the finished pack inspection workflow. The analysis revealed that a significant portion of the inspector's cycle time is consumed by

NVAs, which do not directly contribute to value creation. Specifically, the identified NVAs include collecting finished packs from the bottling line, transporting them to the inspection area, transferring them to the stacking area, getting the tag, and going back to the stacking area. These inefficiencies highlight the need for workflow optimization and waste reduction strategies to enhance productivity and streamline the finished pack inspection process.

3. It was found that significant portions of the process were consumed by unnecessary activities such as inefficiencies in the workflow, non-standardized process flow, and the unavailability of prepared tags were key factors contributing to overprocessing, excessive transportation, and unnecessary motion. These inefficiencies lead to increased cycle times per unit and a reduction in overall output.
4. To improve the finished pack inspection, this study applied Kaizen, a Lean Principles, to reduce non-value-added activities. By addressing issues such as excessive transportation, motion, and overprocessing, Kaizen helped streamline the workflow. Key improvements included optimizing the process flow and ensuring prepared tags were readily available. These changes led to a significant reduction in cycle time, resulting in increased productivity. Overall, the implementation of Lean Principles successfully enhanced efficiency and productivity in the inspection process.
5. The finished pack inspection process significantly improved, reducing the cycle time from 352.24 seconds to 157.02 seconds—a 55% reduction. This substantial decrease in cycle time was achieved by eliminating non-value-added (NVA) activities, optimizing workflow, and streamlining inspection procedures. Redundant manual handling, excessive motion, and unnecessary transportation were minimized, resulting in a more efficient and standardized inspection process. With the reduction of NVA activities, the daily output increased from 110 pallets to 152 pallets, reflecting a 38% improvement in productivity.
6. There was a significant difference in the finished pack inspection cycle time before and after the implementation of Lean Principles. The p-value of 0.000* was lower than the 0.05 significance level which means that the null hypothesis was rejected.
7. There was a significant difference in the finished pack inspection output before and after the implementation of Lean Principles. The p-value of 0.000* was lower than the 0.05 significance level which means that the null hypothesis was rejected.
8. There was a need to propose an action plan to implement Lean Principles in finished pack inspection of all bottling lines.

Conclusions/Recommendations

1. The finished pack inspection process had a longer cycle time, which hindered output productivity. The implementation of Lean Principles streamlined the workflow, reduced non-value-added activities, and improved efficiency, resulting in enhanced productivity and overall operational performance. It is recommended that the company continuously monitor and refine the finished pack inspection process. Implementing real-time performance tracking and regular process evaluations can further enhance efficiency and eliminate bottlenecks.

In the case of finished pack inspection, the presence of redundant processes, excessive motion, and non-value-adding tasks significantly impacts output. To address these challenges, implementing Lean principles, such as process streamlining, and waste elimination, is

essential. By optimizing workflows, eliminating unnecessary steps, and ensuring a more structured process, the system can achieve higher efficiency, reduced cycle time, and improved daily output (Mhlanga & Pradhan, 2020).

2. Non-value-added activities caused delays, inefficiencies, and hindered productivity in the finished pack inspection process. Excessive motion, redundant handling, and unnecessary steps prolonged cycle time and reduced operational efficiency. The implementation of Lean Principles helped by eliminating waste, optimizing workflows, and standardizing processes, leading to improved efficiency, reduced cycle time, and increased productivity. The researcher recommends a thorough review of the workflow should be conducted to identify and remove remaining non-value added activities.

According to Saputra et. al (2021), Lean focuses on identifying and eliminating non-value-adding activities through continuous improvement to enhance workflow efficiency and operational excellence. The current process reflects inefficiencies in workflow, leading to wastes and increased cycle time. Non-value-adding activities contribute to unnecessary costs and resource consumption without improving the final product, making process optimization essential. By applying Lean principles, the process can be streamlined through waste elimination. Reducing unnecessary steps, optimizing work sequences, and eliminating redundant tasks will improve overall efficiency and ensure a smoother, more responsive inspection process.

3. The results revealed inefficiencies like non-standardized processes, workflow bottlenecks, and unavailability of prepared tags, which caused overprocessing, excessive movement, and delays. These issues increased cycle times and lowered overall output. Addressing these problems through process improvements will be key to improving the efficiency and productivity of the inspection workflow. It is recommended to provide standard operating procedures and ensure the availability of materials such as prepared tags, and improving workflow design to minimize overprocessing and unnecessary movement.

Almotairi et. al (2024) emphasized that excessive motion and transportation are often the result of poor workflow design, inefficient workstation layouts, and a lack of standardized procedures. Over-processing, on the other hand, occurs when inspection tasks exceed the necessary quality requirements, consuming additional time without adding real value to the product. These factors align with Lean Principles, which highlight that eliminating waste such as unnecessary movement and over-processing can significantly enhance productivity and efficiency. Lean Principles such as Kaizen can help to reduce non-value added activities.

4. Applying Kaizen to the finished pack inspection workflow effectively reduced non-value-added activity and streamlined process. These improvements significantly lowered cycle time, boosted productivity, and enhanced resource utilization, demonstrating the success of Lean Principles in optimizing the inspection process. The researcher recommends to conduct Kaizen improvements. Encourage team collaboration and employee participation to identify further opportunities for continuous improvement to maintain streamlined operations.

According to Mahir et. al (2023), companies should integrate Lean Principles, including Kaizen, to streamline the workflow including inspection process and remove NVA activities. This can be achieved through process standardization, workstation optimization, and continuous monitoring of performance metrics to sustain improvements. By doing so, organizations can ensure a more efficient inspection process, reduce delays, and enhance operational performance.

5. The implementation of Lean Principles had a significant impact on reducing the cycle time and output of the finished pack inspection, demonstrating improved efficiency and productivity. The researcher highly recommends to implement Lean Principles to the company's standard practices to sustain lasting benefits.

According to Santos et al. (2023), applying Lean Principles to process enables companies to increase productivity and streamline operations. By systematically evaluating workflows and eliminating unnecessary steps, businesses can enhance efficiency and reduce waste, leading to a more effective inspection process. Reducing non-value-added activities in the finished pack inspection process allows organizations to optimize operations, improve productivity, and enhance product quality. Implementing Lean principles, company can create a more streamlined and efficient inspection workflow that focuses on essential quality checks while minimizing waste.

6. The results of the finished pack inspection cycle time before and after the implementation of Lean Principles has a significant difference as evident in the reduced cycle time. It highlights the impact of Lean Principles eliminating non-value-added activities, optimizing processes, and enhancing overall efficiency. The researcher recommends to track the cycle time to ensure improvements remain effective and to identify further refinement.

The wide range of Lean Principles offers solutions to many operational challenges, making them highly valuable for organizations striving for continuous improvement. As organizations recognize the effectiveness of Lean, they are increasingly integrating these approaches to minimize waste and align production processes with market demands. For organizations to fully leverage Lean, top management must identify the most relevant tools, understand their functions, and assess their potential impact on efficiency and productivity (Proença et al., 2022).

7. The results of the finished pack inspection output before and after the implementation of Lean Principles has a significant difference as evident in the increased output. It highlights the impact of Lean Principles in improving the productivity. The company should capitalize on the productivity improvements by reallocating resources affectively.

The implementation of Lean Principles has had a positive impact on both the efficiency of the finished pack inspection process and the overall productivity. Organizations that implement Lean principles experience significant benefits, including enhanced product quality, cost reduction, and optimized resource utilization, which contribute to higher productivity and profitability. In the manufacturing sector, Lean drives streamlined operations, shorter lead times, and improved workflow efficiency, enabling companies to adapt to market demands, reduce waste, and maintain a competitive edge. By continuously improving processes, Lean

fosters operational excellence and long-term sustainability, ensuring that businesses remain efficient, agile, and customer-focused (Souza et al., 2021).

8. The proposed action plan was made to be implemented so that Lean Principles can be applied in the XYZ Manufacturing Company to ensure more efficient process by reducing waste, optimizing workflows and enhancing productivity. The recommended action plan is suggested to be implemented where Lean Principles be applied in all the bottling lines to effectively reduce waste, optimize cycle time and improve productivity.

The Lean implementation has led to significant improvements in the efficiency, value contribution and productivity of the processes. Lean principles, Kaizen, have been successfully applied across various organizations and manufacturing industries worldwide, demonstrating their effectiveness in reducing NVA activities and optimizing operational processes (Byrne et. al, 2021).

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