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A PROJECT TO IMPROVE THE PRODUCTION PROCESS USING LEAN MANUFACTURING TOOLS

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Purpose: This study investigates the production process of the selected product, aiming to identify and implement improvements. The objective is to analyze various stages of the production process to pinpoint areas that can be optimized for enhanced efficiency and quality. By focusing on the selected product, the study will evaluate current methodologies, employ advanced techniques, and propose actionable solutions to improve overall production outcomes.
Design/methodology/approach: The core methodologies employed in this project were Value Stream Mapping (VSM) and the 5S framework. VSM was utilized to visualize the current state of the production process, identify inefficiencies, and design an optimized future state. Concurrently, the 5S methodology was applied to organize the workspace, enhance efficiency, and maintain discipline in operations. These methodologies were chosen for their proven effectiveness in Lean Manufacturing and continuous improvement initiatives.
Findings: The study meticulously documented the state of the production process before the implementation of these improvements, providing a baseline for comparison. After the application of VSM and 5S, the production process was re-evaluated to measure the impact of the improvements. The results demonstrated significant enhancements in efficiency, organization, and overall productivity.
Practical implications: The findings of this research underscore the importance of structured project management and the strategic application of lean methodologies in manufacturing. The improvements observed in the production process of selected product serve as a testament to the effectiveness of VSM and 5S in driving process optimization. This study provides valuable insights for manufacturing professionals seeking to implement similar improvements in their own production processes.
Originality/value: The originality and value of this research lie in its practical application and comprehensive analysis of Value Stream Mapping (VSM) and the 5S framework, demonstrating their combined effectiveness in significantly enhancing efficiency, organization, and productivity in the production process of the selected product.
Keywords: Lean Manufacturing, Visual Management, Standardization, Value Stream Mapping.
Category of the paper: Case study.

1. Introduction

In the modern world, the Lean Manufacturing strategy is recognized as an effective production management tool, utilized by both small local businesses and international corporations. The introduction of a Lean Management culture facilitates the creation of transparent organizational structures, effective management of human resources, and continuous process improvement (Carreira, 2005; Dekier, 2012; https://kunziteindia.com/lean_manufacturing.php; Pranav, 2020). Such an approach promotes increased efficiency and 1-flexibility in operations, which are crucial for maintaining competitiveness in the dynamic industrial environment.

A fundamental condition for the successful implementation of Lean Management is the commitment of the management team, which must actively support the transformation and promote a culture of continuous improvement. According to Liker (Liker, 2004), leadership is critical to the success of Lean projects—leaders should provide necessary resources, organize training, and motivate teams to engage in optimization efforts. The willingness of lower-level employees to embrace changes is insufficient without the deliberate involvement of leaders who make thoughtful decisions and systematically implement Lean strategies (Rother et al., 2009). Awareness among managers regarding potential savings, increased efficiency, and improved work quality forms the foundation of successful organizational transformations. Without their understanding and active support, achieving sustainable and effective implementation of Lean Management principles is challenging, as highlighted in industry literature (Liker, 2004; Rother et al., 2009; Deming, 1986; Pranav, 2020; Bhasin et al., 2006; Wang, 2011; Carreira, 2004; Graupp et al., 2010).

Quality improvement—whether related to processes, products, or the work environment—should be an integral part of management strategy rather than an additional managerial task. According to Deming (Deming, 1986), continuous monitoring, data analysis, and feedback loops are essential for maintaining high standards and driving further improvements.

Today's demanding and rapidly changing market conditions compel companies to redesign production processes, which not only enhances operational efficiency but also contributes to overall business growth. As Womack and Jones (Womack et al., 2003) emphasize, the implementation of Lean strategies enables the elimination of waste and the generation of greater value for customers, thereby enhancing market competitiveness. Tools such as Value Stream Mapping (VSM) and 5S play a crucial role in achieving these goals by enabling the identification and elimination of inefficiencies and improving workplace organization.

In this context, the application of Lean tools like VSM and 5S gains particular significance. As Rother and Shook (Rother et al., 2009) point out, VSM facilitates the visualization of material and information flow in production processes, identifies bottlenecks, and helps design process improvements. Meanwhile, the 5S methodology contributes to better workplace organization and ergonomics, leading to increased work efficiency and reduced errors. Research by Singh and Ahuja (Singh et al., 2014). Implementation of Lean Practices in Indian Automotive SMEs. International Journal of Lean Six Sigma. demonstrates that implementing 5S shortens operation times, boosts employee morale, and minimizes the risk of inconsistencies.

The article presents the application of Lean Management tools in a food industry company, where issues such as high inventory levels, bottlenecks, and inefficient machine layouts were identified. Excessive inventory tied up capital and space, bottlenecks slowed production rates, and inefficient machine layouts led to unnecessary movements and time losses.

To address these challenges, the FIFO method was introduced, enabling better inventory management, elimination of unnecessary operations, acquisition of a carton folding machine, and reorganization of workstations. The practical application of this method has resulted in better alignment of production and storage processes. As highlighted in the literature (Liker, 2004; Bowersox et al., 2013), FIFO not only streamlines material flow but also reduces operational costs by minimizing losses caused by improper inventory management. In the context of the discussed company, implementing FIFO contributed to eliminating excess inventory, improving workspace organization, and increasing operational efficiency (Wild, 2017; Slack et al., 2016; Hopp et al., 2011; Schonberger, 2007). These changes ultimately had a positive impact on the company's competitiveness in the market. These actions, consistent with the literature (Liker, 2004; Rother et al., 2009) represent typical examples of Lean strategy implementation that deliver quick and measurable benefits (Wolniak, 2013; Amrbriz et al., 2023; Ortiz et al., 2016; Maciąg et al., 2021; Tiwari, 2018).

The proposed solutions were validated, confirming their effectiveness. The results demonstrated significant improvements in operational efficiency, waste reduction, and workplace organization. The outcomes included not only increased productivity but also a safer and more ergonomic working environment. Enhanced process efficiency and quality also contributed to greater employee satisfaction and their engagement in future Lean initiatives.

The research and implementation of Lean Management tools in the food industry confirm their effectiveness and versatility in optimizing production processes. The article makes a significant contribution to both theoretical literature and production management practice, providing valuable insights for companies aiming to improve competitiveness and operational efficiency.

2. Methodology

The research was designed based on a mixed-methods approach, combining both quantitative and qualitative methods to obtain a comprehensive understanding of the analyzed issue and evaluate the effectiveness of the implemented actions.

As part of the quantitative research, a detailed analysis of production data collected before and after the implementation of Lean Management tools in the analyzed food industry company was conducted. A key element was the comparison of performance results, such as:

- Overall Equipment Effectiveness (OEE): determining the percentage of machine utilization in relation to their full potential.
- Cycle Time (CT): covering the time required to carry out specific production operations at different stages of the process.
- Total lead time (LT): the total time that the production process begins until its completion.
- Inventory status: the structure and level of inventory were analyzed, with particular attention given to excessive stock, which could have represented a bottleneck in logistics and production processes.

The use of these indicators allowed for the quantitative measurement of the effects of implementing Lean methods such as FIFO, Value Stream Mapping, and 5S (Harvey, 2019; Obora, 2010; Hamed et al., 2020; Parmenter, 2016). For the qualitative research, the following methods were applied:

- Direct observation of production processes: conducted before and after the implementation of Lean Management tools. Observations helped identify inefficiencies, including bottlenecks, excessive movements of workers, and non-ergonomic work layouts.
- Analysis of the production floor layout: assessing the workspace in terms of work organization, material flow, and machine placement. By comparing the layout before and after changes, it was possible to identify the impact of new solutions on process efficiency and work ergonomics.

This comprehensive research method enabled an objective assessment of the effectiveness of the implemented solutions and provided practical recommendations for the company.

3. Suggestion for production process improvements

3.1. Characterization of the production facility along with a description of the problem

The subject of the analysis was a manufacturing company engaged in the processing of meat products. The name and details that could identify the company have been withheld. The plant is divided into two halls - production and packaging. The facility meets ISO 22000 standards, which include the Food Safety Management System and HACCP requirements (Hui, 2021; Feiner, 2006; Olszewski, 2007). In the analyzed area, activities such as packing, labeling, and transporting finished products are carried out. This area is also known as the finished product packaging department. It is the final stage of product preparation before being sent to the customer. The product produced in the analyzed process is a meat product. This process consists of eight operations, for which nine workstations are allocated, staffed by thirteen employees. The flow between the workstations occurs in a parallel manner. Information regarding the names and number of workstations, unit times, and the number of employees is presented in the table (Table 1).

Table 1.
List of operations of the analyzed production process

Operations	Position title	Number of workstations	FTE	CT [s]	Description
10	Thermal treatment	2	1	2700	Introducing the filled trolley with the product into the thermal treatment chambers
20	Thermal treatment	1	1	60	Weighing the trolley after leaving thermal treatment and registering it in the system
30	Deposition of the product	-	-	86400	After thermal treatment, the product waits in a cold store for further processing
40	Transferring products from trolleys to containers	2	4	300	Reloading product from trolleys to containers
50	Packaging	3	5	30	Packing products into hand-folded cartons
60	Wrapping pallets with foil	1	1	180	Wrapping the finished pallet with a wrapper
70	Weighting	1	1	100	Weighing the finished pallet and registering it in the system
80	Transport to the shipping warehouse	-	1	120	Transport of the finished pallet to the shipping warehouse

where: FTE - number of employees, CT – duration of operation.

Based on the analysis, it was found that the main issues in the analyzed area are high inventory levels, unnecessary employee movements, and suboptimal workstation layout. These inefficiencies affect the quality of the produced goods, the order fulfillment time to the customer, and the overall ergonomics and work culture at the stations. As shown in Table 1, the longest operation in the analyzed production process is the settling of the product after exiting the thermal processing chambers. The shortest operation in the process is packing the products into manually assembled cartons.

3.2. Creating a current state map and identifying the bottleneck

Creating a current state map of the analyzed process requires significant dedication and an in-depth understanding of the work culture at individual positions. One of the most important aspects of creating a current state map is the precise identification of any bottlenecks present in the process, if they exist.

Value Stream Mapping (VSM) is a technique used to analyze the flow of materials and information necessary to deliver a product or service to the consumer. In today's competitive environment, there is a trend towards delivering high-quality products based on the voice of the customers (VOC) while also offering them at competitive prices. To become a profitable company, it is crucial to effectively streamline the workflow and reduce waste. VSM allows manufacturers to understand their current state and identify types of waste that need to be eliminated or significantly reduced. VSM helps visualize value, waste, and the sources of waste within the value stream, making it a valuable tool for manufacturers across various industries.

VSM involves mapping the flow of all components and subassemblies within the value stream, which includes production, suppliers, and distribution to the customer.

Another significant aspect is that VSM can be led by someone knowledgeable about the process but not necessarily familiar with the production facility (Rother et al., 2009).

Additionally, it is essential to conduct a detailed analysis of all operations in terms of their cycle time (CT), the number of workstations, the number of employees assigned to a given workstation (FTE), and the time duration of activities between operations, which do not add value from the customer's perspective. The sum of all times will allow the determination of the total lead time (LT).

This comprehensive analysis is crucial for identifying inefficiencies and areas that need improvement, ultimately aiming to enhance the overall efficiency and productivity of the process. The analyzed part of the production process ranges from thermal treatment to the shipment of the finished product to the customer. The product, once prepared, is moved to a room where it undergoes a setting process that lasts exactly 24 hours. This is a process required from the standpoint of food technology, and it cannot be shortened or extended.

The next operation is transferring the product from T-forklifts to E2 containers, which is marked in red on the map. This operation is completely unnecessary and has been identified as waste. The subsequent operation is packaging the finished product into cartons, which is also marked in red because a bottleneck occurs at this point in the process. The following operations include wrapping the pallet with film, weighing, and registering it in the system. The entire production process concludes with the transport of the finished pallet to the warehouse. The total time is 28 hours.

Figure 1 shows the Value Stream Map prepared according to the above for the analyzed process before implementing changes. The symbols used in the value stream map have been slightly enhanced with drawings depicting the actual activities performed by the employees, significantly facilitating the interpretation of the map and the processes it includes (Table 2).

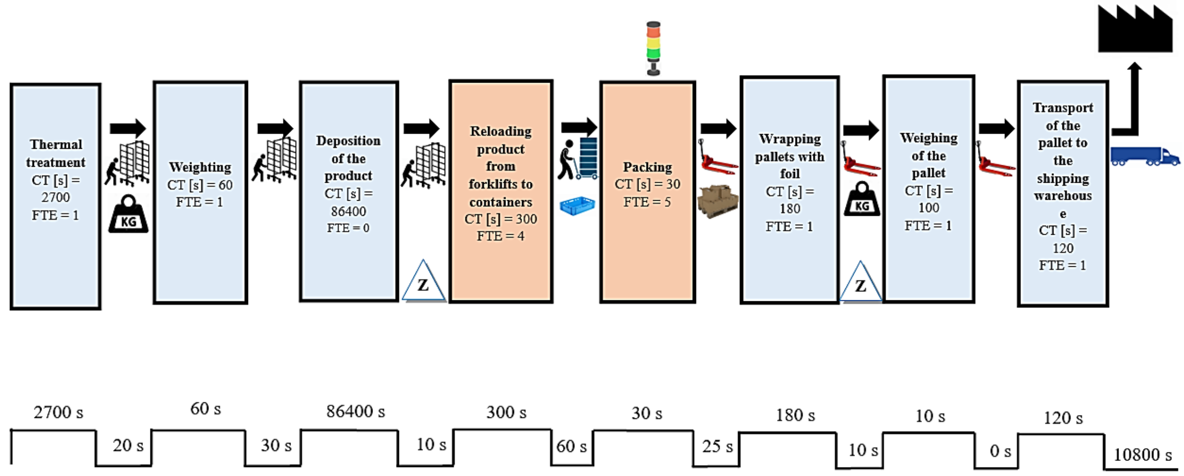
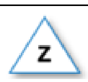
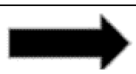


Figure 1. Value Stream Map of the Analyzed Area – Current State.

Source: own work.

Table 2.
Symbols in the Value Stream Map

Symbol	Symbol description
	Customer/supplier plant
	Inventories: warehouse, in production, handy, buffers
	Pallet with goods
	Internal transport
	Pallet truck
	Weighting

Cont. table 2.

	Andon
	Mobile phone
	Working on a tape
	Transport of a truck with raw materials
	Transporting the T-cart
	E2 container
	Transport of E2 containers on the platform
	Transport by truck

3.3. Inventory Measurements

One of the fundamental problems in the analyzed area is high inventory levels, which significantly hinder work and movement for the employees on the shop floor. To reduce the stock levels and identify the source of waste, four measurements of the current state of the inventory were initially taken. These measurements were conducted during the first shift on different days of the week to obtain the most accurate results. The focus was mainly on the number of forklifts and containers, in which the products are primarily transported, as well as on the pallets ready for shipment to the customer (Table 3).

Table 3.
Current state of the inventory in the analysed area

Measurement number	Amount of forklifts [pcs.]	Amount of containers [pcs.]	Amount of pallets [pcs.]
1	112	5596	78
2	130	7314	66
3	175	6836	72
4	41	12595	53
Average	**114**	**8085**	**67**

Based on the data in the table, it can be observed that measurements significantly differ from each other, especially concerning the number of forklifts and containers. This variation might be due to bottlenecks or suboptimal production planning. The lack of utilizing the FIFO method could be critical, since product shelf life is essential in the food industry. Additionally, the packaging area doubles as a warehouse for finished goods, making movement within the hall challenging, impacting operator efficiency, and hindering the establishment of transport routes for employees.

Employees often don't know which goods they should deliver to the shipping warehouse first. This causes delays in deliveries and results in a high number of pallets in the warehouse. An effective approach would be to use the FIFO method and label finished pallets with large, easily visible cards indicating their creation date.

3.4. Elimination of the operation: reloading goods from forklifts to containers – employee training

The process of transferring goods from a forklift to a container has been identified as waste. The employee performs unnecessary movements by transferring the product from a type T cart to an E2 container and then only transporting filled E2 containers to the packing station. Instead of the aforementioned operation, the T-type forklift can be directly transported to the packing area without prior transfer to containers. This approach will save time and human resources, as four workers specifically assigned to the task of transferring goods from forklifts to containers can be reallocated. After the product placement process is complete, the worker will transport the forklifts directly to the packing stations.

The new operation involves the packaging employee taking a rod from the T-type forklifts, which holds meat products, and then placing them on the packing table. The cycle time for this operation has been reduced from 300 seconds to 180 seconds. This 40% optimization will result in additional profits for the company on a monthly or yearly scale.

3.5. Implementation of the 5S tool – shadow boards

Proper workplace organization and standardization are crucial for maintaining order and improving the culture and ergonomics for operators.

One effective practice is to introduce shadow boards for cleaning tools in workspaces and garment factories. Each tool has its designated "shadow" on the board, along with a serial number, making cleaning tasks significantly easier—even for foreign workers. Yellow tape marks equipment specifically for floor cleaning

3.6. Verification of implemented improvements

The implementation of changes, especially the application and maintenance of the FIFO method, as well as the reorganization of the product packing hall—such as arranging workstations in parallel and introducing a machine for folding cartons—significantly reduced the number of pallets ready for shipment. The total count of T-type forklifts, E2 containers, and pallets ready for shipment is presented in Table 4.

Table 4.
Inventory levels after improvements introduced in the analyzed area

Measurement number	Amount of forklifts [pcs.]	Amount of containers [pcs.]	Amount of pallets [pcs.]
1	102	5664	43
2	132	7688	32
3	150	6509	37
4	40	10124	40
Average	**106**	**7496**	**38**

The total lead time remained relatively stable after optimization. Initially, it was 1680 minutes (equivalent to 28 hours). Following the optimization, it decreased by less than 1%. Two operations within the value stream map underwent changes, highlighted in green. This signifies process optimization in terms of time, human resource utilization, and overall work organization. Prior to process improvement, 9 workers were required for unloading and packing operations. After optimization, only 5 workers are needed. Freed resources can be reallocated to other positions, effectively supporting additional production tasks. This not only reduces the required workforce at a specific stage but also optimizes overall human resource utilization within the company. The value stream map based on these improvements is presented in Figure 2.

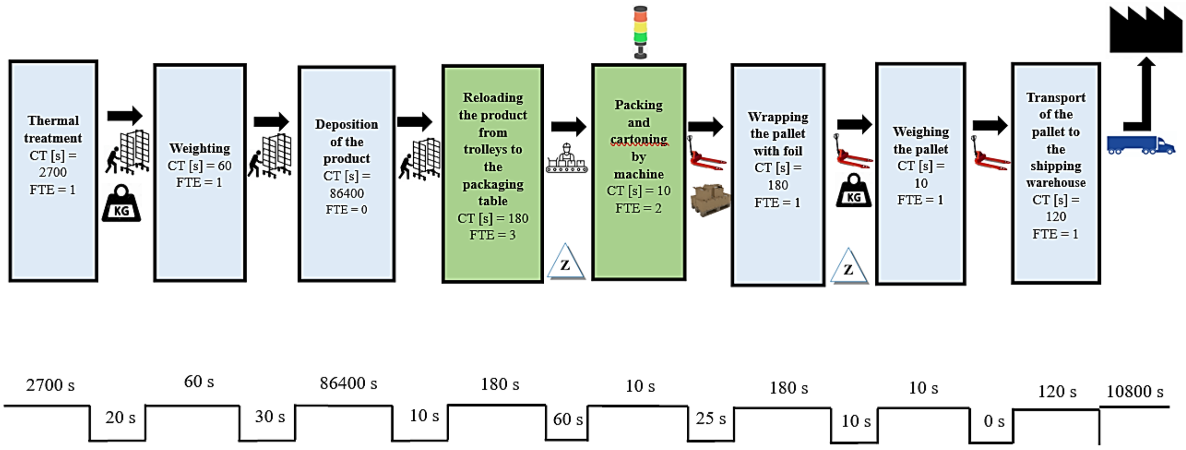


Figure 2. Value Stream Mapping of the analyzed area – future state.

The application and consistent control of the FIFO method, along with eliminating bottlenecks through the purchase of a machine for folding and gluing cartons, optimized the product packaging process. Additionally, arranging packing stations in parallel contributed to waste reduction, cost minimization, and overall improvement in workplace culture.

The overall comparison before and after the implemented changes is presented in Table 5.

Table 5.
The comparison of the project's results

	Before	After	Percentage difference
Average amount of E2 containers [pcs.]	8085	7496	7,5%
Average amount of forklifts [pcs.]	114	106	7%
Average amount of palettes [pcs.]	67	38	44%
FTE (amount of employees)	14	10	30%
Lead Time [h]	28	28	-
			58,5%

4. Summary

The subject of the conducted research was a selected production process in a food industry company. The analysis revealed that there were aspects in the studied area causing waste and requiring improvement. In the project, Lean Manufacturing tools such as Value Stream Mapping (VSM) and 5S were utilized. As a result of the conducted analyses, it was determined that:

- Effective Project Implementation: The research demonstrated that implementing Lean Manufacturing tools effectively is achievable in a food-producing company. This finding underscores the adaptability and applicability of Lean principles beyond traditional manufacturing sectors into food production, which often deals with unique challenges related to hygiene, safety, and regulatory compliance.
- Identification of Production Bottlenecks: Through observations and analysis using the Value Stream Mapping tool, a production bottleneck was identified at the packaging stage. This bottleneck was a critical point in the process that hindered overall efficiency. By pinpointing this stage, it became clear where optimization efforts needed to be concentrated. Other areas requiring optimization were also highlighted, demonstrating the comprehensive diagnostic capability of VSM.
- Reduction in Workforce and Inventory Levels**:** The project tasks led to a significant reduction in the required workforce and inventory levels. This outcome was achieved through the elimination of unnecessary steps in the process and the optimization of workflow. The reduction in inventory levels directly translated into lower holding costs and reduced waste due to perishable goods. Additionally, fewer workforce requirements without compromising output indicate streamlined operations and better use of human resources.
- Cost Savings and Improved Work Culture: These operational improvements resulted in annual cost savings, which can be reinvested into the company for further improvements or other strategic initiatives. Moreover, the improvements in work culture and ergonomics were notable. Enhanced work environments not only improve employee

satisfaction and productivity but also reduce the risk of workplace injuries, which can further contribute to overall cost savings.

- Enhanced Production Efficiency and Organization: In summary, the application of Lean Manufacturing tools, such as VSM and 5S, in the food industry enabled the identification and elimination of waste, significantly enhancing production process efficiency and organization. The systematic approach provided by these tools helps create a more responsive and agile production system, better aligned with customer demands and market conditions.

The results of research on the application of Lean Manufacturing tools in the food industry confirm their effectiveness in increasing productivity and reducing waste, despite challenges related to hygiene and regulations. Studies conducted in similar research areas, such as the works of Teixeira and Costa (Teixeira et al., 2015) and Rother and Shook (Rother et al., 2009), show that tools like VSM and 5S effectively identify bottlenecks, such as in the packaging stage, allowing for process optimization. The reduction of inventory and workforce, confirmed by research from Sreedharan et al. (Sreedharan et al., 2011), leads to savings and increased efficiency. Furthermore, the implementation of Lean in the food industry, as indicated by the studies of Knol et al. (Knol et al., 2014), allows for the elimination of waste, optimization of material flows, and improvement of work organization.

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