

Integrating Lean Manufacturing and Systematic Layout Planning to Enhance Efficiency: A Case Study in Chemical Trading SMEs

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Abstract

The Lean and SLP-based operations model addressed inefficiencies in packaging and order preparation for chemical trading SMEs. Previous research showed that Lean Manufacturing and Systematic Layout Planning (SLP) improve operational efficiency, though their use in chemical trading SMEs had been limited. The main challenges were delays and defects that affected customer satisfaction. This study applied Lean tools, including SLP and 5S, along with standardized work processes to optimize layout, reduce delays, and eliminate defects. These actions improved workflow, consistency, and operational performance. Key results included a 32.09% increase in the On-Time In-Full (OTIF) rate, an 82.35% reduction in packaging defects, and a 73.33% decrease in cylinder location delays, demonstrating the model's effectiveness. The research made significant contributions by enhancing operational performance and reducing costs, leading to increased customer satisfaction and long-term competitiveness. Further research should explore the model's adaptability in other industries, promoting continuous improvement and broader applications of Lean principles.

Keywords

Lean Manufacturing, Systematic Layout Planning, OTIF, Chemical Trading SMEs, 5S Methodology.

1. Introduction

The significance of the small and medium-sized enterprises (SMEs) that commercialize chemical products in Latin America, and specifically in Peru, cannot be overstated. This sector not only plays a vital role in the economic development of the region but also is crucial for job creation and poverty alleviation. According to a study, SMEs account for approximately 90% of the businesses in Latin America, employing around 50% of the workforce and generating a substantial portion of the Gross Domestic Product (GDP). In the Peruvian context, SMEs are fundamental to the economy, as their flexibility and adaptability allow them to respond more swiftly to market demands compared to larger corporations. However, despite their importance, these enterprises face significant challenges, particularly in adopting information and communication technologies (ICT), which can create a competitive gap compared to larger firms. The urgent need to modernize their processes and enhance operational efficiency is evident, as quality and competitiveness are critical factors for their survival and growth in an increasingly demanding market.

The operational problems faced by companies that commercialize chemical products are varied and complex. One of the primary challenges is the low level of On Time in Full (OTIF) compliance, which translates into late deliveries, defective orders, and, in some cases, undelivered orders due to stock shortages. These operational deficiencies are often the result of delays in locating finished products and cylinders, as well as defects in the packaging and bottling processes. Inefficiencies in inventory management and the lack of standardization in processes contribute to these issues, which in turn affect customer satisfaction and the company's reputation. Implementing methodologies that optimize these processes is essential for improving efficiency and the quality of service offered by SMEs in the chemical sector. Furthermore, the lack of training and education in management and quality control tools limits these companies' ability to adapt to market demands and enhance their competitiveness.

Addressing these problems is of utmost importance for the metalworking SMEs sector, as improvements in operational efficiency and product quality can have a direct impact on their competitiveness and sustainability. The implementation of methodologies such as Lean Manufacturing can be an effective solution to tackle operational inefficiencies and enhance service quality. These tools enable companies to identify and eliminate waste, optimize processes, and improve customer satisfaction, which is essential in an increasingly competitive business environment. Moreover, enhancing the quality of products and services not only benefits companies in terms of competitiveness but also contributes to the economic development of the region by promoting job creation and wealth generation. Therefore, it is crucial for metalworking SMEs to adopt a proactive approach to resolve these issues and improve their operational performance.

Despite the relevance of these topics, there exists a significant gap in the literature addressing the specific operational problems of SMEs that commercialize chemical products and the methodologies that can be implemented to improve their performance. This research aims to fill this gap by developing a production model based on Lean Manufacturing tools such as 5S, standardized work, and systematic layout planning. These tools have proven effective in improving operational efficiency and quality across various industries, and their application in the context of chemical SMEs can offer practical and effective solutions to the identified problems. By addressing these challenges, it is expected that SMEs will not only enhance their competitiveness but also contribute to the sustainable development of the local and regional economy. The research will focus on identifying best practices and implementing a model that enables these companies to optimize their processes and improve their overall performance.

2. Literature Review

2.1 Application of Lean Manufacturing in Packaging and Order Preparation Processes

Lean Manufacturing methodology has been widely adopted across various industries, including the chemical sector, to optimize packaging and order preparation processes. Recent research demonstrates that the implementation of Lean practices can lead to significant improvements in operational efficiency and waste reduction. For instance, highlight that organizations adopting Lean Manufacturing can experience enhanced business performance by identifying and applying specific practices that serve as benchmarks in their implementation journey. Furthermore, emphasize the importance of critical success factors such as leadership and organizational culture in the successful implementation of Lean in process industries, which is particularly relevant for chemical companies seeking to enhance their packaging operations. Additionally, indicate that integrating Lean Manufacturing with sustainable practices not only improves efficiency but also contributes to a more positive environmental performance, which is essential for chemical companies facing stringent environmental regulations. Lastly, the study by Rojas et al. (2020) suggests that Lean practices can significantly reduce lead times in chemical packaging processes, thereby improving customer satisfaction and overall competitiveness.

2.2 Implementation of SLP in Packaging and Order Preparation

The Systematic Layout Planning (SLP) methodology has been utilized to optimize workflow in the packaging and order preparation processes within chemical companies. Research by shows that applying SLP allows for better arrangement of equipment and materials, resulting in reduced cycle times and increased productivity. Moreover, the study by suggests that systematic plant layout planning can facilitate the implementation of Lean Manufacturing, creating synergies that further enhance operational efficiency. On the other hand, indicate that combining SLP with sustainable manufacturing practices can lead to significant positive impacts on multiple measures of operational performance when implemented concurrently rather than separately. Finally, emphasizes that an appropriate plant

layout not only improves operational efficiency but also contributes to safety in the handling of chemical products, a critical aspect in the industry.

2.3 Effectiveness of the 5S Methodology in Packaging Processes

The 5S methodology has been implemented across various industries to improve organization and efficiency in the workplace, and its application in the chemical sector has shown promising results. According to Chóez and Suárez (2021), implementing 5S in manufacturing companies has led to notable improvements in productivity and waste reduction. This systematic approach not only organizes the workspace but also fosters a culture of continuous improvement. Additionally, highlight that applying 5S in the handling of chemical products can contribute to greater safety by reducing the likelihood of accidents and hazardous exposures. Furthermore, the work of suggests that the 5S methodology can be a key component in the implementation of Lean Manufacturing, as it establishes the foundation for a more efficient and safe work environment. Finally, the analysis by indicates that adopting 5S not only improves organization but can also enhance employee morale, which is fundamental for maintaining a productive work environment in the chemical industry.

2.4 Standardized Work in Packaging Processes

The Standardized Work methodology has been employed to improve consistency and quality in packaging and order preparation processes within chemical companies. Research by shows that implementing standardized work procedures can reduce variability in processes, resulting in higher quality final products. Moreover, the study by suggests that standardizing processes not only enhances quality but can also increase operational efficiency by facilitating the training of new employees. On the other hand, highlights that standardization is essential for complying with safety regulations in the handling of chemical products, which is particularly relevant in the context of packaging. Finally, the work of indicates that standardizing processes can facilitate the implementation of continuous improvements, which is critical for companies seeking to remain competitive in a constantly changing market.

2.5 Kaizen in Packaging and Order Preparation Processes

The Kaizen philosophy, which emphasizes continuous improvement, has been adopted in the chemical sector to optimize packaging and order preparation processes. Research by Benítez and Silva (2022) indicates that implementing Kaizen practices can lead to significant improvements in efficiency and cost reduction. Additionally, the study by highlights that the continuous improvement culture promoted by Kaizen can encourage active employee participation in identifying problems and implementing solutions, which is crucial in a dynamic work environment. Furthermore, the analysis by suggests that applying Kaizen in the handling of chemical products can contribute to greater safety and efficiency by proactively addressing risks associated with hazardous substance handling. Finally, the work of emphasizes that continuous improvement not only benefits operational efficiency but can also enhance customer satisfaction, a vital aspect for chemical companies seeking to maintain their competitiveness in the market.

3. Methods

3.1 Basis of the Proposed Model

In Figure 1, the Lean and SLP-based operations model for chemical trading SMEs is presented, focusing on improving operational efficiency in packaging and order preparation processes. The model integrated Lean Manufacturing principles, particularly Systematic Layout Planning (SLP), 5S, and Standardized Work (SW), to address inefficiencies in these areas. SLP was implemented to optimize space utilization and streamline workflow, facilitating smoother operations and reducing unnecessary movements in the packaging and order preparation processes. The 5S methodology aimed to enhance workplace organization, safety, and cleanliness, which played a critical role in improving efficiency and reducing errors. Standardized Work (SW) ensured consistency in task execution, reducing variability and maintaining high levels of quality in the processes. This combination of Lean tools sought to increase overall operational efficiency by addressing the root causes of delays, defects, and inefficiencies within the packaging and order preparation tasks. The ultimate goal of the model was to improve the company's operational performance by fostering a more organized, efficient, and streamlined workflow, contributing to improved customer satisfaction and the company's competitiveness in the market. The model provided a systematic approach to achieving sustainable improvements in the SME's operational processes.

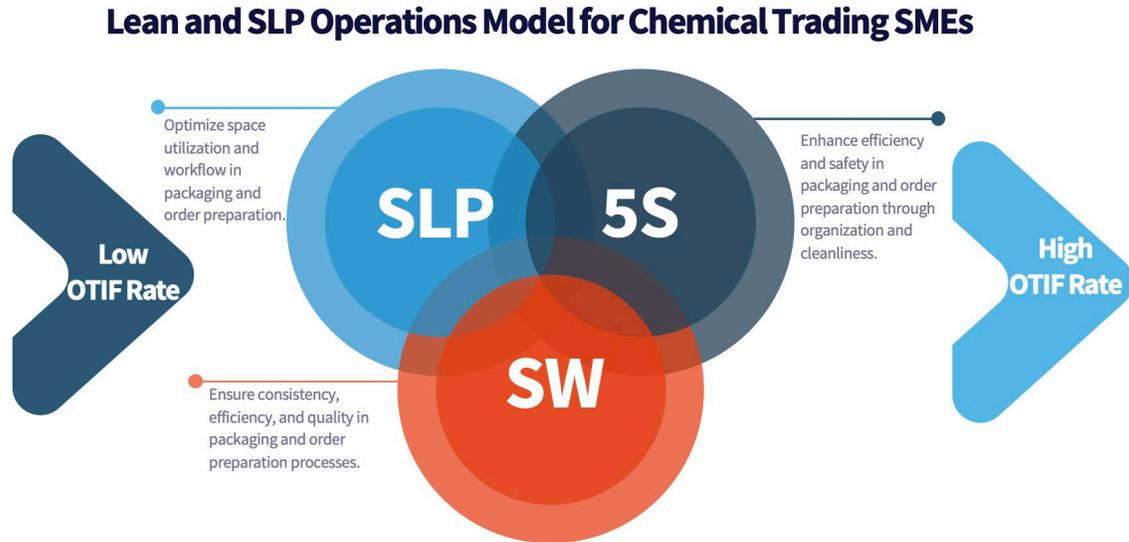


Figure 1. Proposed Model

3.2 Description of the model components

The Lean and SLP-based operations model proposed in this study contributes to the existing literature by offering a structured approach to addressing inefficiencies in the packaging and order preparation processes of chemical trading SMEs. Building on the principles of Lean Manufacturing, the model integrates tools such as Systematic Layout Planning (SLP), 5S, and Standardized Work (SW), each tailored to the specific needs of the sector. Previous studies have demonstrated the benefits of Lean Manufacturing in various industries; however, the application of these principles in chemical trading SMEs has been underexplored. The proposed model aims to fill this gap by providing a comprehensive methodology that enhances operational efficiency, reduces errors, and optimizes workflows. The systematic integration of Lean tools with SLP allows for a holistic improvement, ensuring that physical layout, organization, and standardization are addressed in tandem. The model draws upon core Lean principles such as waste reduction, flow optimization, and continuous improvement, while also incorporating space planning and ergonomic considerations to further enhance operational performance. By doing so, it not only improves day-to-day operations but also fosters a culture of efficiency and quality that can be sustained over the long term.

Systematic Layout Planning (SLP)

The first stage of the proposed model focused on the application of Systematic Layout Planning (SLP) to optimize the spatial arrangement and workflow within the SME's packaging and order preparation areas. SLP is a methodical approach used to arrange physical spaces and workflows in a manner that maximizes efficiency and minimizes unnecessary movement and handling (Muther, 1973). The application of SLP in this context was particularly crucial due to the complexity of chemical packaging and the specific safety requirements associated with handling hazardous materials. By systematically analyzing the space requirements, workflow patterns, and material flow, the layout was redesigned to reduce bottlenecks and streamline operations.

The SLP process began with a detailed analysis of the current state of the facility's layout, including the identification of high-traffic areas, material handling paths, and space utilization inefficiencies. From this analysis, it was clear that excessive movement between the storage, packaging, and dispatch areas was contributing to delays and errors. The redesign, therefore, focused on clustering related activities together and creating more efficient flow paths for both personnel and materials. By strategically positioning storage areas closer to the packaging stations and ensuring that materials followed a linear path through the facility, the model reduced unnecessary handling and transportation times. This not only improved efficiency but also enhanced safety by reducing the likelihood of accidents during the transportation of hazardous chemicals.

In addition to optimizing the physical layout, the SLP stage also incorporated ergonomic considerations to improve worker comfort and productivity. By minimizing the distance that workers needed to travel and ensuring that

frequently used materials were positioned within easy reach, the redesign aimed to reduce fatigue and the risk of repetitive strain injuries. This aspect of the model aligns with Lean principles, which emphasize the importance of designing processes that not only improve efficiency but also enhance worker well-being (Womack & Jones, 1996).

5S Methodology Implementation

The second stage of the model involved the implementation of the 5S methodology to improve workplace organization, cleanliness, and safety. The 5S methodology—Sort, Set in order, Shine, Standardize, and Sustain—is a fundamental Lean tool that seeks to create an organized and efficient workspace by eliminating waste and ensuring that all tools and materials are readily available and easy to find (Hirano 1995). In the context of chemical packaging, where safety is a paramount concern, the implementation of 5S was critical to ensuring that hazardous materials were properly stored, labeled, and handled. The first step, Sort, involved identifying and removing unnecessary items from the packaging and preparation areas. This step was particularly important in eliminating clutter that could obstruct workflows or pose a safety hazard. Next, the Set in order phase focused on arranging the remaining tools and materials in a logical and easily accessible manner. In this stage, specific storage areas were designated for different types of chemicals, packaging materials, and tools, ensuring that everything was clearly labeled and easy to find.

The Shine phase emphasized the importance of cleanliness in maintaining an efficient and safe workspace. In the context of chemical packaging, this phase not only involved routine cleaning but also the implementation of procedures for regularly inspecting equipment and workspaces to identify potential safety hazards, such as leaks or spills. By establishing a clean and organized environment, the company was able to reduce the likelihood of accidents and improve overall productivity. The Standardize phase involved creating clear, standardized procedures for maintaining the organization and cleanliness established in the previous phases. These procedures were documented and shared with all employees to ensure consistency in how tasks were performed and how the workspace was maintained. Finally, the Sustain phase focused on creating a culture of continuous improvement, where workers were encouraged to take ownership of their workspace and contribute to ongoing efforts to maintain a clean, organized, and efficient environment. This was achieved through regular audits and employee feedback sessions, which helped to identify areas for further improvement and ensure that the benefits of 5S were sustained over the long term.

Standardized Work (SW)

The final component of the proposed model was the implementation of Standardized Work (SW), which aimed to ensure consistency and quality in the packaging and order preparation processes. Standardized Work is a Lean tool that involves documenting the best practices for performing a task and ensuring that all workers follow these procedures consistently (Liker, 2004). By standardizing the way tasks were performed, the model sought to reduce variability, minimize errors, and ensure that all orders were prepared and packaged to the same high standard.

The first step in implementing Standardized Work was to conduct a detailed analysis of the packaging and order preparation processes to identify the most efficient way of performing each task. This involved working closely with employees to understand the challenges they faced and observing the current methods used for packaging and preparing orders. Based on this analysis, new standardized procedures were developed, focusing on minimizing waste, reducing handling times, and ensuring that all safety protocols were followed. Once the new procedures were developed, they were documented in clear, step-by-step instructions that were easy for employees to follow. These instructions included visual aids, such as diagrams and photographs, to further ensure that tasks were performed consistently and correctly. Training sessions were then conducted with all employees to ensure that they fully understood the new procedures and the importance of following them consistently.

The implementation of Standardized Work not only improved the consistency and quality of the packaging and order preparation processes but also made it easier to identify areas for improvement. By having a clear, documented standard for how tasks should be performed, the company was able to quickly identify any deviations from the standard and take corrective action. This helped to further reduce errors and improve overall efficiency. In conclusion, the proposed Lean and SLP-based operations model provided a comprehensive framework for improving the packaging and order preparation processes within chemical trading SMEs. By integrating Systematic Layout Planning, 5S, and Standardized Work, the model addressed key inefficiencies and created a more organized, efficient, and safe working environment. The systematic approach to layout optimization, workplace organization, and standardization not only improved operational efficiency but also fostered a culture of continuous improvement that could be sustained over the long term. This model contributed to the literature by demonstrating the applicability of Lean Manufacturing

principles in the context of chemical trading SMEs, providing a valuable framework for other companies in the sector seeking to improve their operations.

3.3 Model Indicators

To assess the impact of the Lean Manufacturing and SLP-based operations management model for chemical product marketing SMEs, specialized metrics were developed. These metrics were carefully designed to monitor and evaluate performance throughout the case study, providing a robust foundation for analyzing critical aspects of the packaging and order preparation processes within the SME environment. This systematic approach facilitated a detailed review of key performance indicators, ensuring a comprehensive evaluation of operations. The evaluation enabled effective monitoring and supported the continuous improvement of packaging and order preparation, ultimately contributing to enhanced efficiency and effectiveness in order handling within the SME.

OTIF (On-Time In-Full Rate):

This indicator measures the percentage of orders delivered completely and on time. It provides insight into the company's ability to meet customer demand in a timely manner.

$$OTIF = \frac{\text{Orders completed and on time}}{\text{Total orders}} \times 100\% \quad (1)$$

Rate of Orders Delayed in the Location of Finished Products (I_1): This indicator measures the percentage of orders delayed due to issues in the location of finished products, affecting the overall delivery time.

$$I_1 = \frac{\text{Orders delivered on time} - \text{Orders delayed in finished products location}}{\text{Total orders}} \times 100\% \quad (2)$$

Rate of Orders Delayed in Cylinder Location (I_2): This measures the percentage of orders delayed due to problems with cylinder location, which impacts the timely delivery of orders.

$$I_2 = \frac{\text{Orders delivered completely} - \text{Orders delayed in cylinder location}}{\text{Total orders}} \times 100\% \quad (3)$$

Rate of Orders with Defects in the Packaging Process (I_3): This indicator measures the percentage of orders affected by defects in the packaging process, which influences product quality and delivery efficiency.

$$I_3 = \frac{\text{Orders delivered completely} - \text{Orders with packaging defects}}{\text{Total orders}} \times 100\% \quad (4)$$

Rate of Orders with Defects in the Packing Process (I_4): This metric assesses the percentage of orders that experience defects during the packing process, impacting the quality of final delivery.

$$I_4 = \frac{\text{Orders delivered completely} - \text{Orders with packing defects}}{\text{Total orders}} \times 100\% \quad (5)$$

4. Validation

4.1 Validation Scenario

The validation scenario was conducted in a case study of a company dedicated to the commercialization of chemical products in Peru, with branches in several South American countries. The company specialized in the import and

distribution of chemical products for various industries, including mining, textiles, food, and pharmaceuticals. The operations plant was located in the port of Callao, where the reception, storage, and dispatch of products were managed nationwide. Over the past three years, the company positioned itself among the top three chemical importers in the country, with a portfolio of more than 50 products and an annual distribution volume of 14,000 tons. However, despite its market success, the company faced operational challenges, such as delays in order deliveries and defective products, which negatively impacted both customer satisfaction and operational efficiency. The research focused on implementing Lean and SLP tools to improve these key processes, optimizing on-time delivery and reducing defects in delivered orders.

4.2 Initial Diagnosis

In Figure 2, the problem tree summarizes the diagnostic conducted in the case study to identify the causes and root causes of the research problem. The primary issue identified was the low OTIF (On-Time In-Full) rate, with the case study showing a performance of 71.74%, significantly below the industry standard of 90%. This discrepancy resulted in an economic impact of 228,756 PEN/year, representing 5.29% of the company's annual revenue. The analysis uncovered three main causes contributing to the problem: orders delivered out of time (61%), an excess of defective products (32%), and orders not delivered due to lack of stock (7%). Further investigation into root causes revealed delays in locating finished goods (34%), delays in cylinder location (27%), defects in the packaging process (17%), and defects in the execution of the packing process (15%). The diagnostic approach aimed to systematically identify and categorize these factors to facilitate targeted improvements in the company's operations. This structured analysis provided a clear understanding of the underlying issues affecting the company's packaging and order preparation processes, establishing a solid foundation for the subsequent implementation of Lean Manufacturing and SLP-based improvements.

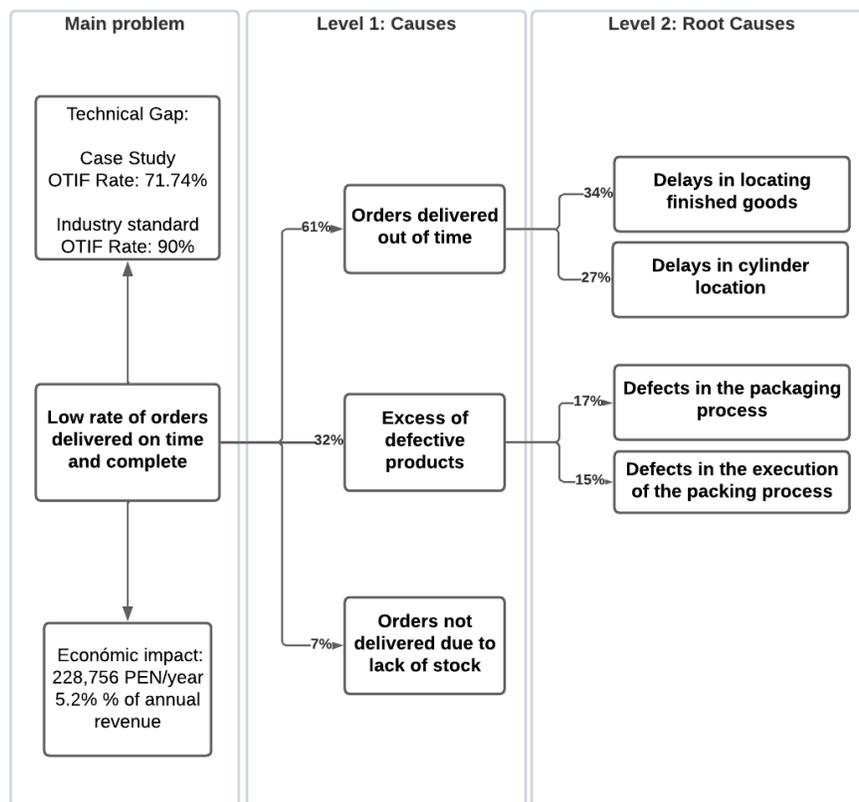


Figure 2. Problem Tree

4.3 Implementation of the model in the case study

The detailed solution design was divided into two phases. The first phase focused on reducing delays in locating finished products and cylinders. To achieve this, the SLP (Systematic Layout Planning) tool and 5S methodology were applied, aiming to reorganize company areas according to their importance and create manuals to maintain

organization within the facility. The second phase concentrated on standardizing work processes, particularly in the packaging and packing processes. This phase aimed to improve the timely delivery of defect-free orders, thereby reducing operational time and ensuring that employees consistently performed their tasks. Each of these phases was meticulously planned and executed to meet the specific needs of the company, which faced significant delays and inefficiencies. The key objective was to streamline processes and enhance the performance of employees by introducing clear standards and optimizing the layout of the workspace. The results were evaluated using various indicators, which helped quantify the improvements achieved.

Phase 1: Application of SLP and 5S Tools

The first step in implementing the solution involved analyzing batch sizes using the PQ analysis to classify products based on quantity and demand. This classification was vital for reorganizing the storage and dispatch areas, ensuring that products with higher demand were stored closer to the dispatch zones. Through the representation of the SLP tools, a new layout was designed, which allowed for more efficient use of space and reduced the time spent searching for and retrieving products. Additionally, the 5S methodology was applied to maintain order and cleanliness in the workspace. This involved sorting, setting in order, shining, standardizing, and sustaining, which are essential steps to ensure that the workplace remains organized and functional. The implementation of 5S resulted in a reduction of 61% in the time spent searching for materials and a 16% decrease in the storage space required for frequently used items.

Figure 3 presents the proposed layout for the company's warehouse, designed to optimize the flow of materials and improve operational efficiency. The layout includes several distinct areas: four storage zones (warehouses 1, 2, 3, and 4), a cylinder depot, a reprocessing zone, and tanks for storing chemicals. The transit aisles (traffic routes) have been widened to facilitate smoother movement of personnel and products, reducing delays in locating and transporting items. Notably, warehouses 1 and 2 are positioned close to the dispatch zone (Dispatch area) to prioritize high-demand products and expedite order preparation. Additionally, warehouses 3 and 4 are located near other critical operations, such as the cylinder depot and reprocessing zone, ensuring that less frequently needed items are easily accessible. This configuration also includes specific areas for offices and loading zones, contributing to a more streamlined, efficient, and safe operational workflow within the facility.

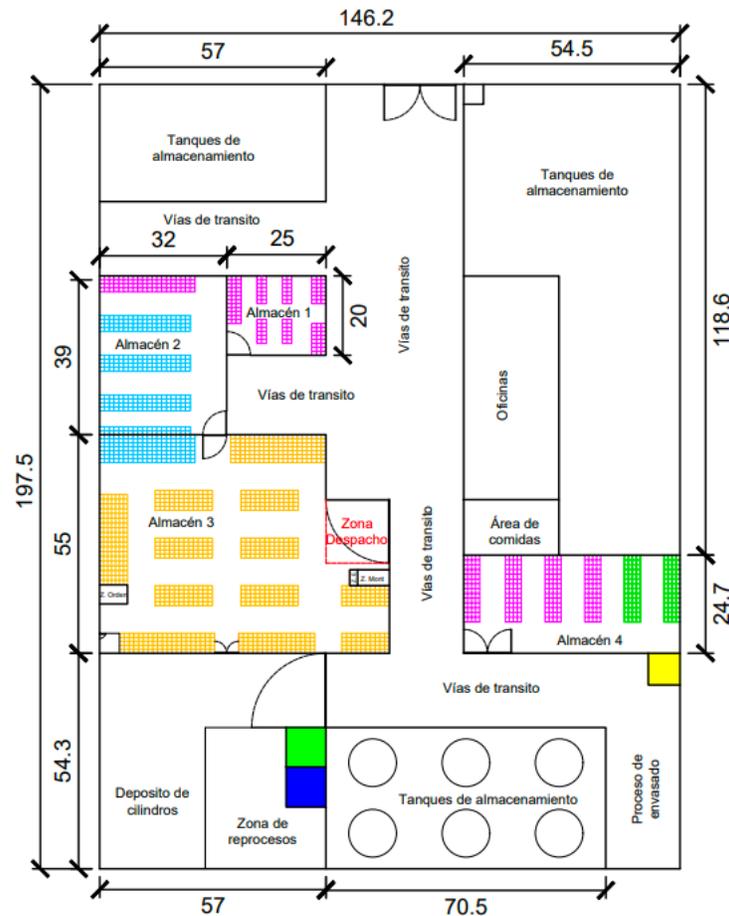


Figure 3. Proposed Layout

Phase 2: Standardization of Work

The second phase of the solution design focused on standardizing the work processes involved in packaging and packing. This phase was crucial for reducing the number of defective products and improving the overall efficiency of the order preparation process. By analyzing the current work processes, the team identified areas where improvements could be made and developed standardized work procedures to ensure that employees followed consistent, efficient practices. The standardization of work resulted in a 66% reduction in defective products in the packaging process and an 18.44% decrease in the time required to complete standard tasks. In the packing process, the standardization efforts led to a 45% reduction in activity time and a 90% decrease in defects during shifts, significantly improving the quality of the final products.

Figure 4 displays the Activity Diagram for the proposed packaging process. The diagram outlines the key steps involved in the packaging operation, comparing the current and proposed workflows in terms of activity, distance, and time. The process begins with inspecting empty cylinders, followed by transporting them to the packaging area, filling them with product, sealing, verifying the seal, and then transporting the filled cylinders to storage. In the proposed process, four cylinders are filled simultaneously, reducing total operational time to 9.21 minutes from the current 12.7 minutes. Key improvements include using forklifts for transportation to minimize manual handling, significantly reducing the risk of damage and operational delays. The diagram also highlights the reduction in defective orders from 17 in the current process to 7 in the proposed one. Overall, the proposed improvements streamline the workflow, enhance efficiency, and minimize defects in the packaging process, ensuring better operational performance.

DIAGRAMA DE ACTIVIDADES DEL PROCESO										
PROCESO DE ENVASADO										
Diagrama No.	Hoja No.	Operario <input checked="" type="checkbox"/>	Material <input type="checkbox"/>	Equipo <input type="checkbox"/>						
Objetivo:	RESUMEN									
Evitar los reprocesos de envasado	ACTIVIDAD	ACTUAL			PROPUESTO					
Proceso analizado:	Operación	3			4					
Envasado	Transporte	2			2					
Método:	Inspección	2			4					
Actual <input type="checkbox"/> Propuesto <input checked="" type="checkbox"/>	Combinada	0			0					
	Espera	0			0					
Localización:	Almacenamiento	1			1					
	Tiempo	12.7 min			9.21 min					
Empresa comercializadora de químicos	Pedidos defectuosos	17			3					
Descripción	Distancia (m)	Tiempo	Símbolo					Observaciones		
			○	➔	□	◐	◑		▽	
Verificar cilindro vacío	0	0.25 min							Inspección del estado del envase	
Transportar a zona de envasado	40	0.56 min							Transporte con montacarga	
Verificar parihuela	0	0.2 min	X							
Paletizar cilindro	0	0.71 min	X							
Llenar cilindro	0	5.1 min	X						Se llenan 4 cilindros al mismo tiempo.	
Verificar llenado	0	1.04 min								
Sellar cilindro	0	0.36 min	X							
Verificar sellado	0	0.15 min								
Enfilar	0	0.11 min	X							
Transportar a almacén	70	0.5 min							Transporte con montacarga	
Almacenar	30.2	0.23 min								
TOTAL		9.21 min								

Figure 4. Activity Diagram of the proposed packaging process

Figure 5 shows the Activity Diagram for the proposed packing process, comparing the current and proposed workflows in terms of activities, time, and distance. The process involves transporting cylinders to the dispatch area, verifying the condition of the cylinders, securing them with straps, and cutting the excess straps. In the proposed workflow, the time is reduced to 4.14 minutes from 9.47 minutes in the current process. One of the major improvements includes using forklifts to transport the cylinders, which minimizes manual handling and reduces the risk of damage. Additionally, the proposed process increases the number of straps applied from two to four for enhanced stability during transport. The diagram indicates a reduction in defective orders from 15 in the current process to 4 in the proposed version. The adjustments lead to improved efficiency and product security, minimizing the time required and decreasing errors in the packing process, thus ensuring better order preparation and handling.

DIAGRAMA DE ACTIVIDADES DEL PROCESO								
PROCESO DE PACKING								
Diagrama No.	Hoja No.	Operario <input checked="" type="checkbox"/>	Material <input type="checkbox"/>	Equipo <input type="checkbox"/>				
Objetivo:	RESUMEN							
Evitar los reprocesos de packing	ACTIVIDAD	ACTUAL	PROPUESTO					
Proceso analizado:	Operación	6	4					
Packing	Transporte	1	1					
Método:	Inspección	2	6					
Actual <input type="checkbox"/> Propuesto <input checked="" type="checkbox"/>	Combinada	1	2					
	Espera	1	0					
Localización:	Almacenamiento	0	0					
	Tiempo	9.47 min	4.14 min					
Empresa comercializadora de químicos	Pedidos defectuosos	15	4					
Descripción	Distancia (m)	Tiempo	Símbolo					Observaciones
			○	➡	□	◻	◇	
Transportar a zona de despacho	10	0.21 min	X					Transporte con montacarga
Rodear los cilindros con el zuncho		1.17 min	X					Se colocan 2 zunchos
Verificar el enzunchado horizontal		0.17 min		X				
Rodear los cilindros y paleta con el zuncho		2.1 min	X					
Verificar el enzunchado vertical		0.18 min		X				Se colocan 4 zunchos
Cortar zunchos sobrantes		0.31 min	X					
TOTAL		4.14 min						

Figure 5. Diagram of the proposed packing process activities

Indicators and Results

The effectiveness of the solution was evaluated using various indicators, including the OTIF (On Time In Full) rate, which measures the percentage of orders delivered on time and without defects. The implementation of the SLP and 5S tools resulted in an increase in the OTIF rate from 71.74% to 90%, exceeding the industry standard. Additionally, delays in locating finished products were reduced by 66.67%, while delays in cylinder location were reduced by 73.33%. Defects in the packaging and packing processes were also significantly reduced, with an 82.35% reduction in packaging defects and a 73.33% reduction in packing defects. These improvements contributed to a more efficient and effective order preparation process, ensuring that orders were delivered on time and met the required quality standards. In conclusion, the detailed solution design, which incorporated SLP and 5S tools in the first phase and work standardization in the second phase, successfully addressed the company's operational challenges. The indicators used to evaluate the solution demonstrated significant improvements in the company's ability to deliver defect-free orders on time, ultimately contributing to increased efficiency and customer satisfaction.

5. Results

Table 1 shows the key results of the validation of the operations management model based on Lean and SLP for chemical trading SMEs. The OTIF rate increased by 32.09%, while defects in the packaging process were reduced by 82.35%, and cylinder location delays decreased by 73.33%. Additionally, order delays in the finished product location were reduced by 66.67%, and picking defects saw a 73.33% reduction. These results demonstrate significant improvements in both efficiency and quality within the processes evaluated, confirming the effectiveness of the proposed management model.

Table 1. Results of validation of the proposed model

Indicator	Unit	As-Is	To-Be	Results	Variation (%)
OTIF Rate	%	71.74%	90%	94.76%	32.09%
Rate of orders with delays in the location of finished products	%	36%	11%	12%	-66.67%
Order rate with cylinder location delays	%	30%	7%	8%	-73.33%
Rate of orders with defects in the packaging process	%	34%	5%	6%	-82.35%
Rate of orders with picking defects	%	30%	7%	8%	-73.33%

6. Conclusions.

The main findings of this study indicate a significant improvement in operational efficiency and quality control in the packaging and order preparation processes of chemical trading SMEs. The implementation of a Lean and SLP-based operations model resulted in a 32.09% increase in the On-Time In-Full (OTIF) rate, while packaging defects were reduced by 82.35% and delays in cylinder location decreased by 73.33%. Additionally, delays in locating finished products were reduced by 66.67%, contributing to a more streamlined workflow and improved customer satisfaction. These findings demonstrate the effectiveness of applying Lean principles and Systematic Layout Planning to address operational inefficiencies, reduce delays, and improve overall productivity.

The importance of this research lies in its application to an underexplored sector—chemical trading SMEs. While Lean Manufacturing has been widely studied and applied in various industries, its integration with Systematic Layout Planning (SLP) in chemical trading companies has not been extensively researched. The results of this study show that Lean tools, when properly applied, can lead to substantial improvements in operational efficiency, safety, and quality control. The findings highlight the need for SMEs in the chemical industry to adopt Lean and SLP methodologies to remain competitive and ensure continuous improvement in their operations.

This research contributes to the field of industrial engineering by demonstrating the effectiveness of combining Lean Manufacturing, SLP, and work standardization to enhance operational performance in SMEs. The study offers a comprehensive approach to addressing inefficiencies in packaging and order preparation processes, which are critical components of supply chain management in the chemical sector. By optimizing layout, improving workplace organization, and standardizing work procedures, the model provides a framework for SMEs to improve their operations and reduce waste. Additionally, the research fills a gap in the literature by providing empirical evidence of the positive impact of Lean and SLP integration in chemical trading SMEs.

Final observations suggest that while the model has proven effective in this case study, further research is necessary to explore its applicability in other sectors and contexts. Future studies could investigate the long-term sustainability of the improvements achieved and examine the model's adaptability to other industries with similar operational challenges. Furthermore, the integration of advanced technologies, such as automation and data analytics, could enhance the model's effectiveness and provide additional opportunities for continuous improvement. In conclusion, this research provides a solid foundation for future studies aimed at optimizing operational efficiency in SMEs, with the potential to expand the model's application to a broader range of industries.

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