Original Article
ISSN (Online): 2454-1907

International Journal of Engineering Technologies and Management Research
March 2024 11(3), 47–62

LEAN MANUFACTURING IMPLEMENTATION THROUGH DMAIC APPROACH: A CASE STUDY IN THE GLASS TRANSFORMATION COMPANY

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Received 15 February 2024
Accepted 16 March 2024
Published 31 March 2024

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DOI
10.29121/ijetmr.v11.i3.2024.1406

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Manufacturing companies are constantly driven to minimize costs, maximize efficiency, and enhance production quality, as these factors are pivotal for maintaining a competitive edge in the market. Lean manufacturing is a pivotal strategy that plays a crucial role in assisting companies for achieving significant continuous improvement in performance through the elimination of all wastes of resources and time in the total business process. The main objective of this paper is to validate the results of implementing Lean manufacturing through the DMAIC concept. This study focuses on a case study conducted in a glass transformation company that aims to improve the flow within the production workshop by implementing pull systems and minimizing waste.
To achieve this objective, a comprehensive literature review was conducted to examine different frameworks for applying the Lean method.
The implementation of DMAIC has provided a better structure for the entire project, enabling the selection of appropriate improvement solutions and the use of the right Lean tools. This approach offers several advantages that are not present in other frameworks. The results of this implementation have shown a significant improvement in production planning, flow efficiency, and a substantial financial gain for the company.

Keywords: Lean Manufacturing, DMAIC, Lean Tools, Continuous Improvement

1. INTRODUCTION

In today's highly competitive business landscape, numerous companies strive to establish their presence despite limited resources. However, in order to achieve greater profitability, these companies often find themselves in need of more efficient manufacturing processes. This is where the adoption of lean management techniques comes into play. By implementing this approach, businesses across various sectors such as manufacturing, for-profit, non-profit, education, and healthcare can significantly enhance their effectiveness and efficiency The lean approach has proven to be a game-changer for numerous industries, enabling them to produce superior products in less time and with fewer efforts Dave (2020).

After the conclusion of World War II, Japanese manufacturers, specifically those in the automotive industry, were confronted with a significant predicament: shortages of essential resources such as materials, finances, and manpower. It was during this challenging period that Eiji Toyoda and Taiichi Ohno, visionaries at the Toyota Motor Company in Japan, pioneered a groundbreaking concept known as the Toyota Production System. Kumar et al. (n.d.).

Following its resounding success in Japan, lean manufacturing quickly gained traction among companies and industries worldwide, particularly in the United States Fawaz Abdullah (2003). Moreover, the lean approach fosters a culture of continuous improvement, encouraging employees to identify and address inefficiencies, resulting in a more agile and adaptable organization.

This document presents a relevant Lean Manufacturing application, implemented by following the systematic steps of the DMAIC approach to reduce the various waste forms that involve a high inventory of work-in-process for a glass transformation company with a complex workflow. In order to successfully implement the Lean concept, the team used a plethora of Lean tools like, value stream mapping, 5S, etc. For the paper's organization, the first part is dedicated for a literature review concerning Lean Manufacturing and its applicability as well as the DMAIC cycle. The second part will be focusing on the methodology used for the implementation of the Lean Manufacturing project. The third part will include the gain generated and the Lean application's efficiency in this company. A conclusion and some perspectives will be discussed in the last part.

2. LITERATURE REVIEW

2.1. LEAN CONCEPT

The Lean philosophy is centered around the reduction and elimination of non-value added activities, commonly referred to as "Mudas" in Lean terminology. By implementing Lean production techniques, companies can achieve higher levels of productivity with fewer human resources, reduced financial investment, less space, and fewer equipment requirements to manufacture the same product Salonitis & Tsinopoulos (2016).

Figure 1

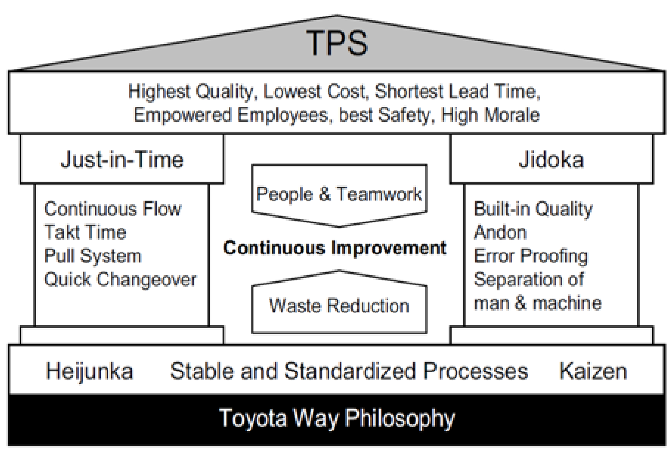

Figure 1 The Core Principles of the Toyota Production System **Romvall et al. (2010)**

Toyota, the originator of Lean, has likened its philosophy to a temple, symbolizing the foundation of Lean project construction and the pillars that fortify its strength (refer to Figure 1). Each component of this temple serves to define the objectives of the methodology, highlighting the areas that require attention and the tools that should be employed Rüttimann & Stöckli (2016).

It also adds five principles to improve the company's functioning: determining the product's value in the eyes of clients, identifying, and clarifying the value stream for the product, providing a fast and undisturbed value stream, allowing clients to elicit value from the producer, and striving for excellence Dekier (2012).

2.2. LEAN MANUFACTURING

Lean Manufacturing was first coined in 1991 by James P. Womack, Daniel T. Jones, and Daniel Roos in their book "The Machine That Changed the World." They compared Japanese and American companies and found that Toyota Motor Company, with its Toyota Production System, was the most efficient. Dekier (2012).

The Toyota Production System (TPS) was hailed as the first system that followed the principles of Lean. In 2001, Womack and Jones published "Lean Thinking: Banish Waste and Create Wealth in Your Corporation," which defined the foundations of the Lean Philosophy. Lean Manufacturing is considered a successor of the TPS and applies the instruments developed by Toyota. Palange & Dhatrak (2021).

In order to effectively implement Lean principles, companies must adhere to the principles of Lean implementation. These principles have been extensively discussed in various books and articles, including works by Jerry (2003), Liker (2004), Andersson et al. (2006), Su et al. (2006). For a comprehensive overview, refer to Figure 2.

Figure 2

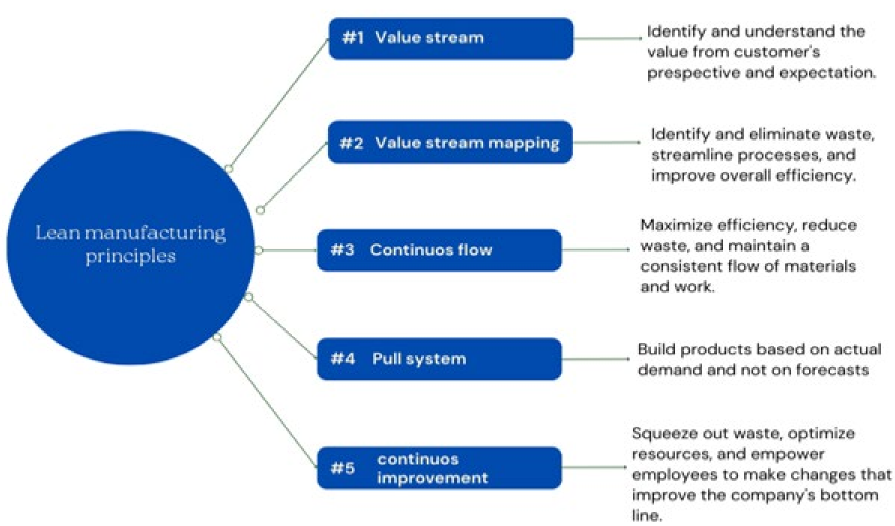

Figure 2 The Lean Manufacturing Principles

The implementation of Lean has been closely linked and integrated with various other concepts, services, and paradigms. One such example is Lean Sigma Mostafa et al. (2016) which combines Lean's focus on efficiency and speed with Six Sigma's emphasis on accuracy and precision. By utilizing Lean principles, resources are effectively utilized to create value, while Six Sigma ensures that tasks are done correctly the first time.

2.3. DMAIC APPROACH

DMAIC, inspired by Deming practices and the Plan, Do, Check, and Act (PDCA) Cycle Gupta (2013). This process ensures continuous improvement and has proven to be highly beneficial for numerous organizations.

DMAIC stands for the five steps: Define, Measure, Analyze, Improve, and Control. Interestingly, DMAIC can be operated without making reference to the Six Sigma approach. For instance, in one study, the DMAIC cycle was exploited to improve the supply chain Dossou & Dedeban (2016), while in another study, it was used to analyze the root causes of circuit breaker failure in a distribution system Popov et al. (2018).

The DMAIC Methodology is a six-step approach used in Six Sigma projects. The first step is the Define Phase, where the problem is identified, the project goal is established, and the customers affected by the problem are determined. The second step is the Measure Phase, where the existing system or process is measured and metrics are established. The third step is the Analyze Phase, where the defective process is analyzed to identify input variables that affect the output. The fourth step is the Improve Phase, where solutions to the problem are selected and implemented to improve efficiency, cost-effectiveness, and speed. The fifth step is the Control Phase, where modifications to management systems are made to ensure the improvements are sustainable. Continuous monitoring is also necessary to confirm the desired improvement has been achieved Kumar and Sharma (2012).

3. MEHODOLOGY

A diagnostic is an important step in any project as it helps identify issues within an organization. It involves observation, identification, and analysis to establish connections between relevant variables. In this case, a Lean assessment was used to evaluate the company's operations and determine indicators related to costs, quality, and timelines. Lean assessment is based on the “Genchi Genbutsu” approach which means going to the source to check the situation for yourself and emphasizes Gemba processes, a Japanese word meaning “where reality is”. The Genba or Gemba walk is an activity for managers which consists of going into the field to look for waste and opportunities for improvement that are at the origin of added value. Loyd et al. (2020b).

Company managers were involved in the assessment and rated the level of Lean integration using a scale from 0 to 4. A questionnaire based on eight Lean principles was used to calculate results, with each principle assigned a rating out of 100 points for a total evaluation score of 800 points. The company scored 120 points, indicating deficiencies in accountability, continuous improvement, and transparency. Due to the challenges posed by the COVID-19 pandemic, the company chose to prioritize areas that can be improved with minimal cost and bring added value to society, focusing on the principles of process orientation, flow, and transparency. The Lean methodology was implemented with the primary objective of enhancing the physical flow within the polishing workstations and optimizing stock management. The project team recognized that Lean Manufacturing is the most effective solution for identifying non-value-added activities and improving overall workflow, provided that the company is committed to eliminating various forms of waste within the workshop.

The DMAIC problem-solving methodology has been selected to implement Lean Manufacturing like presented in the Figure 3.

Figure 3

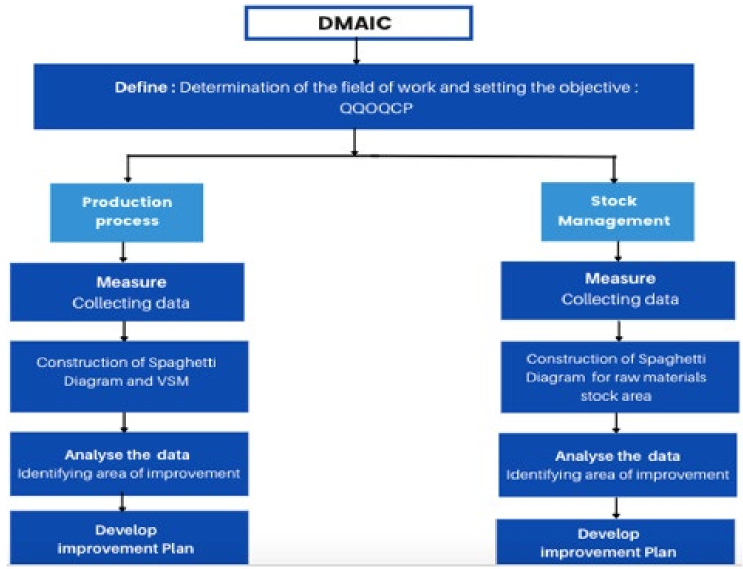

Figure 3 The DMAIC Problem-Solving Methodology

3.1. PRODUCTION LINE

The first step is to observe the production line and collect required information During the observation of the production line we discovered the existence of different categories of products that the company manufactures refer to the Figure 4 in which is represented all the process of the transformation of the glass.

Figure 4

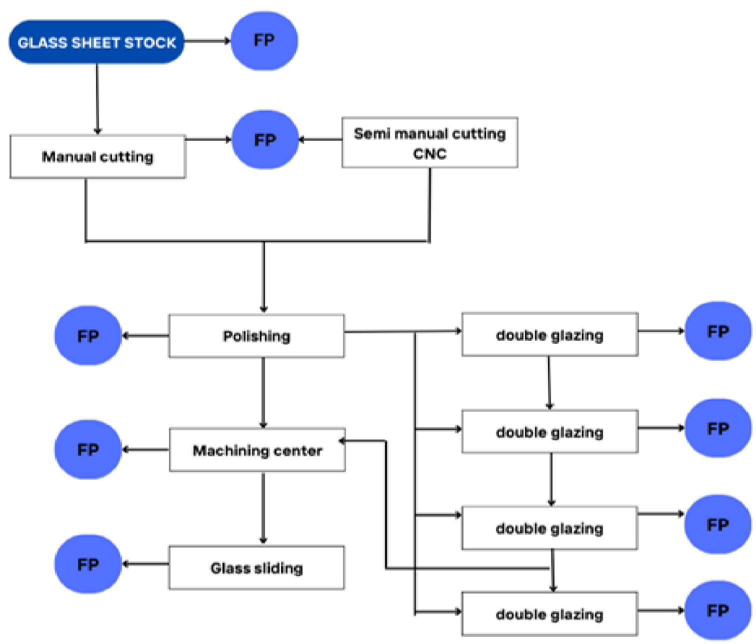

Figure 4 Glass Transformation Flow Diagram

The initial layout of the production departments has unveiled a series of challenges that warrant attention. The primary focus was on analyzing the distance between each workstation, alongside assessing production quantities and intermediate stock levels between each process. This critical evaluation has been succinctly represented in the diagram below, illustrating the spatial arrangement of workstations, the flow of materials, and the accumulation of intermediate stocks.

Figure 5

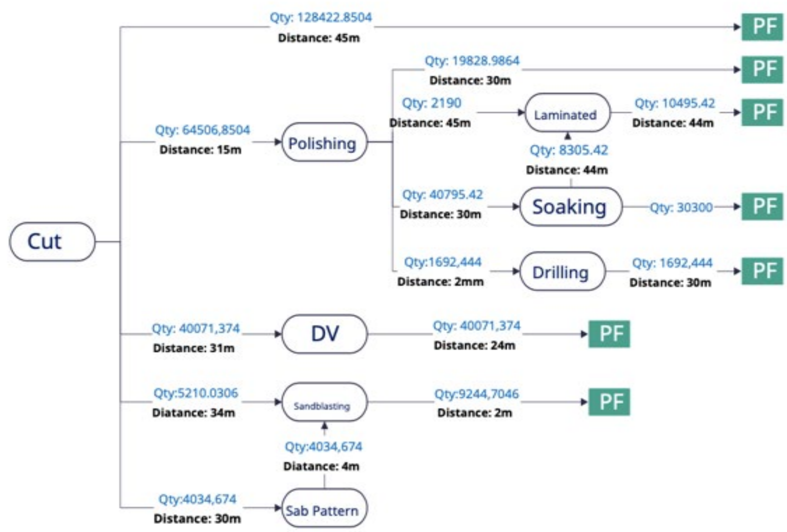

Figure 5 Workstations Overview

The Figure 5 illustrates that the automatic cutting machine serves as the main machine in the factory, as all products go through it. The polishing station, double glazing, sandblasting, and sandblasting pattern are directly related to the cutting machine, while there is a significant distance between the stations in relation to the quantity demanded. Taking the example of the double-glazing department, it is located 31m away, and the sandblasting department is 34m away. As shown by the spaghetti diagram (Figure 6), due to the flow intersections, operators spend between 10 and 15 minutes to bring a trolley with a frequency of 3 times per day, resulting in a total of 45 minutes per day.

Based on this analysis, one can observe the presence of a poor layout causes waste in transportation, handling, and movement between workstations.

Figure 6

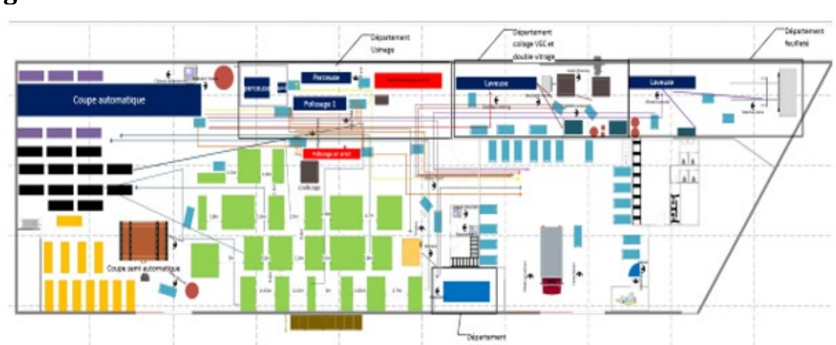

Figure 6 Diagram Spaghetti

Among the problems encountered in the production workshop is that of an imbalance between the production departments and a high stock of work in progress (WIP) and given that the company does not have any production monitoring indicators, we calculated the capacity of each station to determine the bottleneck station by conducting timing assessments for each workstation over a span of five days as shown the Table 1:

Table 1

Table 1 Workstation Capacity

Operations	Machine capacity	Number of machine	Client orders
Cut	0.05 m/s	1	0.045 LM
Polishing	0.002 m/s	2	0.008 LM
Double glazing operation	0.009 m/s	1	0.005 LM
Sandblasting	0.003 m/s	1	0.001 LM
Drilling	0.01 m/s	1	0.0002 LM
Lamination	0.014 m/s	1	0.0014 LM
Soaking	0.008 m/s	1	0.005 LM

Upon analyzing the table, it becomes evident that the capacity of the polishing machine falls short of meeting customer demand. Furthermore, when comparing the capacities of the drilling, laminating, and soaking processes with that of the polishing operation, it becomes apparent that the latter is significantly lower. This discrepancy leads to a substantial waiting time for work-in-progress inventory, as depicted in the flow maps.

Consequently, the table uncovers the presence of a bottleneck machine, namely the polishing machine.

From this analysis the focus was on developing a comprehensive Value Stream Map (VSM) tailored specifically to the polishing process. This strategic approach enables to gain a deep understanding of the current state of affairs, pinpoint areas of inefficiency, and identify opportunities for improvement.

For the polishing workstation, the manufacturing time for a specific number of pieces was tracked, along with calculating the linear meterage of each piece. Subsequently, the capacity of each workstation in meters per second was determined.

All the data collected will be presented in the tables below (Table 2) and (Table 3).

Table 2

Table 2 Surface Measurement for the Glass Sheet

Number of glass sheet	Lenghth	Width	LM
1	0.947	0.662	3.218
2	0.947	0.912	3.718
3	0.14	2	4.28
4	1.16	0.78	3.88
5	1.16	0.78	3.88
6	1.16	0.78	3.88
		Sum	22.856

Table 3

Table 3 Timing Measurement

Operation	1	2	3	4	5	6	Average Value Added
Verification of the dimensions of the piece	12						
Placement of the piece on the machine	6	6	15	10	7	6	
Passage of the piece on the conveyor	11	17	6	17	26	11	
Polishing operation on the side (Width)	70	78	50	50	71	72	**6,51,66,66,667**
Passage of the piece on the conveyor	15	17	15	18	24	23	
Return and placement of the piece on the machine	10	14	17	15	15	12	
Passage of the piece on the conveyor	17	10	9	11	28	14	
Polishing operation on the side (Length)	78	78	54	51	81	80	**7,03,33,33,333**
Passage of the piece on the conveyor	11	17	15	13	21	9	
Return and placement of the piece on the machine	17	20	23	14	11	15	
Passage of the piece on the conveyor	22	9	11	8	18	11	
Polishing operation on the side (Width)	70	77	53	81	70	70	**7,01,66,66,667**
Passage of the piece on the conveyor	10	17	16	18	23	24	
Return and placement of the piece on the machine	14	14	26	15	15	9	
Passage of the piece on the conveyor	20	12	11	13	11	14	
Polishing operation on the side (Length)	78	77	54	81	81	81	**7,53,33,33,333**
Convyor	16	12	6	20	12	33	
Return and placement of the piece on the machine						13	
Polishing operation						70	**70**
Passage of the piece on the conveyor						36	
Placement of the finished product on the glass transport and storage trolley	8	10	35	6	13	6	
Sum of the operations	485	485	416	441	527	585	Sum of AV

After implementing all necessary measures, the Value Stream Mapping (VSM) for the polishing process was designed. This map involved every step of the polishing operation, from the initial preparation of materials to the final placement of the finished product. By visualizing the entire value stream. Each stage was carefully analyzed to identify potential inefficiencies, bottlenecks, and opportunities for improvement. The VSM is represent in Figure 7.

Figure 7

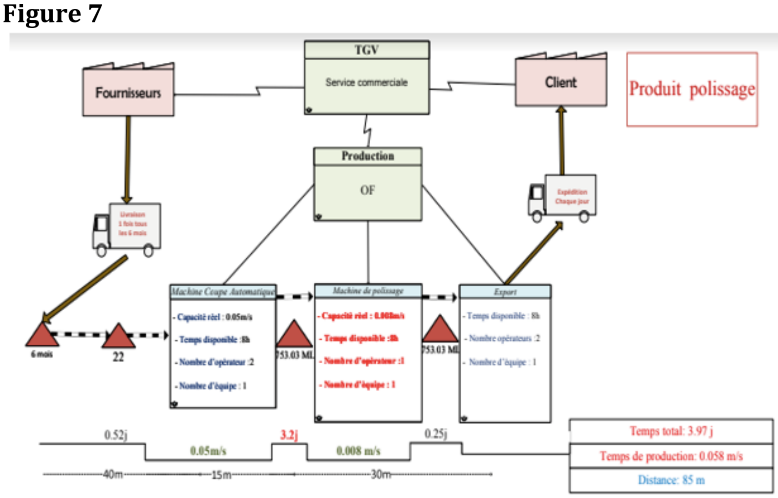

Figure 7 Value Stream Mapping (VSM) of the Polishing Process

The analysis of the indicators has revealed the following issues:

- Problems with departmental layout.
- Poor synchronization between all positions, resulting in a significant gap between the capacities of each position and consequently, high waiting time for work-in-progress stocks.
- The polishing machine is causing a bottleneck at the workstation.
- The production time for the laminated product is very high due to the polishing machine and the subcontractor's delivery delay (dipping operation).

With the identification of the polishing station as the bottleneck within the production line, the improvement plan is strategically oriented towards optimizing the flow process at this critical juncture. Recognizing the pivotal role that efficient polishing operations play in the overall productivity and output of the manufacturing process, the primary objective is to streamline and enhance the flow of work specifically within the polishing stage.

3.2. STOCK MANAGEMENT

The storage areas at the production workshop level present problems at the level of Organization and administrative tasks, flows and risks for the employees.

The main objective must be the organization and optimization of storage station flows so that they generate real added value in the production process.

The storage area for raw materials consists of various models of glass sheets that are stored in wooden boxes. These boxes have a width of 30 cm and a height of 2.5 m. The number of glass sheets in each box varies depending on the model, ranging from 13 to 31 sheets as represented by the green zone in the Figure 8.

In order to gather accurate data, we measured the distances between the wooden boxes and the passageways, as well as the time it takes for the operator to handle and transport the glass sheets from the warehouse to the cutting stations. These measurements were crucial in determining the efficiency of our operations.

By carefully analyzing these factors, we aim to enhance our storage system, streamline our processes, and ultimately improve overall productivity.

Figure 8

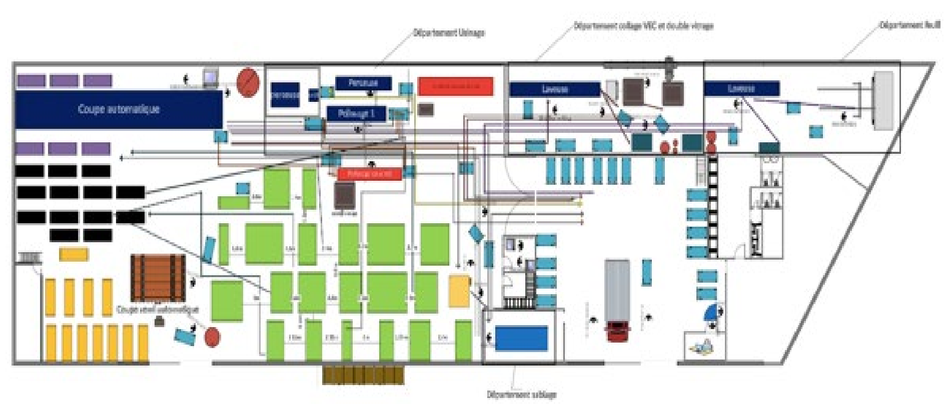

Figure 8 Spagetti Diagram of Glass Sheet Stroage

According to the spaghetti diagram show different problems:

- There is a crossing of flows between the boxes, since the storage trestles are not well arranged. Additionally, the crossover between the storage flow and the polishing machine flow.
- The boxes of glass sheets presented by the green color are not organized according to any classification despite the existence of all the names of the models. The distance between each trestle is different which has caused a disorder in terms of stock but also the spaces for handling and moving the boxes are very narrow which shows a loss considerable time.

The next step is to analyze the various issues encountered in the maintenance store and mezzanine storage areas, the 5M method was employed. This method helped identify the root causes of the problems (Figure 9) and facilitated their resolution.

Figure 9

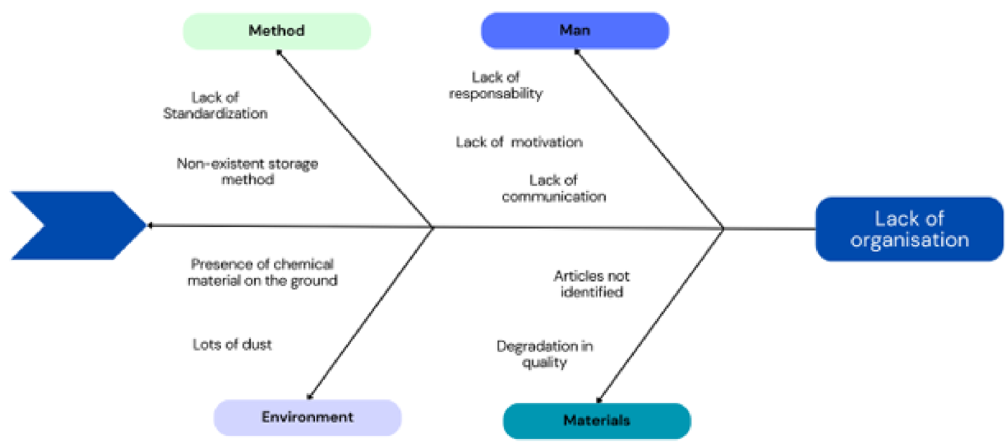

Figure 9 Ishikawa Diagram (Storage Areas)

The analysis reveals several key issues contributing to the inefficiencies in stock management:

- **Inadequate Space Utilization:** Storage areas are not optimized for maximum capacity utilization, leading to wasted space and congestion.
- **Poor Organization:** Items are haphazardly stored without a coherent organizational system, making it difficult to locate and retrieve specific items promptly.
- **Absence of Standard Operating Procedures (SOPs):** The absence of clear SOPs for stock management leads to inconsistency and confusion among staff members
- **Poor Organization:** Items are haphazardly stored without a coherent organizational system, making it difficult to locate and retrieve specific items promptly leads to inconsistency and confusion among staff members.

3.3. IMPROVEMENT PLAN

Optimizing operations within the production workshop, it's imperative to address not only the efficiency of the production line but also the effectiveness of stock management. This section outlines comprehensive improvement plans for both aspects, aiming to streamline processes, minimize waste, and maximize productivity. Those tables below represent the improving plan for both production workshop and stock management.

Table 4

Table 4 Improving Plan (Production Flow)

Problems detected	Improving actions
- **Wasted Operator Travel:** The existing layout requires operators to traverse unnecessary distances between workstations, resulting in wasted time and energy. - **Crossing of Flows**: Inefficient arrangement of machinery and workstations leads to the unnecessary crossing of material flows within the department, increasing the risk of congestion and delays. - **Productivity Impacts**: Cumulative effects of inefficient layout contribute to decreased productivity, higher operational costs, and potential quality issues.	***1. Machinery Reconfiguration*** Optimize the placement of polishing machinery and equipment to minimize the distance traveled by operators and reduce processing times. Consider reconfiguring the layout to create a more linear workflow, allowing materials to move seamlessly from one workstation to the next without unnecessary detours. ***2. Employee Involvement*** Involve frontline employees in the layout redesign process to leverage their insights and expertise. ***3. Continuous Monitoring and Improvement*** Encourage a culture of continuous improvement within the polishing department, where employees are empowered to propose innovative ideas and solutions for enhancing efficiency.
Machine Downtime: The unexpected stoppage of the second polishing machine halts the production process, leading to delays and potential loss of productivity. **Bottleneck Formation:** The idle second polishing machine creates a bottleneck in the production line, causing congestion and impeding the smooth flow of work. **Operational Disruptions:** The impact of machine downtime extends beyond immediate production delays, affecting downstream processes and overall operational efficiency.	***1. Repair of the Second Polishing Machine*** Promptly initiate the repair process for the malfunctioning second polishing machine to minimize downtime and resume normal production operations. ***2. Improved Value Stream Mapping (VSM)***

Table 5

Table 5 Improving Plan for Storage Areas

Problems	Improving actions
- **Inadequate Space Utilization**: Storage areas are not optimized for maximum capacity utilization, leading to wasted space and congestion. - **Poor Organization**: Items are haphazardly stored without a coherent organizational system, making it difficult to locate and retrieve specific items promptly. - **Absence of Standard Operating Procedures (SOPs):** The absence of clear SOPs for stock management leads to inconsistency and confusion among staff members	***1. Implementation of 5S Practices*** **a) Sort:** Remove unnecessary items from the storage spaces, disposing items that are no longer needed. **b) Set in order:** Establish a systematic storage system, organizing items in a logical and accessible manner to maximize space and facilitate easy retrieval. **c) Shine:** Clean and maintain the storage areas regularly to ensure a safe and hygienic working environment. **d) Standardize:** Implement standardized procedures for storing and accessing items including labeling systems and storage protocols. **e) Sustain:** Develop a plan for ongoing maintenance and monitoring to sustain the improvements achieved through the 5S practices. ***2. Maximizing Storage Capacity for the glass sheet*** Implementation of the ABC method to standardize the stock of glass sheets, optimizing inventory levels, and improving efficiency. ***3. Optimization of Flow Crossings*** Redesign layout and pathways to minimize unnecessary crossings and optimize material flow, enhancing efficiency and reducing the risk of accidents or delays.

The following section will comprehensively present all results achieved and improvements attained as a direct consequence of the implemented actions aimed at enhancing efficiency and optimizing operations.

4. RESULTS AND DISCUSSION

The implementation of the new layout in the machining department has yielded several significant improvements. Most notably, the restructuring has successfully eliminated the crossing of flows within the department, a previously persistent issue contributing to inefficiencies and waste. By streamlining the flow of materials and activities, we anticipate a notable reduction in waste generation, thereby enhancing overall productivity and cost-effectiveness. Moreover, the reconfigured layout has provided additional space for storing trolleys adjacent to the machines, optimizing accessibility, and facilitating smoother workflow operations. Additionally, the relocation of the second polishing machine has resulted in the liberation of the corridor space, creating a safer and more navigable environment for operators maneuvering with trolleys. This newfound spatial freedom has had a tangible impact on operational efficiency, notably reducing the delivery time of trolleys from the cutting machine to the double glazing department. (Figure 9)

Figure 10

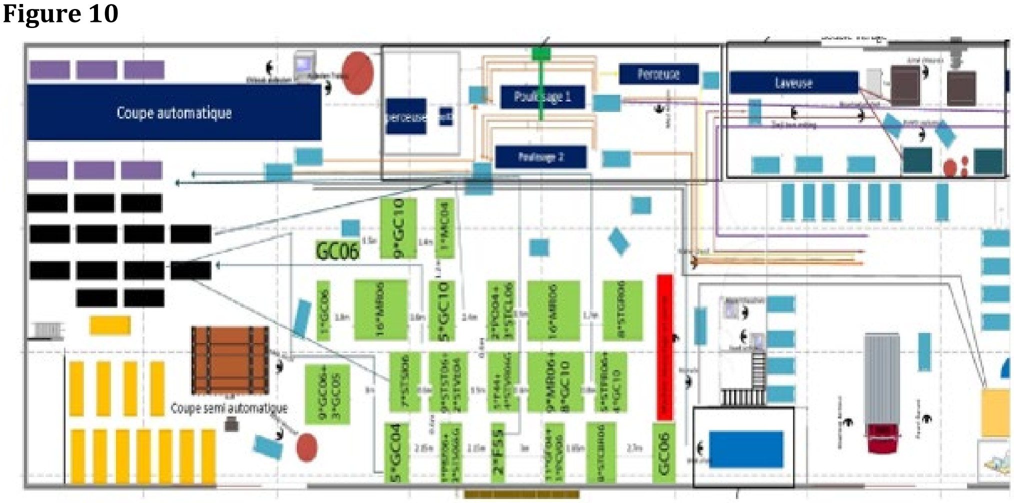

Figure 10 Diagram Spaghetti After the Improvement Action

Following the implementation of these initiatives, improvements were expected within the Value Stream Mapping (VSM). In the subsequent section, a thorough comparison was made between the indicators of the value flow map of the polishing station before and after the application of the improvements (Table 6).

Table 6

Table 6 Comparison Between the Different Indicators Before and After the Improvement

Indicator	Initial state	Current state
Production capacity of the two polishing machines ML/days	57.6	**230.4**
Number of operators for one polishing machine	2	**1**
Production lead times for polishing products	13.77d	**0 m2**
Production lead times for laminated products	17,509day	**3.97 day**
Production lead times for drilling products	4.106d	**1.695 day**
Crowded space in front of the polishing machine	48m2	**8.689 day**

The implementation of 5S principles has brought about significant improvements in the efficiency and organization of store storage and the mezzanine area.

- ***Time savings*****:** previously, employees spent approximately 10 minutes searching for items, tools, or spare parts up to 10 times a day. With the 5S improvements, this time has been reduced to just 3 minutes, resulting in a daily time saving of 1 hour and 50 minutes, a remarkable gain of **80%.**
- ***Elimination of losses*****:** poor organization led to 10% of items being unable to be found, necessitating replenishment of stock. However, with all items now identified and visible, and with the store manager having a tracking log for stock status, losses due to misplaced items have been effectively eliminated.
- ***Preservation of lifetime of articles*****:** items previously subjected to dust and dirt suffered from degradation in quality, and clutter resulted in destruction of some parts and tools. However, through the implementation of 5S, all items and tools are now cleaned, well-maintained, and stored appropriately, minimizing the risk of damage, and prolonging their lifetime.
- **Time and Risk Reduction:** the previous lack of organization led to wasted time searching for items, while cluttered spaces posed risks to employee safety. However, with improved organization and easy access to desired items, time is saved, and the risk of accidents is minimized.

The redesign of the storage space for glass sheets, coupled with the implementation of the ABC method, has led to several notable improvements.

1) Gain #1: Maximizing storage capacity

By strategically applying the ABC method, we were able to categorize glass sheets based on their value and importance, allowing us to allocate storage space accordingly. High-value sheets are stored in easily accessible areas, while low-value sheets are placed in less accessible locations. This optimized arrangement maximizes the utilization of available space, ensuring that every square inch is utilized efficiently.

2) Gain #2: Minimization of risks

The redesign of the storage space has resulted in the creation of a new corridor, providing operators with ample room to maneuver safely. This not only reduces the risk of work accidents but also mitigates the risk of material loss due to breakage of glass sheets. With more space to work in, operators can handle materials more safely and securely, minimizing the likelihood of accidents and costly damages.

3) Gain #3: Reduction in handling times

The implementation of the ABC method and redesign of the storage space have also resulted in a significant reduction in handling times. The new storage layout, guided by the ABC categorization, ensures that high-value items are easily accessible, reducing the time required to locate and retrieve them. Additionally, the new organizational flow, depicted in the updated "spaghetti" diagram, highlights the improvement in material flows. With the absence of crossings and the presence of a continuous flow, materials can move seamlessly through the production process, reducing handling times and improving overall efficiency refer to Table 7 and Figure 10.

Table 7

Table 7 Measurement of Distance and Time After Improvement Actions

Distance		Time	
Before	**After**	**Before**	**After**
53	39	25	10
42	33	21	10
49	27	24	8
25.2	21	16	8
19.6	17	11	8
15.9	8.2	9	8
25.3	12.6	10	8

Figure 11

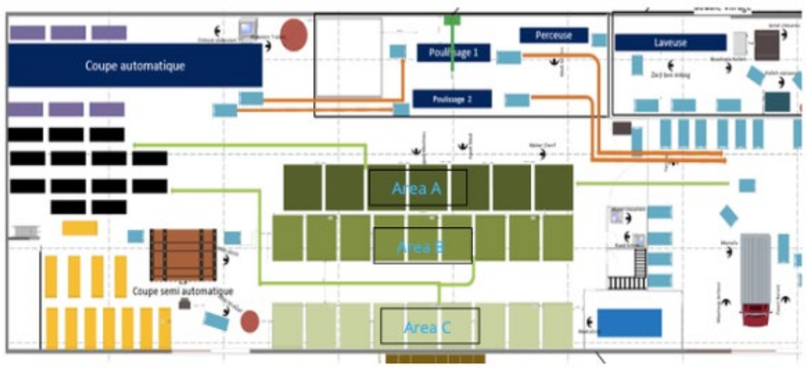

Figure 11 The Current State of the Production Manufacturing

To effectively demonstrate the impact of improvement actions from the initial state to the final state, a comprehensive reassessment was conducted of Lean principles that were targeted in the initiatives of the project. Through this reassessment, the objective was to provide a clear visualization of the progress achieved. The results revealed a significant improvement in the evaluation scores, which increased from 120 to 154 out of a total of 800 points.

This notable increase underscores the effectiveness of the improvement actions undertaken, highlighting tangible advancements in operational efficiency, process optimization, and adherence to Lean principles.

5. CONCLUSION AND PRESPECTIVES

This paper presents a practical application of Lean Manufacturing utilizing the DMAIC approach, a concept often associated with Six Sigma methodologies. Through the implementation of Lean principles, notable improvements were achieved across various aspects of the production workshop. The optimization of physical flows within the workshop layout led to a significant reduction in unnecessary travel, enhancing efficiency. Additionally, the application of 5S resulted in improving and optimizing the stock management and work organization. Furthermore, these enhancements contributed to a positive impact on the working environment, fostering motivation and employee engagement.

As the future of this project is considered, several prospects emerge. One potential area of focus is the implementation of Total Productive Maintenance (TPM) programs can optimize, this proactive approach can help minimize downtime and ensure optimal equipment performance. Additionally, using the concept of Just-in-Time (JIT) inventory management to minimize waste and inventory holding costs, while establishing a production schedule could aid in reducing work-in-progress inventory and promoting synchronization between workstations.

A comprehensive proposal for the enhancement of production manufacturing has been put forth to the company, aimed at streamlining operations and optimizing workflow while simultaneously improving working conditions. This proposed plan (Figure 11) encompasses a multifaceted approach, addressing various aspects of the production process to drive efficiency and effectiveness. Central to the proposal is the optimization of flow within the production line, achieved through strategic layout adjustments, workflow reorganization, and the implementation of lean principles. By reconfiguring the layout and redefining workflow sequences, the aim is to minimize bottlenecks, reduce cycle times, and enhance overall productivity. The ultimate goal of this proposal is to create a more efficient, productive, and employee-friendly manufacturing environment that fosters continuous improvement and sustainable growth. Through careful planning, implementation, and monitoring, the company can expect to realize significant benefits in terms of operational efficiency, product quality, and employee satisfaction.

Figure 12

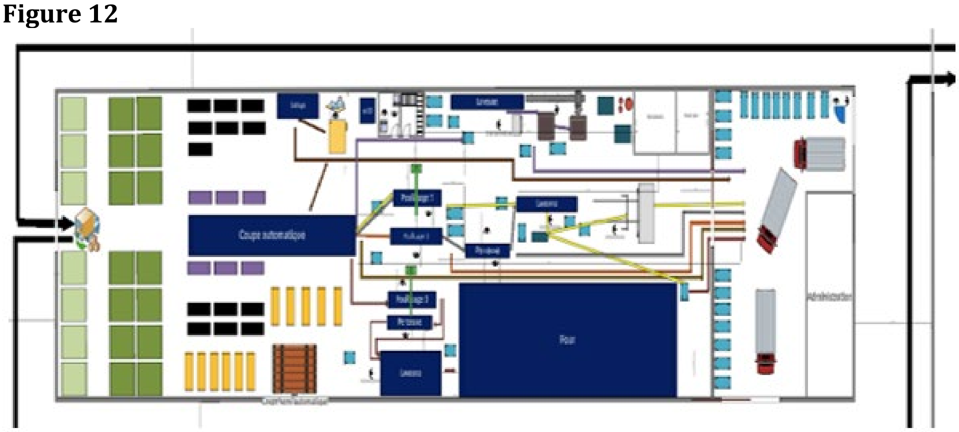

Figure 12 Proposal of New Workstations Layout

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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