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Productivity Improvement in the Glass Enameling Process of a SME Using 5S and SLP

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Abstract

This study aimed to increase the productivity of the glazing process in a glass company by eliminating waste (defects, inventory, over-processing, waiting and unnecessary movements) through 5S and SLP (Systematic Layout Planning) implementation. An SME (Small and Medium-sized Enterprise) dedicated to the manufacture of bodywork and architectural glass was chosen, which at the beginning of the research had a productivity of 0.88 HH/und. The research methodology was based on the DMAIC methodology (define, measure, analyze, implement, control) and included data collection techniques, process analysis and review of indicators. The results showed a 51.24% increase in the productivity of the enameling process, confirming that the tools used were able to eliminate activities that consume resources and do not add value to the process. The findings of this research are relevant for managers of small and medium-sized enterprises, since they provide them with useful information for making decisions related to the investment and allocation of resources aimed at increasing the productivity of their own processes. One of the limitations is based on the economic budget available for the implementation of the project, since other tools and techniques are known to be more expensive. Successful implementation of 5S may require financial, time and personnel resources, and if the organization does not allocate sufficient resources to carry out the project, it is likely to face obstacles along the way.

Keywords
Productivity, Waste, Small and Medium-sized Enterprises (SMEs), 5S, Systematic Layout Planning (SLP).

1. Introduction

In a dynamic and competitive world, companies are under pressure to stay in the market (Vidal et al. 2018). Industry growth depends on innovation, operational efficiency, productivity, and quality (Sundharesalingam et al. 2020). Currently, worldwide, the glass industry is present in various sectors: construction, automotive, agribusiness and related, which are necessary for the development of each country (Ingle, 2023) which directly affects the determination of the amount of glass to be produced. In 2019, Mexico produced 3.2 million tons of glass while, in Peru, 260 thousand tons were produced (Comercio, 2021), evidencing the challenges faced by the glass industry in the country. This difference is mainly since 70% of the industry focuses on marketing and 30% on processing/production (Avalos, 2018). It is important to increase the productivity of the glass industry since the manufacturing sector represents 12.5% of the national GDP (Gross Domestic Product), being the second largest sector in the national economy (Ministry of Production, 2022).

1.1 Objectives

Main Objective: To propose the implementation of 5S technique and SLP to validate usability in a SME through a case study.
Hypothesis: The implementation of 5S technique and SLP will contribute to increasing productivity in the glass enameling process of a glass company.
Specific Objectives:

- Identify the root causes that impact the productivity of the glass enameling process in a glass company.
- Propose an operational model that addresses the root causes and allows for increased productivity.
- Observe and evaluate the results derived from the application of the proposed model to verify the feasibility of implementing the improvement.

2. Literature Review

The increasing competitiveness among companies to stay in the market demands the constant search for strategies to optimize their processes and increase productivity (Herrera et al., 2018). Within this context, the 5S methodology has emerged as a fundamental tool for continuous improvement, focusing on the organization, cleanliness and standardization of the workplace (Osada, 1991). Additionally, Systematic Layout Planning (SLP) is presented as a structured methodology to design efficient space layouts, considering the flow of materials, activities and relationships between work areas (Muther, 1973).

Several studies have explored the implementation of 5S in different industrial and service sectors. A study by Shahriar et al. (2022) in a manufacturing company in India revealed a positive and significant correlation between 5S implementation and productivity improvement. Eliminating two wastes (unnecessary movement and waiting time) resulted in an 8 % reduction in sorter search time and 18 % reduction in block search for the printing operation. These findings underscore how an organized and standardized work environment facilitates smoother workflows and minimizes interruptions. The sustainability of 5S benefits through “Separate” (Seiri) and “Order” (Seiton) has received attention in recent research. Garza and Reyes (2022) analyzed the implementation of 5S in the Mexican automotive sector highlights how it contributes to the identification and elimination of unnecessary materials, optimizing space and reducing costs associated with inventory and material handling. Likewise, “Cleanliness” (Seiso) is linked not only to occupational safety, but also to the prevention of equipment deterioration and early detection of problems that could affect productivity (Jasti & Kodali, 2021).

In terms of distribution planning, the application of Systematic Layout Planning (SLP) has proven to be effective in minimizing unnecessary movements and increasing operational efficiency. For example, Lista et al. (2021), conducted a study in a medium-size Indian producer and found that the systematic application of SLP phases show a materials flow reduction of approximately 48%, resulting in efficient service provision and land utilization by optimizing the flow of materials and minimizing unnecessary movement and long routes. This study underscores the importance of considering the relationships between activities and physical space to achieve efficient distribution.

The integration of 5S and SLP methodologies has also been the subject of interest. It has been suggested that the implementation of 5S can create a work environment more conducive to the effective application of SLP by eliminating clutter and facilitating the identification of space and flow needs (Amoretti et al. 2024). However, more research is needed to fully understand the synergies and specific benefits of the combined application of these tools in different production contexts.

3. Methods

This research is based on a mixed approach of an applied nature, combining the collection and analysis of quantitative and qualitative data to obtain a comprehensive understanding of the impact of the 5S methodology and Systematic Layout Planning (SLP) in increasing productivity.

In terms of scope, the study presents a correlational scope, as defined by Hernández Sampieri et al. (2010), by seeking to establish the relationship and degree of association between the implementation of the 5S methodology and SLP and the productivity variables identified in the specific context of a glass production Mypetira. This scope will allow determining if there is a significant connection between the application of 5S and SLP and improvements in productivity indicators.

Since the research will be developed in real organizational environments, a quasi-experimental design will be used, where the manipulation of variables is not always completely controllable, a design that allows introducing intentional changes in the independent variable (waste) and observing its effect on the dependent variable (productivity) is chosen, maintaining the natural structure of the study groups (Campbell & Stanley, 1963). The application of this design will make it possible to analyze the potential causality between the adoption of 5S, SLP (Systematic Layout Planning) and variations in productivity, although with the limitations inherent to environments that are not completely controlled. The implementation of the research methodology will be structured following the DMAIC (Define, Measure, Analyze, Improve, Control) cycle, a robust tool within the Lean Six Sigma framework for process improvement (Pyzdek & Keller, 2014). The initial step involves defining the variables that will be utilized and assessed in relation to the proposed improvements.

Define

- Independent Variable: Waste, any human activity that consumes resources (costs) but does not create value for the customer.
- Dependent Variable: Productivity, the correlation between production and the optimal use of resources.

Measure

The following guidelines were used to collect information (Table 1 and Table 2):

Table 1. Indicators of the variable "Waste”

Dimension	Indicators	Unit of Measure	Actual Result	Calculation Expression
Waiting	Cost of lost time	Soles/year	82.57	Salary per hour per waiting time
	Waiting time	Seconds	1981	Σ Waiting times
Unnecessary movements	Lead time	Seconds	1671.36	Delivery time - Start time

Table 2. Indicators of the variable "Productivity”

Dimension	Indicators	Unit of Measure	Actual Result	Calculation Expression
Labor	Productivity	units/man-hour	1.83	Units Produced / Man-hours
Production	Efficiency	Percentage	69%	Actual Production / Expected Production

Qualitative data was obtained through interviews with operators and supervisors, a 5S checklist to assess the initial state, and photographs taken with a cellphone. For quantitative data, a time study was conducted with 3 samples using a stopwatch and video. Additionally, measurements of the enameling area were taken with a tape measure (Figure 1-Figure 6). With the collected information, a Value Stream Map (VSM) was applied, as it provides a description of both the information and the material flow through the process (Prasetyawan & Simanjuntak, 2020).

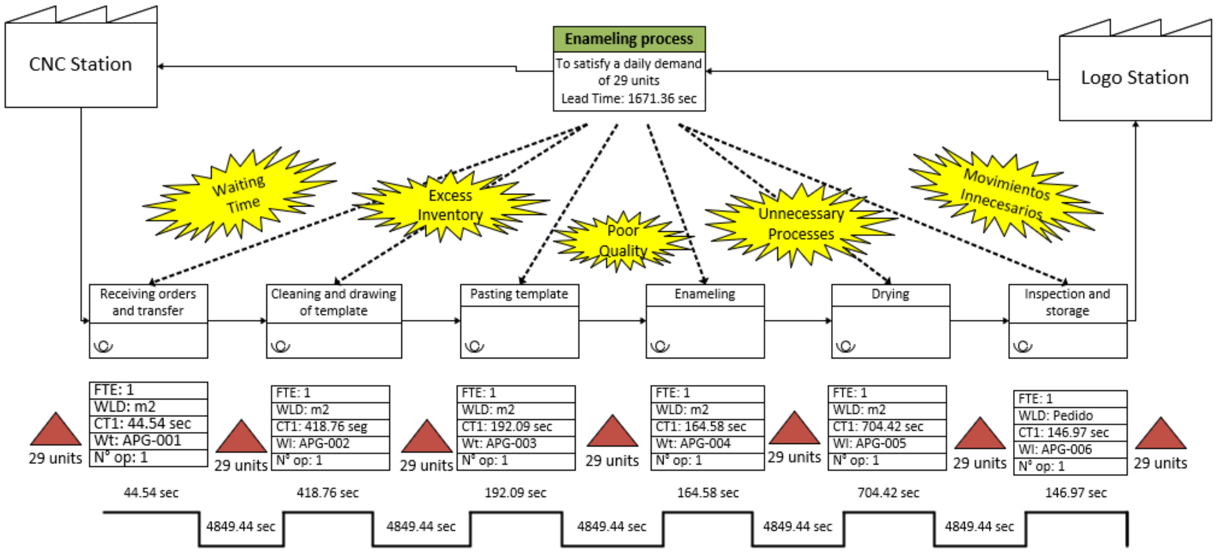


Figure 1. Value Stream Map of the enameling process before 5S and SLP implementation.

The enameling process begins with the reception of the plans and pre-cut glass, which is cleaned with alcohol and has kraft paper placed under the holes. Then the glass is enameled and subsequently taken to the drying oven for 15 minutes. After cooling for 11 minutes, the plant engineer verifies the quality of the glass according to the customer's specifications. The company takes 16.55 minutes/unit to produce a product (one unit/piece, which is an average xm2 glass plate) to meet customer demand and has a value-added time of 1671.36 seconds per order, a high time mainly due to the waiting times evident in each activity as a result of the different wastes present in the enameling process.

- Takt Time (TT) = 480/29 = 16.55 min/unit.
- Value-added Time (VAT) / Delivery Time (DT) = 1671.36/24247.2 = 6.8930%.
- Delivery Time (DT) = 24247.2 seconds.

Analyze

A Pareto analysis was performed to identify the critical few problems. The Pareto analysis revealed that the inefficient layout of the workspace, contributing to 28% of process time, and the absence of standardized procedures, resulting in 50% of time spent waiting, were the primary drivers of the problem. Subsequently, an Ishikawa diagram was constructed to determine the root causes of the most critical issue and ensuring that the key issues to be addressed are clearly identified and prioritized.

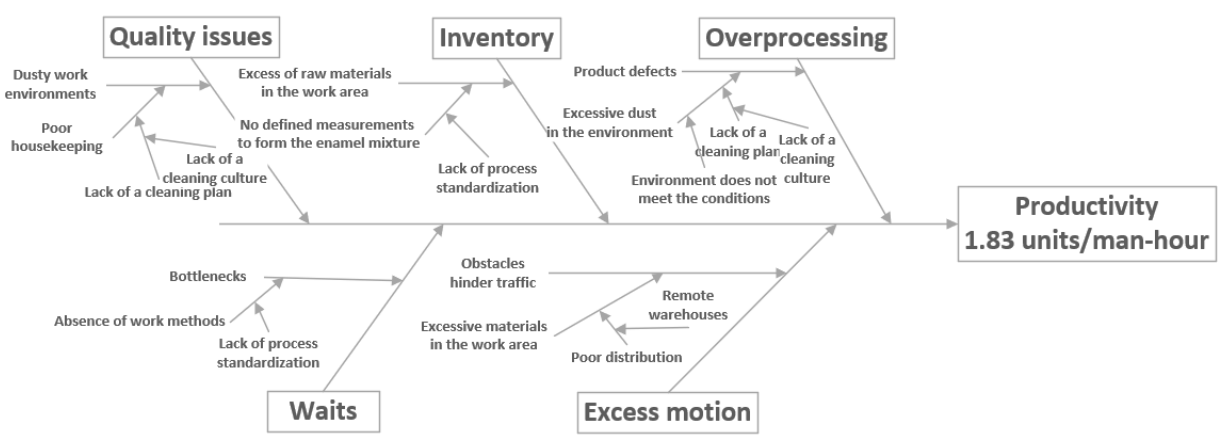


Figure 2. Ishikawa diagram identifying possible root causes of current productivity

Improve

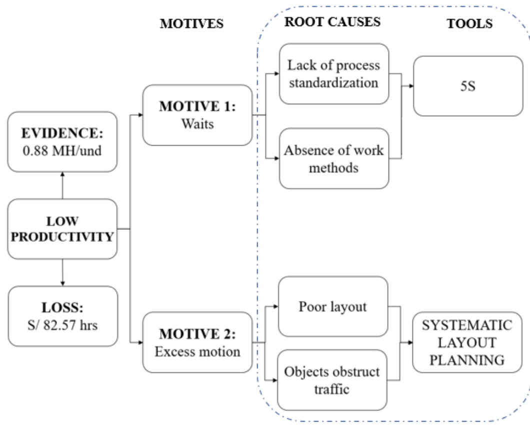


Figure 3. Alignment Matrix of the 5S methodology and SLP for productivity enhancement

The research is applied to the enameling area of a glass company, selected through a non-probabilistic sampling that included SMEs in the manufacturing sector. It is proposed to apply the 5S technique in the area and carry out Systematic Layout Planning (SLP) of the area. From this, a pilot test with simulation in Arena software will be conducted to obtain results of the implemented improvements.

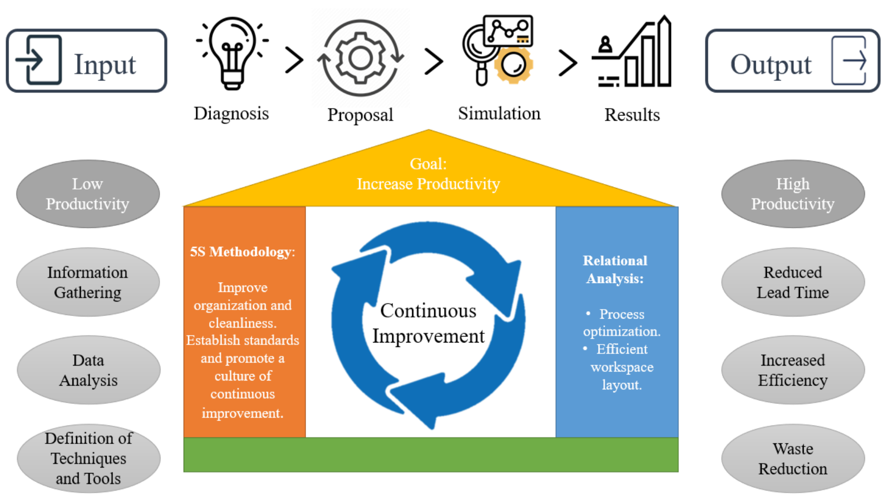


Figure 4. Proposal design

Control

In order to sustain the improvements derived from the proposed methodologies (5S and SLP), it is imperative to cultivate a culture of continuous improvement. This entails the standardization of processes, along with the ongoing assessment and potential adoption of new methodologies and tools, as detailed in the final recommendations.

4. Data Collection

Data collection was conducted in three phases, which focused on gaining a comprehensive understanding of the initial state of the glazing area and gathering the data necessary for layout planning and 5S implementation.

4.1 Initial Status Assessment with the 5S Checklist

A detailed checklist was applied to evaluate the level of implementation of each of the 5S in the glazing area. This checklist included specific criteria for each "S", designed to obtain objective evidence about workplace conditions. For example, for "Sort", the presence of unnecessary tools, materials or documents at workstations was evaluated. For "Order", the existence of designated and clearly identified locations for each item was verified. "Cleanliness" was evaluated by observing the presence of dirt, dust or debris. For "Standardize", the existence and visibility of documented procedures for organization and cleanliness were reviewed. Finally, for "Sustain," operator compliance with these standards was observed.

The percentage of compliance for each "S" was calculated by dividing the number of criteria met by the total number of criteria for that "S", expressed as a percentage. This initial data provided an objective baseline of the level of 5S adoption in the area.

The result of the checklist showed that the area is below 30% compliance with the 5S system, with the most critical variable being discipline, scoring 6 out of 30 (Figure 5).

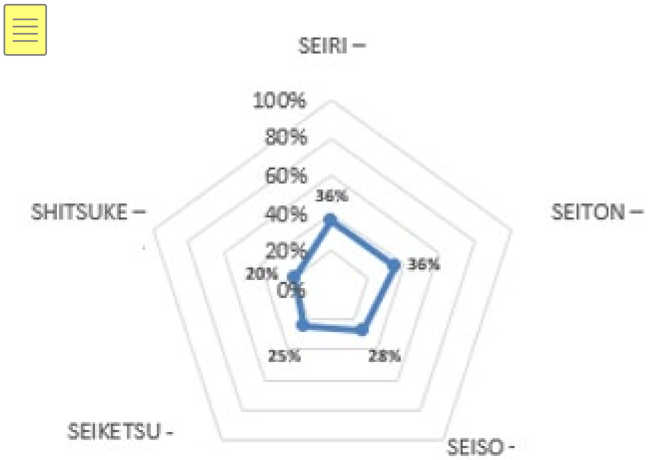


Figure 5. Current 5S compliance level

To identify the main problems for each S we evaluate by observation and monitoring the whole operation 5 times to identify the repetitive problems (Table 3).

Table 3. Main problem for each S

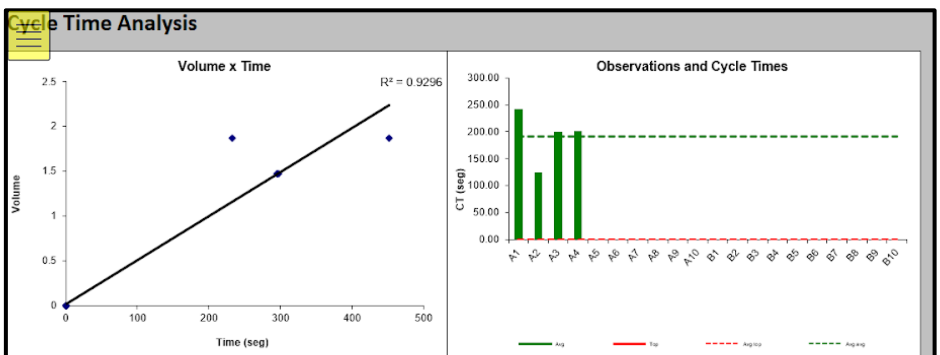
ID	5S	Problem
S1	SEIRI – CLASIFICATION	The items are not kept in the necessary quantities
S2	SEITON – ORGANIZATION	The items are not labeled
S3	SEISO – CLEANING	Garbage in the work zone
S4	SEIKETSU – STANDARDIZATION	The processes are not standardized and do not have manuals
S5	SHITSUKE –DISCIPLINE	There is not a culture of organization in the area nor initiative

4.2 Measurement and Classification of Cycle Times

To obtain accurate data on operation times, Excel spreadsheet formats were used. These formats allowed breaking down each operation of the glazing process into discrete activities. Measurement of the duration of each activity was performed using. The start and end points of each activity were clearly defined, and at least three consecutive measurements were taken for each, at different times of the day and during various production cycles, to mitigate variations inherent in the process and operator performance. Individual measurements were labeled A1, A2, A3, etc., for later analysis. After measurement, each activity was classified into one of the following categories based on its contribution to the process.

- T (Transport), for activities involving the physical movement of materials or supplies
- M (Motion), for tasks that involve the physical handling of materials or products with a specific purpose W (Waiting), for idle times within the process
- R (Rework), encompassing all activities related to reprocessing due to any cause
- D (Data Manipulation), for the management and transformation of physical or digital information
- A (Abnormalities), referring to activities that fall outside the standard process and generate delays or disruptions; and finally
- V (Value-Added), which includes activities that contribute added value not originally contemplated within the company's standard operational process

Additionally, each time measurement was associated with a volume value, representing the linear meters of glass handled or processed during that specific activity. By combining the recorded time and the corresponding volume, the cycle time per unit volume was calculated for each activity. These detailed cycle time data, including the identification of waste time (non-V activities), were subsequently used for process simulation in Arena software. Arena simulation software was selected as a tool to quantitatively assess the impact of proposed improvements in the actual processes, leveraging Lean thinking methodologies due to the fact that the combined use of Arena and Lean principles enables the simulation of improvement initiatives supported by Lean tools, aiming to minimize the issues identified in this study (Dias, 2022), as illustrated in Figure 6.



	Transport	Motion	Waiting	Data Manipulation	Rework	Abnornalities	Value Added			192.09		
Obs A #	T	M	W	D	R	A	V	Total	VOL	CT	Exclude?	Top?
A1	8.0	333.0	111.0					452.0	1.8675	242.0		
A2	10.0	223.0				12.0		245.0	1.8675	124.8		
A3	11.0	275.0	9.0					295.0	1.4742	200.1		
A4	7.0	290.0				84.0		381.0	1.4742	201.5		

Figure 6. Standard cycle time for template wrapping (activity 2)

After all the data were extrapolated to the arena Software (a sotware use to simulate process situations and variables) a uniform distribution was used for the model, as the time in the activities follows a linear equation with minimal variation and an R-squared greater than 0.8. The arena software showed a production of 29 units of glass with the times of the actual situation.

4.3 Taking measurements of the layout

The information necessary for the application of Systematic Layout Planning (SLP) was gathered through taking measurements of the area layout (Figure 7).

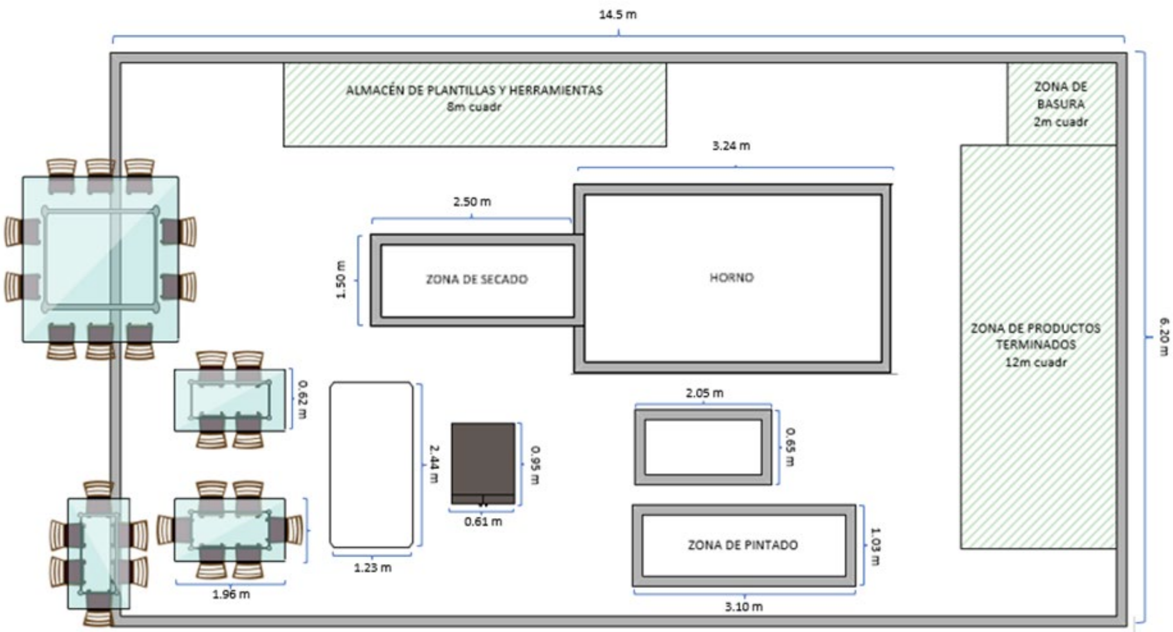


Figure 7. Actual layout of the enameling area

5. Results and Discussion

After identifying all our independent variables, we can see that their effect causes low productivity due to poor resources management. After collecting the information, the 5W-2H tool was applied, the 5WH methodology is a qualitative analytical framework that facilitates comprehensive examination through six fundamental inquiries: what (Table 4), who, how, where, when, and why. Originally developed by Lasswell in 1979, this tool supports the formulation of strategic initiatives aimed at enhancing organizational processes and outcomes (Trias et al. 2009), which helped us develop an action plan (Mello and Carvalho, 2017).

Table 4. Matrix 5W-H

Factor	Solution	What	Why	Who	How	Where	When	How Much
Lack of cleaning culture	Cleaning checklist	Make a manual for cleaning process	It is necessary to keep a clean workplace	Worker 2	Supervising and evaluating the area	Glazing area	20-May	-
	5S	Apply discipline and cleaning S	To reduce waste and keep the culture of 5S	Supervisor	Using checklist, lean corner and taking cycle times	Glazing area	22-Abr	S/ 4,735.0
Lack of standardization	5S	Stablish minimum quantity of inputs in each activity	To make a quality work	Worker 1	Performing a comprehensive analysis of the process	Glazing area	6-May	S/ 610.0

Bad distribution	Systematic Layout Planning	A relational diagram will be done to improve the workspace	Necessary to perform an efficient work without wasted times	Area supervisor	Identify the work areas to propose a new distribution	Glazing area	22-Abr	S/ 1,000.0

Prior to implementation, the workers were trained to raise awareness and share knowledge about the 5S methodology. The training lasted 3 days, and the implementation committee was selected, which will help us supervise, plan, execute, and promote the importance of the 5S.

Classification - Seiri:

The desired and undesired items were classified.
Desired materials:

- Useful materials
- Essential materials for carrying out the activity

Undesired materials:

- Excess materials
- Materials that do not work
- Materials that are not useful in the process
- Then, the desired items were classified according to their frequency of use.

ORGANIZATION - SEITON:

Proper arrangement of materials, tools, and equipment that allows the work to be done correctly, with proper delimitation and labeling for quick and easy identification in the corresponding location. This will reduce cycle time, increasing productivity (Sundharesalingam et al. 2020).

Table 5. Before (materials without order) vs Now (Saved materials)

Before	Now
	

To achieve an ideal layout of the area, an SLP (Systematic Layout Planning) was carried out. First, the dimensions of each station in the area were measured. Then, the activity relationship Table 5 was created, and with the collected information, the relational diagram was developed (Figure 8).

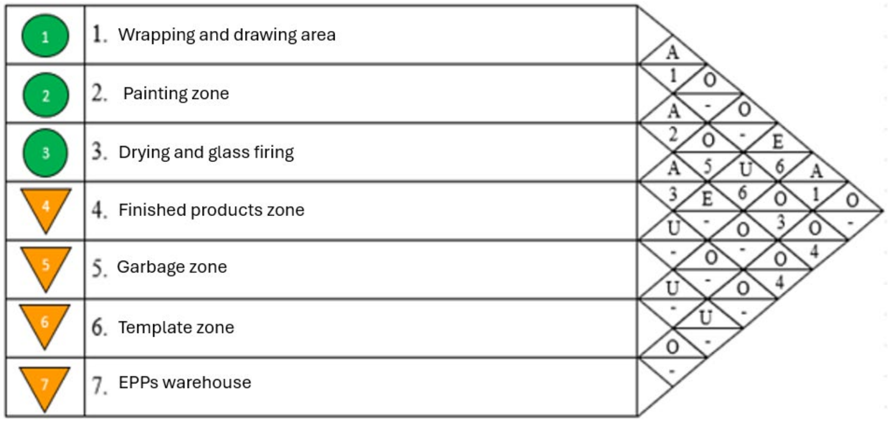


Figure 8. Activity relationship table

For the development of the activity relationship table, a proximity value table and a list of reasons were needed to verify the proximity value assigned to each of the areas. The symbols employed denote two distinct types of spaces: those intended for the storage of materials or waste, and the triangle, which signifies operations associated with the enameling process (Table 6- Table 7).

Table 6. Proximity values between areas

Código	Valor de proximidad
A	Absolutely necessary
E	Especially necessary
O	Normal or common
U	Not important

The proximity values of the areas were determined based on the relevance of their interrelationships and independently assessed. Areas classified as **absolutely necessary** must be located adjacent to one another due to their high level of interdependence—such as areas involved in the same process. **Especially necessary** areas share a certain degree of connection, although not as closely as the previous category. **Common or normal** refers to areas that can be placed further apart, as they are neither restrictive nor mutually dependent. Lastly, **not important** applies to areas with a secondary or supportive role in the process; their placement does not significantly impact operational efficiency, and they do not maintain a strong functional relationship with the other areas.

Table 7. Reasons for proximity values

Reasons
1. Process flow
2. Control
3. Load and dispatch
4. Avoid danger
5. Avoid contamination/ cleaning control
6. Workers comodity

Likewise, the corresponding symbols were determined according to the type of activity (circles for operations and traignles for storage). With this information, a relationship of reasons and proximity was established to support the rearrangement of the area (Figure 9).

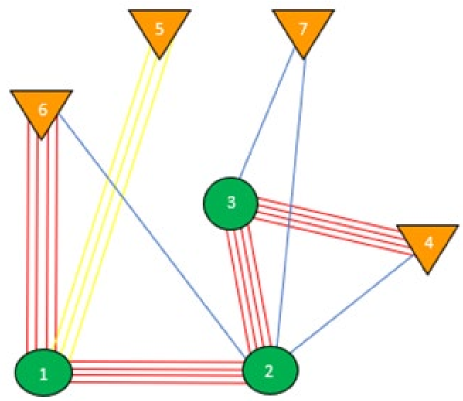


Figure 9. Activities relational diagram

With this information and the develop of the diagrams a possible re design was proposed. The lines depicted in the diagram illustrate the degree of interrelationship between the areas. The thick red lines denote the strongest connections, indicating a high level of interaction or dependency. Yellow lines represent moderate relationships, while the thin blue lines indicate minimal interaction between the respective areas (Figure 10).

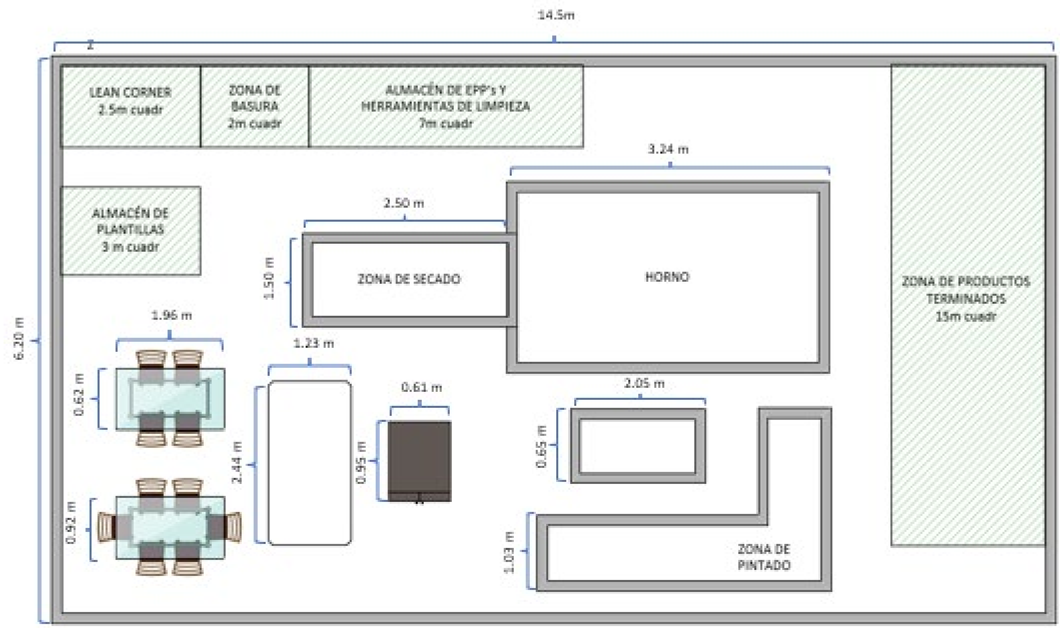


Figure 10. Layout proposed

Cleaning - Seiso:
It is proposed to create a cleaning plan for the area, specifying the sources of contamination, areas difficult to access for cleaning, and assigned responsibilities, all in conjunction with a checklist placed in a visible area of the zone where a routine and continuous control of the designated cleaning activities can be maintained. Additionally, proper waste containers and items were acquired to keep the area clean (Table 8).

Table 8. Cleaning S before and after

Before	After
	

By establishing more organized and clean work areas, the incidence of accidents is reduced, which in turn improves employee well-being, facilitating compliance with Law 29783 on Occupational Health and Safety. Non-compliance could lead to fines of S/240,000

Standardization Seiketsu

It is proposed to create process documentation that includes detailed instructions on the operations of the glazing process, outlining the material inputs and outputs and the corresponding controls. Additionally, the 5S document and the 5S panel will be implemented in the "lean corner" along with work guides and a Value Stream Map (VSM) to standardize the process flow and facilitate feedback. This documentation will be used to train the staff. Finally, visual controls will be established:

- Location labels
- Direction arrows
- Maximum levels (Kanban)
- Delimitation of work tables and machinery

Discipline - Shitsuke

The aim is to promote discipline among workers, making it a deeply rooted culture through training and management commitment to continuous improvement. This involves turning the compliance with established methods and standards into a habit, which is the most challenging step. After implementation, a closing audit is recommended to assess performance and recognize the work areas with the best results

Once the improvement was applied new cycle times were taken and when all the data was collected, we use a simulation in software arena with the new values to estimate our new KPI´s. The results are show in the following Table 9:

Table 9. Results before and after improvement (Units produced)

Production	Before (units per day)	After (units per day)
Estimated	29	44
Real	20	40

We defined wasted time as time which do not add value to the operation or exceed a prudent waiting time (Table 10).

Table 10. KPI (key performance indicators) before and after

Indicator	Before improvement	After improvement
Efficiency	69%	91%
Wasted time	1980 seconds per 3 orders	205 seconds per 3 orders
Lead time	1671.36 seconds per order	1529.80 seconds per order
Productivity	1.21 units/HH	1.83 units/HH

For the efficiency calculation, data provided by the Arena system was collected before and after the improvement, which showed the estimated current production and how it would be with the proposed improvements. Likewise, for the calculation of actual production, information provided by the plant supervisor was used. An increase in productivity of 51.24% was obtained, the productivity of the enameling process went from 1.21 units/HH to 1.83 units/HH.

For the calculation of the productivity and efficiency the following formulas were used:

$$\Pr o\,ductivity = \frac{Total\ \Pr o\,duction}{H - H}$$

$$Efficiency = \frac{Real\ \Pr o\,duction}{Estimate\ \Pr o\,duction}$$

The number of daily HHs was calculated as the product of the number of operators (3 operators) by the number of effective hours per day (8 hours). With this data, the current production (40 units) is divided by the number of daily hours and the productivity in Man Hours is obtained.

For the wasted time the formula used was:

$$Wasted\ time\ = \sum_{APP-006}^{APP-001} (W + A)$$

W+A is the sum of the waits or waiting's (W) and the abnormalities (A) which were given by the standard cycle, with the latter being the most critical as they are events that do not form part of the process and add time due to some kind of inconvenience. Similarly, the acronyms APP-00n refers to the 6 activities that compose the whole operation of the glass enameling.

We can observe and validate the existence of a relationship between the independent variables (waste) and the dependent variables (productivity) since after implementation there has been a significant improvement in the key indicators of the process. At the same time, it can also be seen in Table 3 that after eliminating waste, the lost time was reduced by 89.66%. The result in a more specific view is shown in the following Figure 11:

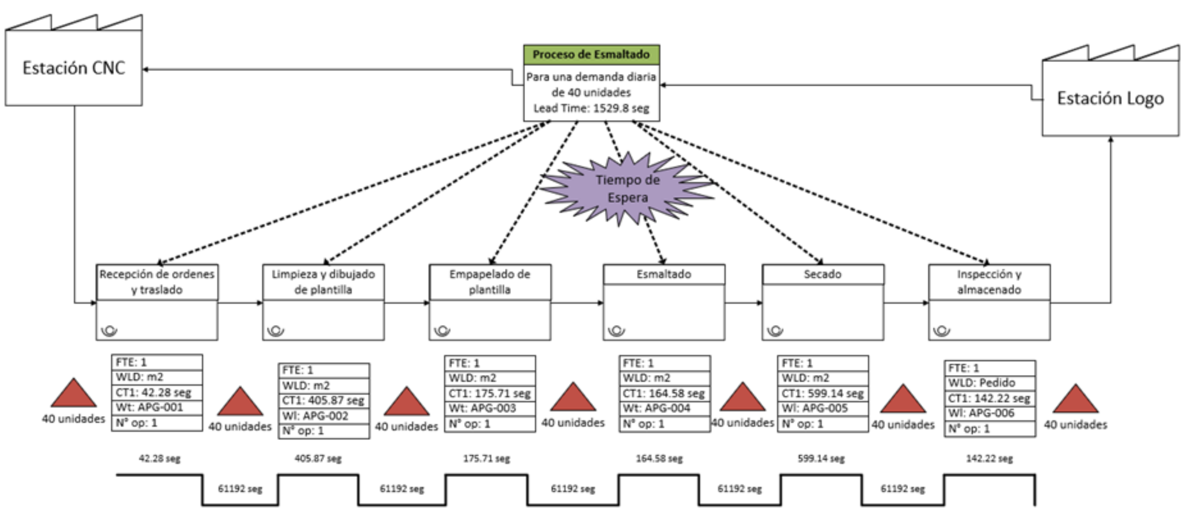


Figure 11. Value Stream Map of the Enameling Process after 5S and SLP implementation

As can be observed, the lead time per square meter of glass decreases once the improvements are implemented and the waiting times and abnormalities are reduced. At the same time, for the second case, the TVA (added value time) was calculated as the sum of the CT (Cycle time) because only one operator performs each task, there will be no major issues in the calculation, and it will be equal to the lead time.

The present article also shows the economic save and impact that the implementation of this methodology (5S) involves. To calculate the monetary loss, an estimate of the time lost per month was calculated and this time was multiplied by the value of one hour of work, we took 8 hours of work per day and 26 days per month as standard values. The formulas we used are outlined below:

$$Salary(hour) = \frac{Monthly\ Salary}{Hours(day) \cdot Day(month)}$$

$$Salary\ per\ hour = \frac{347 \cdot 8}{8 \cdot 26} = 1.67$$

The calculation took a base of 26 workdays a month with a working day of 8 effective hours a day for 6 days a week and receiving a monthly remuneration of 1,300 new soles. The data transformed into dollars for a better understanding at the international level were used taking as the exchange rate a value of 3.75 new soles per US dollar.

To estimate the monetary loss per month first, we calculate the wasted time in hours per month by the following Table 11:

Table 11. Time lost (in hours) per month

Time wasted per 3 orders	Estimated orders per day	Wasted time per day (seg)	Wasted time per day (h)	Wasted time per month (h)
1981	29	19149.67	5.32	127.66

To estimate the economic loss the value of the wasted time per month was multiplied with the salary per hour, obtaining an economic loss of 797.70 new soles or 212.97 USD per month.

After the implementation of the 5S the monetary loss, estimated as explained before showed a result of 82.57 new soles or 22.04 USD, as a result the company makes a monthly save of 715.13 new soles or 190.93 USD. The time used for the estimation was the new wasted time after the execution of the improvements.

Through an investment of less than S/7,000 (1868.87 USD), all these improvements have been achieved, an investment which is expected to be recovered based on monthly savings of approximately 715 new soles (190USD) within a period of 10 months (Figure 12).

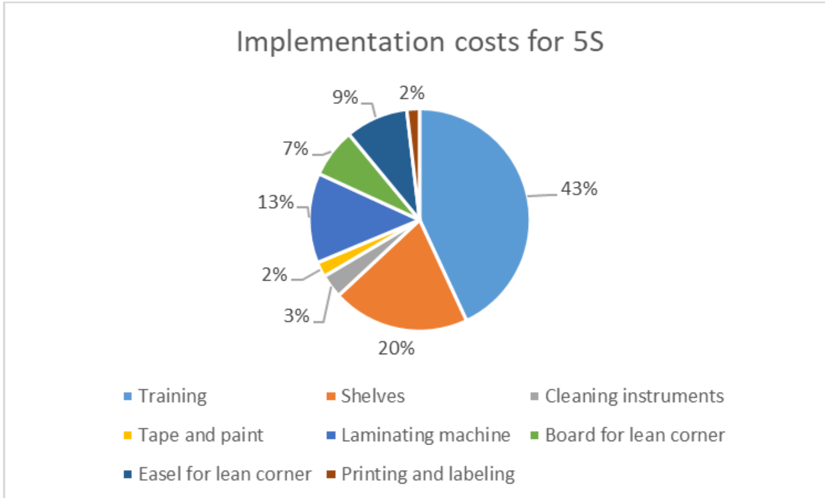


Figure 12. Costs of implementation

The study sample confirms that the application of the 3 engineering techniques together reduced the waste existing in the process, streamlining the development of activities. Since there is a relationship with the implementation of 5S and application of VSM with the elimination of waste from overproduction, excess inventories, unnecessary movements, transportation of materials and waiting times, in said research an increase in productivity was achieved. of 20% compared to the initial situation. In addition, the lead time was reduced by 10%, verifying what was found by Sundharesalingam (Sundharesalingam et al. 2020)

The viability of the proposed solution has an IRR (Internal Rate of Return) greater than 80%, this is due to the high profitability of the company and the low cost of the investment. These results surpass similar studies such as that of Callo (2017), which obtained an IRR of 43% and an NPV of S/7179.05, indicating the viability of the project. Finally, our results can be compared with other studies which methodology was similar, highlighting that our study is applicable to different industrial sectors as seen in the following chart (Table 12):

Table 12. Productivity increases in different studies

Proyect	Productivity increases
Aguilar & Montoya	51.24%
Flores	50.00%
Ortiz	20.00%
S.Escudero	20.00%
P.Callo	27.00%

From this, we can observe a 27% increase in a similar study compared to the 51.24% that we present. Nevertheless, it should be considered that the processes executed in our study company have a much more significant impact since they focus on a single area of the entire production chain. However, it is positive to have obtained an increase of more than 50% in productivity, which has exceeded the expectations set at the beginning of the project.

Finally, it was found that the 5S technique is related to 4 of the 17 SDGs (Sustainable Development Goals), demonstrating its sustainability and being helpful for companies that want to be sustainable or are sustainable.

6. Conclusion

The implementation of the 5S methodology together with Systematic Layout Planning (SLP) in the glass enameling process in a micro and small enterprise (MSE) has proven to be highly effective in improving productivity and operational efficiency. The results obtained show a significant increase in production, reaching an increase of approximately 50%, as well as a reduction in waiting times, which contributes to a better organization of the work environment and a more fluid and efficient process flow. The 5S methodology made it possible to establish a cleaner, more organized and efficient work environment, favoring the standardization of tasks and staff commitment. In parallel, the redesign of the layout using SLP facilitated a better distribution of work space and an effective reduction in unnecessary movements, improving process flow. This work represents a valuable contribution to the manufacturing sector, serving as a practical guide for the implementation of continuous improvement tools in companies with limited resources. These findings are consistent with recent studies that support the effectiveness of tools such as 5S and SLP in labor-intensive manufacturing environments, especially in developing countries (Amoretti et al. 2024).

Despite these positive outcomes, the project encountered limitations. A primary challenge was employee resistance to change, stemming from an established culture of disorder and lack of cleanliness. Overcoming this resistance required significant time and effort. Additionally, ensuring ongoing adherence to the new processes presented a challenge, due to the research team's limited on-site presence. This was addressed through weekly meetings for progress review and audits. The need for comprehensive employee commitment was also identified, leading to training on 5S principles and SLP benefits. Financial limitations also presented a constraint, restricting the integration of more sophisticated technological solutions, such as automated process control systems. Financial limitations also presented a constraint, restricting the integration of more sophisticated technological solutions, such as automated process control systems.
Finally, opportunities for future improvement are identified through the integration of complementary methodologies such as Poka-Yoke for error prevention and Total Productive Maintenance (TPM) for equipment improvement, both aimed at product quality optimization.

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Biographies

Luis Eduardo Aguilar Vigo graduate in Industrial Engineering from the University of Lima, with a specialization in Food Innovation from the Pontifical Catholic University of Chile. Professional experience in the food industry, product design, logistics, planning, and process improvement, with advanced skills in food innovation, data management, KPIs, and tools like Excel, Power BI, and SQL. Fluent in English, results-driven, a team player, and adaptable, with a willingness to work in provinces or abroad. Currently, works as a Junior Project Manager at Trazzo, where they handle sales orders, product costing, project coordination for Peru and the USA, and process improvements using SAP, Excel, and Monday CRM. They have successfully improved response times and met KPIs such as Lead

Time and customer satisfaction. Previously, was an Intern at the University of Lima's Institute of Scientific Research, where they contributed to scientific publications, developed gluten-free pasta, and created vegan ice cream using innovative ingredients. Additionally, worked at CEVA Logistics as a Billing and Logistics Assistant, automating billing processes with macros and improving KPIs, and as an Administrative Assistant at Apple Glass Peruana S.A.C., identifying key suppliers and generating savings. With solid academic training and hands-on experience in food industries and logistics, has pursued professional development through courses in food innovation, SAP, Power BI, Excel, and business process methodologies such as Lean and Six Sigma. Passionate about climbing, nutrition, physics literature and is dedicated to continuous learning.

My name is **Vanessa Montoya**. I was born in 2001 and studied Industrial Engineering, a path that was deeply influenced by my older brother, who pursued the same career and has always been a great source of support and inspiration for me. As the middle child in my family, I naturally learned to find balance and adapt easily skills that have shaped both my personal and professional journey. I know, I always backed by the constant encouragement of my parents, who have been an essential part of my journey. I currently work at the same company where I began as an intern, which has allowed me to grow within an environment I know well and care about. My focus is on designing and improving processes, and I'm passionate about creating efficient, sustainable solutions that add real value to the organization. I enjoy learning, adapting to change, and collaborating with different teams to make things work better every day.

Maria Claudia Aguilar is a Master's degree in Business Administration from EGADE Business School at Tecnológico de Monterrey and a Bachelor's degree in Industrial Engineering from the University of Lima, with over fifteen years of experience leading multidisciplinary teams across multinational corporations and academia. Combines a solid technical background with strategic focus on human capital development and process management. Since 2015, teaches courses in business organization, leadership, and process analysis, and coordinates academic programs designed to enhance soft skills through neuroleadership-based methodologies. From 2017 to 2024, leads the Career Services Center at the University of Lima, designing employability initiatives, managing institutional relations with public and private organizations, and overseeing job fairs and placement platforms. At LATAM Airlines, directs operational units, spearheads Lean-based improvement initiatives, and oversees pilot training programs in coordination with national aviation authorities. Prior experience includes roles in process automation and performance management at BBVA and Yanbal. Demonstrates a consistent results-driven approach through the application of continuous improvement tools and the cultivation of conscious leadership in dynamic, high-demand contexts.