Production Model under the Integrated Approach of Lean Manufacturing and SLP to Increase Efficiency in A Company of the Metal Mechanic Sector

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Abstract—**Metal mechanics plays a relevant role in the entire productive structure of the economy since it is an indispensable supplier of capital goods such as equipment, infrastructure, spare parts, and machines. However, the lack of efficient production processes, the high rate of defective products, and unnecessary routes in factories and production workshops are some of the frequent problems that companies in this area have that directly affect their productivity. Consequently, extreme routes and the profiling area have been identified as the main bottlenecks in the production process, impacting production efficiency. Therefore, the main objective of this case study is to demonstrate how the implementation of Lean tools has managed to increase the efficiency of the process for the production of thermoacoustic panels, reducing unnecessary routes and defective products. The proposed model comprises Lean tools such as the standardization of work and the 5S methodology and the Systematic Layout Planning (SLP) was also applied to carry out the redistribution of activities. A simulation was carried out in the Arena software to validate the improvement proposal's results. The results obtained from the simulation were an increase of 19.24% in the overall efficiency of the process, a decrease of 42.4% in hours lost due to defective products, and a 26.7% reduction in downtime.**

Index Terms—**Lean manufacturing, layout, Systematic Layout Planning (SLP), 5S, standardized work, metalworking, expanded polystyrene, manufacturing industry**

I. Introduction

This industry mainly supplies the domestic market and, to a great extent, the primary mining sector, the construction sector, industrial fishing, and the hydrocarbon sector, making this industry vital for productive processing and employment generation [1].

Exports from the peruvian industry amounted to US$ 563 million and 872 thousand in 2021; this amount was reached by demand from countries within the Latin American region. Exports of this industry was in 2014 where it was possible to export an amount of merchandise equivalent to US$ 599 million 357 thousand [2].

The increasing competitiveness faced by the industry means that the activities' productivity and efficiency have a role as a competitive advantage in reducing time and costs. Reducing the duration of activities and eliminating delays in delivery times is critical for a company to survive in this highly competitive environment [3] Another case study identified the low productivity and efficiency of companies in the metal-mechanical industry due to their workshop nature; in this case, it was determined that unnecessary movements, as well as nonconforming products detected before and after the delivery of the products, directly, influence the profitability of the company and its productivity, having to remanufacture entire batches due to the high rate of defective products. To solve this problem, the author proposes integrating lean manufacturing tools to increase productivity and reduce waste and the percentage of nonconforming products [4].

It is necessary to increase productivity in companies in the metal-mechanic industry to make them more efficient in reducing their production costs, decrease their delivery time and lower the rate of defective products. The problems evidenced in the selected case study were the high rate of faulty products, the low productivity due to excessive manual and repetitive operations, and the high speed of downtime. In this sense, to address the above problems, a model for improving the processes composed of manual activities that have unnecessary routes and loss of time for making defective products were developed. This model integrates the tools of Lean Manufacturing: 5S and standardization of methods, as well as the SLP, to distribute the activities in such a way as to eliminate dead time due to unnecessary routes. This combined model was proposed based on similar problems in other companies in the sector, where the combination of highly manual activities with inadequate tools for an efficient process generates high downtime and time lost due to an increased number of defective products [5].

II. Literature Review

A. Lean Manufacturing in the Metal-Mechanical and Similar Industries

The correct implementation of lean manufacturing techniques enables companies to manufacture value-added products, increase profitability and minimize waste [6]. The lean methodology summarizes a set of methods, principles, and practices aimed at improving industrial processes, maximizing their value, and reducing their costs; the procedure also has an ecological approach by preventing pollution and reducing waste [7, 8].

For manufacturing companies, a key feature to increase their productivity, profitability, competitiveness, and sustainability is quality management. This is achieved through lean processes where the number of defects in the final product is minimized. A production with a lot of waste can impact different levels, from ecological implications to economic and resource losses. Poor quality also affects the company's image and customer dissatisfaction [9].

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B. 5S in the Metalworking and Similar Industries

This tool proposes to establish orderly and clean environments and standardize processes so as not to return to the previous situation. The 5S is the gateway to achieving an optimal approach without waste. It is vital to increase the efficiency and effectiveness of the processes and the existing workspace [10, 11].

Luis Romero, Mariano Jiménez, and Manuel Domínguez propose the application of the 5S by demonstrating that this tool increases control, resource maintenance, and efficiency and increases the space available for the location of resources, as well as decreases production time and reduces costs. By applying this tool, 25% of the workspace was increased, laboratory preparation time was reduced by 30%, a new teamwork mentality was created, the number of breakdowns and accidents was reduced, and inventory was reduced [12, 13].

C. Standardization of the Work in the Metalworking and Similar Industries

Standardized work is one of the most powerful tools, but less used in the industries since it is based explicitly on collecting the necessary information and classifying it into which are the most valuable and efficient in production, according to the method that is currently being used [14, 15].

The result would be a single work system that all operators must follow; this system must be controlled and monitored to be continuously evaluated to achieve maximum efficiency in the process. Specifically, in the metal-mechanical sector, this tool is applied to reduce times, precisely the total setup time and total cycle time were given 180 minutes and 98 minutes, respectively, as a direct consequence of an increase in productivity and successful reduction of component manufacturing costs is obtained [16–18].

D. Systematic Layout Planning (SLP) in the Metalworking and Similar Industries

Companies in the metal-mechanic sector are continuously seeking to increase their efficiency. However, this is indirectly affected by the long distances between machines and tools to be used, causing unnecessary movements and, consequently, an increase in production times [19]. In addition, in the case of success in the footwear industry, it was implemented as a solution to unnecessary delays due to the movement of personnel and SLP materials. As a result, a 3.13% decrease in defective products was obtained, and productivity improved by 38% [20].

In another case study, in the food sector in Indonesia, after conducting a time study, it was identified that spare time was incurred in transportation after improving the workstations by reorganizing and designing the layout of activities; the result was the reduction of unnecessary movement of workers and increased productivity [21, 22].

III. Contribution

A. Model Bases

This model's value proposition is found in the tools presented in state of the art. The model is directed to a niche industry, the construction with thermoacoustic panels; this industry is not very investigated to have a specific use in certain climatic conditions of extreme cold, which is why the value of this research will contribute to a model that integrates the tools of SLP, 5S, and standardization of work for people who want to investigate this industry.

The main objective of the model is to increase the overall efficiency of the manufacturing process of thermoacoustic panels through the intervention of the profiling area and the tools warehouse since the root causes derive from these two areas; by implementing the model, it will be possible to eliminate the root causes found in the initial diagnosis of the company. The disorder and disorganization in the areas above where the 5S methodology takes on greater relevance to eliminate these problems.

To eliminate these problems, the tool best suited for this task is the SLP, which measures the effort made in the transfer of materials by the operators and elaborates a proposal that reduces the action that the operator must make to move the material chosen.

The proposal is divided into three main components. The initial component is the analysis or diagnosis of the current situation of the company; it consists of collecting information and mapping the existing process taking into account the time that each operation takes and the delays present in these; this component is the basis to be able to make an adequate intervention to the process. The tools used in this initial diagnosis are the problem tree, the objective tree, the lane diagram, and the Pareto diagram [23, 24].

The second component is the implementation of the tools where the development of the SLP, the 5S, and the standardization of the process are carried out to improve the indicators and achieve the industry standard. The last component of the model is the evaluation of results and measurement of indicators.

B. Proposed Model

The proposed model aims to increase efficiency and significantly improve the objectives of each cause. The model shown in Fig. 1 is built on two essential supports; on the one hand, there is the initial diagnosis, which includes several processes and tools to better analyze the current situation of the company. The bar chart, VSM diagram, Pareto diagram and root cause tree are used to calculate and analyze the KPIs. Secondly, the model has technical validation. The model is adapted to SMEs in the sector, as the proposal sought does not require significant investments. The cost-effectiveness is the most efficient in terms of economic benefits for the company, as it is mainly proposed to evaluate and change the methodology before seeking a much more costly investment. Once again, the model uses practical, functional and previously used tools.

Another contribution of the model is that it uses tools to improve inventory efficiency and employs a 5S approach to sort devices into workstations and warehouses, which reduces delays in finding usable tools. Although lean manufacturing tools have proven effective across industries, there are few studies on the niche market of thermoacoustic panel manufacturing. In addition, there is not much scientific evidence to guide the metalworking industry. Finally, the use of lean manufacturing methods in the industry must be demonstrated to achieve the set targets. As a result, the efficiency of the company will improve significantly. There are many case studies on the application of SLP, 5S and standardization of work, especially in the food, textile and service industries. However, there is not much research on their use in the production of thermoacoustic panels. Therefore, it will be essential to corroborate its use in this sector to contribute to future research. Finally, I hope that the application of this tool will be useful for the circulation of mypes, which I wish to use in the future.

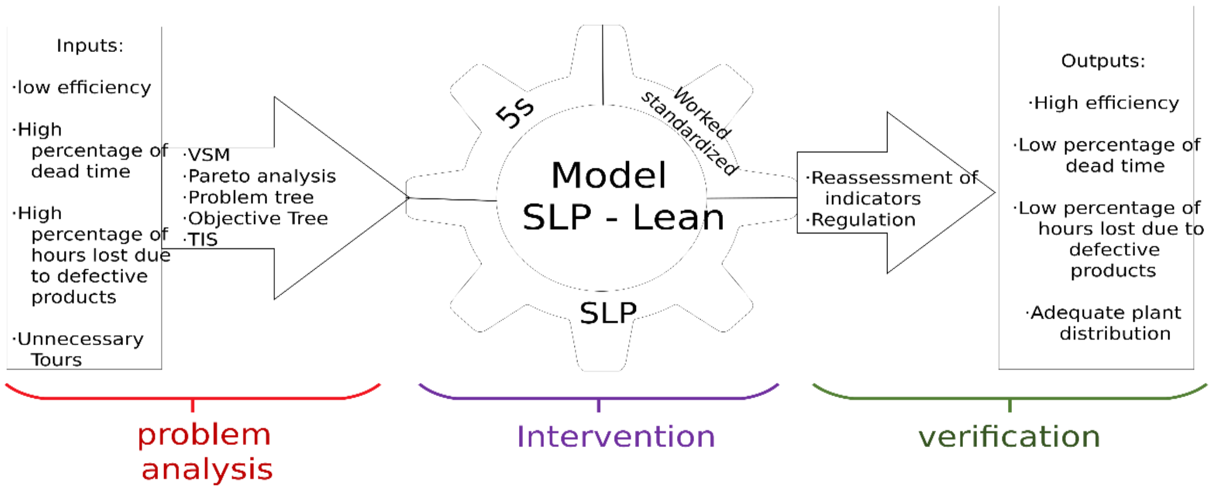

Fig. 1. Integrated lean manufacturing-SLP model [16, 19].

C. *Model Components*

The following subsections detail the different phases of implementing the integrated Lean manufacturing-SLP model.

Phase 1: *Problem analysis*

In this phase, all activities are identified and analyzed before implementing the proposed model to determine the main problems of the organization. To know the whole process and see where the critical activities generate bottlenecks and the actions that create the longest waits for the material to be processed, a VSM must be applied, a tool that allows knowing the entire flow from raw material to finished product. It is essential to make a problem tree to find the reasons, causes, and root causes of the problem; once the root causes have been identified, it is necessary to evaluate if the proposed model fits what is to be optimized or if there are more appropriate engineering tools for the problem found. It is essential to calculate the indicators to be improved to evaluate their variation once the model has been implemented.

Phase 2: *Intervention*

Next, the application of the tools of the proposed model to be implemented is detailed. For this, the development of these tools will be progressively specified. The second phase involves intervening in the critical processes identified in the previous step and implementing the mechanisms proposed in the improvement model. The first thing to apply is the combined SLP model to achieve an efficient activity distribution and workstation design. This way, it will be possible to have greater efficiency in using the company's resources. Then, for the selection of the alternatives proposed by the SLP, the depreciation of unnecessary routes will be taken into account since, this way, we increase productivity, and the second criterion is the proximity between activities.

In the case of 5S, an initial warehouse diagnosis was carried out to develop a training plan for the personnel. Also, measures to be adopted were proposed, such as the delimitation of spaces, signage of areas, use of waste containers, implementation of cleaning times, etc. In addition, a schedule of weekly audits was implemented to ensure that the new work method would be sustainable.

To apply work standardization, a time study must be made before implementing the proposed model and afterward to see how much the company's productivity increased. Once the times have been obtained, the work sequence must be determined, which is fundamental to standardizing each series activity. Training must be done with the new methodology, which contains the most efficient way to perform each action. The operators performing the movement must be trained to resolve doubts and minimize errors.

Phase 3: *Verification*

In the last stage, it is evaluated and checked whether the objectives have been achieved. This verification of the model was carried out in two ways. In the case of 5S, a pilot test was conducted for three months in the warehouse and workstations. On the other hand, for the case of standardized work and SLP, the feasibility was tested using a simulation in Arena software. Finally, the pilot test validated the improvement by measuring the accuracy of the tool sorting, the accuracy of the location recording, and the indicators after the test time. In the case of the simulation, the model calculated the average times of the processes through which the thermoacoustic panels pass. All of these were calculated to ensure the reliability of the improvement model. These results were compared with the initial values to calculate the impact of the applied model. Finally, a regulation to record the improvements achieved and not return to the same starting point.

D. *Improvement Model Diagram*

Fig. 2 below shows in detail each stage through which the proposed model passes, and it can also be seen that this figure involves the three components mentioned above.

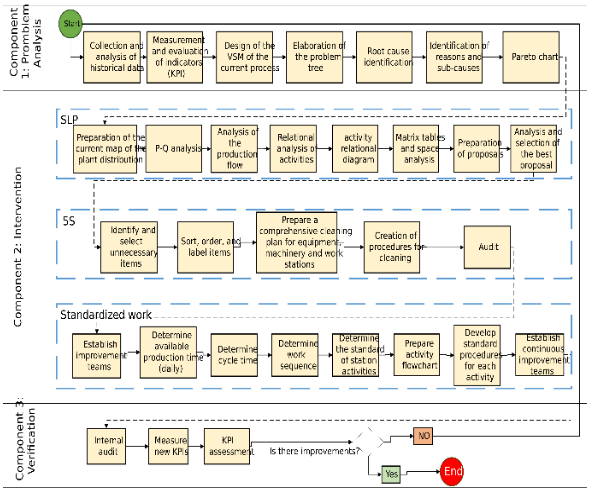

Fig. 2. Improvement model diagram.

E. Indicators

To evaluate the improvements obtained after the implementation of the proposed model, the following indicators were used.

Efficiency: Measures the performance of the resources used with respect to the desired production.

$$Efficiency = \left(\frac{Hours\ of\ defective\ product}{Total\ hours\ produced}\right) \times 100$$

Hours of downtime per operator: It is understood as any time incurred by the operator during the transformation of the product, but which does not generate value, nor is it established in its functions.

$$Variable(\alpha) = \Sigma\ \ Hours\ of\ downtime\ per\ operator$$

Hours per time for defective product: Refers to hours that were poorly utilized because defective products were produced.

$$Variable(\beta) = \Sigma\, Hours\ per\ time\ for\ defective\ product$$

IV. Validation

For the validation of this research, the Arena software was used, which allows the simulation of the proposed model. Therefore, the first step was the diagnosis of the company to identify the possible problems in the production activities, and the points to improve. Likewise, the design of the validation and how the simulation was developed are presented, explaining the inputs and outputs of the process, as well as the improvements through indicators of the company, compared to the sector.

A. Initial Diagnostic

The company under study belongs to the metal-mechanical sector, which is mainly engaged in the production and marketing of thermoacoustic panels in Peru. After carrying out a diagnosis through different tools, a critical activity in production was identified, based on the measurement of times, the critical activity identified is the profiling of the blocks, which has an efficiency of 76.56% due to the lower processing speed that this activity has with respect to the others. The problem generates an economic impact on the organization of 11,848.66 PEN in additional costs for defective products and dead time, which represents 7.22% of the gross profit for the last 12 months.

According to the Pareto diagram based on time measurement, the fundamental causes of the problem were found to be high hours due to defective products (61.70%) and high hours due to downtime per operator (38.3%).

B. Validation of the Design and Comparison with the Initial Diagnosis

Design validation included simulation of the proposed model in Arena software and the original model shown in Figs. 4 and 3, respectively. First, a representation of the complete process was drawn. In this way, the collection of the process times, the comparison between the current indicators and the determination of the target indicators were started.

The production times were measured over a period of three months to obtain the highest possible level of confidence, the product under study is the production of thermo-acoustic panels (the product with the highest demand of the company).

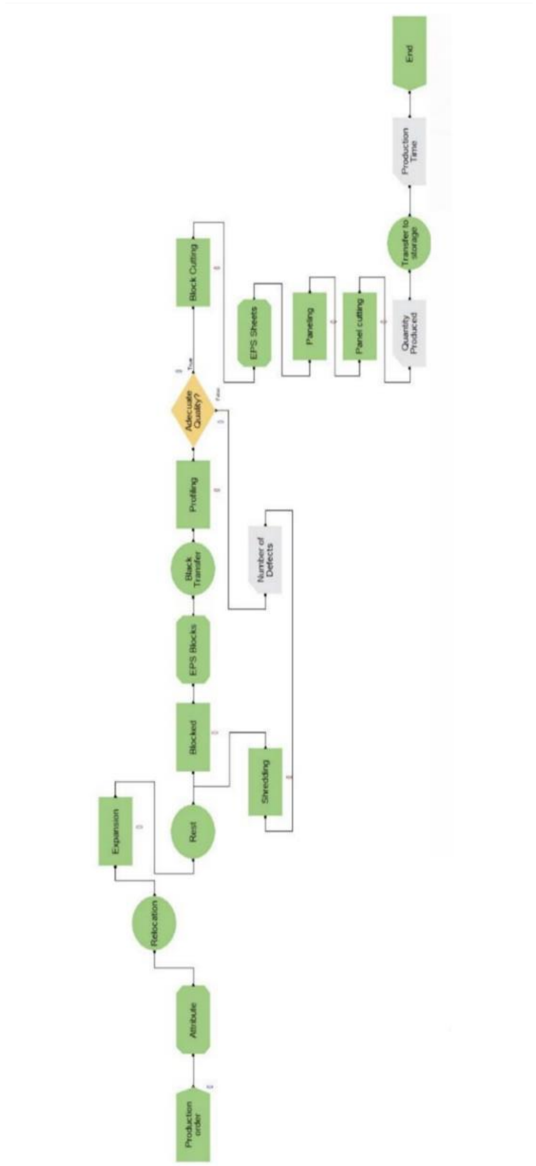

Fig. 3. Original simulation model of the process.

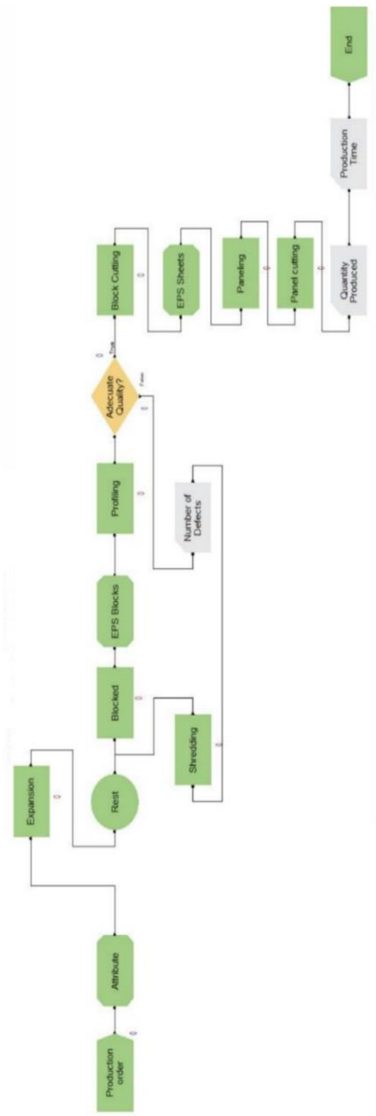

Fig. 4. Improvement simulation model.

The first tools implemented were 5S and SLP. First, a measurement of the company's current indicator was made without any intervention. Then, after 12 weeks of implementing these tools, another measurement of the same indicators was taken to see the difference. The indicators of the diagnosis, collection of new distances traveled, and time measurement were taken into account. All of them are detailed in Table I.

TABLE I. COMPARISON OF CURRENT AND EXPECTED INDICATORS

	Name of the indicator	Current	Expected	Obtained
1	Low efficiency in the profiling activity	76.56%	95%	95.8%
2	High percentage of hours for defective products	61.7%	18.44%	19.3%
3	High percentage of hours due to downtime per operator	38%	15.74%	11.27%

C. *Simulation of the Proposed Improvement*

In the simulation, a model was built that graphs the proposed improvement to the problems observed, for which standardized work and SLP implementation is used.

In addition, the tool's impact is analyzed in depth in the Arena simulation model. The modeling goes from the receipt of the production order to the final production of the thermoacoustic panels. Finally, the proposed improvements are visualized in the model in Fig. 4.

Before starting the simulation, collect input data from the same research unit. This way, time studies were performed using industrial timekeeping, and standard times were calculated for each production operation. This is done to obtain some observations on the reasonable use of the software and the expected simulations. For this purpose, a confidence level of 95% and a margin of error of 4.1% were used as statistical parameters. Then, the collected data are imported into the input analysis tool, and according to the statistical correction, the most appropriate distribution and statistical parameters for each process are obtained. The values obtained are shown in Table II.

TABLE II. FITTED DISTRIBUTION VALUES

Process	Distribution	Units
Expansion	NORM (29.9, 1.15)	Hours
Rest	48 + 6×BETA (1.19, 1.06)	Hours
Blocked	53 + 4×BETA (1.19, 1.06)	Hours
Profiling	53 + 3.53×BETA (1.19, 1.06)	Hours
Shredding	3.46 + ERLA (0.22,2)	Hours
Block cutting	NORM (53.8, 0.957)	Hours
Paneling	UNIF (68,71)	Hours
Panel cutting	44 + 3×BETA (1.13, 0.954)	Hours

The corresponding number of repetitions for the simulations was statistically determined at 50 to ensure the statistical validity and reliability of the data. The results obtained are shown in Table III.

TABLE III. COMPARISON MATRIX OF THE EXPECTATIONS OF THE CURRENT SITUATION AND THE RESULTS OF THE SIMULATION

Indicator	Current	Simulation	Units
Total hours produced	388.99	312.45	Hours
Hours per time for defective products defective products	53.598	22.84	Hours
Hours of downtime per operator	33.274	15.196	Hours

The improved system model achieves a significant reduction in downtime by operators. This is because the implementation of the 5S tool allows periodic reviews to be carried out for the continuous improvement of the new provisions, as explained in detail in the first two S's, which focus on classifying and ordering the tools according to their state of operation, frequency of use and whether they belong to the station in which they are working. Therefore, it is evaluated if the new dispositions in which all the people related to the company are involved correctly perform the procedures. Consequently, the downtime or delays caused by the lack of organization would no longer be generated.

In addition, a unique methodology for performing various jobs was implemented using the work standardization tool for the profiling activity, which was the most critical activity of the process. This, in turn, is based on Poka Yoke and ergonomics tools, which were complemented to compile a work style that will reduce errors and those that originate defective products since the workstation would have the necessary tools and the high number of hours of faulty products is reduced from 53.598 hrs to 22.84 hrs.

Finally, about the percentages of hours of downtime per operator, the current rates were considered, as well as those improved by applying the SLP and 5S methods. Thus, fewer reprocesses are generated in the cycle, and consequently, less time and less human factor resources.

Finally, as mentioned above, the total investment cost to fully implement the proposed model is estimated at PEN 4500.

Among the costs to consider when implementing the proposed model are the time tools of each expert. An essential part of the implementation is to support the planning and confirm the correct implementation of the planning framework. In addition, they will be responsible for the medium and long-term compliance of the instruments. Training time for operators and warehouse managers has been considered and will be completed in working days. Finally, various materials such as formats, colors, and ribbons must be acquired to disseminate information and increase order.

An economic analysis was carried out to corroborate the feasibility and profitability of the proposed improvement.

V. Conclusions

After conducting this study, we can conclude that applying lean manufacturing methods can improve efficiency in at least one area of the metal-mechanic sector. In addition, the results show that the indicators proposed in the diagnosis show significant improvements in the company's current situation.

Through the use of the Pareto diagram and the analysis of causes, it was determined that the main reasons for low efficiency in the roll-forming area were the high percentage of hours for defective products and the high percentage of hours for dead time per operator, with 61.70% and 38.3%, respectively.

When analyzing the root causes of the reasons, it was observed that the most critical sense, which was the high percentage of hours for defective products, was caused by delays in measuring and cutting the length of the wire to be used, uncertainties in estimating the section to be profiled and delay in correctly positioning the table on the trestles, In other words, there was no single work methodology, the workspace was not the most adequate and, as is the case, if there is a probability that the operator will make a mistake, the error will occur. Therefore, the most appropriate tools that had a positive result were the standardization of the work, based on the Poka Yoke and ergonomics, obtaining in specific tasks a time reduction of at least 70. 92% as a minimum.

The proper implementation of the 5S methodology in the profiling area and the warehouses reduced the number of defective products. It decreased downtime due to the search for tools and unnecessary trips. This resulted in a decrease of 53,598 h to 22.84 h of travel time by the operators.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Marcelo Barreto and Mauricio Sassarini jointly conducted the research; Mauricio Sassarini analyzed the data; Marcelo Barreto wrote the article; Juan Quiroz supervised this project and contributed ideas for the document 's drafting; all authors approved the final version.

References

[1] INEI, *National Business Survey 2019*, Lima: National Institute of Statistics and Informatics, 2020.

[2] ADEX, *Metal-Mechanic Exports Recovered in 2021*, Exporters Association, p. 1, 2022.

[3] J. Silva, "Improvement of planning and time control in the project," *Procedia Computer Science*, vol. 196, pp. 288–295, 2022.

[4] C. Monteiro, L. Ferreira, and I. Amaral, "Improving the machining process of the metalwork industry by upgrading operative sequences, standard manufacturing times and production procedure changes," *Procedia Manufacturing*, vol. 38, pp. 1713–1722, 2019.

[5] V. Mercado, D. Acosta, and D. Rodado, "Design of lean manufacturing-based strategies to improve the production process of a metalworking company," *International Journal of Services And Operations Management*, pp. 566–593, 2021.

[6] K. Qureshi, B. Mewada, S. Alghamdi, and M. Mohamed, "Accomplishing sustainability in manufacturing system for Small and Medium-Sized Enterprises (SMEs) through lean implementation," *MDPI*, 9732, 2022.

[7] C. Valentina, F. Mirko, S. Stefano, and R. Federico, "Lean and green production for the modular construction," *Procedia Computer Sciend,* vol. 200, pp. 1298–1307, 2022.

[8] J. Possik, A. Zouggar, and B. Vallespir, "Lean techniques impact evaluation methodology based on a co-simulation framework for manufacturing systems," *International Journal of Computer Integrated Manufacturing*, pp. 91–111, 2022.

[9] P. Foivos and S. D. Joao, "Zero-defect manufacturing the approach for higher manufacturing sustainability in the era of industry 4.0: A position paper," *International Journal of Production Research*, pp. 73–91, 2022.

[10] M. María and G. Víctor, "Lean manufacturing 5S implantation," *3C Tecnología*, pp. 16–26, 2016.

[11] A. Nilipour and J. Mehdi, "5S as an environmental organization management tool; benefits and barriers," in *Proc. International Management Conference*, 2019.

[12] M. Jimenez, L. Romero, and M. Dominguez, "5S methodology implementation in the laboratories of an industrial engineering university school," *El Sevier*, pp. 163–172, 2015.

[13] M. Shahriar, M. Parvez, and M. Islam, "Implementation of 5S in a plastic bag manufacturing industry: A case study," *Cleaner Engineering and Technology*, Bangladesh, 2022.

[14] J. Lee, N. Cho, M. H. Yun, and Y. Lee, "Data-driven design solution of a mismatch problem between the specifications of the multi-function console in a Jangbogo class submarine and the anthropometric dimensions of south koreans users," *Applied Sciences*, vol. 10, no. 1, p. 415, January 2020.

[15] A. Realyvásquez, F. J. F. Moltalvo, and J. Blanco, "Implementation of production process standardization—A case study of a publishing company from the SMES sector," *Processes*, vol. 7, no. 10, p. 646, September 2019.

[16] R. Suganthini, Periyasamy, and Nallusamy, "Lean tools implementation for lead time reduction in CNC shop floor of an automotive component manufacturing industry," *Journal of Science and Technology*, pp. 1–6, 2016.

[17] C. Arredondo, J. Blanco-Fernandez, and J. Denisse, "Work standardization and anthropometric workstation design as an integrated approach to sustainable workplaces in the manufacturing industry," *Sustainability*, 3728, 2020.

[18] O. C. Chi and L. Huay, "Combining lean tools application in kaizen: A field study on the printing industry," *International Journal of Productivity and Performance Management*, pp. 45–65, 2018.

[19] D. David, G. Yeimy, G. Santivanez, and E. Castena, "Optimization model to increase the productive flow, applying SLP, 5S and Kanban-Conwip hybrid system in companies of the metalworking sector," in *Proc. International Conference on Information Management*, 2022, pp. 186–190.

[20] M. Sergio, V. Paucar, A. J. Carlos, and S. Nallusamy, "Implementation of a lean manufacturing and SLP based system for a footwear company," *Production*, pp. 1–27, 2022.

[21] T. P. Nilda and S. Lora, "Application of lean manufacturing concept for redesigning facilities layout in Indonesian home-food industry," Department of Industrial Engineering, Universitas Andalas, Padang, Indonesia, pp. 815–829, 2019.

[22] C. Lucy, L. Elizabeth, M. Fernadno, and M. Eloy, "Application of mixed methodologies in the production planning of screw conveyors for the flour and pasta food industry," *Seventh Sense Research Group*, pp. 435–446, 2022.

[23] D. Silva-Campusano, D. Vega-Romero, A. Flores-Perez, J. C. Quiroz-Flores, and M. Collao-Diaz, "Improvement proposal applying standardized work and 5S to reduce the rate of returned orders of a poultry company under the PDCA Cycle," in *Proc. 7th North American International Conference on Industrial Engineering and Operations Management*, June 2022.

[24] J. C. Quiroz-Flores, D. S. Canales-Huaman, and K. G. Gamio-Valdivia, "Integrated lean logistics-warehousing model to reduce lead time in an SME of food sector: A research in Peru," in *Proc. 2022 The 3rd International Conference on Industrial Engineering and Industrial Management (IEIM 2022)*, January 2022, pp. 182–188.