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A Production Process Efficiency Improvement Model at a MSME Peruvian Metalworking Company

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Abstract. This research study seeks to improve the efficiency of the production processes at a MSME metalworking company operating under the Make to Order (MTO) strategy. For these purposes, the authors first assessed the previous problems reported by the company, detecting a low efficiency rate of 69.56% in its production process, which generated an economic impact at 14.6%. Then, the design of a custom model based on several Lean Manufacturing tools, such as Sort and Set in Order Focused on the 5S, Visual Management Board and Work Standardization, production process efficiency improved by 6.4%, reprocessing experienced a 12.63% reduction, and search times decreased by 24 minutes, which translated into a 5.83% savings for the company. In fact, the proposed model generated positive improvements for the research study.

INTRODUCTION

As the metalworking industry is currently facing constant competition, using tools that may foster continuous improvement and generate competitiveness within today's global market has become a very common scenario among small, medium and large enterprises. In Peru, metalworking companies contributed to 12% of the national Gross Value Added [1] and 1.6% of Gross Domestic Product [2] in 2016. In this country, 98.7% of all metalworking companies are either micro or small enterprises [2], with 17.6% exporting their products to other countries, mainly the U.S, Panama and Mexico [3].

Among the most common problems reported by these metalworking companies are high waiting times, late deliveries, low productivity, high production costs, and quality deficiencies in their final products [4][5]. However, several previous research studies conducted in small and medium-sized companies have been successful in solving some of the issues reported by these companies. For example, a case study set out to solve low efficiency and machine availability issues through Lean Manufacturing tools, such as the 5S and Total Productive Maintenance (TPM), improving its efficiency indicators by 5% [6]. In another study, the authors detected that the actual production time exceeded the expected production time of 130 minutes, wherein at least 30 minutes were dedicated to activities that did not add value. For these purposes, the authors used VSM, the 5S, Work Standardization and Line Balancing to exert a 39% and 15% reduction in cycle times and NVA activities, respectively, and to increase efficiencies by almost 10% [7]. Yet another case study focusing on reducing finished product delays used VSM, 9S, SMED, TPM and Visual Management to increase production rates by 8.33% and on-time deliveries by 6.10% [8].

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Within this context, and due to the limited amount of literature on Lean Manufacturing tools adapted to Micro and Small Enterprises, our research study designs a Lean Manufacturing model adapted to the specific needs and characteristics of a small metalworking company seeking to increase the efficiency of its production processes. This model contains the Sort and Set in Order components from the 5S, as well as components from Visual Management Board and Work Standardization.

This paper is organized as follows: Introduction; State of the Art, where success stories or efforts from other researchers to solve similar issues are described; Contribution, wherein the proposed solution is presented; Validation, wherein validation technique is detailed; and in the final sections, we include our Conclusions and References.

In some research studies, the Lean philosophy has been implemented in Micro and Small Enterprises to successfully address the issues reported in each case. However, a study reveals that only 12% of Micro and Small Enterprises actually manage to successfully implement the Lean Manufacturing philosophy. Still, there are factors that may guarantee positive results, such as adherence to the philosophy for at least two years, communication, learning approach, employee motivation, commitments from senior management, adaptability to change, technique awareness, attitude, improvement structure and consistent support. These factors will contribute to a proper and seamless implementation of the Lean tools in each company [9] [10].

The 5s is renowned for its effectiveness in guaranteeing orderliness and cleanliness in an organization. Hence, it is used as the foundation to facilitate the implementation of other techniques and ensure they present an optimal behavior [11] [12]. In addition, this tool also improves company performance by reducing production times, the time spent searching for materials and costs, while, in turn, improving quality and operational performance, among others [11] [12]. There are case studies where productivity increased by 11.04% and late deliveries were completely eliminated after the successful implementation of the 5S tool [18]. Another case study mentions that, after applying the 5S, added value productivity experienced a 49.2% increase [13].

The Visual Management Board is used to better manage production processes, information flows, and control activities [14] [15]. A study conducted in a Make To Order environment used Visual Management Board because the company assessed reported low efficiency rates, late deliveries, and low productivity rates. With this tool, delivery times were reduced by 50% [16]. In another study, a company reported workload estimation, activity organization and delivery variability issues. For these purposes, Visual Management Board was used to address the problem, thus improving on-time delivery rates from 30% to 90% [15].

The Work Standardization tool has been successful in several companies since it establishes procedures that allow employees to better conduct their activities, meet their objectives, and reduce waste [17]. In addition, this tool has yielded positive results in terms of efficiency and productivity by eliminating activities that do not add value to the company [17]. In a particular success story, the Work Standardization tool was implemented in a small manufacturing company to increase productivity, reduce bottlenecks, decrease production delays, and lower operation costs. Here, production rates increased by 42.62% [18]. In yet another success story, Work Standardization managed to cut off 31.6 seconds from product cycle times, increase the number of parts produced from 54 to 58, and improve productivity by 6.5% by simply removing activities that did not add value [19].

CONTRIBUTION

Overview

This research study focuses on designing a model based on Lean Manufacturing techniques, such as the Sort and Set in Order components from the 5S, Work Standardization and Visual Management Board, as illustrated in Fig. 1. These components were adjusted to the specific characteristics and needs of a MSME metalworking company, with the purpose of increasing its production process efficiency. The foregoing because Lean tools have mostly been implemented in small, medium-sized or large enterprises, but not so much in MSME companies. For this model, we used the Deming Cycle was used as a foundation, but focusing on the "Do" stage because, in this stage, opportunities for improvement can be defined that may guarantee an increase in efficiency [9].

Detail View

The model comprises four stages: Plan, Do, Check and Act. The "Plan" stage refers to making an assessment of the company, designing a solution model and defining the corresponding indicators. The "Do" stage comprises different Lean Manufacturing techniques, such as the Sort and Set in Order components from the 5S, and other components from Visual Management Board and Work Standardization. The "Check" stage corresponds to assessing the results from the previously defined indicators. In the "Act" stage, the implementation of the Lean approach is fostered.

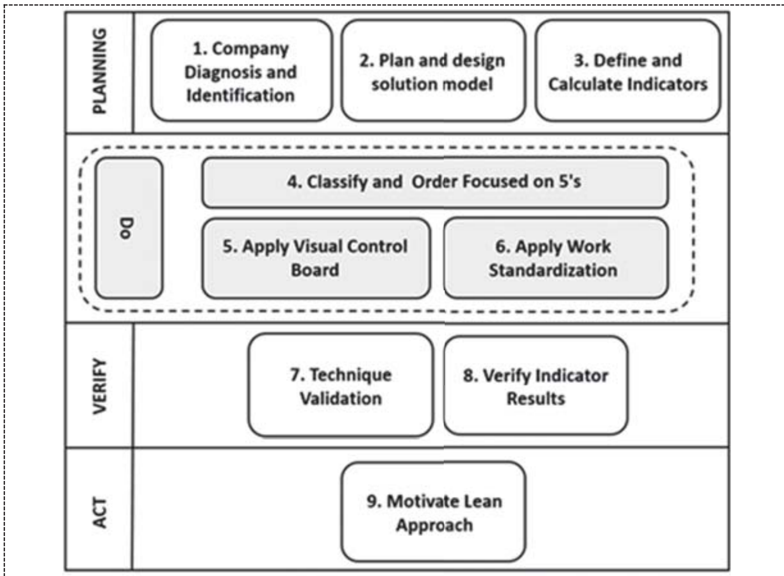

FIGURE 1. Proposed Model.

The model illustrated in Figure. 1 is focused on "Do" as its main objective is to increase efficiency. Hence, "efficiency" is defined as a global indicator to measure improvement from this model. This indicator measures the relationship between the times that add value to production process and the total production time. This indicator is expressed as a percentage, and it is calculated as follows.

$$\text{Efficiency} = \frac{\text{Effective Work Hours}}{\text{Total Work Hours}} \times 100 \quad (1)$$

The following paragraphs detail the components from the "Do" stage with their corresponding indicators.

"Do" Stage; The Sort and Set in Order Components from the 5S

The Sort and Set in Order techniques of the 5S philosophy are applied as groundwork for the other Lean techniques since it establishes an orderliness approach in the work area. The first step is to set objectives regarding reducing unnecessary displacements when collecting tools, removing unused items from the work area and eradicating clutter in the production areas. These objectives must be fully supported by senior management to make sure that all employees strictly adhere to this philosophy. In addition, a 16-question 5S audit focused on Sort and Set in Order is conducted. Then, all employees must take training and motivation sessions. Next, all work area items and objects are classified based on criteria such as unused time, current status, and usage in area. Unused items will be sold, recycled or relocated. The following step is to organize the work area by using tool holsters, sorters, and shelves. Finally, the results are assessed by calculating the Tool Search Time indicator, which measures the time which the operator spends gathering the tools required to conduct production activities. This indicator is expressed as time in minutes.

"Do" Stage; Component from Visual Management Board:

This component requires a previously defined work team and establishing objectives such as designing a user-friendly board aimed at improving production flows. Since the board composition must be defined as part of its design, we used criteria such as its constituting stages, complexity and urgency. Here, four stages were defined: Work Order, Due Today, In Process and Completed. The complexity criterion is divided into "high", which means that more than five machines are required to process the part, “low”, which means that part requires only two machines, and “medium”, which is an average of the former two. Regarding urgency, a color system was used, wherein red represents a due date of less than five days, yellow a due date of less than one week, and green, a due date of more than two weeks. Then, the Plant Manager prepares the product development plans because this person is well aware of average product development times and their related complexity. Afterwards, training is conducted on the use of the Board and it is implemented in the company. Finally, the results generated from using the board are assessed. For this component, the On-Time Delivery indicator is defined, which measures the relationship between orders that were delivered on time and the total number of orders, expressed as a percentage. The metric calculation formula is as follows.

$$\mathrm{OTD} = \frac{\mathrm{On-Time\ Deliveries}}{\mathrm{Total\ Numbero\ fOrders}} \times 100 \quad (2)$$

“Do” Stage; Component from Work Standardization:

The development of this component starts by assessing the process to be improved. For these purposes, we must capture data through multimedia files such as photos or videos. Next, we make a list of the process activities identified, which are subsequently divided into activities that add value to customers and to the process in general (VA), activities that do not add value to customers, but add value to the process (NNVA) and activities that neither add value to customers nor the process (NVA). This classification seeks to reduce or remove all activities that do not add value and to identify opportunities for improvement. In our case, these opportunities for improvement were considered when developing the standard operating procedure, which includes criteria such as cutting speed required to process the part, the time required to adjust the part on the machine, and the use of templates to avoid measurement errors. Then, the results from the implementation of the component are assessed through the reprocessing indicator, which measures the relationship between the total number of items reprocessed in the production process and the total number of parts manufactured, and it is expressed as a percentage. The formula used for this calculation is presented below.

$$\mathrm{Reprocesses} = \frac{\mathrm{Reprocessed\ Items}}{\mathrm{Total\ Items\ Processed}} \times 100 \quad (3)$$

VALIDATION

Description and Assessment of the Validation Scenario

The validation scenario was conducted at a MSME Peruvian metalworking company, which manufactures industrial parts and accessories to order with specific measurements and designs for different companies in the mining, construction and metallurgical industries. After observing and assessing the production processes at the company, we identified low efficiency rates as its main production process problem. The efficiency rate was then set at 69.56%, which affects 14.6% of the turnover of the company, and translated into losses of S/55,202.71. Likewise, an inadequate work method, production delays, and disorder in the work area were identified as the probable root causes for the problem.

Design Validation

Since the Covid-19 situation did not allow us to conduct a pilot test, we relied on a simulation and success stories to validate our study. The simulation was conducted based on the Work Standardization and Sort and Set in Order components from the 5S, using the Arena Simulation software student version 16.00.00 as per the model presented in Fig. 2. On the other hand, for the Visual Management Board component, we reviewed and indexed several success cases that were similar in nature and were applicable to similar sector than the case assessed.

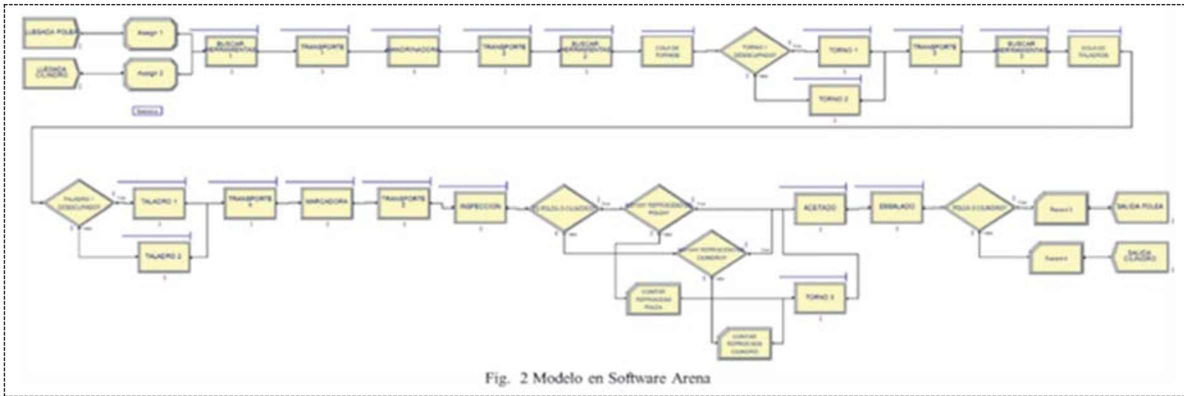

FIGURE 2. Model in Software Arena.

Work Standardization:

The number of reprocesses experiences a 13% reduction. In addition, the proposal decreased the number of lathing activities conducted and machining times were reduced by 6.35%.

The Sort and Set in Order Components from the 5S

Unnecessary displacements were reduced, decreasing tool search times by 77%.

Visual Management Board

Two papers that used the component and addressed similar problems were assessed in terms of activity scheduling and delivery time delays. In these papers, communication flows and activity planning were improved, obtaining an average increase of 55% in their on-time delivery indicator [15] [16]. However, the research considers a 27.5% increase, which is an international indicator, because, otherwise, it would exceed 100%.

Results

With the validation conducted, the results shown in the following table are obtained.

TABLE 1. Results.

Indicator Name	Before	After
Efficiency	65.56%	75.98%
Tool Search Time	31 min	7 min
On Time Delivery	69%	96.50%
Reprocesses	48.18%	35.55%

CONCLUSION

The Lean Manufacturing model increased the efficiency of the MSME metalworking company by 6.4%, since the number of reprocessed units was reduced from 48.18% to 35.55%, the time spent searching for tools was reduced from 31 to 7 minutes and the on-time delivery rate increased from 69% to 96.5%.

The implementation of the model also presents positive results in the turnover of the company since the monetary impact is reduced from 14.6% to 8.77%, which translates in savings of S/22,059.

The simulation and success stories methodology helped us validate the research conducted. which serves as groundwork for future research conducted in MSME metalworking companies.

This research study yielded very positive and favorable results for the company. Nevertheless, we recommend reinforcing the "Do" model components with a tool that motivates the continuous inspection, adjustment and lubrication of the machines, so that production process times may be boosted by reducing downtimes due to machine failures.

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