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Applying Lean Manufacturing Principles to reduce waste and improve process in a manufacturer: A research study in Peru

J Kaneku-Orbegozo¹, J Martinez-Palomino¹, F Sotelo-Raffo¹, E Ramos-Palomino^{1,*}

¹ Ingenier ía Industrial, Universidad Peruana de Ciencias Aplicadas (UPC), Lima 15023, Perú

*edgar.ramos@upc.edu.pe

Abstract. In the present scenario, lean manufacturing techniques are the most successful improvement concepts that many companies can apply in order to eliminate waste and non-value-added activities related to the manufacturing process. This paper discusses the implementation of lean manufacturing tools and an integrated framework between production planning and quality in a SME dedicated at a production of kitchen equipment. Studies of the company processes showed that the cutting and bending processes tend to create the most amount of sheet metal waste and non-value-added activities. The main objectives of the research were to standardize work, reduce waste, eliminate machine failures and develop the guidelines for a correct planning that meets quality requirements. The improvement results have shown a positive impact reducing the waste ratio and this has meant a saving of 13% in the manufacturing cost.

1. Introduction

Lean manufacturing is a methodology that reduces waste and increases productivity within the organization. It seeks to use fewer resources, such as manufacturing time, the number of workers and to develop highly efficient processes [1]. Likewise, waste reduction focuses on reducing overproduction, the amount of inventory of finished parts, defective products, waste, work in process inventory, waiting times and unnecessary movements [2]. However, the main objective of Lean Manufacturing is to maximize the value for the customer by eliminating the waste of production. The value is described as the ability to provide products at the right time and at the right price to meet the customer's needs. [3].

In this context, production waste can be eliminated through the development of different lean tools such as 5S, preventive maintenance, Kaizen, value flow mapping and standardization of work that can be applied in small-scale industries [4]. This interaction between the different tools encourages the reduction of reprocessing, defective products, high lead times and scrap, so the processes become smoother and reduce manufacturing costs [5]. The practice of the 5s principles is useful to improve the workplace by organizing, classifying, cleaning, standardizing and maintaining the different work stations in order to produce better quality products without the generation of waste associated with the work environment [6]. This Lean tool allows you to reduce quality errors and waste that occur during the production process. In this way, productive operations will generate homogeneous products [7].

Finally, preventive maintenance involves all employees of the organization in a constant equipment improvement. This kind of maintenance consists of a range of methods, which are known for being effective in improving reliability, quality, and production with simple maintenance actions [2].



The present investigation was undertaken at a company focused on the production of kitchen equipment in Lima, Perú. The main objectives were to present an overview of the manufacturing plant like the productive process and apply the lean manufacturing methodology in order to reduce waste since it is the main problem in the production line, generating an over-cost of 13% at the cost of manufacturing [3][8]. For this purpose, the operations in the workstations were standardized, the activities that did not generate added value were eliminated, the failure rate of the machinery was reduced and the work environment was organized.

2. Methodology

The implementation of lean manufacturing tools in this investigation was done step by step without losing sight of the coupling they must have with each other. For this reason, it was schematized as follows (fig.1):

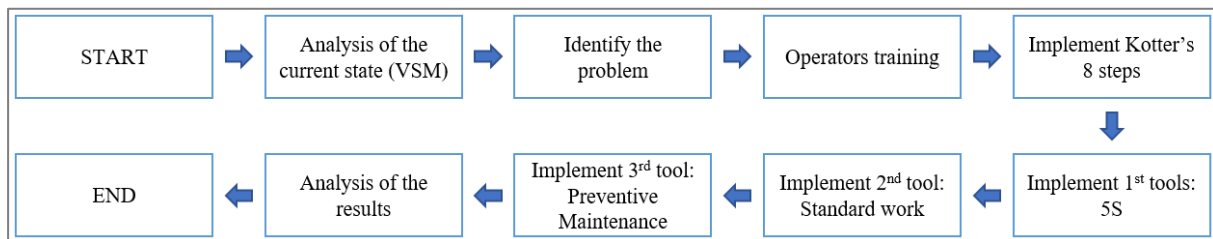


Figure 1. Implementation Methodology.

3. Literature Review

This section provides a review of lean implementation focused on 5S, Standard Work and Preventive Maintenance.

A review paper emphasizes the 5S implementation in the creation of a culture of safe, clean and organized company that is in continuous improvement based on risk assessment and cost for SMEs in India. At this way, the objective is to give a panoramic vision of the small business to improve its productivity to grow as company [6][9]. Furthermore, in another paper the implementation of 5S require the assignment of specific responsibilities for some members of each workstation and create forms for the standardization to use as a step by step manual [10] [5].

On the other hand, a furniture research paper shows the steps for the standard work since the elimination of the non-value-added activities to the calculation of the working ratio and workload fulfilling customer orders on time [11]. For this paper, one of the most important factors to take care is the use of the raw material because of the high costs they represent; for that reason, it was elaborated a process flow diagram to calculate the necessary resources for each area and not to waste raw materials [8].

Another research survey demonstrates the benefits of integrate and stablish a midpoint between production and maintenance planning as reducing the production costs and obtain the best solution for the company in order to minimize inventory levels and reduce workforce and equipment to produce just the necessary quantity with the major quality using the required resources [9]. Considering the scenario of small-scale industry, it is important to integrate philosophies that can work together to obtain better results. Total Productive Maintenance, Total Quality Management and operational performance is an example of these performances that bring a better plan of maintenance requirements having into consider state of final products.

The synergy of multiple techniques will make possible the production system improvement if they are correctly used. This does not mean implementation of one technique do not reduce wastes or improve productivity, but it is also focused in just one operation or activity and will not be expand to the entire company [12].

4. Results

The company ABC is a small-medium manufacturer of gastronomic equipment used in restaurants and fast food retails. The main products for these sectors are worktables, shelves, kitchen sinks, gas

cookers and refrigerated tables. However, the first three products represent the highest volume of sales within the organization and their manufacturing process is similar from each other. Due to this reason, it will be considered as a single family to carry out the investigation. It should also be noted that the company manufactures the products according to the specifications of the customers, which is why it follows a "Make to Order" production.

The production process of ABC manufacturer is separated into five operations: design, cutting, bending, welding and surface finishing process. Despite the importance of all operations, the present research will only take into consideration the design, cutting and bending processes due to their relevance in the generation of waste during the manufacture of the products. These operations will be briefly detailed below:

- **Design process:** Products that will be fabricated using AutoCAD software are designed following the specifications granted by the client.
- **Cutting process:** The pieces to be cut are distributed in the steel plate according to the criteria of the operator and then they are cut.
- **Bending process:** In the hydraulic bending machine, the bends are made and the pieces are sent to the welding area.
- **Welding process:** The union of the pieces is done by TIG type welding, guaranteeing a better surface finish.
- **Surface finishing process:** In the assembled product, the weld cord, sharp edges are worked and the surface of the final product is polished to ensure the safety of the food.

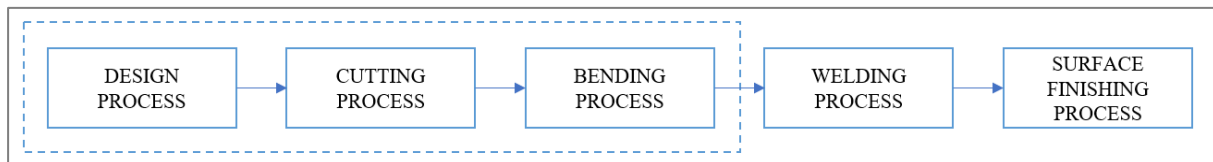


Figure 2. Production process.

The present research will focus on the design, cutting and bending process due to the costs related to the generation of waste in these operations. For this reason, to understand the activities of the processes to be study, the documentation of the operations, the productive areas performance and the manufacturing process were reviewed. In addition, the standard time for each activity was determined through a time study. In addition, the non-value-added activities were identified with the purpose of being deleted [4][11]. In addition, the lead-time of the raw material and the delivery of finished products to the customers were registered. In order to map the whole production process, the operations are present in a VSM diagram, showing their cycle time and the metrics related with the VSM [5][13]. Likewise, the WIPs are detailed between the areas and the Kaizen opportunities were identified [5].

The TAKT time was calculated through the customer demand and the available working time [9]. The current TAKT time is 4.4 hours, which is under the production time of 5.9 hours. This signifies that the organization is not fabricating the products fast enough to fulfill with the demand requested by customers. On the other hand, between the bending and welding area is a relevant amount of WIP relate to the high cycle time in the welding process. In addition, improvement opportunities were detected such as the work standardization, 5'S tool implementation and the development of preventive maintenance. This Kaizen opportunities are related to the variability in the work method at the cutting area, the frequently faults in the bending machine and the disorganized workplaces in the manufacturing line.

5'S Methodology: The five stages of the 5S methodology (Seiri, Seiton, Seiso, Seiketsu and Shitsuke) were implemented in the productive areas of the organization. Opportunities for improvement were identified and efforts were focused on them through the 5'S tool in order to reduce errors in production and manufacturing times. For this reason, unnecessary materials were discarded by identification cards and work tools were organized according to the scheme proposed by [6],[14]. In addition, a cleaning instruction was developed so that operators can carry out cleaning activities in a

standardized manner. Likewise, internal audits were carried out based on the guidelines presented by [15]. The joint work of the implementation of the 5S methodology and the standardization of processes resulted in a reduction in manufacturing times in all areas, as shown below.

Table 1. Results by area

PRODUCTION AREAS	TIME BEFORE IMPLEMENTATION	TIME AFTER IMPEMETATION	TIME REDUCTION
Design	252.4 min	198.18 min	52.22 min
Cutting	59.24 min	50.28 min	8.96 min
Bending	32.58 min	26.51 min	5.3 min
Welding	190.71 min	132.50 min	58.21 min
Surface Finishing	71.65 min	58.87 min	12.78 min

Work Standardization: The work standardization activities were carried out following the guidelines proposed by for the areas of design, cutting and bending [16]. To determine the activities that add value, the value-added analysis matrix was used and the standard time for each activity was determined through a time study. After the standardization activity's in the process of the organization, the time of the cycle was reduced from 5.9 to 5.0 hours, so that the customer's demand would be met. For this, the standard operating procedure was drafted and validated in the areas of design, cutting and bending. In the design process, a new blueprint layout was developed where the pieces to be cut are distributed, in this way the workers reduce the waste index by cutting the pieces following a standard working method.

On the other hand, the procedures for cutting and bending operations were structured to reduce manufacturing time and use only activities that add value to the product. When comparing the waste index, a reduction of 6% was noticed after the implementation of the new procedures focused on determining the exact cutting area by means of the use of blueprints with precise measurements. This decrease in the percentage of waste has a positive impact on the reduction of manufacturing costs (13%) because stainless steel plates account for 80% of the costs associated with the use of raw materials.

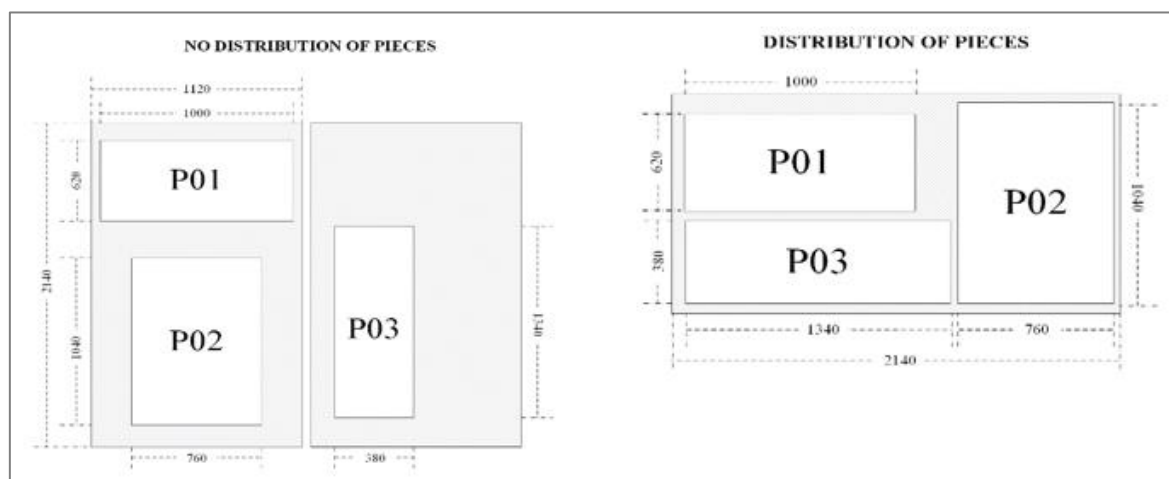


Figure 3. Distribution of pieces

Preventive Maintenance: The company had not defined a maintenance plan for the machinery used in the production process, so it resorted to using corrective actions when the failures occurred. Due to this, training sessions were carried out on simple maintenance actions with the purpose of allowing operators to perform them. In addition, the frequency of the activities to be carried out was defined, as

well as what actions to be taken and the persons responsible. This was reflected in the increase in the average time between failure from 5 to 10 days due to the constant cleaning of the equipment, the placement of oil, grease and lubricants in the machines [15].

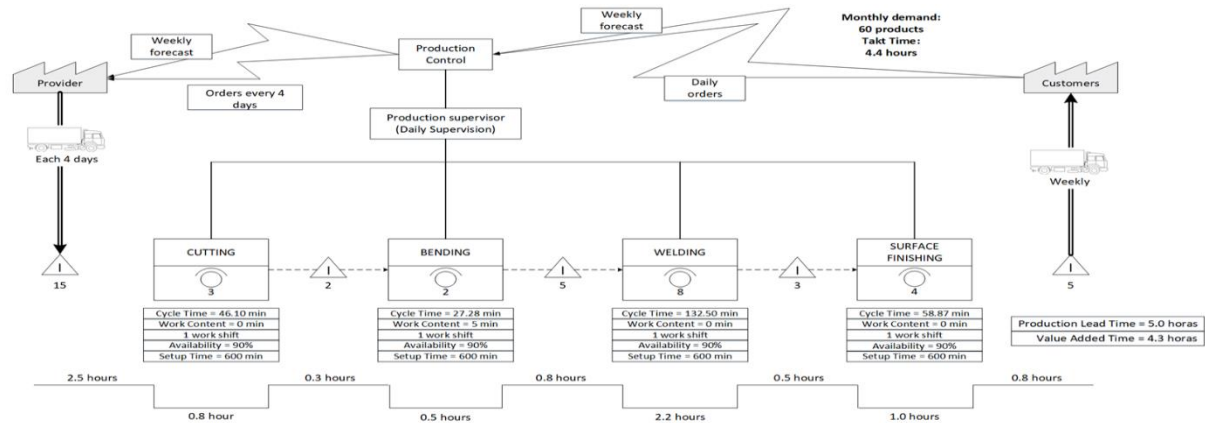


Figure 4. Proposed Value Stream Mapping

A value stream mapping of the future state of the production line was created taking into consideration the results obtained after the implementation of the Lean Manufacturing tools. In the new VSM, there is evidence of a reduction in the number of WIPs among the priority areas due to the implementation of work instructions that regulate activities in operations, reducing unnecessary movements and activities, seeking to increase productivity [5]. Likewise, the joint work of the 5S methodology with the standardization of the work achieved to reduce the cycle time of the operations and consequently the total manufacturing time from 5.8 to 4.3 hours.

5. Discussion

The results obtained after the implementation were the expected, starting with 5'S where were introduced instructional manuals and process management eliminating non value activities, this tool is jointed directly with standard work where manufacturing costs were reduced in 13% reducing wastes in cutting and bending processes. As well, preventive maintenance helped to focused on previous activities before machine failures and not after eliminating costs per machine stops and corrective maintenance.

6. Conclusion

This paper was focused in the synergy between different lean manufacturing tools and a soft one. At this way, this proposal generated a faster understanding by the employees including implementation support and giving an extra motivation.

On the other hand, in order to reach the goals, set, the materials that were not used in the fabrication of the products were eliminated. The standardization of the work through standardized procedures in the productive processes resulted in a 6% reduction in the waste index generated when cutting the stainless-steel plates. The preventive maintenance was also implemented reducing the incidences of faults in the cutting and bending machine, increasing the frequency from 5 to 10 days. These implementations formed the basis for a later application in the rest of the areas of the organization. In general, the implementation of these tools demonstrated their relevance for achieving the proposed results generating a reduction of 13% of manufacturing costs.

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