Lean Service Management Model to Increase the Level of Service in Peruvian a Metalworking SMEs

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***Abstract*—The absence of scientific models, techniques, and work strategies actually applied to small and medium-sized enterprises has been evidenced in the metalworking sector due to the lack of financial support in research and development. In the pandemic context, a methodological change is needed to recover from the ravages, and it is necessary to use methodologies that can minimize losses in industries. The purpose of the bibliography presented and gathered here is to expose the use of lean manufacturing tools for improvement of current systems and processes, revealing the trends of use within the industry, their application in conjunction with these techniques and their combination with methodologies from other areas. The model was validated through a simulation in the Arena software where the results achieved were a reduction in the packaging cycle time from 231.6 to 109.2 sec, the welding time from 69.26 to 65.26 sec, the external delivery delays from 367 to 46 min and internal from 52 to 7 min. Thus, a significant improvement in the level of service from 74% to 87%. This model shows a methodological integration of the differences applied to the Peruvian reality.**

Keywords*—service level, lean manufacturing, production model, metal working, SMEs

I. Introduction

In the vast majority of countries in the western hemisphere, especially underdeveloped or developing countries such as Peru, there is evidence of the absence of scientific models, techniques and work strategies really applied to small and medium-sized companies, due to the lack of financial support for research and development, one of the main concerns in the metal-mechanic sector, in addition to the presence of active workers with very little formal training or technical preparation (Agustiady and Cudney, 2018; Landaz *et al.*, 2019). Reviewing the information obtained from Sunat, the exports of the metal-mechanic sector at the end of 2020 decreased by 24.59%, a very hard fall that will force the businessmen of this sector to rethink strategies to recover these lost months (Vasquez, 2017).

Observing these results we can say that the Peruvian metallurgical industry needs a change of methodology to recover from this pandemic. In this context we can appreciate the great need that prevails in our country and worldwide to use methodologies that can minimize losses within the metallurgical industry. A review of literature related to the implementation of Lean Manufacturing tools in the industry is presented, under this context, improvement proposals were raised by developing a progressive model using the Lean-TPM model tools of Lean optimization, lean manufacturing, TPM, service level linked to lean manufacturing (Farfan-Meza, 2019; Lucherini and Rapaccini, 2017).

The purpose of this literature review is to present and explain the use of lean manufacturing tools for the improvement of systems and processes at present, showing the trends of use within the industry, its application in conjunction with lean manufacturing techniques and its combination with methodologies from other areas. Much research states that continuous improvement encourages the development of processes based on existing patterns, and that the leader-coach is one of the key players in this network (Coronado *et al.*, 2017). Thus to be able to achieve an improvement in production, the maximization of processes achieving what the exposed methodologies raise and to be able to raise the economy in this sector so necessary according to the events by the pandemic COVID 19. The present model shows a methodological integration of different studies applied to our Peruvian reality.

II. State of the Art

A. *Level of Services in Manufacturing Companies*

Productivity is known as the relationship between the total production level and the utilization of relevant resources to achieve the production level (Gupta and Vardhan, 2016). This represents the way in which production inputs are used during the elaboration of products and services to satisfy the needs of society and, in addition, it establishes that it is a strategic factor in

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organizations, since goods and services cannot be competitive if they are not elaborated with high productivity standards (Rosa *et al.*, 2017). In recent years, several projects have been carried out to support and help processes that impact on the productivity of companies, however, in most cases these have been limited mainly to economic sectors such as the automotive sector and others such as the metal companies (Vieira *et al.*, 2019). In May 2021, industrial manufacturing production again experienced a significant growth of 84.0% compared to the same month of the previous year. This result is due to a statistical effect of the months of great confinement and mandatory social isolation (March to May 2020) due to the COVID-19 pandemic, where only essential goods activities operated (CBMETALBLOG, 2021).

B. Lean Manufactering

The Lean philosophy is based on the continuous improvement of processes, so the following production systems promise to pave the way towards the achievement of these results: a) value chain map (VSM), b) 5 s (five es), c) JIT: just in time, d) Kaizen: continuous improvement, e) TQM: total quality, f) TOC: theory of constraints, g) process reengineering, h) flexible manufacturing, i) TPM: total productive maintenance, among others. Similarly, Lean tools implement the foundations that seek to reduce waste by improving the methods proposed and applied to solve this product mix(Benites, 2018; Monteiro *et al.*, 2019, Sharma *et al.*, 2018).

C. TPM

It is a philosophical system designed to ensure that the maintenance of equipment in the manufacturing process is complete. In addition to maintaining them, it improves the integrity of the production systems through machines, equipment and processes that add value to the product (Yulian *et al.*, 2018). At the same time, its main objective is to maintain all equipment in perfect condition to avoid failures, malfunctions and delays, as well as minor stoppages and defects during the production process by providing a safe working environment and a comprehensive vision throughout the company for maintenance management, which can be short and long term. Therefore, many companies are looking for TPM to improve their business strategy (Morales and Rodriguez, 2017). In this sense, this methodological work strategy is aimed at creating an operating system that increases the efficiency of all equipment involved in the production process of the company to ensure its proper functioning, thus avoiding wasteful waste of time when a piece of equipment fails, which would lead to non-compliance with customers and higher costs for the company (Tsarouhas, 2019).

D. Lean-TPM Model of Lean Optimization in the Metal Mechanic Sector

Waste generation in manufacturing processes has a strong relationship with machine or equipment performance. Therefore, strategic maintenance management such as TPM is really necessary to ensure the success of lean production (Sharma, 2019). Plant management will also be more effective if these initiatives are integrated into a set of manufacturing practices (Ramezanian *et al.*, 2019).

These days, the industry is going through a heyday in terms of development, as it is developing considerably and is getting closer and closer to automation and digitalization. (referred to as TPM and Lean Industry) (Yang *et al.*, 2020). This research is a proof that by involving all personnel, even that person who only performs manual tasks, and with little investment, many very important benefits can be achieved.

III. Contribution

Nowadays, many small and medium-sized companies in the metal-mechanic sector are faced with the need to optimize their resources and improve their production lines. In this way, they seek to achieve a better performance in order to optimize the company's resources and increase its productivity. In this sense, different tools of the Lean TPM integrated model, highlighted in the state of the art, have been proposed.

A. Proposed Model

Based on the previous investigation, It was proposed a management model to reduce the service level in the organization in the heading of metal mechanic applying a lean integrated model. With this model, it seeks to eliminate operating times and non added value times. This model was made by 3 components, whose are: The analysis of the current situation, the tool development and finally the implementation and evaluation of indicators.

The components are born from a diagnosis of the current situation of the organization, consequently, it seeks to increase the level of service of the company.

B. Foundation of the Model

The comparative matrix of the components of the proposal vs. the state of the art is presented below, as shown in Table I.

TABLE I. Comparison Matrix of the Proposal Components vs the State of the Art

Causes/Scientific Articles	**Reduction of excessive time in the packing and welding area**	**Reduced mold change time**	**Incorrect working method**	**Reduced sourcing time**
Monteiro *et al.*, (2019)		SMED		
Landazábal *et al.*, (2019)			5S	
Gupta, P., & Vardhan, S. (2016)				JIT
Yang, Wen, Hsieh, & Zhang (2020)	Work standardization			
This investigation	Work standardization	SMED	5S	JIT

C. Model Components

The following is a brief explanation of the 3 components presented, which are shown in Fig. 1. At this point we Will procced to detail each of these in more detail:

- Analysis of the current situation: Its objective is to know the real situation that the company is going through, this will be carried out through the application of the evaluation of KPIs and through the VSM tool. The application of the VSM will allow us to detect and solve the existing causes in the production process. In addition, the Pareto tool will be used to graphically classify the information from most to least relevant in order to recognize the most important problems of the organization. Finally, a problem tree will be built where all the reasons, causes and root causes of the company will be presented in order to determine the main problem.
- Tool development: In the first place, the implementation of SMED will seek to improve the efficiency of the availability and conditions of the tools. Second, the standardization of the 5S is proposed for the welding process in order to increase the order of work and reduce the time in the selection of mold changes. Third, the implementation of the JIT system has the purpose of reducing the level of inventory stock, this is proposed to reduce the abstention time and the elimination of non-added value times such as those produced by the transport of parts between areas . Finally, the standardization of work is key to establish the clear methodology of the processes and guidelines to follow to carry out the elaboration of the product based on the standardized norms.
- Implementation and evaluation of indicators: This component focuses of measure the implementation of the different tools applied in the model. An implementation of proposed designs will be carried out through the use of Arena software with the purpose of get outputs like the reduction of time by implementing the tools previously mentioned. Finally, an evaluation of the KPIs will be made according to each applied tool, in addition, a comparison of the current and final situation of the organization will be made to show us how near to the objective is this variation.

D. Indicators of the Proposed Model

The indicators of the proposed model that will be used to evaluate the expected performance and verify the feasibility of the model in order to increase the level of service in the case study are as follows:

Service level (current) = 74%

Service level (target)= 87%

Objective: Increase the service level by 13%

Service level = Units delivered on time / units produced.

Interpretation: The level of service is measured in percentage based on the units produced and the units served.

- Welding Time (WT): It will be used to calculate the decrease in initial welding time with the final welding time, specifically decreasing the mold change time and the gas inventory breakage.

  Objective: Reduce the initial welding time by 10%.

  $$\frac{(WTi - WTf)}{WTi\ X\ 100}$$

  Interpretation: The variation of the current welding time with respect to the new time of welding will be measured. This mold is used to give a form to the specific parts.

- Packing Cycle Time (TCE): This indicator will be used to track cycle times in bagging. In this area six different parts are joined into a stretch film. The variation of the initial time with the final time will be indicated.

  Objective to reduce packaging cycle time by 25%

  $$\frac{(TCEi - TCEf)}{TCEi\ X\ 100}$$

  Interpretation: It measures the variation of the final packing cycle time with respect to the current packing cycle time.

- Gas Inventory Breakage (GIR): This will indicate the delay in the internal supply. Under this indicator it will be possible to know the times that there was a lack of gas balloon for the welding process. The variation of initial times with the final times will be indicated. This indicator was calculated thinking of produce 1000 units.

  Objective: To reduce by 100% the missing gas cylinders for the welding process.

  $$\frac{GIRi - GIRf}{GIRi\ X\ 100}$$

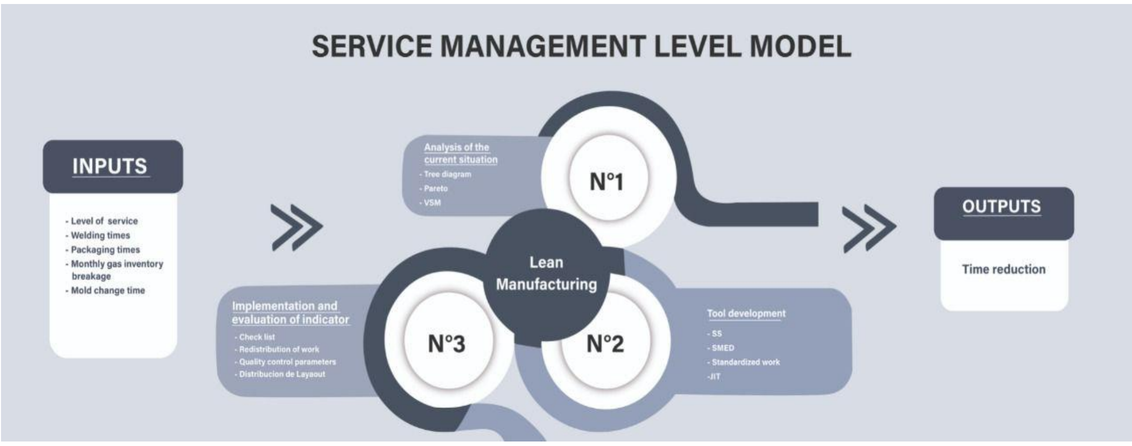

Figure 1. Service level management model.

Interpretation: It measures the variation of inventory breakage with respect to the variation of initial inventory breakage.

- Time of Mold Change (TMC): This indicator is the variation between the time of mold change initial with the time of final mold change. The mold change is used in the welding area because it generates so many reprocesses with the parts that do not fit in the molds. This indicator was calculated thinking of produce 1000 units.

Objective: To reduce by 90% the time of mold change.

$$\frac{(TMCi - TMCf)}{TMCi\ X\ 100}$$

Interpretation: The variation of time after the improvement in the problem of the mold change.

IV. Validation

The pilot plan developed using the Lean methodology was implemented in a metal mechanical SME to verify the proposed results in a real scenario. The levels of the company's service KPI during the year 2020 which had an average of 74%.

A. Initial Diagnosis

The low level of service in the company generated economic impacts such as 50% more expensive overtime paid to operators to increase production capacity, delivery costs, as well as the labor involved will be paid by the company each time an order is delivered out of time. The costs amount to a total of S/684.00 per month or S/8208.00 soles per year. Considering that the annual net income of the company is S/40,365.00, the losses represent 20.33% of it. Among the main causes of this defect are: (a) excessive time in the soldier area and, (b) excessive time in the packing area.

B. Validation Desing and Comparison with the Initial Diagnosis

To make the validation in this research, a simulation was enriched with data achieved on three months from July to September. This simulation was developed using the Arena software where each part of the process of transformation of steel was detailed to enhance in the modeled using the data mentioned. In consequence this define the system scope, input variables, entities, system elements but principally the areas with important problems such as time of packing, time of welding, delays in the supply and the most important was the service level. Next, the current indicators of the company area presented versus the expectation that we propose after the implementation and simulation of the model as shown in Table II.

TABLE II. Comparison Matrix of the General Indicator Results vs the State of the Art

Indicator	Current	Expectation
Packing cycle time	231.6 seg	109.2 seg
Welding time	69.26 seg	65.26 seg
Gas Inventory Breakage	367 min	46 min
Time of mold change	52 min	7 min
Service level	74%	87%

C. Improvement-Proposal Simulation

First it was necessary to get the enough data to have a great simulation, a newest simulation was developed to recover the performance of this research. Using the data, we will determinate the distribution of this data using the same software. The software says that the greatest distribution is Normal because the conclusion of Kolmogorov -Smirnov test with a P-value greater than 0.15 in the Arena Software.

In addition, thanks to the production data collected, it was obtained that to demonstrate optimal results it was necessary to replicate the simulation 30 times. The second step consisted of schematizing the processes using the sand resources, parameters were entered (discrete and continuous variables.) Thus, when obtaining the complete diagram of the production process as shown in Fig. 2.

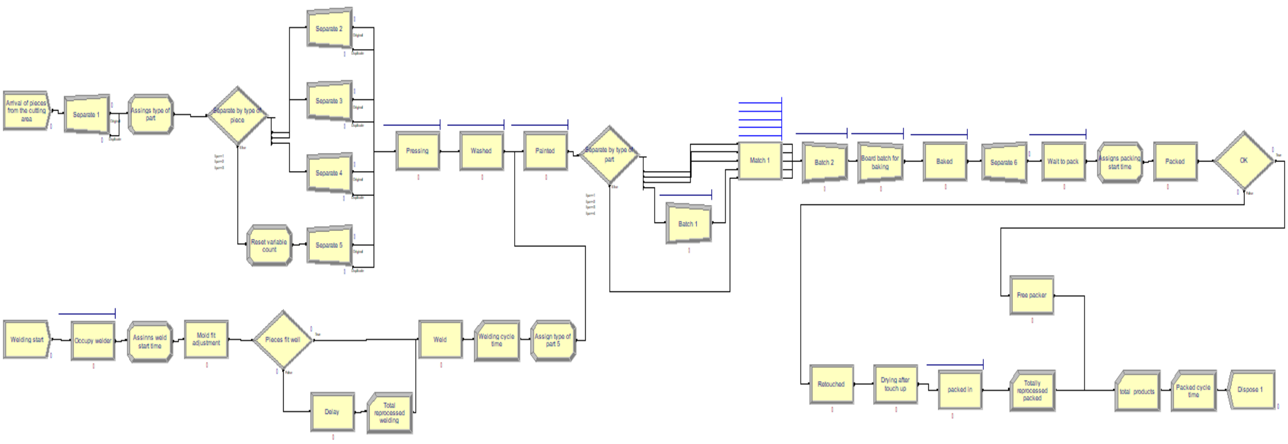

Figure 2. Representation of the current system.

After running the simulation and processing the data, significant improvements could be observed, so that a decreased in time could be observed in the packing area, welding area and Delays in supplies. All these changes have therefore an increase of the Service Level. This becomes to a better projection of the production and the delivery deadline. The following Table III shows the current situation and the improvement situation regarding the level of service of the organization, real result obtained after the simulation.

TABLE III. SIMULATION CURRENT SITUATION VS IMPROVED SITUATION

	Arrived on time	Not arrived on time	% Not arrived on time
Initial Situation	14750	5250	26,25%
Improvement Situation	17400	2600	13%

V. CONCLUSIONS

The results obtained highlight that with the use of tools from the integrated Lean Service Management Model they show an improvement in areas with less efficiency in a company in the metalworking sector, such as the packaging cycle time, showing a change from 231.6 sec to 109.2 sec, to optimize resources and increase its internal productivity, supporting the main idea of obtaining a better performance in the projection of production.

The use of engineering tools that promote the optimization of problem areas within a production plant, generate substantial benefits for an entire sector. The level of service is the end of the production chain that, without a doubt, should also show efficiency in its activities, after the application of the studied model, an increase of 74% to 87% in delivery time was evidenced. This increase in efficiency is due to the collective improvement of areas such as: Cycle time of packing, Welding time, Delays in external supply, Delays in internal supply.

In the future, it is recommended to continue working on the improvement and innovation of tools that can be applied to areas of lesser or slow operation for the design of new operational objectives as well as the application of collective models for satisfaction at the level of service acquired with time.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Jhon Kennedy Campos-Villanueva conducted the research, analyzed the data and drafted the manuscript. Renzo Navarrete-Rodriguez supervised the research. All the authors had approved the final version.

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