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INVENTORY MANAGEMENT MODEL INTEGRATING LEAN AND FLD TO INCREASE SERVICE LEVEL IN AN AUTOMOTIVE RETAIL: AN EMPIRICAL RESEARCH IN PERU

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Inventory Management Model Integrating Lean and FLD to Increase Service Level in an Automotive Retail: An Empirical Research in Peru

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***Abstract*—The automotive industry has had large participation in the Peruvian economy, as well as a large market penetration; however, there is not optimal retention of these customers, since there is a knowledge gap regarding loyalty strategies, which could impact the level of service offered. It is essential to have good inventory planning and a good distribution of the workshop to meet agreed dates. Also, correct execution of the service, which integrates quality control to avoid problems attributed to defects. This case study proposes a model that integrates Lean Manufacturing, Facility Layout Design, and ABC inventory management, intending to achieve an improvement in the current service. After the implementation of the model, on-time service was increased by 30.55%, reprocessed vehicles were reduced by 6.50%, labor efficiency was increased by 16.66%, open work orders were reduced by 13.79%, and transfer times were reduced by 20.90%.**

***Keywords*—lean service, standardized work, Jidoka, Poka Yoke, facility layout design, service level, automotive industry**

I. INTRODUCTION

The automotive industry is part of those sectors that are recognized for their contribution to the Peruvian economy [1], the automotive sector contributed about 12% of GDP and generated approximately 400,000 direct jobs and 800,000 indirect jobs. In 2019, activities related to the automotive industry have made significant tax contributions to Peru (15% of the total collected) [2]. In terms of sales, the sector was greatly affected during 2020 by Sars-Cov-2, mostly due to restrictions imposed by the Peruvian people [3], however, economic indicators are currently showing a great improvement, since March 2021, the variation of vehicles sold was over 85% compared to the previous year [1].

Even though the automotive industry is growing, there is a knowledge gap in terms of customer loyalty strategies, this is how customer retention in 2019 was approximately 54.6% where repurchases of a new vehicle of the same brand were made [4].

Currently, the biggest complications in the Peruvian market are operation defects after the execution of the service and claims due to services provide to customers [5]. Also, Peru has a lot of potentials to continue growing, since for every 1000 citizens only 5 vehicles are sold [6].

The problem identified in this research work, according to the general diagnosis of the company, is a low service level, which impacts customer retention. The service level can be defined as the quantification of performance to achieve strategic objectives, customer satisfaction and thus retain them [7]. Not reaching customer expectations, according to several studies is reflected in a reduction of the quality of service offered, this could decrease the probability of repurchases or increase the demotivation of at least ten potential customers [8]. Similarly, this low level of service may be a consequence of poor work performed in the repair of the vehicle that leads to the reuse of materials, equipment, staff, spare parts, among others. As well as the loss of potential customers [9]. Likewise, another cause can be attributed to the inadequate distribution of work areas, as well as incorrect management of the service, which generates a lower level of response to customers [10].

In this sense, companies in the automotive industry must maintain an adequate service level to increase retention by taking care of customer satisfaction. A tool that helps to identify activities that do not generate value in a production line or business is the VSM because it schematizes the process, which allows a broad overview of this [11]. Some benefits of this tool presented in case studies demonstrate improvements in the productivity of the system from the reduction of cycle times and thus the reduction of delivery times so it generates better responsiveness to customers [12].

For this reason, one of the most important authorized dealers of a vehicle brand was selected. This dealer presents the main problems of the sector: Inefficient management and planning of spare parts, lack of standardization of activities, and inadequate distribution of the workshop. As well as a lack of specialized quality control and erroneous technical diagnoses, which is reflected in 6% of the total invoicing which means approximately 881,830 Peruvian soles. In consequence, this research proposes a new model for the application of Facility Layout Design, Lean Manufacturing tools such as Standardized Work and Jidoka, and finally, an inventory management model ABC. It is important to mention that, according to the literature reviewed, there are still knowledge gaps regarding the impact of the service level in the automotive sector and this is the reason that motives to propose a new integrated model to solve this problem arises.

II. State of Art

This methodology focuses on achieving an improvement in the profitability of the processes to be performed by eliminating activities that do not generate value [13].

Among one of the studies seen, a lean tool called Standardized Work was applied, since this tool points out that the objective of its implementation is to create a sequence of steps for the execution of activities, to ensure that their performance is the same regardless of the collaborator who executes them [14]. Among the applied case studies, it has been demonstrated an improvement in the reduction of 70% of transport times in the production line, as well as a growth in the overall equipment efficiency (OEE) of three different processes between 16% and 18%.

Likewise, it is proposed to complement this methodology with the Poka-Yoke tool, belonging to Jidoka, which is considered as a mechanism that supports the operator not to make mistakes during the execution of the process. The Poka-yoke tool was introduced in 1960 by Japanese engineer Shigeo Shingo, who contributed positively to the line quality process in Japan by reducing defect errors using simple and low-cost prevention techniques [15]. The main objective is to prevent, detect and/or correct the source of the error. Among the case studies seen, it was demonstrated that by applying this tool through the motion step method, it was possible to reduce the number of customer complaints from 34.7% to 5.3% [16].

A. *Facility Layout Design*

The Facility Layout Design methodology achieves an improvement in the process in terms of quality service and travel flow. This method is mainly used to counteract problems with the location of departments, workstations, machines, among other important areas in a facility, as well as to help maintain a constant flow of materials during the process [17]. In a case study where the main problem was the total distance traveled, there was a reduction from 2295.40 m to 2206.43 m, which had a positive impact on a decrease in travel time of 140 minutes, achieving a 4% improvement in travel distance [18].

B. *Inventory Management ABC*

The method of inventory classification helps to classify them and maintain efficient management and control. This method is based on an analysis of importance from the Pareto tool where they are classified into 3 families of products, class A where the most important items are included, class B with items of relative importance, and class C with items of little importance [19].

The ABC classification is an important method among manufacturing industries that require an organization of their inventories. It is based on classifying items A, B, or C according to their consumption value per year [11]. Among one of the studies, where this method was applied, a new periodic review policy (PRP) was developed and resulted in a decrease in the inventory ratio from 3.15 to 2.13 [11].

III. Contribution

A model has been developed, this consists of 5 components and integrates three engineering methodologies, among these, first, Facility Layout Design (FLD), second, Lean Manufacturing tools such as Standardized Work and Jidoka, and finally, a model of ABC inventory classification method. The integration of these methodologies has been achieved based on a compilation of scientific articles where case studies have been found with positive results from the implementation of the methodologies mentioned before.

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

Objectives	**Competent labor and reduction of reprocesses**	**Effective Inventory Management and Planning**	**Efficient distribution of the work area**
Chan, C. O., & Tay, H. L. (2018)	Standardized work and design, line balancing		
Weng, S.-J. Tsai, M.-C. Tsai, Y.-T. Gotcher, D.F. Chen, C.-H. Liu, S.-C. Xu, Y.-Y & Kim, S.-H. (2019)			Facility Layout Design
Nallusamy, S., Balaji, R., & Sundar, S. (2017)		ABC Analysis	
Wijaya, S., Hariyadi, S., Debora F., & Supriadi, G.(2020)	Poka Yoke		
Proposal	Standardized work and Poka Yoke	ABC Analysis	Facility Layout Design

A. *Model Components*

The application of this proposed model looks for the integration of the Facility Layout Design (FLD) tools for the reorganization of the mechanical workshop layout, Standardized Work with the objective that the collaborators follow a single work procedure, Jidoka to avoid errors during the execution of the service and ABC inventory management for better planning of spare parts control.

1) Component 1: Data collection, evaluation, and diagnosis

It focuses on three stages, first, the evaluation of the mechanical workshop, both visually from face-to-face visits, as well as interviews with senior employees of the company and a collection of information from the CRM platform, which mainly details a set of customer satisfaction surveys.

Second, an outline of the maintenance service process was drawn up with the help of one of the Lean Manufacturing tools, Value Stream Mapping (VSM). Similarly, a report of the interviews previously conducted was constructed using the systematic questioning technique.

Finally, with the information collected with data and initial diagnostics of the processes, an issue tree was drawn up outlining the main cause that affects the workshop as well as its causes and possible solutions based on the use of engineering methodologies.

2) Component 2: Implementation of facility layout design method and standardized work

This second component is based on the simultaneous application of the Facility Layout Design (FLD) methodology and Standardized Work. To carry out the FLD method, it was necessary to schematize the current floor plan of the workshop with Microsoft Visio software and to analyze the workflow by constructing a diagram of process activities. Then, a scale of values was made to indicate the degree of importance of the proximity between workstations, as well as a table of relational motives, to develop a relational diagram of activities.

As for the standardized work tool, a structure is proposed that presents a single work method and that is impacted in a single cycle time for each technician performing the maintenance service. This format contains tools, lubricants, spare parts involved, the theoretical times established by the factory, as well as the activities to be performed sequentially.

3) Component 3: Implementation of Jidoka (motion-step method)

This third component implements the Jidoka method, through the Poka-Yoke tool according to Motion-step methods. An Operation Checklist is applied to ensure that the mechanical technician accomplishes all the steps of the process and prevents errors from being made by doing something out of this. The purpose of this checklist is that the technician can use it at the end of the maintenance and check that it has been performed satisfactorily, fulfilling the customer's request and making sure that the elements involved in the repair are working properly and that there is no subsequent problem.

4) Component 4: Implementation of the ABC inventory classification method

This fourth component starts with the identification of the rotation of spare parts used in maintenance to know the demand and make correct planning of replenishment under a policy of periodic review of inventories.

5) Component 5: Simulation of the service process

This fifth component is based on a simulation using the Arena software to schematize the preventive maintenance service process and the input analyzer software to find the appropriate distributions of the times of each of the activities of the process.

To analyze the benefits of the implementation of the proposed model, six performance indexes are presented to evaluate the improvements between the current scenario of the maintenance shop and the proposed scenario with the integration of the engineering tools model.

B. Indicators

To measure the performance of the proposed integrated model, six performance indexes are presented to evaluate the improvements achieved.

- Net Promoter Score (NPS): This indicator provides a qualitative and quantitative assessment of overall customer satisfaction with the service, as well as loyalty based on the possibility of recommendation to others.

$$Promoters\,(\%) - Detractors\,(\%) \qquad (1)$$

- On-Time service (%): Measures on-time service performance expressed in the number of vehicles delivered within the timeframe agreed with the customer

$$\frac{\text{Spent days at the workshop}}{preparation\ days} \times 100 \qquad (2)$$

- Reprocessed vehicles (%): Measures the amount of reprocesses due to poorly executed maintenance services.

$$\frac{Number\ of\ reprocessing\ cases}{number\ of\ work\ orders} \times 100 \qquad (3)$$

- Labor Efficiency (%): Identifies the efficiency of the workers when performing the maintenance service, using the actual time spent and the theoretical time.

$$\frac{Theoretical\ labor\ hours}{Real\ labor\ hours} \times 100 \qquad (4)$$

- Openwork orders (%): Measures the number of vehicles that cannot complete their service due to lack of stock or correct diagnosis.

$$\frac{Openwork\ orders}{total\ work\ orders} \times 100 \qquad (5)$$

- Transfer times (%): Measures the total transfer time about the total cycle time.

$$\frac{Transfer\ time}{cycle\ time} \times 100 \qquad (6)$$

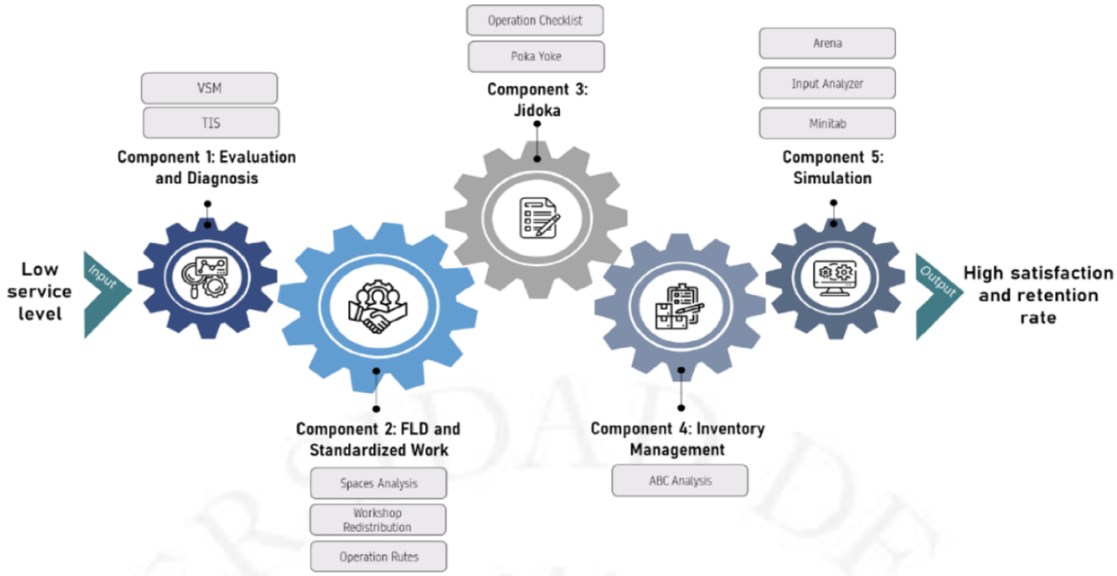

Fig. 1. Proposed improvement model.

IV. Validation

The integrated model proposed in this research has as its object of study an authorized dealer of a vehicle brand in Lima, Peru. This dealership provides three types of maintenance services, including ironing and painting, preventive and corrective. From the analysis of the quality service management indicators, it was observed that one of them presented a service level of 30%. This indicator, compared with an estimated optimal value, generates a technical gap of 65%, which shows an opportunity for improvement.

A. *Initial Diagnosis*

According to the company's initial diagnosis, the Net promoter score indicator showed a value of 30%, which affects the customer retention indicator by 6%, which is reflected in a loss of approximately 881,830 Peruvian soles per year. The poor service management is attributed to the low service level of 79.49% and the main causes of this poor management are (a) the reprocessing rate, (b) the increase in times.

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

To validate the model, it was necessary to go through 5 different components, in the first component it was required to obtain the data corresponding to the months between January and June 2019, from the different areas involved in the maintenance process, these data will be entered into the Arena software in the last phase to be able to verify that the methods and engineering tools used will generate the expected improvements in the company.

In component two, the FLD method was used, which will decrease the dead times inside the workshop concerning unnecessary movements that will be measured in the simulation, and also the Standardized Work method will be applied where a route of operations will be implemented by the technicians.

In the following component, implementation of the Jidoka method, a new process will be added, which consists of the application of a checklist that will use at the end of each maintenance.

In the case of the fourth component, implementation of the ABC method, a better replenishment of spare parts concerning their rotation will be established.

The following indicators were obtained in both scenarios, demonstrating an improvement from the integration of the proposed model.

TABLE II. Indicators Result

Indicator	Initial Situation	Expectations
Net promoter score	30%	95.00%
On-Time service (%)	66.35%	95.00%
Reprocessed vehicles (%)	11.37%	5.00%
Labor Efficiency (%)	66.67%	90.00%
Openwork orders (%)	17.67%	5.00%
Transfer times (%)	49.27%	25.00%

C. *Improvement-Proposal Simulation*

The simulation was performed with Arena software, taking into account a confidence level of 95%, an average error of 10%, and a total of 181 replications were obtained. The scope of the system starts from the arrival of each customer with his vehicle until the delivery of the vehicle has gone through each of the activities included in the maintenance service.

It should also be noted that two scenarios were considered and compared. The first scenario presents the current situation.

In the second scenario, the development of the design of the proposed integrated model, which consists of three engineering methodologies that were mentioned above.

To quantify the improvement we present the next indicators:

TABLE III. CURRENT SIMULATION VS IMPROVED SIMULATION

Indicator	Initial Situation	Improvement Situation
Net promoter score	30%	81.25%
On-Time service (%)	66.35%	96.90%
Reprocessed vehicles (%)	11.37%	4.87%
Labor Efficiency (%)	66.67%	83.33%
Openwork orders (%)	17.67%	3.88%
Transfer times (%)	49.27%	28.37%

V. DISCUSSION

One of the indicators with the best results was the number of vehicles attended on time, with an increase of 30.55%, thanks to the use of Lean tools. In a study seen, where Lean tools were applied and also tested through a simulation, there was an increase of 37.5% in the number of automotive parts produced [20]. This means that both the productivity of this case study and the one compared had a significant improvement.

VI. CONCLUSIONS

The indicator of vehicles serviced on time reaches an improvement of 30.55%, which means that the agreed delivery dates of the vehicles will be met at 96.90%.

In the case of reprocessed vehicles, a decrease of 6.50% was obtained as a result of the integration of quality control in the process thanks to the implementation of a checklist at the end of the process.

As for the efficiency of the workers, it has an increase of 16.66%, thus achieving overall efficiency of 83.33%.

As for open work orders, they have a reduction of 13.79%, achieving a decrease in the time that vehicles remain in the workshop due to a lack of spare parts.

Likewise, for non-effective times there was a reduction of 20.90% and distance in meters of 93.36, generating more time only for the execution of the service and avoiding unnecessary movements of technical personnel, vehicles, and tools.

Finally, based on these indicators obtained from the simulation, a projection of the service level in the second scenario was made, which shows an average value of 81.25%, which shows an improvement in meeting the needs of customers.

For future research in other vehicle models, services and industries, further data collection and analysis of the sector and/or companies involved is required. It is important to include tools that provide continuous improvement to maintain and improve the results obtained. Constant training and commitment from senior management to operators are crucial. Finally, it is recommended to perform customer satisfaction surveys once the integrated model has been implemented.

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