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APPLICATION OF A MAINTENANCE MANAGEMENT MODEL BASED ON LEAN TPM TO INCREASE OEE IN CANNING SMEs

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Application of a Maintenance Management Model Based on LEAN TPM to Increase OEE in Canning SMEs

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***Abstract*—Regardless of the factory type, the performance of machinery is an important factor to be competitive. To ensure optimal equipment performance, many companies focus on establishing continuous improvement programs. This is the reason why there are methods, with the final purpose to increase the disponibility and operation, additionally, it also produces regulations of order, because it helps to reduce unused times, as is the case of 5S. Likewise, efficiency is also measured through the OEE maintenance KPI (equipment effectiveness) averaging a moderation towards the implementation of management methods. This article presents the implementation of two of the pillars: the TPM (preventive maintenance and autonomous maintenance) and 5s. Further, the most relevant contribution after the application of these methods, is the performance increase on the OEE. For this case study, after the simulation, the result is 6.85%, a plus than the current situation, where the performance is 6.45%.**

Keywords—5s, preventive maintenance, OEE, TPM, Lean

I. Introduction

The Peruvian Sea has a great hydrobiological diversity [1], the unusual thing is that, in its market, 70% of canned tuna is imported, generating 80 million dollars [2]. This is because globalization and ever-rising customer demand forces organizations and decision makers to come up with strategies to improve processes and products continuously [3]. Frequent jams and sudden stops cause the OEE to be not optimal; causing degradation of the quality and losses. One of the causes of these interruptions is the lack of maintenance management of the machines [4]. Among the problems identified. that directly affect the availability of machines in industries, we have downtime losses which has been considered as the most difficult one to reduce. [5]

In this context, it is necessary to mention the importance of using an efficient maintenance system in Peruvian industries, since it will increase the total efficiency of production, thus fulfilling the projected demand, adding value to the product and increasing quality, leading to obtaining greater recognition of the product. For this project, we looked for specific problems in the industrial sector and we decided to take as a starting point a limited production capacity and its productive development. Likewise, it was identified that the times of unscheduled stops, generally caused by dents or uncoating of the cans, generate monetary losses of 42% of the net profit of the case study. In addition, a base analysis of previously successful cases was developed because they quantitatively verify the influence of the methods on the corresponding indicator. In addition, these studies have similarities with the investigated problem.

The purpose of the project is to satisfy both the need to solve one of the most problematic issues in the sector and its contribution to the national scientific community since the case study articles corroborate the scarce information on "Lean Manufacturing" work models for this type of companies in Peru and Latin America

II. State of the Art

A. Overall Equipment Effectiveness

The OEE (overall equipment effectiveness) is a tool used for the identification of a possible deficiency in availability, performance, and quality. It is used specifically by competitive companies. Argues that OEE is a value used in an evaluation and measures the extent of successful TPM implementation, this measurement is very important to find out which areas need to be improved in machine productivity and product quality [6]. In the first case, high downtimes, problems with the flow of energy and problems with the operator are observed, after the application of VSM and lean production it was found that the OEE increased 7 percentage points [7]. In the second case, there is evidence of historical deficiency in the OEE, 61.7% in October 2019, 58.6% in November and 61.9% in December [6]. This is due to problems on the part of the operator in the preparation of the production matrices as well as the lack of time, after the application of the methodology of TPM and plan, do, check, act and cycle. An improvement was found in February 2020 resulting in the oee increasing to 65.5%, as well as increasing the efficiency of the process cycle by 10% and reducing downtime by 15% [6].

B. Lean Manufacturing

Lean manufacturing is a method of continuous improvement, it is also a systematic process of identification and elimination of activities that cause inefficiency in the production process. In the first case related to the tempering machine, the lack of productivity regarding working time was a problem, that, after applying the 5s system, better results were obtained with a total reduction of 82 minutes and an improvement of 304% [8]. In the second case, it was evident that the problem was the manufacture of a carburetorvalve with a minimum deviation or error, causing the draining during engine stop, so, using the methodology Jidoka, Arima, Oss, Sarima and pareto resulted in the reduction of defects by 0.7%, rescuing 7000 products per million of production [9]

C. TPM, Preventive and Stand-alone Maintenance

Nowadays, an efficient and flexible preventive maintenance plan is necessary. For the following cases, it will be analyzed how the factories have implemented efficient maintenance plans in machines to minimize existingproblems [10] and implement the TPM to solve poor performance in time, productivity, materials, and costs. Full implementation of TPM means using all eight pillars, but most industries use only a few pillars. The impact of the TPM program on manufacturing performance depends on how they are used. It has been widely identified as a significant aspect in improving production efficiency, effectively managing machines and improving their capacity. There were constant failures in a machine, therefore, it was decided to create a preventive maintenance plan [3]. A proper preventive maintenance (PM) policy minimizes the likelihood of machine failure. Therefore, the consideration of Preventive Maintenance and quality control policies may be more significant in terms of performance costs. [3].

III. CONTRIBUTION

A. Proposed Model

The maintenance management area is an important component within the value chain of canning processing companies and has an impact on the competitiveness and efficiency of organizations. It faces constant changes and new challenges, so it must be constantly learning and implementing changes at a strategic level. This article presents an implementation proposal based on the literature of different models and tools of Lean Manufacturing and Total Productive Maintenance to ensure the overall efficiency of the equipment, thus contributing to increasing its competitiveness and level of service to customers. The proposed model is shown in Figure 1.

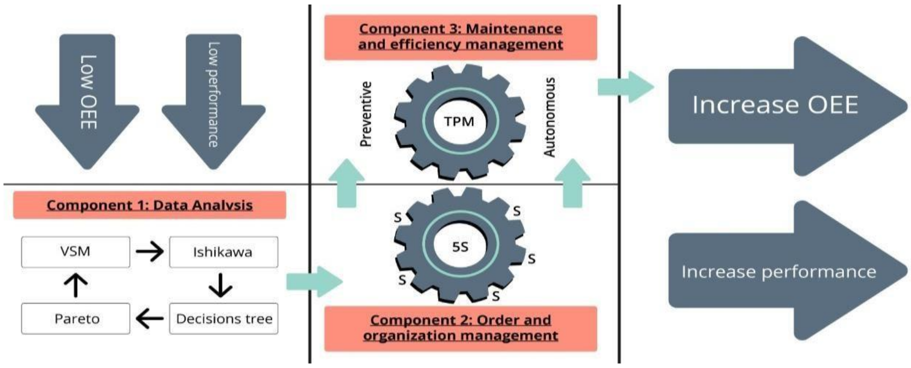

Fig. 1. Model proposed.

Table 1 shows the comparison of the proposed tools identified in the literature review.

TABLE I. COMPARISON MATRIX OF THE COMPONENTS OF THE PROPOSAL VS STATE OF THE ARTE

Causes/ Study Articles	**No Equipment Performance**	**Lack of Order and Organization in Workers**	**No Maintenance Plan**
Dadashnejad, A. A. D., & Valmohammadi, C. V., 2017 [7]	Lean Production		
S. Nallusamy & Adil Ahamed M.A., 2017 [13]		5S	
J. Morales and R. Silva, 2017 [8]	Maintenance		Preventive and Autonomous Maintenance
Barrak Alsubaie and Qingping Yang, 2017 [12]	Maintenance	5S	Preventive and Autonomous Maintenance
T. Haddad , Basher W. Shaheen and István Németh , 2021[5]	Maintenance		Preventive and Autonomous Maintenance
This research	**TPM**	**5s**	**Preventive and autonomous Maintenance**

B. Components

1) Component 1: Data Analysis

The first component of the project, the VSM tool is used to visualize and analyze in a summarized way the OEE, applied to all the processes. After that, The ISHIKAWA Diagram is used to find the root causes, previously found in the VSM tool. These causes are organized in a Pareto Chart, to find the most important causes, and finally a Decision Tree is used to identify the correct tool to fix the row causes.Table 2 shows the comparison of the world-class indicators versus the current state of the case study.

TABLE II. COMPARATIVE TABLE OF THE WORLD CLASS AND THE CURRENT STATE OF THE FACTORY

	Availability	**Quality**	**Performance**	**OEE**

Current	94.49%	99.85%	50.33%	47.48%
Standard	60%	98%	75%	44%
World class	90%	99%	95%	85%

2) Component 2: Order and organization management

The second step is to use the 5S methodology. This model will serve mainly to add order and organization, which is currently lacking in the area. In addition, it will serve as the basis for the following implementations.

3) Component 3: Maintenance and efficiency management

The implementation of preventive and autonomous maintenance begins by identifying the problematic parts of the machine, then each part is kept under strict lifetime control and it is comparison as well. Emphasize that for the application of this autonomous maintenance, a training plan is applied to all the collaborators in the maintenance team. Finally, Arena Simulation will be used to model the proposal.

C. Indicators

1) Computer Performance Rate

$$\%R = \frac{Nro\ Total\ units}{Operation\ time\ x\ Nominal\ Speed}$$

This rate measures the processing speed of the sealing machine. Currently, this indicator stands at 50.33%. Our goal is to increase it by at least 25%.

2) Overall OEE Equipment Effectiveness

$$OEE = \%\ Performance\ x\ \%Quality\ x\ \%Availability$$

This rate measures the Total Effectiveness of the Equipment with the 3 most important indicators of the machine. It is currently at 47.48%. Our goal is to increase it by 20%.

Own elaboration

3) MTBF

$$MTBF = \frac{Availability\ time - Inactive\ time}{Total\ stops}$$

This formula measures the average time between failures, together with the MTTR as the most relevant indicators in the application of preventive maintenance.

4) MTTR

$$MTTR = \frac{Total\ Maintenance\ time}{Total\ Repairs\ time}$$

The MTTR is found as one of the most used metrics in maintenance management, representing the average repair time.

5) Virtual Autonomy 5s

The result will be presented by 5 indicators: cleaning, order, discipline, select, safety, and hygiene. Those are measured by a poll, where each one is divided in 5 phases with an independent form, in addition, every answer is graphed in a set, in other words, the 5 indicators have a qualification, independent, and will be compared in a joint chart.

IV. VALIDATION

A. Initial Diagnosis

The current situation of the company is based on the collection of data in relation to the performance of the machinery. This diagnosis is displayed on a value stream map or VSM. It was determined that the main problem of the company is low income, which is directly related to poor performance and the production of defective products. The company's performance is below the industry standard performance at 44.67%, which is reflected in the low percentage of real revenue over percentage revenue. The company currently only generates 53.1% of what it could generate in an optimal scenario. Figure 2 shows the representation of the system proposed for simulation in the Arena Simulator.

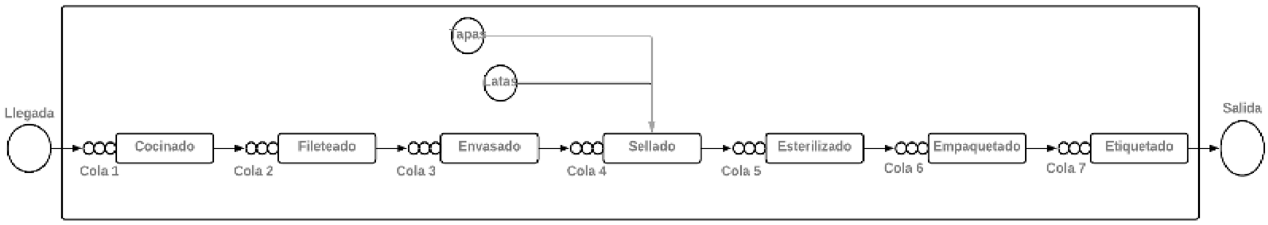

Fig. 2. Model proposed.

B. Validation design and Comparison with the initial Diagnosis

The proposed model was verified by Arena 16.10 software (performing simulation), where, was modeled, the total manufacturing process. In this way, by comparing the current indicators and the result of the simulation, the effectiveness of the proposal will be evidenced

C. Improvement-Proposal Simulation

To simulate the model, the data was first captured, in the case study it was how long it takes to produce 400kg of raw material. Secondly, the sand software was installed with the software input analysis installed which allows to know if the data captured in the first step the p-value is reliable, additionally, generating its distribution. Finally, the process was simulated, obtaining the following results.

Likewise, emphasizing that a 90% confidence and 10% margin of error were used, additionally, the software input analysis was used to accept a group of data to have a p-value greater than 0.05 in the chi-square and in the Kolmogorov-Smirnov test. As you can see in the following graph the distributions. Table 3 shows the distribution of the system processes to be entered into the Arena Simulator.

TABLE III. DISTRIBUTION VALUES

Process	Adjusted distribution
Cooked	NORM(2.8;1.01)
Filleted	NORM(6.07;0.928)
Package	UNIF(3.01;5.84)
Sealed	NORM(7.11;0.969)
Starring	UNIF(0.736;1.96)
Packaging	UNIF(0.906;5.37)
Labeling	NORM(7.03;0.978)

Based on these results, an improvement proposal was formulated, which was implemented in the Arena software to validate its effectiveness. As a result, a new return of 57.16% was obtained, which is only 37.85% below the industry standard yield. Table 4 shows the comparison of the diagnosis of the case study versus the expected results and the results of the simulation in Arena.

TABLE IV. COMPARISON MATRIX OF THE CURRENT SITUATION, EXPECTIVE AND RESULTS OF THE SIMULATION.

Indicator	As Is	To Be	Results
% Performance	50.33%	75.33%	57.16%
% OEE	47.48%	66.00%	53.93%

V. CONCLUSIONS

Due to the application of the 5s it was obtained, that the management of order and organization increased 12.45 ptos to 35.35 ptos on 50 ptos in the three months of research. However, in the first month it only increased 2.9 ptos, this is because these methods were new to the operators, and they had to go through an adaptation phase before obtaining the results of month 3. It is necessary to give time to this model to obtain satisfactory results.

It was demonstrated that the implementation of the 5S model served as the basis for the implementation of the chosen pillars of the TPM. Some methods of the 5S were also used in autonomous maintenance. For example, theschedule established for cleaning was also used for the inspection of the machines.

In the implementation of 5S the evaluation test increased from 2.7 ptos to 7.3 ptos from month 0 to month 3. There was great commitment from the group after the adaptation. In addition, greater creative participation is expected from this group.

The simulation of the implementation of the designed proposal demonstrated an improvement in the performance of the sealer production process. This improvement is reflected in the absolute increase in yield by 6.83%, as well as in the absolute increase in OEE by 6.45%.

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