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The Application of Lean Manufacturing for Standardization of the Canned Chicken Production Process in Peru Food Companies

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Abstract

In Peru, chicken is one of the most consumed foods in all regions. Due to the constant increase in population, chicken production is increasing in the country. For this reason, a food company must improve its efficiency to satisfy more customers and reduce its costs per productive unit without reducing its quality. The research can be useful to canning companies as well as companies where their machines suffer from many failures within production due to a lack of maintenance planning and worker training. The model used is based on two methodologies: 5S and TPM. These methodologies reduced the total production time per batch by 8% and improved the utilization rate by 7 percentage points. The use of these tools helped reduce corrective maintenance time and standardize processes to avoid recurring equipment failures.

Keywords
Lean manufacturing, food industry, machine performance, TPM, 5S.

1. Introduction
In Peru, the population is expected to reach 35,792,079 inhabitants by 2030 (INEI ,2019), this will generate a growing demand for food locally. The investigation focuses on a food company with more than 70 years in the Peruvian market, specializing in the production of canned foods and fruits. The main product of this research is canned chicken, its consumption in the country reaches 48 kg per capita annually. (MINAGRI, 2022). Companies within the sector grow at an accelerated pace, which means that they face different challenges in their daily operations; the use of lean tools becomes more common to adapt to a volatile environment. This research seeks to increase the performance of the process using different tools of the lean manufacturing philosophy.

Lean manufacturing is a methodology that aims to improve performance, use fewer resources (Alefari and Salonitis, 2020), and eliminate inefficiencies (Vieira and Lopes 2019). The implementation of Lean manufacturing became known thanks to the Japanese company TOYOTA, which aimed at operations with reduced cost and zero waste. (Ospina 2021). Lean tools have generated a wave of productivity, increasing the performance of the production system (Banga et al. 2020) and reducing waste (Suhardi et al., 2019). Además, Maware, and Adetunji (2019) consider that lean manufacturing has emerged as a powerful approach that is being used by companies in developing countries to improve their operations and reduce manufacturing costs for their products while maintaining high competitiveness. Productivity in companies is affected by downtime between activities (Sabadka et al. 2017).

According to Salma et al. (2021), lean manufacturing is governed by five principles to increase the value of the product: define value (that is, what creates value for consumers), identity value flows (means having mapped the activities that the product goes through in order to define which whether or not they add value to it), maintain a continuous flow (this means standardizing the processes so that the flow of materials occurs without problems), establish a traction system (this means that flexibility must be gained to base production on the customer demand) and strive for perfection (refers to continuous improvement and striving for perfection to eliminate waste). On the other hand, Guzel and Shahbazpour (2021) mention the most recognized Lean methodology are the Value Flow Map: This serves to identify the activities that add or subtract value in production throughout the main flow of each product; Kaizen: It is used to raise awareness and identify production problems and 5S: It is a Japanese technique that is used to organize jobs in a safe and efficient way to increase productivity.

In this article, the implementation of two lean tools will be developed to improve plant performance. The current production system and post-implementation improvements will be evaluated. Finally, a simulation model will be carried out to quantify the improvement and the effect that would be had on the different parts of the process.

1.1 Objectives

This study seeks to increase the performance of the machines within the canned chicken production process in the factory using lean manufacturing tools. To achieve this, some objectives must be met that will be presented below.

1. Prepare a diagnosis of the process and identify opportunities for improvement.
2. Create improvement proposals considering the tools of the lean manufacturing philosophy.
3. Create a simulation of the proposal, calculating the effect of the tool and the significant improvement it generates.
4. Carry out a comparison of process times with the simulation results and quantify the improvement.

2. Literature Review

The basis for the literature review is Lean Manufacturing (LM). From this, different related articles were found to increase knowledge about the tools and know the author's points of view about the application. For the effective search of papers, two databases were used: Scopus and Web of Science. In each one, different search equations were carried out to discard irrelevant papers. There were three fundamental tools for the development of the research.

Firstly, total productive maintenance, better known as TPM, is a tool that ensures the proper functioning of machines by avoiding accidental stops. This tool should be seen as a requirement in continuous flow process activities (Farissi et al. 2021). Secondly, value stream mapping (VSM) is an appropriate tool for analyzing the value of different activities. Helps visualize cycle times, human resources, inventory and information flow at each stage of the process. It is also a valuable tool for diagnosing and solving problems. (Daniyan et al. 2022). Finally, 5S is a method of organizing the workspace whose name comes from 5 Japanese words: seiri, seiton, seiso, seiketsu and shitsuke. Translated into English it would be classification, order, cleanliness, standardization and discipline. This tool takes two different perspectives, on the one hand, it is an organization improvement strategy related to efficiency and work conditions. On the other hand, it is a tool to eliminate waste. (Vieira & Lopes 2019).

3. Methods

In this section the methodology carried out to reach the results will be reviewed. A simulation of the canned chicken production process will be built according to the data obtained from a factory located in Lima, Peru. First, the plant was visited to gather information about the process and pain points. The plant manager gave us a detailed explanation of the machines and the most significant problems in his daily work. With this explanation we prepared the operations diagram of the canned chicken process that can be seen in figure 1. Thanks to the information provided and the comparison with the literature reviewed, we recognized that the most appropriate tools to increase production performance were TPM and 5S, since the main pain point found was frequent machine failures throughout the process. According to Condo et al., (2022) the TPM methodology focuses on maintenance management by introducing management by introducing different tools to meet the TPM pillars that, according to the research, are selected in order to reduce selected with the purpose of reducing times and rejections of non-conforming products, achieving the increase of quality, performance and quality, performance and availability factors.

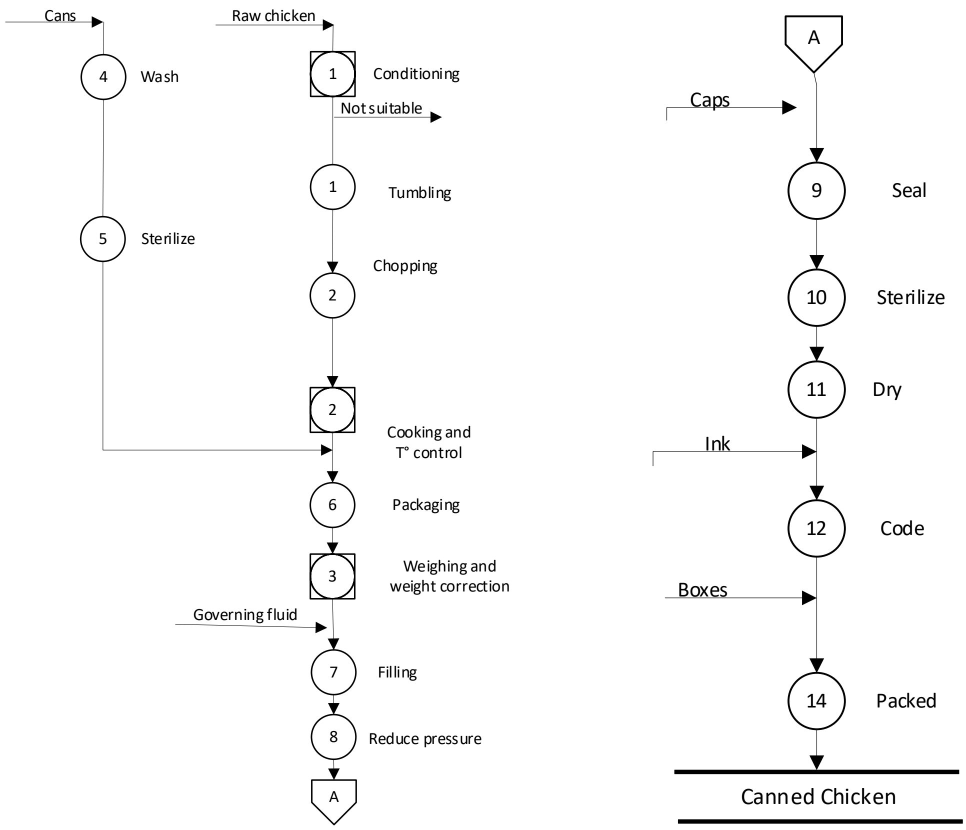


Figure 1. Diagram of operations of the canned chicken production process.

Using the operations diagram of the process, the simulation model was created in Arena software to measure the indicators in the most significant activities according to the interview with the plant manager.

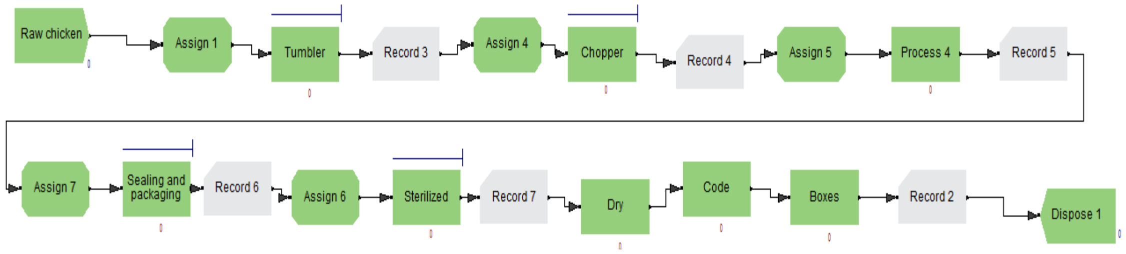


Figure 2. Process simulation model

Once the simulation model was prepared with the company's data, the parts of the process and the machines that would receive an improvement according to the tools to be implemented were selected. In this case, the most significant TPM improvements would be in the tumbler and the packaging machine since the failures of these machines would be dealt with. Then, the failures that would be solved or mitigated with the tools were determined in conjunction with the plant manager according to their experience and knowledge. It was determined that for the tumbler breakage, training the employee in charge of the machine would be key to not forcing the machine and not causing the failure. In addition, reinforcing the machine's breakage zone before starting production and with regular maintenance would prevent it from happening during the process.

Corrective maintenance will be changed to preventive maintenance, which will decrease the total production time due to the delay. In addition, it was determined that for shaft breakage, training would also be a key factor since the shaft breaks due to overloading of the machine by the operator. On the other hand, it was determined that the out-of-calibration of the packaging machine would still be a machine failure, but it would occur less frequently and would be attended to more quickly since the operator would be trained to attend this failure. The 5S would also help to maintain order and cleanliness in the factory to reduce accidents, increase operator efficiency, and standardize manual processes.

	Name	Type	Up Time	Up Time Units	Count	Down Time	Down Time Units
1	Breakage tumbler	Time	UNIF(215,250)	Minutes	UNIF(215,250)	UNIF(30,36)	Minutes
2	Packaging machine decalibration	Count	1.0	Minutes	UNIF(3,4)	UNIF(35,55)	Minutes
3	Axis tumbler	Count	UNIF(Min , Max)	Hours	UNIF(8,10)	UNIF(80,120)	Minutes

Figure 3. Mains machine failures

Figure 4 shows the desired scenario through the implementation of the tools.

	Name	Type	Count	Down Time	Down Time Units
1	Packaging machine decalibration	Count	UNIF(12,16)	UNIF(15,25)	Minutes

Figure 4. Desired mains machine failures

The number of replicates to be used in the simulation was calculated to compare the indicators of the current scenario and the desired scenario.

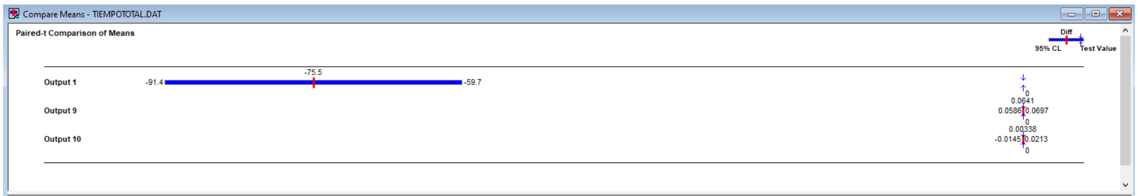
n: number of replicates of the sample
s: standard deviation of time
e: error (time)

$$\textbf{Number of replicates} = \frac{\textbf{Student's T(n-1, confidence level) * standard deviation of time}}{\textbf{error (time)}}$$

$$\frac{2.1448 \quad * \quad 19.7\ \text{min}}{3\ \text{min}} = 15$$

Figure 5. Sampling calculation formula

A paired means analysis was performed with a 95% confidence level for the indicators: total process time, percentage of tumbler utilization and percentage of packer utilization. Thanks to this, it was validated that there is evidence to affirm that the average total production time per batch improves, the percentage of tumbler utilization improves and that the percentage of utilization in the packaging machine does not have a significant change.

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        Paired-T Means Comparison :

    IDENTIFIER         ESTD. MEAN   STANDARD  0.950 C.I.    MINIMUM    MAXIMUM  NUMBER
                       DIFFERENCE  DEVIATION  HALF-WIDTH      VALUE      VALUE  OF OBS
-------------------------------------------------------------------------------------
Output 1                    -75.5       28.6        15.8        835        893      15
                                                                897        987      15
        REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
Output 9                   0.0641     0.0101     0.00557      0.743      0.757      15
                                                              0.673      0.702      15
        REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
Output 10                 0.00338     0.0323      0.0179      0.385       0.46      15
                                                              0.376      0.469      15
        FAIL TO REJECT  H0 => MEANS ARE EQUAL  AT  0.05 LEVEL
```

Figure 6. Paired T- Comparison of Means

4. Data Collection

To gather the necessary information for the simulation, a document was shared with the machine operator to be filled out by the person in charge of each machine to obtain a varied sample of many batches. The document requested the date, start time and end time, the quantities produced, the waste, the reason for failure, if any, and the person in charge of the machine. In the case of finding samples that were too dispersed due to atypical errors, they were discarded from the sample. Format to be filled in for the tumbler.

Autoclave	Start time	Stop time	Restart time	End time	Reason for stop	Q of cans produced or other unit of measure	Q of discarded cans or other unit of measure	Person who used it
25/09/2023	09:55			11:46		3980	0	WALDO GONZALES
25/09/2023	12:00			13:57		4453	0	WALDO GONZALES
25/09/2023	15:05			17:02		4309	0	WALDO GONZALES
25/09/2023	17:14			19:12		4309	0	WALDO GONZALES
26/09/2023	10:09			12:02		4108	0	WALDO GONZALES
26/09/2023	12:17			14:18		2091	0	WALDO GONZALES

Figure 7. Data Collection Form

5. Results and Discussion

5.1 Numerical Results

The machine failure maintenance times of the two scenarios were compared in table 1 and their performance indicator.

Table 1. Machinery failure comparison

Failure	Tumbler breakage		Tumbler shaft breakage		Packaging machine decalibration	
	Before	After	Before	After	Before	After
Corrective maintenance time	33 min	-	102 min	-	40 min	20 min
%Utilization	68.70%	75.10%	68.70%	75.10%	42.80%	42.90%

In the statistical analysis of the percentage utilization of the tumbler, an improvement of 6 percentage points is seen. This improvement in percentage utilization positively affects the cycle time of the canned chicken and increases the OEE (Overall Equipment Effectiveness) of the system. However, it does not reach 90% levels for both cases. This is mainly because the total productive maintenance does not remove the manual labor that causes the delay in the use of the packaging machine and in the case of the tumbler, the main delay is due to the loading of the 300 kilograms of chicken per batch in the machine.

The indicators of the two simulation scenarios were compared in Table 2.

Table 2. Simulation indicator comparison

Indicator	Before	After
Total production time	945 min	870 min
% Utilization tumbler	68.70%	75.10%
% Utilization packaging machine	42.80%	42.90%

It is statistically demonstrated that the total cycle time had an improvement due to the applied changes. Also, the utilization of the tumbler has a statistically proven significant improvement. However, the sealer did not have a significant effect on its utilization, since statistically the utilization averages are equal.

5.2 Proposed Improvements

One of the problems seen during the visit was the management of cleanliness, possible accidents and lack of organization, the machines were in good condition. Nevertheless, they were found with chicken scraps on the floor or on the machine itself. The floor was wet throughout. There were no designated spaces for tools. There was also no delimited area for storing boxes of finished product on one side of the machine. There was a lack of visualization of processes and areas in substandard conditions. 5S should be implemented to improve these common errors in the plant, since according to Schindlerová et al. (2020) the control and recognition of risks through efficient and effective maintenance based on autonomous maintenance is fundamental.

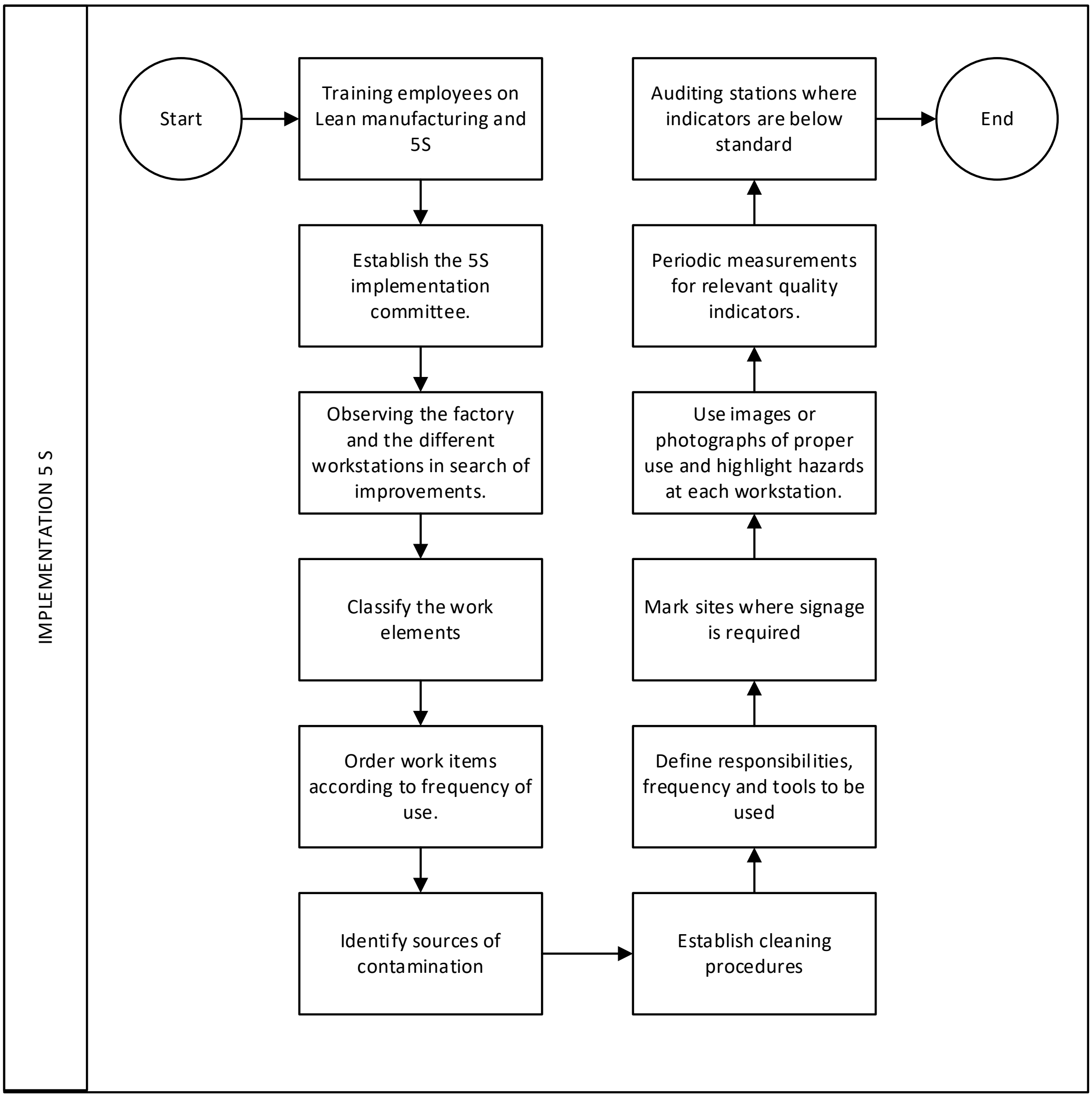

Figure 8. 5S implementation at the plant

One of the main problems with the tumbler is that the base of the tumbler breaks with movement. This means that at the start of each routine it must be welded so that it does not break during the process. There is even the possibility that it may break during use and the process must be stopped to weld the base. Also the shaft breaks from time to time and this causes production to stop completely during the day.

Another major problem is in the packing machine, which fills the cans with chicken according to a set weight range. However, it continually fails and must be calibrated weekly so that the amount of chicken does not exceed or fall short of the required amount per can. It is found with chicken residue on the outside and wet.

Maintenance should be scheduled according to the supplier's specifications and the history of machine failures in order to take corrective actions before a machine failure occurs. One of the proposals for improvement is autonomous maintenance so that the operator in charge of operating the machinery operates it correctly in activities such as cleaning and tidying, calibration, adjustment, identification and repair of minor failures.

Table 3. TPM implementation plan

Activities What?	Who?	How?	Where?	Why?
TPM Training	Production manager, collaborators and work team.	Explain the advantages of using TPM on production and the benefits of using this methodology.	In a canned food production company	Employees must understand the methodology for a correct implementation.
Establish a committee in charge of TPM implementation.	Production manager, collaborators and work team.	Select operators who are willing and experienced with the machines.	In a canned food production company	For a successful TPM implementation
Autonomous maintenance	Production manager, collaborators and work team.	Designate persons in charge of each machine and train them in their maintenance.	In a canned food production company	Cost and time are saved every time the machine has simple failures.
Preventive maintenance	Production manager, collaborators and work team.	Set up a schedule to coordinate preventive maintenance for each machine.	In a canned food production company	To prevent machine failures before they occur.
Predictive maintenance	Production manager, collaborators and work team.	Use tools to measure the condition of parts that need to be changed on a regular basis	In a canned food production company	Predicting when a part will fail will reduce downtime and save costs.
Place in the initial state of the line	Production manager, collaborators and work team.	The machines must be cleaned and in their original condition	In a canned food production company	To find flaws and thus avoid failures or accidents.

The step-by-step for the implementation of TPM in the plant is shown in Table 3 it is important to select partners who will support you in implementing a different way of working, as they will provide you with valuable information about internal problems. Also, Dora et al. (2020) mentioned that lean implementation requires an initial investment concerning training, hiring external consultants, providing materials for visual management, and allowing key employees to take responsibility. These are critical elements for the SMEs and need close attention from the top management.

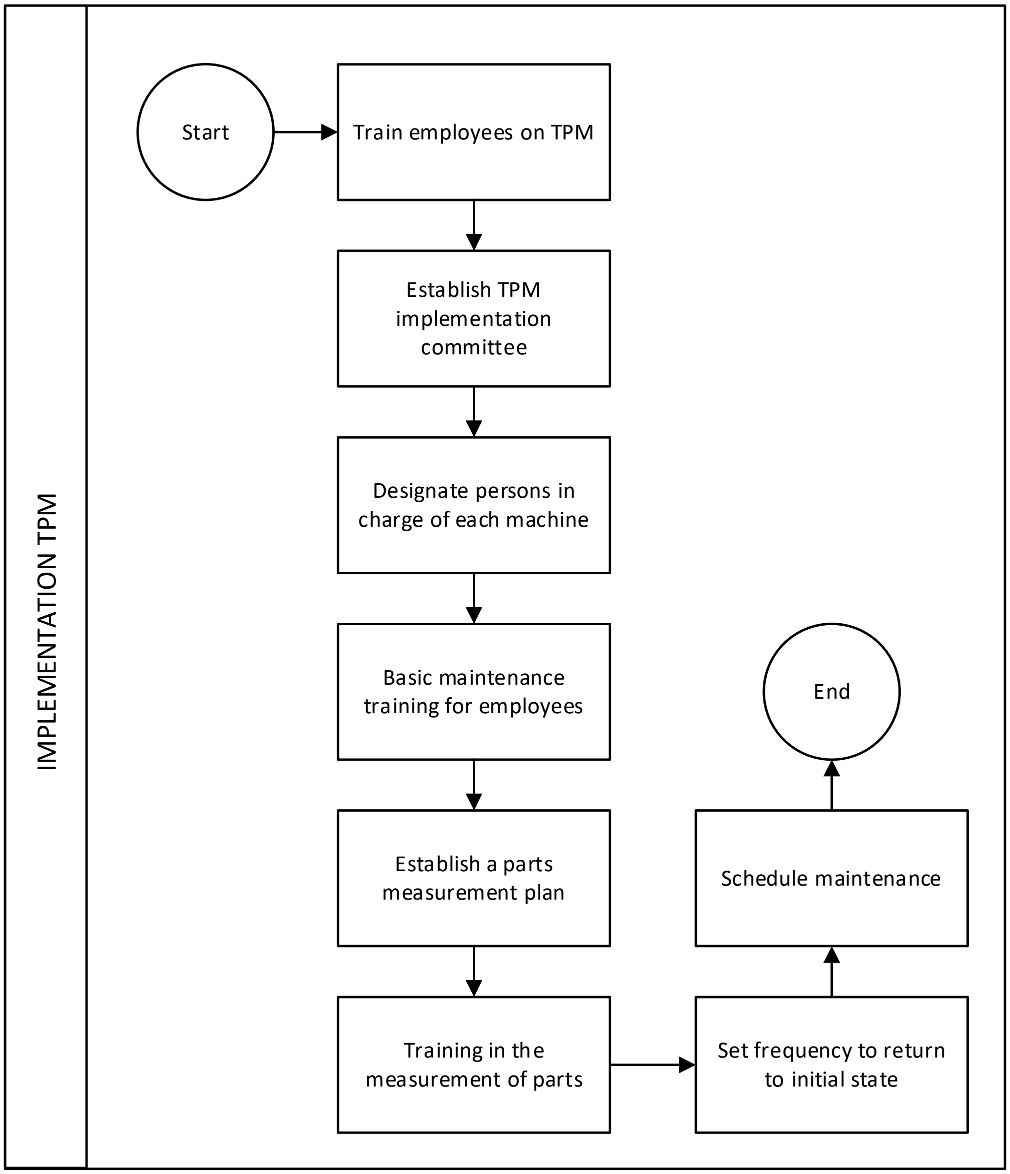

Figure 9. TPM implementation at the plant

6. Conclusion

The main problem was machine failures since the equipment became bottlenecks due to recurring errors in short periods of time. Due to comments received from the plant manager, two machines were identified as causing the most problems: the tumbler and the packaging machine. After simulating the implementation of the tools with the improvements according to the feedback received from the plant managers, the utilization percentage in the packaging machine did not improve and in the tumbler there was an improvement from 68% to 75%, however, applying the tool improved the total production time per batch by 8%. TPM and 5S were useful in improving time, however, most of the causes that caused waste in the different processes were not affected and this is proven by the fact that there was no significant difference in the tumbler indicator before and after. It was necessary to use another tool to improve the loading times of the machines since moving all this material involves a significant delay due to the large number of batches.

The improvement in times and indicators could have been greater by using tools to identify the root causes of waste and thus have greater precision in choosing the most effective tools for each part of the process that needs improvement.

Because it is a simulation, the results expected according to the research could vary in a real implementation. There are other factors that also influence the implementation that could worsen or improve the expected results, such as employee motivation and management support.

References

Alefari, M., Almanei, M., and Salonitis, K., Lean manufacturing, leadership and employees: the case of UAE SME manufacturing companies, *Production & Manufacturing Research*, vol. 8, no. 1, pp. 222-243, 2019.

Banga, H. K., Kumar, R., Kumar, P., Purohit, A., Kumar, H., and Singh, K., Productivity improvement in the manufacturing industry by lean tool, *Materials Today: Proceedings*, vol. 28, no. 3, pp. 1788-1794, 2020.

Condo, R., Cruz, L. and Quiroz, J. Increased equipment performance in agro-industrial companies through a maintenance model based on the TPM approach. *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, Florida, USA, July 18-22, 2022.

Daniyan, I., Adeodu, A., Mpofu, K., Maladzhi, R., and Kana-Kana Katumba, M., Application of lean Six Sigma methodology using DMAIC approach for the improvement of bogie assembly process in the railcar industry, *Heliyon,* vol. 8, no. 3, pp. xx-xx, 2022.

Dora, M., Kumar, M., and Gellynck, X. Determinants and barriers to lean implementation in food-processing SMEs - A multiple case analysis. Production Planning and Control, vol. 27, no. 1, pp. 01–23, 2016.

Farissi, A., Oumami, M., and Beidouri, Z., Assessing Lean Adoption in Food Companies: The Case of Morocco, *International Journal of Technology,* vol. 12, no. 1, pp. 05-14, 2021.

Guzel, D., and Shahbazpour Asiabi, A., Increasing Productivity of Furniture Factory with Lean Manufacturing Techniques (Case Study), *Tehnički Glasnik,* vol. 16, no. 1, pp. 82-92, 2022.

Instituto Nacional de Estadística e Informática. PERÚ: Características Económicas y Financieras de las Empresas Manufactureras, Available: https://cdn.www.gob.pe/uploads/document/file/3444615/Per%C3%BA%3A%20Caracter%C3%ADsticas%20Econ%C3%B3micas%20y%20Financieras%20de%20las%20Empresas%20Manufactureras.pdf, Accessed on Nov 30, 2023.

Maware, C., and Parsley, D., The Challenges of Lean Transformation and Implementation in the Manufacturing Sector, *Sustainability (Switzerland),* vol. 14, no. 10, pp. xx-xx, 2022.

Ministerio de Desarrollo Agrario y Riego. BOLETÍN ESTADÍSTICO MENSUAL, Producción y comercialización de productos avícolas, Mes; diciembre 2022, Available: https://www.gob.pe/institucion/midagri/informes-publicaciones/2881345-boletin-estadistico-mensual-del-sector-avicola-2022, Accessed on Nov 30, 2023.

Ospina Jiménez, L. A., Design of a comprehensive methodology for the lean manufacturing implementation in the colombian context, *Ingeniería Solidaria*, vol. 17, no. 3, pp. 1-30, 2021.

Sabadka, D., Molnar, V., and Fedorko, G., The Use of Lean Manufacturing Techniques – SMED Analysis to Optimization of the Production Process, *Advances in Science and Technology Research Journal*, vol. 11, no. 3, pp. 187-195, 2017.

Salma, A., Anas, C., and Mohammed, E., Bibliographic Study on the Difficulties Encountered by SMEs during the Implementation of Lean Manufacturing, *Journal of Advanced Manufacturing Systems*, vol. 20, no. 1, pp. 163-190, 2021.

Schindlerová, V., Šajdlerová, I., Michalčík, V., Nevima, J. and Krejčí, L. Potential of Using TPM to Increase the Efficiency of Production Processes. *Tehnički vjesnik*, vol. 27, no 3, pp. 737-743, 2020.

Suhardi, B., Anisa, N., and Laksono, P., Minimizing waste using lean manufacturing and ECRS principle in Indonesian furniture industry, *Cogent Engineering*, vol. 76 no. 1, pp. 1-13, 2019.

Vieira, S. and Lopes, R., Improving production systems with lean: A case study in a medium-sized manufacturer, *International Journal of Industrial and Systems Engineering*, vol. 33, no. 2, pp. 162-180, 2019.

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