14th Annual International Conference on Industrial Engineering and Operations Management Dubai United Arab Emirates (UAE), February 12-14, 2024

Publisher: IEOM Society International, USA
Published: February 12, 2024
DOI: 10.46254/AN14.20240028

Maintenance Model Based on Lean and TPM to Increase Machine Availability in an SME in the Plastic Sector

Jorge Sebastian Abad-Mendoza
Faculty of Engineering and Architecture, University of Lima, Perú
20182194@aloe.ulima.edu.pe

Miguel Angel Palga-Condori
Faculty of Engineering and Architecture, University of Lima, Perú
20183027@aloe.ulima.edu.pe

Martin Fidel Collao-Díaz
Research Professors
Faculty of Engineering and Architecture, University of Lima, Perú
mcollao@ulima.edu.pe

Abstract

The plastics industry has grown in recent years due to growing demand in sectors such as construction and transportation, contributing 4% of the industrial GDP and employing more than 200,000 workers in the country. However, it has been identified that companies in the sector operate with low availability (70.83%) due to various production problems, including hours lost due to lack of machine maintenance. On the other hand, because of these problems, demand exceeds supply due to the low availability of the companies in the plastics sector. The literature review suggests that Lean Manufacturing (SMED, Standardization of Work, 5S) and the TPM (Total Productive Maintenance) technique are necessary tools to solve these problems. Finally, the implementation of these tools will allow solving the mentioned problems by increasing availability by 90%.

Keywords
Lean Manufacturing, 5s, Total Productive Maintenance, Injection machine

1. Introduction

The Manufacturing Sector is important for the Peruvian economy, with a contribution of 17% to PBI and employing 8.9% of the employed PEA. Raw materials for manufacturing production can come from various industries. The sector is divided into Primary and non-Primary Manufacturing, with the latter made up of Consumer Goods, Intermediate Goods, Capital Goods and Industrial Services. The manufacturing of plastic products is 18% of non-primary manufacturing production (INEI, 2022). The production process has different activities that can have problems, such as accidents or deficiencies in machinery, which can negatively affect production. In addition, it is mentioned that demand is greater than supply due to low production in the plastic sector, which is partly due to the lack of maintenance of the machines (Ames, V. et al., 2019). On the other hand, there is research that has identified problems in other countries, such as lack of stock during tool change in a company in India (Ahmad et al., 2018), Another case study from Portugal is presented that shows a diagnosis of the company regarding machine failures and how they affect production processes, in this way it seeks to optimize processes and increase availability through the measurement of indicators. MTTR, MTBF and OEE (Pinto et al., 2020), a study carried out in the United States says that the problem is that the machine overheats, generating cooling problems (Farahani et al., 2022) and a case study from the United Kingdom states that the problems that the authors want to solve are to improve overall performance and increase productivity because they have 6 drawbacks: stops, equipment breakdowns or failures, configuration and adjustment, reduced speed, defects in the process and reduced performance (Ahmad et al., 2018). The objective of the research is to find solutions to improve availability and reduce downtime in the plastic sector. It is crucial for companies in the plastics industry to consider the problems detailed in this work to improve their efficiency and meet high demand. The study focused on machinery shortages, caused by long setup times, frequent maintenance, and lack of technical knowledge. To address these issues, an improvement model was created that combines TPM, Lean Manufacturing, maintenance management, and work standardization, enabling employee engagement and fostering a culture of continuous improvement. This model was based on recurring problems found in the literature and in current organizations and is applied to a continuous production line. Since there is little research in the plastics industry, this research offers new and valuable solutions to address these problems. The scientific articles reviewed contain little information on "Lean Manufacturing" and "Total Productive Maintenance (TPM)" work models for this type of companies, especially in Latin America. For this reason, the need arises to carry out this investigation.

1.1 Objectives

The study aims to demonstrate that applying the production method based on Lean - TPM increases the efficiency of injection activity in plastic companies. Firstly, through the time study, unproductive times and machine stops will be identified; Secondly, TPM and the 5's will be applied to the injection activity and finally the technical and operational feasibility of their implementation will be identified.

2. Literature Review

2.1. Model or Maintenance Management in the plastics industry

Industries must take into account the maintenance model or management, as (Córdova et al., 2022) proposes in this work is a dual-focus optimization design aimed at improving both the production process and the operating conditions. work and the well-being of workers. Also, motivate and recommend the application of the same approach to improve the performance of other production lines that aim to improve the efficiency of their lines, increase the availability and quality of their products (Bataineh et al., 2019). Likewise, to show the importance of machines regarding their efficiency to achieve optimal production and reduction of downtime (Zennaro et al., 2018). Even show what type of failure is generated, in order to increase availability through an experimental design with the MTTR and ANOVA tests (Kong et al., 2021). On the other hand, explore whether a machine-to-machine approach, in which multiple work systems share process data, can be used to improve the accuracy of the fault detection model (Vrabicˇ et al., 2017). Finally, a standard procedure is set up to perform machine calibration in the development of injection molding products and the difference between prediction by simulation and experimental observation is discovered (Huang et al., 2020).

2.2. Lean Manufacturing (SMED, Standardized Work, 5S)

The authors propose the implementation of LEAN tools and concepts with the objective of studying the way in which LEAN practices can contribute to improving the indicators of companies in the manufacturing of plastic packaging (Vieira et al., 2022). Also, (Vega, Melany & Quiroz, Juan, 2022) proposes a maintenance management model based on Lean Manufacturing, which integrates the tools of SMED, TPM, 5S and Jidoka. Furthermore, (López et al., 2022) proposes an optimization model based on the Johnson Method to optimize the productive sequence of work orders, then implement the SMED technique and the pillars of TPM. Likewise, (Quiroz-Flores, JC & Vega-Alvites, ML, 2022) comments that the tools that help reduce delivery times to customers are: SMED (Single Minute Exchange of Die), TPM (Total Productive Maintenance), 5S, KAIZEN and Jidoka. On the other hand, in Turkey the implementation of SMED in the ABC company of the electronics industry was to improve the plastic frame for television production (Cakmakci, M. & Demirel-Ortabas, N., 2019). Even (Bidarra et al., 2018) seeks to improve configuration times by transforming internal activities into external ones, using the SMED methodology. Otherwise, (Yazıcı et al., 2020) presents a new model mixing SMED and fuzzy FMEA tools, to improve preparation times. Likewise, (Ribeiro et al., 2019) make known the activities of each worker for the configuration of the machines, through sequential booklets. Subsequently, SMED demonstrates its importance in optimizing production flow, eliminating bottlenecks and late deliveries (Realyvasquez et al., 2019). In short, (Bhade et al., 2020) Lean Manufacturing is used as SMED to improve the OEE of a machine to improve the production of any company. Finally, it allows the classification and identification of activities that do not generate value for the company to achieve an improvement in availability and reduce costs (Singh et al., 2020).

2.3. Total Productive Maintenance (TPM)
Total Productive Maintenance allows reducing the main losses that are considered significant in production processes, these include losses due to equipment failures, configuration losses, as well as adjustments due to high downtime losses, start-up losses and losses due to defects (Peralta et al., 2020). At the same time, it has fundamental pillars such as autonomous and preventive maintenance, which are key to achieving an increase in the efficiency of equipment in any production process, as well as other pillars such as planned maintenance, quality maintenance, education and training, safety, health and environment, office TPM and development management (Tortorella et al., 2021). In this way, it is based on a Lean tool that promises continuous and rapid improvement in the manufacturing process, involving workers by training them in the use of preventive methods with maintenance concepts (Dennis et al., 2018).

3. Methods
It is proposed to implement a model to solve low availability problems in a company in the plastics sector. Data must be collected from the machines and operators. After analysing the data, several tools are proposed, including 5S and SMED, to eliminate downtime and waste, standardize and reduce unnecessary activities, and improve operator performance. TPM techniques and Lean methodologies are implemented, and the process is standardized through the Bizagi tool.

Finally, the indicators of the model are evaluated to compare them with the initial situation and demonstrate the results obtained. Figure 1 shows the model proposed to the company.

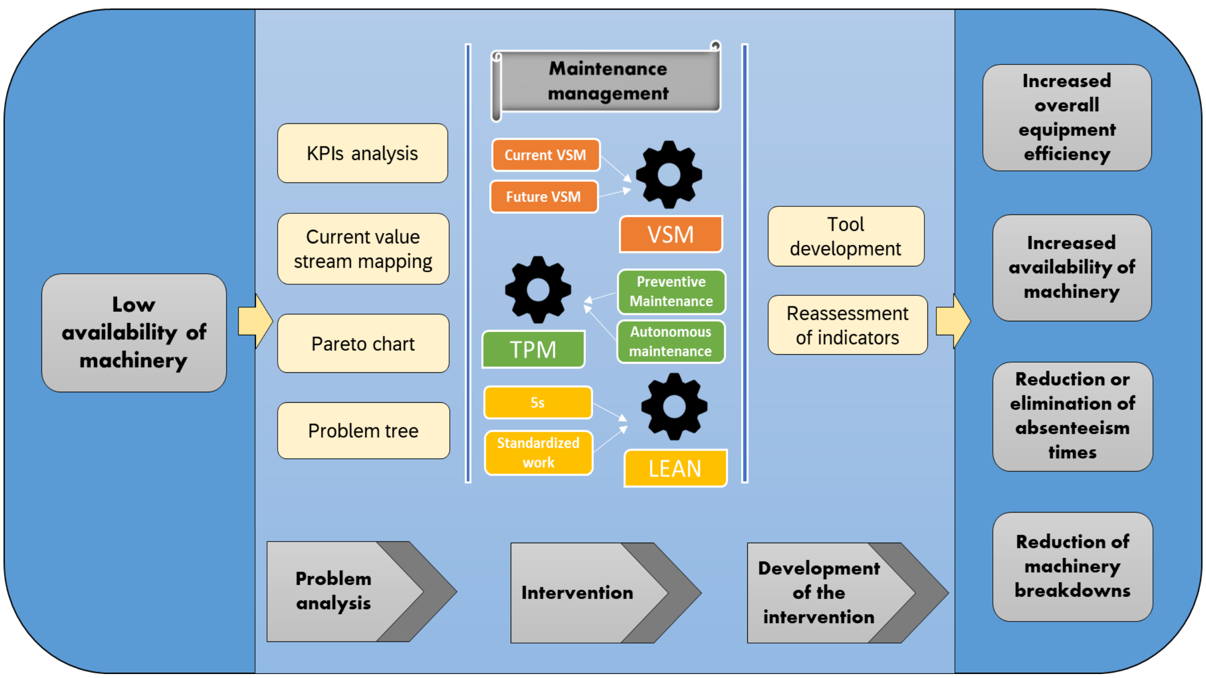

Figure 1. Proposed model

3.1. Component 1: Problem analysis.
The proposal is made by collecting and evaluating the data of the different machines and the management of the personnel that follows in the work area, for example, operating time, the available time that is available during a period of time, the operating time, the quantity of inputs and outputs that are in the machines, how many reprocesses exist in them, number of products that come out of the process in a defective way, as well as the operators with the days of absenteeism, the number of operators working within the area of work (inputs) so that the indicators proposed in this investigation can be measured and calculated, so that complete information on the current situation of the company can be obtained.
Next, with this an analysis is made through a Value Stream Mapping with which it can be evaluated to create value, that is, to understand the stages that are developed within the company so that the information obtained is known in indicators. With this, the most important problem is understood for which the possible reasons that cause it must be

evaluated so that to know its importance or relevance the Pareto diagram is used, with which the magnitude of these can be understood and thus to be able to delve into the root causes that cause the main problem.
Finally, the problem tree is developed with which both the main problem, the economic impact, the technical gap, the reasons and the root causes are schematized, with which the techniques and tools that can be applied can be observed and analysed. and implement to mitigate or eliminate it.

3.2. Component 2: Intervention.
The second component of the model focuses on the application of proposed techniques such as Total Productive Maintenance (TPM) and Lean Manufacturing (SMED, Standardized Work, 5S) which were previously selected to solve the main problem and its root causes. In addition, these techniques will be implemented considering a certain period of time so that their effectiveness can be reassessed within the objectives outlined through indicators, which have also been initially evaluated, so that there is a basis for comparison and how to proposal will be developed.
Regarding the Total Productive Maintenance (TPM) strategy, this will be developed using some of its pillars such as Autonomous Maintenance, Planned Maintenance and focused improvements (Kaizen) which will help us to apply the main problem in the best way. On the other hand, it will be developed through the application of tools which are important such as 5S, which helps us to improve the development and flow of processes within the work area.
With respect to Lean Manufacturing (SMED, Standardized Work, 5S), this is a transversal tool since it impacts the entire development of the model, that is, it becomes a basis for how the other techniques will be implemented, so it can be considered as a pillar within the entire model. All this will be applied in order to increase the availability of machinery for the case study, which is the main problem.

3.3. Component 3: Validation
Finally, the development and implementation of the intervention focuses on the comparison between the indicators evaluated at the beginning with the indicators obtained at the end of the implementation. To achieve this, these data obtained at the beginning and at the end are evaluated in a simulator and thus evaluate the results and impacts of the applied tools and techniques.

4. Data collection
The data collection consisted of obtaining and measuring information from various sources that will allow a complete evaluation, where a series of tools such as surveys and interviews were used to receive information about the activities and techniques carried out in the tapas production area. , as well as the Pareto to determine the most critical problems in the area and the problem tree to identify the main causes. Once the information was collected, it was determined that it was feasible to use tools such as preventive maintenance referring to a pillar of the TPM, 5's, standardized work and within it the time study. Figure 2 shows the step-by-step process to obtain the results of this research.

4.1. Implementation of 5S and Preventive Maintenance
4.1.1. Pilot Plan
A pilot plan was carried out to demonstrate the validation of the 5S tool in the injection area because it is considered a critical area where operators spend a long time looking for the tools due to considerable disorder.

5s audit in the injection area
The initial audit was carried out in order to evaluate the level of the 5S and it was possible to identify the areas that require improvements. As part of this methodology, a brief training was given to workshop employees about the importance of this tool.

4.1.1.1. First S: Classify
The first phase of this tool consisted of classifying; Therefore, a red card was used to improve the management of tools and molds in the work area. In this way, the tools that were and materials that were disordered on the worktable were relocated without using them, in the same way, unnecessary elements were identified (items in poor condition, unknown and that do not belong to the work area). In the following images, you can see the situation of the warehouse, after implementing the improvement (Figure 3).

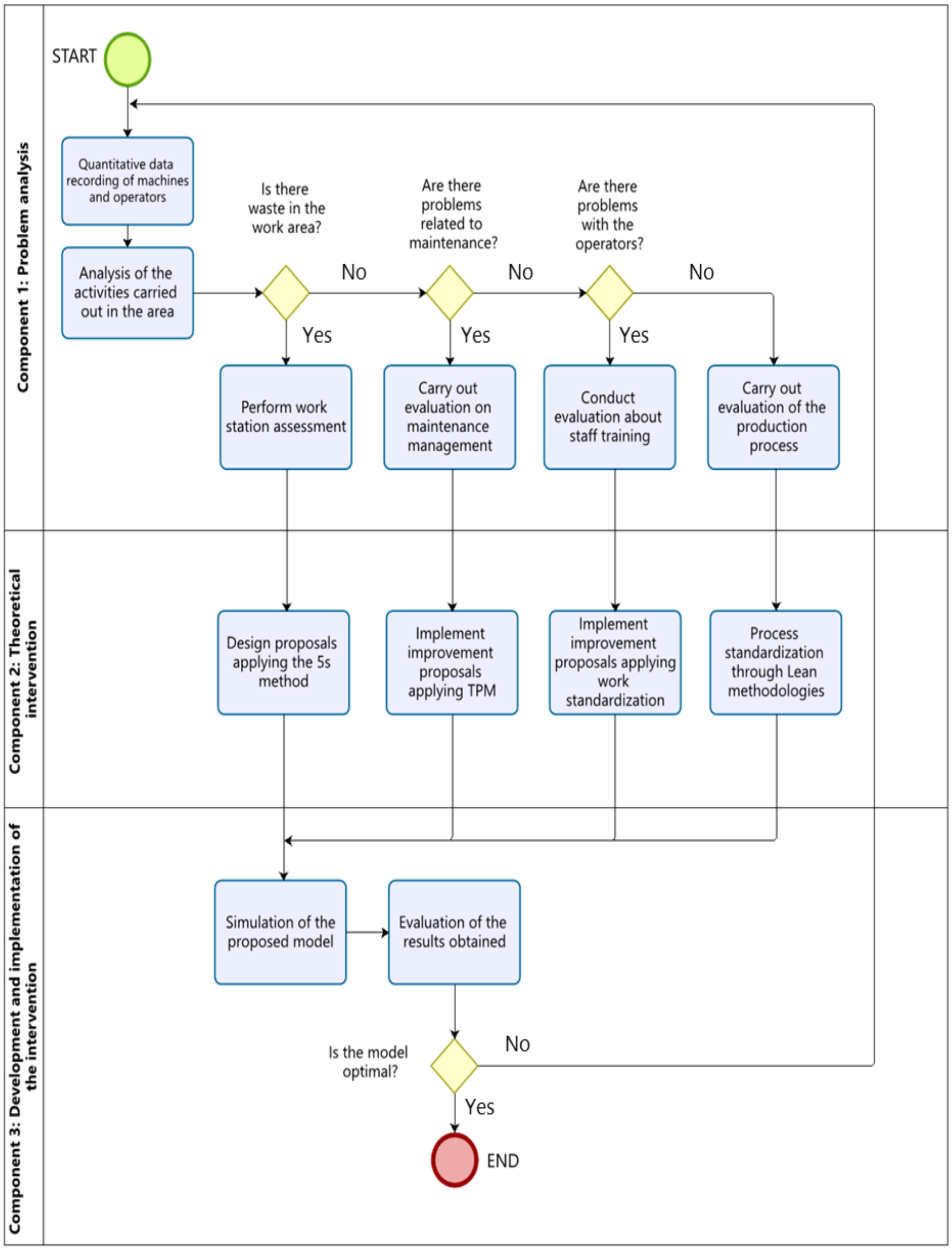

Figure 2. Diagram of the results

Figure 3. Messy tools (before and after)

4.1.1.2. Second S: Organize

The second S deals with how the bags and sacks used to pack the lids and also the other bags that are for another product manufactured in the same plant (20lt drums) were organized. On the left side of the metal shelf, the bags will be located to facilitate passage. In addition, some printed sheets were placed to determine the space that each material should occupy (Figure 4).

Figure 4. Ordered metal shelf Strategic space (before and after)

4.1.1.3. Third S: Cleaning

In the third S, a cleaning plan was carried out for both the tool store and the elements found in the injection machine. Likewise, in order to better control cleanliness in the injection area, a record sheet was prepared with the cleaning activities according to the days and shifts in the respective area, in the same way, the benefits of keeping the area clean and orderly were communicated. production area to the operators in a meeting(Figure 5).

Figure 5. Cleaning plan record in the injection area.

4.1.1.4. Fourth S: Standardization

The fourth phase consisted of, first, tracking the number of inspections for the maintenance of the tools and shelves. Then, a procedure was developed to maintain the cleanliness of the injection machine and it was located on the left side of the machine so that it is visible and within the reach of all collaborators (Figure 6).

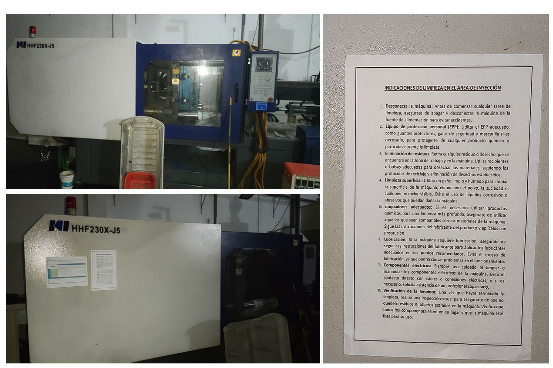

Figure 6. Cleaning procedure in the injection area.

4.1.1.5. Fifth S: Discipline

Finally, employees must be reminded of the 5s phases and the method to follow in order to satisfactorily meet the objective. For this, a panel was placed that is visible to all, which indicates the meaning, objective, and steps to follow of the 5S philosophy (Figure 7).

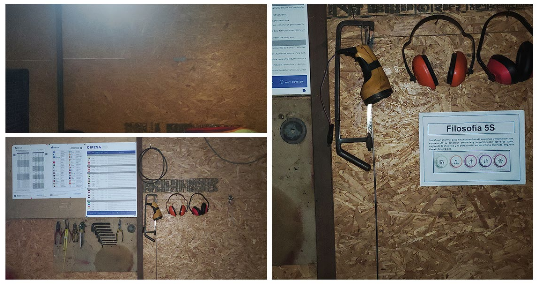

Figure 7. Philosophy 5s

4.1.2. Simulation

The simulation is carried out with the use of the Arena software for the implementation of the TPM tool. For this, it was determined that the minimum sample will be used for a simulation model to be valid, which is 30 samples and, on the other hand, also the entities and resources; as well as its own variables and attributes.

1.1.1 System scope

The scope of the system begins with the arrival of the high-density polyethylene bags requested by the production batch until the storage of the manufactured lid bags ready for their corresponding distribution (Figure 8 and Figure 9).

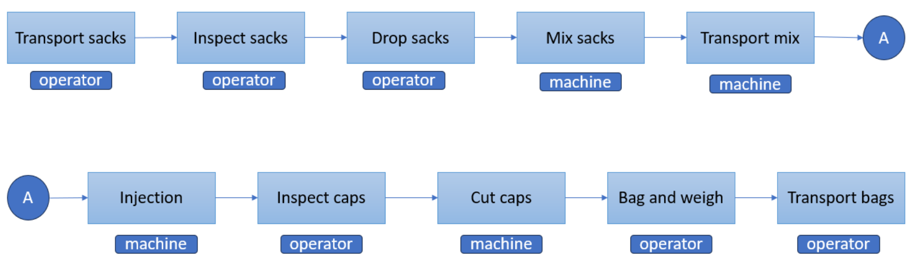

Figure 8. Current system

1.1.2 Simulation model in Arena software

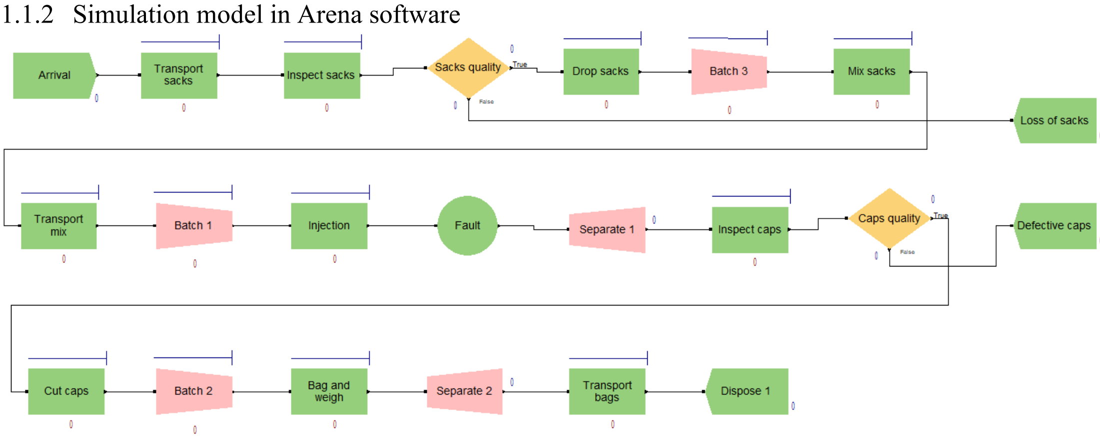

Figure 9. Model of the system in Arena

5. Results and discussion

Regarding the proposed simulation, the following results were obtained (Table 1 and Table 2)).

Table 1. C.I. of the model indicators

	% Efficiency	Availability
Current situation	[55,88%; 58,67%]	[67,32%; 70,83%]
Improved situation	[61,85%; 64,94%]	[75,87%; 78,64%]

A diagram was prepared with the indices before and after the improvement, implying that an intervention and improvement was needed in the indicator of each of the 5s (Figure 10).

Figure 10. Review of 5s

Table 2. Comparison of 5S indicators

Indicators	Before improvement	After improvement
Average time to locate and access the necessary materials and tools	10 min	2 min
Percentage of equipment and tools correctly classified and organized	32.81%	85.94%
Number of employees trained in basic maintenance of injection machines	2	5
Average time to carry out the scheduled maintenance of the injection machines	4 hours	2.5 hours
Average of the 5s audit indicator	4.6	7.6

5.1. Validation

Analysis of metrics and results

With the improved scenario, a significant variation in availability was obtained, increasing from 68 min to 77 min, which is proportional to 1.3 hours. Likewise, it can be seen that the efficiency was increased from 55.88% to 61.85% (Table 3).

Table 3. Results of the indicators studied

	Indicators	Current	Aim	Improved
General	Efficiency	55,88%	90%	61,85%
TPM	Availability	67,32%	80%	75,87%
5S	Average of the 5s audit indicator	4,6	8,9	7.6

6. Conclusions

After carrying out this investigation, it can be concluded that the implementation of Lean Manufacturing techniques can lead to an increase in efficiency in a certain area of a company in the manufacturing sector. The findings reveal that all the parameters suggested to evaluate the current situation of the company have undergone significant improvements. Through the use of the Problem Tree, Pareto Diagram and Value Stream Mapping (VSM), it was possible to show that indicators such as the percentage of machinery stoppages (74.26%) and power outages (26.74%) were the two main causes of the low availability of machinery (70.83%) which negatively influences the Total Efficiency of the Equipment (55.88%). After analysing the main root causes, it is concluded that the injection area is the one that presents the greatest problems in the plant that impairs the production of caps. This is because the main unproductive hours of machinery are affected by the lack of maintenance of the same. Therefore, with the improvement proposal using the 5s and TPM methodology in the simulation, a better result of efficiency and availability of the machinery was obtained by 64.94% and 78.64% respectively, By properly applying the principles of 5S and standardized work in the area of injection and tools, it was possible to reduce tool search times by 80% while the percentage of tools and equipment classified and organized increased to 85.94%. The accuracy of the simulation model was confirmed by testing it under three different scenarios over different time periods. The results obtained in each scenario were favourable, indicating that the project is viable and suitable for implementation in the business environment.

References

Ahmad, N., Hossen, J., & Ali, S. M. Improvement of overall equipment efficiency of ring frame through total productive maintenance: A textile case. International Journal of Advanced Manufacturing Technology, 94(1-4), 239-256. 2018. doi:10.1007/s00170-017-0783-2

Ames, V., Vásquez, W., Macassi, I., & Raymundo, C., Maintenance management model based on lean manufacturing to increase the productivity of a company in the plastic sector. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, 2019. doi:10.. 18687/LACCEI2019.1.1.33 Retrieved from www.scopus.com

Bataineh, O., Al-Hawari, T., Alshraideh, H., & Dalalah, D., A sequential TPM-based scheme for improving production effectiveness presented with a case study. Journal of Quality in Maintenance Engineering, 25(1), 144-161, 2019. doi:10.1108/JQME-07-2017-0045

Becerra Santos, L. J. & Oscanoa Zacarias, L. W., Modelo de mejora de proceso productivo para incrementar la eficiencia en pymes del sector calzado en Perú aplicando 5s, SMED, TPM y estandarización de trabajo. Repositorio académico UPC. 2020. https://repositorioacademico.upc.edu.pe/bitstream/handle/10757/655273/BecerraS_L.pdf?sequence=3&isAllowed=y

Benites Gutiérrez, L. A.; Ruff Escobar, C.; Ruiz Toledo, M.; Matheu Pérez, A.; Inca Alayo, M. & Juica Martínez, P., Análisis de los factores de competitividad para la productividad sostenible de las PYMES en Trujillo (Perú). Revista de Métodos Cuantitativos para la economía y la empresa, 2020. https://bit.ly/3Sw8y0y

Bhade, S. & Hegde, S., Improvement of Overall Equipment Efficiency of Machine by SMED. Materials Today: Proceedings, 24, 463-472, 2020. https://doi.org/10.1016/j.matpr.2020.04.298

Bidarra, T., Godina, R., Matias, J. C. O., & Azevedo, S. G., SMED methodology implementation in an automotive industry using a case study method. International Journal of Industrial Engineering and Management, 9(1), 1-16. 2018. Retrieved from www.scopus.com

Cakmakci, M., & Demirel-Ortabas, N., Performance measurement of SMED improved plastic injection molding production by using process capability analysis for attribute data. 2019. doi:10.1007/978-3-030-18789-7_17 Retrieved from www.scopus.com

Cordova-Pillco, D., Mendoza-Coaricona, M., & Quiroz-Flores, J. , Lean-SLP production model to reduce lead time in SMEs in the plastics industry: A empirical research in perú. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology,. 2022. doi:10.18687/LACCEI2022.1.1.151 Retrieved from www.scopus.com

Farahani, S., Khade, V., Basu, S. & Pilla, S., A data-driven predictive maintenance framework for injection molding process. Journal of Manufacturing Processes, 80, 887-897, 2022. https://doi.org/10.1016/j.jmapro.2022.06.013

Flores, G., Valenzuela, R., Viacava, G., & del Carpio, C., Model to reduce waste in the production of labels in peruvian companies of the plastic sector by applying autonomous maintenance, kanban and standardization of work. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, 2020. doi:10.18687/LACCEI2020.1.1.96 Retrieved from www.scopus.com

Gupta, V., Jain, R., Meena, M. L., & Dangayach, G. S., Six-sigma application in tire-manufacturing company: A case study. Journal of Industrial Engineering International, 14(3), 511-520. 2018. doi:10.1007/s40092-017-0234-6

Huang, C. T., Xu, R. T., Chen, P. H., Jong, W. R. & Chen, S. C., Investigation on the machine calibration effect on the optimization through design of experiments (DOE) in injection molding parts. Polymer Testing, 90, 106703. https://doi.org/10.1016/j.polymertesting.2020.106703

INEI., Población económicamente activa por condición de ocupación y características de la población ocupada. Obtenido, 2017 de https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1676/03.pdf

INEI., Producción en el sector manufactura de alimentos y bebidas. Obtenido de, 2020. https://www.inei.gob.pe/estadisticas/indice-tematico/manufacture/

Kong, L. W., & Moreno, O., Characterization and prediction of performance loss and MTTR during fault recovery on scale-out storage using DOE RSM: A case study with ceph. IEEE Transactions on Cloud Computing, 9(2), 492-503, 2021. doi:10.1109/TCC.2018.2874054

Kumar, S., Dhingra, A. K., & Singh, B., Process improvement through lean-kaizen using value stream map: A case study in india. International Journal of Advanced Manufacturing Technology, 96(5-8), 2687-2698, 2018. doi:10.1007/s00170-018-1684-8

Londoño-Patiño, Julio Albeiro, Toma de decisiones basada en la productividad en Pymes manufactureras: aproximación desde la Lógica Difusa (Productivity-Based Decision Making in Manufacturing SMEs: A Fuzzy Logic Approach). Revista CEA, Vol. 6, No. 12, 2020. https://ssrn.com/abstract=3788194

Miranda-López, Y., Toledo-Loza, F., & Altamirano-Flores, E., Optimization model to increase the efficiency of the flexible packaging production process applying the johnson method, SMED and TPM in a SME in the plastics sector. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, 2022. doi:10.18687/LACCEI2022.1.1.748 Retrieved from www.scopus.com

Nallusamy, S., Kumar, V., Yadav, V., Prasad, U. K., & Suman, S. K. , Implementation of total productive maintenance to enhance the overall equipment effectiveness in medium scale industries. International Journal of Mechanical and Production Engineering Research and Development, 8(1), 1027-1038. 2018. doi:10.24247/ijmperdfeb2018123

Pérez Rave, J.; La Rotta, D.; Sánchez, K.; Madera, Y.; Restrepo, G.; Rodríguez, M.; Vanegas, J.; Parra, C. 2011. Identificación y caracterización de mudas en Pymes manufactureras incorporando la perspectiva del nivel operativo. Ingeniare. Revista chilena de ingeniería, v. 19, n. 3, 396-408, 2011. https://doi.org/10.4067/S0718-33052011000300009

Pinto, G., Silva, F. J. G., Fernandes, N. O., Casais, R., Baptista, A., & Carvalho, C., Implementing a maintenance strategic plan using TPM methodology. International Journal of Industrial Engineering and Management, 11(3), 192-204, 2020. doi:10.24867/IJIEM-2020-3-26

Quiroz-Flores, J. C., & Vega-Alvites, M. L., REVIEW LEAN MANUFACTURING MODEL OF PRODUCTION MANAGEMENT UNDER THE PREVENTIVE MAINTENANCE APPROACH TO IMPROVE EFFICIENCY IN PLASTICS INDUSTRY SMES: A CASE STUDY. South African Journal of Industrial Engineering, 33(2), 143-156, 2022. doi:10.7166/33-2-2711

Realyvásquez-Vargas, A., Flor-Moltalvo, F. J., Blanco-Fernández, J., Sandoval-Quintanilla, J. D., Jiménez-Macías, E., & García-Alcaraz, J. L., Implementation of production process standardization-A case study of a publishing company from the SMEs sector. Processes, 7(10), 2019. doi:10.3390/pr7100646

Ribeiro, R. B., Souza, J. D., Beluco, A., Biehl, L. V., Braz Medeiros, J. L., Sporket, F., . . . Amaral, F. A. D. D. Application of the single-minute exchange of die system to the CNC sector of a shoe mold company. Cogent Engineering, 6(1) 2019. doi:10.1080/23311916.2019.1606376

Sharma, R., Overall equipment effectiveness measurement of TPM manager model machines in flexible manufacturing environment: A case study of automobile sector. International Journal of Productivity and Quality Management, 26(2), 206-222, 2019. doi:10.1504/IJPQM.2019.097767

Singh, J., & Singh, H., Application of lean manufacturing in automotive manufacturing unit. International Journal of Lean Six Sigma, 11(1), 171-210, 2020. doi:10.1108/IJLSS-06-2018-0060

Suryaprakash, M., Gomathi Prabha, M., Yuvaraja, M. & Rishi Revanth, R. , Improvement of overall equipment effectiveness of machining centre using tpm. Materials Today: Proceedings, 46, 9348-9353, 2020. https://doi.org/10.1016/j.matpr.2020.02.820

Thorat, R. & Mahesha, G., Improvement in productivity through TPM Implementation. Materials Today: Proceedings, 24, 1508- 1517. 2020. https://doi.org/10.1016/j.matpr.2020.04.470

Vega-Alvites, M., & Quiroz-Flores, J., Increased machine availability in a plastic injection molding plant through the implementation of TPM and lean manufacturing tools: An empirical research in perú. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, 2022 doi:10.18687/LACCEI2022.1.1.185 Retrieved from www.scopus.com

Vieira, M. D., Azevedo, S. G., Pimentel, C. O., & Matias, J. C. O. Implementation of lean management system in a plastic packaging industry. Paper presented at the ACM International Conference Proceeding Series, 147-154, 2020. doi:10.1145/3524338.3524361 Retrieved from www.scopus.com
Vrabič, R., Kozjek, D. & Butala, P., Knowledge elicitation for fault diagnostics in plastic injection moulding: A case for machine-to-machine communication. CIRP Annals, 66(1), 433-436, 2017. https://doi.org/10.1016/j.cirp.2017.04.001
Yazıcı, K., Gökler, S. H., & Boran, S. An integrated SMED-fuzzy FMEA model for reducing setup time. Journal of Intelligent Manufacturing, 32(6), 1547-1561, 2021. doi:10.1007/s10845-020-01675-x
Zennaro, I., Battini, D., Sgarbossa, F., Persona, A., & De Marchi, R. (2018). Micro downtime: Data collection, analysis and impact on OEE in bottling lines the san benedetto case study. International Journal of Quality and Reliability Management, 35(4), 965-995. doi:10.1108/IJQRM-11-2016-0202

Biographies

Jorge Sebastian Abad Mendoza has a degree in Industrial Engineering from the University of Lima with experience in the logistics and commercial area, with specialization in supply chain and currently works as a commercial assistant in an importing company.

Miguel Angel Palga Condori has a degree in Industrial Engineering from the University of Lima with experience in administration and production area, with specialization in logistics and currently works as a plant intern for a plastics company.

Martín Collao-Diaz at ESAN University and Industrial Engineer from Universidad de Lima specialized in supply chain management and operations. A leader with more than 25 years of local and international experience in national and multinational companies in industrial, hydrocarbon, and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport, distribution and warehouse management), operations (planning and control of production and maintenance), and integrated system management (ISO 9001, ISO 14001, and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Besides, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology, among others, focused on being a High-performance Organization (HPO). Development of a high-performance team. Member of IEEE and CIP (College of Engineers of Peru).