ISBN: 978-628-95207-7-4. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LEIRD2023.1.1.524

# Productive management proposal to increase the level of efficiency of the food sector through the application of Lean Manufacturing

Luis Aguirre-Cueva, Bsc[1]; Yasmin Alcantara-Gloria, Bsc[1]; Mercedes Cano-Lazarte, Msc[1] and Carlos Torres-Sifuentes, Msc[1]
[1]Ingniería de Gestión Empresarial, Universidad Peruana de Ciencias Aplicadas, Perú, u201716834@upc.edu.pe; u201721700@upc.edu.pe; pcgemcan@upc.edu.pe and carlos.torres@upc.pe

***Abstract*– The food manufacturing sector in Peru is in constant growth and for 2019 it contemplated 25.20% according to the GDP by manufacturing activity, which represented 3.23% of the national GDP for that year. In our country, most manufacturing companies are classified as mypes, this is the case of the food sector, where more than 90% of the total industry are microenterprises. One of the main problems in these organizations is that the average efficiency level of a food industrial plant is 60%, however, according to studies it should not be less than 82%. In addition, as they are micro-enterprises, they do not have a very large budget to implement major changes or acquire technologically advanced machines that exceed their spending limit. That is why this research proposes the design of a productive management methodology to increase the level of efficiency of the production area of a Mype in the food industry through 5s and Poka Yoke tools. These Lean Manufacturing tools will contribute to the implementation of improvements at a low cost and quick understanding. The main purpose of this methodology is to increase the level of efficiency in the production area of organizations to improve the quality of the products and avoid waste that generates unnecessary expenses. In this way, it will contribute to increase the growth of GDP by manufacturing activity and therefore the national GDP. For the development of the methodology, Lean Manufacturing tools will be used, because the mypes seek to apply low-cost and easy-to-apply procedures.***

***Keywords*-- Lean Manufacturing, Lean Tools, 5S, Poka Yoke, FMEA, Process Management, Continuous Improvement.***

# Productive management proposal to increase the level of efficiency of the food sector through the application of Lean Manufacturing

Luis Aguirre-Cueva, Bsc[1]; Yasmin Alcantara-Gloria, Bsc[1]; Mercedes Cano-Lazarte, Msc[1] and Carlos Torres-Sifuentes, Msc[1]
[1]Ingniería de Gestión Empresarial, Universidad Peruana de Ciencias Aplicadas, Perú, u201716834@upc.edu.pe; u201721700@upc.edu.pe; pcgemcan@upc.edu.pe and carlos.torres@upc.pe

***Abstract*– The food manufacturing sector in Peru is in constant growth and for 2019 it contemplated 25.20% according to the GDP by manufacturing activity, which represented 3.23% of the national GDP for that year. In our country, most manufacturing companies are classified as mypes, this is the case of the food sector, where more than 90% of the total industry are microenterprises. One of the main problems in these organizations is that the average efficiency level of a food industrial plant is 60%, however, according to studies it should not be less than 82%. In addition, as they are micro-enterprises, they do not have a very large budget to implement major changes or acquire technologically advanced machines that exceed their spending limit. That is why this research proposes the design of a productive management methodology to increase the level of efficiency of the production area of a Mype in the food industry through 5s and Poka Yoke tools. These Lean Manufacturing tools will contribute to the implementation of improvements at a low cost and quick understanding. The main purpose of this methodology is to increase the level of efficiency in the production area of organizations to improve the quality of the products and avoid waste that generates unnecessary expenses. In this way, it will contribute to increase the growth of GDP by manufacturing activity and therefore the national GDP. For the development of the methodology, Lean Manufacturing tools will be used, because the mypes seek to apply low-cost and easy-to-apply procedures.***

***Keywords*-- Lean Manufacturing, Lean Tools, 5S, Poka Yoke, FMEA, Process Management, Continuous Improvement.***

## I. INTRODUCTION

In Peru, the manufacturing sector ranks second in terms of the largest contributors to the national economy, accounting for 25.20% of the Peruvian GDP in 2019. This represented 3.23% of the national GDP for that year. Furthermore, within the National Superintendence of Tax Administration (SUNAT), micro and small enterprises (MSEs) have the highest representation among manufacturing companies. This also applies to the food industry, where over 90% of the total industry consists of microenterprises [1].

In food industry organizations, one of the main problems is the low level of efficiency in the production area. The average Overall Equipment Effectiveness (OEE) in a food plant should not be lower than 82%. However, the actual average of companies dedicated to these activities does not exceed 60% efficiency level [2].

It is worth mentioning that when talking about micro and small enterprises (MSEs), it is necessary to consider that they have limited financial resources to achieve an optimal solution to the problem. Therefore, there are various tools focused on continuous improvement that can be developed with a low budget and are easily understandable. In this regard, in order to mitigate the low level of efficiency in the sector, this article proposes the implementation of Lean Manufacturing tools such as 5S and Poka Yoke, to study the potential causes that generate the low level of inefficiency in the production process and create a control model and continuous improvement of internal processes based on them. This way, the goal is to increase the efficiency level in the production area of different organizations that need to improve product quality and avoid waste that leads to unnecessary expenses.

For this research article, a small and medium-sized enterprise (SME) from the food sector called Elaboraciones y Distribuciones GIL S.A.C. will be used as a case study. The company is engaged in the manufacturing and distribution of manjar blanco for wholesale. The methodology will be applied in this company to demonstrate the increase in efficiency levels in its production area.

This research not only aims to increase the level of efficiency of the company under study and the organizations belonging to the food sector but also to establish a philosophy of continuous improvement that can be applied within the strategic processes of the company.

**Digital Object Identifier:** (only for full papers, inserted by LEIRD).
**ISSN, ISBN:** (to be inserted by LEIRD).
**DO NOT REMOVE**

## II. ART OF STATE

### *A. Lean Manufacturing Concept*

The philosophy of Lean Manufacturing helps increase the operational performance of companies if the correct implementation is achieved. Some of the main recommended tools to begin redesigning a lean manufacturing process are Poka Yoke and 5S, as they generate short-term changes [3]. However, to achieve long-term benefits, it is necessary to strengthen and create a connection with the relationships within the culture, values, and traditions of the organization [4].

### *B. Benefits of Lean Manufacturing*

According to the scientific article entitled "Assessing Lean Adoption in Food Companies: The Case of Morocco," Lean methodology tools are useful for continuously improving operational performance in the food industry [5, 6]. This study

aimed to implement this methodology along with other tools such as different quality approaches and performance evaluation to achieve improved profitability, effectiveness, and efficiency in companies. Therefore, for this present work, we aim to implement some complementary Lean Manufacturing tools, so as not to overwhelm the company with various practices and to allow for easy adaptation to enhance its operational efficiency.

### C. *Concept of 5S*

The first tool that will be used is the 5S, since it is one of the most adaptable to the company for a quick and noticeable transition of change. This will provide contributions in reducing unnecessary effort to increase employee performance, redundant stocks, insignificant excesses that cause disorganization, and consequently difficulty in quality control and production processes [4]. According to Piñero and Vivas, the 5S methodology encompasses each of these phases [7].

*1) Seiri*: Select the necessary objects to remove the unnecessary.

*2) Seiton*: The translation of the revised text would be: "Arrange each object in its place.

*3) Seiso*: Clean the workplace thoroughly.

*4) Seiketsu*: Standardize the process to keep the first three S's under control.

*5) Shitsuke*: Self-discipline the 4S regularly to create habits.

### D. *Benefits of 5S*

According to the scientific article titled "Case study concerning the impact of the 5S method in an automotive company," they mention that productivity will increase the company's production capacity, resulting in increased profits[8]. On the other hand, they emphasize that there is a significant relationship between the implementation of the Lean Manufacturing 5S tool and productivity growth. In the present case under study, the 5S will be implemented because the small and medium-sized enterprise (MYPE) requires a structural change within the plant and the production process to enhance its level of efficiency [9, 10].

### E. *Concept of Poka Yoke*

The second and final tool that will be used is Poka Yoke. This will be implemented after the 5S, as it requires a more thorough analysis for its execution and complements the previous tool. Poka Yoke utilizes more financial resources compared to the 5S in order to achieve waste reduction or elimination, improve the productive organization of the company, reduce time in the production process, and prevent errors in production to increase process efficiency of the company [4].

### F. *Benefits of Poka Yoke*

The reduction of the cycle time in the production line of automotive products by using the Poka-Yoke tool reduces, and even eliminates, the possibility of user errors and prevents occurrence errors [11, 12]. In this way, Poka-Yoke is implemented to meet the requirements of reducing failures and defective products to zero in the production line. Similarly, it is established that Poka-Yoke is highly effective in anticipating defects in the product process flow. Additionally, human errors have been eliminated, and the production cycle has been accelerated.

### G. *Concept of FMEA*

The AMFE or AMEF method will be used as a tool to assess potential flaws in the product development process. This method enables an analysis of the problems that may arise when implementing the 5S and Poka Yoke tools in their respective areas. These process failures will be prioritized based on their impact in order to take corrective action [13].

## III. CONTRIBUTION

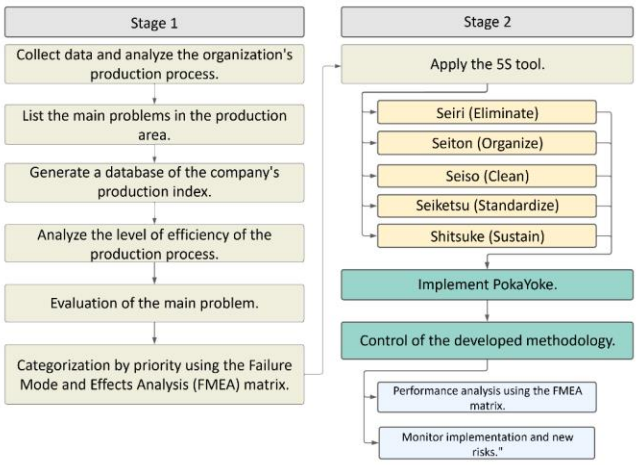
The purpose of this article is to increase the efficiency level of the company and implement a philosophy of continuous improvement in strategic processes and employees, eliminating activities that do not add value in the production process of manufacturing sector companies.

In that sense, the aim is to increase the efficiency level of the manufacturing sector in the food industry to at least 82%, so that the company's profitability reflects the productivity increase due to efficiency. In this way, the production area of organizations will improve the quality of products and avoid wastage that generates unnecessary expenses.

The following, in Figure 1, presents the phases for applying the methodology within the proposed company Elaboraciones y Distribuciones S.A.C., related to Lean Manufacturing tools and techniques to achieve the proposed results.

Fig. 1 Implementation proposal phases diagram

In order to implement the productive management methodology that increases the level of efficiency in the production area, it is necessary to analyze the actual




production of the company and then use tools from the Lean Manufacturing philosophy such as 5S and Poka Yoke. These

will serve as support to carry out the methodology that seeks to improve the efficiency level of the company's process. This methodology will be developed through the following two phases:

*A. Phase 1*

*1)* Compilation of data and analysis of the production process for the elaboration of the product, from the treatment of raw materials to its dispatch to customers.

*2)* Make a list of the main production area problems identified during surveillance.

*3)* Generate a daily production database to obtain the production index of the company.

*4)* Analyze the level of efficiency of the production process, using the efficiency indicator detailed in Table 1.

*5)* Evaluation of the main problem.

*6)* Categorize according to priority using the Failure Mode and Effects Analysis (FMEA) matrix.

TABLE I
EFFICIENCY INDICATOR ANALYSIS

| | Description | | |
|---|---|---|---|
| Indicator Name | Efficiency Level | | |
| Process Name | Production process of light and dark toffee white fudge | | |
| Indicator Objective | Measure the efficiency level of the monthly production process of light and dark toffee white fudge at Elaboraciones & Distribuciones GIL S.A.C. | | |
| Target (Planned Outcome) | Greater than 82% | Measurement scale | Percentage |
| Deadline for Achievement | End of each month | Indicator type (Outcome or Management) | Outcome |
| Mathematical Expression | Efficiency = Actual Production / Effective Capacity | | |
| Compliance Reference Level | Acceptable: Greater than or equal to 82% | Expected trend | Increase |
| | Risk: Between 75% and less than 82% | | |
| | Critical: Less than 75% | | |
| Information Sources | Production record by plant operators | | |
| Measurement Frequency | Monthly | Measurement responsible | Operators |
| Report Recipient | Production Supervisor | Management responsible | Production Management |
| Observations | Reports are carried out by a designated and trained operator. Additionally, the efficiency level of Elaboraciones & Distribuciones GIL S.A.C. will be measured in order to assess the company's situation during the duration of this investigation. | | |

Source: Own elaboration, 2022

TABLE II
PRIORITIZATION CATEGORIZATION

| Cause | Effect | NPR |
|---|---|---|
| Lack of control over the production process | Lack of data on monthly production results | 256 |
| Disorderly work environment | Slow progress in the production process of manjarblanco | 245 |
| Slow processing of production data | Frequent stops in the production process | 180 |
| Lack of control over industrial hygiene | Presence of contaminants in work areas. | 48 |

Source: Own elaboration, 2022

*B. Fase 2*

*1)* Application of the 5S tool to design a plan for organizing and implementing corrective measures to increase the internal performance of the production process. This is carried out through the following phases:

*a) Seiri (Sort)*: Using the red target, obsolete tools and/or equipment are classified for subsequent removal from the production area.

*b) Seiton (Set in Order)*: The new locations for each production area are organized, improvements are made to work tables, and floor markings are placed for material transportation and operator movement. This is based on the previous layout of the production plant before the improvement was implemented.

Based on this layout, a new one was proposed based on the needs of the operators during the production process.

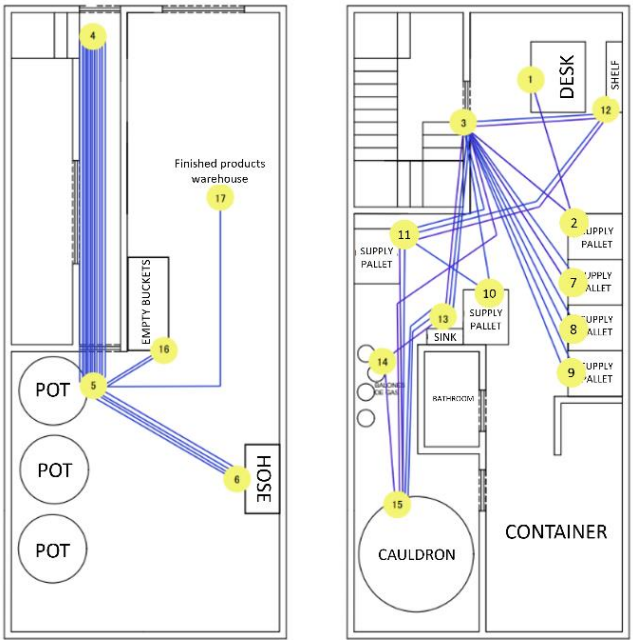



Fig. 2: Production area layout before improvement.

*c) Seiso (Clean)*: All work areas of the company are cleaned. For this process, a cleaning record is developed with responsible parties, where the cleaning, disinfection, and organization of each machine and environment in the production area will be documented.

*d) Seiketsu (Standardize)*: In order to maintain proper execution of the first 3S, procedures and principles to be

followed within the company are presented, as well as routines that will be fully implemented by the operators in a manual of good practices for the production area.

*e) Shitsuke (Discipline)*: With the support of the routines to be created, the operators will incorporate some fundamental values, such as self-discipline, commitment, and the sense of a job well done. For this purpose, a bi-weekly meeting calendar is developed to discuss progress, new ideas, objectives, and new challenges.

*2)* Implementation of Poka Yoke based on the phases of the 5S through a thorough analysis of the facilities and equipment used in the production area. Preventive and corrective measures are established to increase efficiency, such as improving the aspects of clothing signaling, equipment labeling, and work areas. Similarly, the installation of anti-slip floors is proposed to prevent accidents within the plant. A tracking of registered weights of raw materials, product processing, and final packaging (setting guide measures for filling containers) will be carried out.

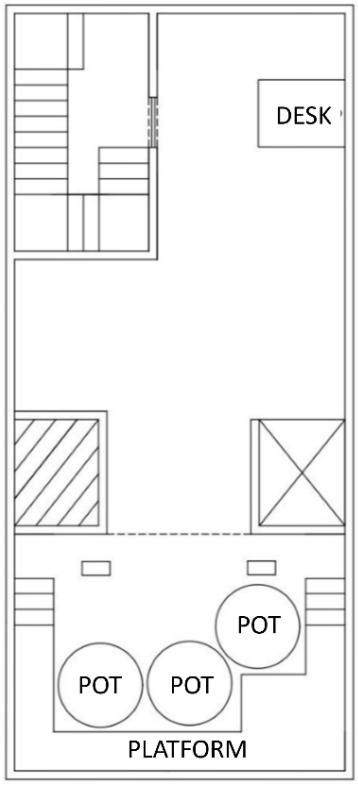



Fig. 3 New Production area layout

Fig. 4 Buckets with marks for packaging.

TABLE III
ESTIMATION OF EFFICIENCY LEVEL RESULTS THROUGH LINEAR REGRESSION

| Quarter | Efficiency level |
|---|---|
| 3er 2021 | 68.51% |
| 4to 2021 | 60.65% |
| 1er 2022 | 64.91% |
| 2do 2022 | 68.18% |
| 3er 2022 | 66.39% |
| 4to 2022 | 66.72% |
| 1er 2023 | 67.05% |
| 2do 2023 | 67.38% |
| 3er 2023 | 67.71% |
| 4to 2023 | 68.04% |

*3)* Control of the developed methodology

*a) Analyzing performance using the FMEA matrix*: After applying the FMEA matrix in phase 1, the results of the corrective measures are analyzed.

*b) Monitoring implementation and new risks:* After implementing the productive management methodology, the results obtained in the medium and long term will be constantly analyzed to identify potential risks that the company may face.

## IV. VALIDATION

### *A. Estimate of Efficiency Level*

For the simulation of the model to be executed in the production area, the linear regression model was used. This allows us to obtain an estimate of the potential long-term efficiency level results. The results of the application of linear regression are presented (see Table III).

The following formula was used to obtain these results, based on the indicators obtained from the production area. In this formula, the variable "X" represents the efficiency level (dependent variable), the variable "Y" represents the quarter under study (independent variable), and the variable $R^2$ represents the coefficient of determination (the variable Y has a low dependency relationship with X). However, it will be used for academic purposes.

$$y = 0.0033x + 0.6474 \quad (1)$$

$$R\text{^}2 = 0.0134 \quad (2)$$

Y: Level of efficiency (Dependent variable)
X: Quarter under study (Independent variable)
R²: Coefficient of determination

On the other hand, a graphical analysis of the linear regression of the production area's efficiency level is presented in Fig. 5.

Through the graph, it can be observed that the efficiency results follow a positive behavior due to the increasing slope, which ensures that the implementation of the productive management model will allow reaching 82% of the minimum expected efficiency level for SMEs in the food sector.

### *B. Simulation Validation*

In order to analyze the effectiveness of the proposed model, a simulation was conducted using Arena Simulator software, with the aim of increasing the efficiency of the company by performing activities more quickly using Lean Manufacturing tools.

Below is the production process for Dulcesita's toffee-flavored manjarblanco.

During the simulation, 72 repetitions were taken into account, each referring to 1 shift per 1 cooking pot. There are 3 cooking pots, and each one operates for 2 shifts during the day. The simulation was conducted for a period of 3 months, from Monday to Saturday.

As a result, it was found that on average, 1 repetition lasts 10.84 hours, so each cooking pot completes its process in approximately 4 hours. This allows for 2 full shifts from 6am to 3.30pm, considering a 1.5-hour break and utilizing the entire effective capacity of the production plant.

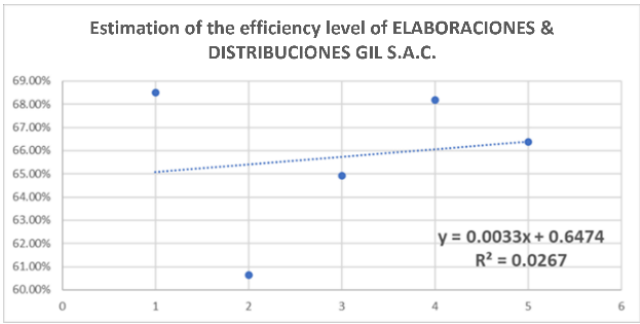



Fig. 5 Estimation of efficiency level through linear regression.

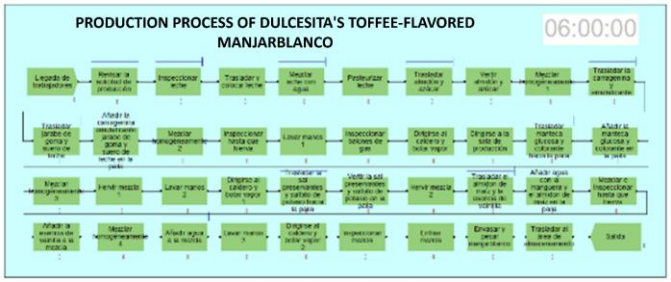



Fig. 6 Process simulation in Arena Simulator Software.

TABLE IV
PROJECT EVALUATION

| | Annual COK | Quarterly COK | VAN | TIR |
|---|---|---|---|---|
| Project evaluation | 20% | 5% | S/ 87,269.88 | 33.82% |

## V. DISCUSSION

In order to analyze the feasibility of the proposed project, the incremental income statement is presented from the third quarter of 2021 to the second quarter of 2026. Based on this projection, the NPV (Net Present Value) and IRR (Internal Rate of Return) analysis will be conducted.

Based on the evaluation presented in Table 4, it is evident that the organization will benefit from an amount of s/.2,167,671.56, due to the projected increase in efficiency in the production area. On the other hand, it can be concluded that the project is viable, as the NPV is s/.87,269.88 over a projected period of 18 quarters, which is supported by an IRR of 33.82%.

## VI. CONCLUSIONS

The application of the proposed productive management results in a benefit of S/.2,167,671.56 and a Net Present Value (NPV) of S/.87,269.88, indicating that the execution of the model in the food sector is viable, as the NPV reflects an additional benefit.

The application of the proposal generates an Internal Rate of Return (IRR) of 33.82%, indicating that the proposed productive management is acceptable, as the profitability is higher than the minimum required profitability. In other words, investing in the proposal would result in high rates of profit.

According to the simulation of the process of making the Dulcesita manjarblanco, it is evident that with the proposed improvement, it is possible to complete 2 full shifts of approximately 3 and a half hours each by using the full capacity of each of the 3 pots. This way, the effective capacity of the company of 3040 kg per day is met.

The proposed productive management for increasing the efficiency level of the food sector through the application of Lean Manufacturing is beneficial, as the estimation of the efficiency level shows an upward trend, indicating that in the

long term, the food sector's small and medium-sized enterprises (SMEs) would reach an 82% efficiency level in the production process.

The recommended redesign of the production plants, as proposed by the productive management, would improve the production process of the SMEs in the food sector, as it would streamline the routes for personnel and raw materials, resulting in an increase in the efficiency level.

## REFERENCES


[1] "Estadística Sectorial," Produce.gob.pe, 2019. Available: https://ogeiee.produce.gob.pe/index.php/en/shortcode/estadistica-oee/estadistica-sectorial.

[2] Tecnología para la industria, "Medición de eficiencia en plantas industriales de alimentación," Tecnología para la Industria, Nov. 01, 2019. https://tecnologiaparalaindustria.com/medicion-de-eficiencia-en-plantas-industriales-de-alimentacion-calculo-de-la-oee/

[3] Y. Andrade, L. Cardenas, G. Viacava, C. Raymundo, and F. Dominguez, "Lean Manufacturing Model for the Reduction of Production Times and Reduction of the Returns of Defective Items in Textile Industry," Advances in Intelligent Systems and Computing. Springer International Publishing, pp. 387–398, Jun. 07, 2019. doi: 10.1007/978-3-030-20444-0_39.

[4] Leksic, N. Stefanic, and I. Veza, "The impact of using different lean manufacturing tools on waste reduction," Advances in Production Engineering & Management, vol. 15, no. 1. Production Engineering Institute (PEI), Faculty of Mechanical Engineering, pp. 81–92, Mar. 31, 2020. doi: 10.14743/apem2020.1.351.

[5] A. Farissi, M. El Oumami, and Z. Beidouri, "Assessing Lean Adoption in Food Companies: The Case of Morocco," International Journal of Technology, vol. 12, no. 1. International Journal of Technology, p. 5, Jan. 20, 2021. doi: 10.14716/ijtech.v12i1.3837.

[6] S. Rojas-Benites, A. Castro-Arroyo, G. Viacava, V. Aparicio, and C. del Carpio, "Reduction of Waste in an SME in the Meat Sector in Peru through a Lean Manufacturing Approach Using a Model Based on 5S, Standardization, Demand Forecasting and Kanban," The 2021 7th International Conference on Industrial and Business Engineering. ACM, Sep. 27, 2021. doi: 10.1145/3494583.3494592.

[7] Edgar Alexander Piñero, F. Esperanza, and L. Kaviria, "Programa 5S´s para el mejoramiento continuo de la calidad y la productividad en los puestos de trabajo," Ingeniería Industrial. Actualidad y Nuevas Tendencias, vol. VI, no. 20, pp. 99–110, 2018, Available: https://www.redalyc.org/exportarcita.oa?id=215057003009.

[8] C. Veres (Harea), L. Marian, S. Moica, and K. Al-Akel, "Case study concerning 5S method impact in an automotive company," Procedia Manufacturing, vol. 22. Elsevier BV, pp. 900–905, 2018. doi: 10.1016/j.promfg.2018.03.127.

[9] M. Mau, J. Llontop, R. Ramos, and C. Raymundo, "Modelo de gestión de producción lean manufacturing para incrementar la eficiencia del proceso productivo de una empresa MYPE del sector químico," Proceedings of the 17th LACCEI International Multi-Conference for Engineering, Education, and Technology: "Industry, Innovation, and Infrastructure for Sustainable Cities and Communities." Latin American and Caribbean Consortium of Engineering Institutions, 2019. doi: 10.18687/laccei2019.1.1.101.

[10] C. Arroyo-Huayta, S. Cruces-Raimudis, G. Viacava-Campos, C. Leon-Chávarri, and D. Aderhold, "Model to Improve the Efficiency in the Extrusion Area in a Manufacturing SME of the Industrial Plastic Sector Based on SMED, Autonomous Maintenance and 5S," Human Interaction, Emerging Technologies and Future Applications III. Springer International Publishing, pp. 545–551, Aug. 06, 2020. doi: 10.1007/978-3-030-55307-4_83.

[11] Hernadewita, F. Ali Tosa, Y. Santoso, L. Herliani Kusumah, and Hermiyetti, "Application Poka-Yoke to Capture Defect (A Case Study in Industry Component Otomotive)," International Journal of Industrial Engineering, vol. 6, no. 1. Seventh Sense Research Group Journals, pp. 14–17, Feb. 25, 2019. doi: 10.14445/23499362/ijie-v6i1p103.

[12] A. Mesones-Guillén, L. Palacios-Jesús, E. Carvallo-Munar, R. Salas-Castro, and L. Cardenas-Rengifo, "Lean Manufacturing Model Adapted for Waste Reduction in Peruvian Condiment Production Agri-Businesses," Proceedings of the 5th Brazilian Technology Symposium. Springer International Publishing, pp. 381–389, Dec. 16, 2020. doi: 10.1007/978-3-030-57548-9_35.

[13] S. Rojas Lema, "Implementación de análisis modal de fallos y efectos (AMFE)," 3C Tecnología_Glosas de innovación aplicadas a la pyme, vol. 29, no. 1. Area de Innovacion y Desarrollo, S.L. 3 Ciencias, pp. 64–75, Mar. 14, 2019. doi: 10.17993/3ctecno/2019.v8n1e29/64-75.