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Implementación de la mejora continua aplicada al proceso productivo de la empresa recicladora sustentable en Reynosa Tamaulipas

Implementation of continuous improvement, applied to the production process of the sustainable recycling company in Reynosa Tamaulipas

Implementação de melhoria contínua, aplicada ao processo produtivo da empresa de reciclagem sustentável de Reynosa Tamaulipas

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Resumen

El objetivo de esta investigación se centró en implementar un proceso de mejora continua dentro del entorno productivo de una empresa recicladora. Para ello, se optó por la metodología de investigación acción. El instrumento utilizado consistió en una lista de chequeo compuesta por 29 preguntas cerradas y de opciones múltiples, y fue aplicado a 62 operarios (42 % mujeres y 58 % hombres) en la empresa recicladora sostenible ubicada en Reynosa, Tamaulipas. Los resultados obtenidos tuvieron un impacto considerable en todas las etapas de la organización, pues se pasó del 71 % al 98 % en términos de eficiencia, y del 60 % al 100 % en lo que respecta a la limpieza. Estos hallazgos resaltan la importancia de la estandarización y el orden en los procesos productivos para lograr una mayor eficiencia e impacto. En conclusión, estos resultados, al ser analizados en el contexto de la gestión por procesos con su medición cuantitativa, constituyen un avance que conduce a una mejora constante en la empresa.

Palabras clave: reciclaje, productiva, sustentable, mejora continua, manufactura.

Abstract

The objective of this research focused on the implementation of a continuous improvement process applied to the productive environment of a recycling company. This research was developed from the Action Research (AI) methodology. The instrument applied was a checklist of closed and multiple questions of 29 items. It was applied to 62 operators, 42% women and 58% men, in the sustainable recycling company in Reynosa Tamaulipas. Tamaulipas. The results obtained had a considerable impact on all stages of the organization, going from 71% to 98% in terms of efficiency, and from 60% to 100% in terms of cleanliness. These findings highlight the importance of standardization and order in production processes to achieve greater efficiency and impact. In conclusion, these results, when analyzed in the context of process management with its quantitative measurement, constitute an advance that leads to constant improvement in the company.

Keywords: Recycling, productive, sustainable, continuous, improvement, manufacturing.

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Resumo

O objetivo desta pesquisa centrou-se na implementação de um processo de melhoria contínua no ambiente produtivo de uma empresa de reciclagem. Para isso, optou-se pela metodologia da pesquisa-ação. O instrumento utilizado consistiu em um checklist composto por 29 questões fechadas e de múltipla escolha, e foi aplicado a 62 operadores (42% mulheres e 58% homens) da empresa de reciclagem sustentável localizada em Reynosa, Tamaulipas. Os resultados obtidos tiveram um impacto considerável em todas as etapas da organização, passando de 71% a 98% em termos de eficiência, e de 60% a 100% em termos de limpeza. Estas descobertas destacam a importância da padronização e da ordem nos processos de produção para alcançar maior eficiência e impacto. Concluindo, estes resultados, quando analisados no contexto da gestão de processos com sua medição quantitativa, constituem um avanço que leva à melhoria constante da empresa.

Palavras-chave: Reciclagem, productiva, sustentable, melhoria contínua.

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Introduction

The 17 sustainable development goals (SDGs) of the 2030 Agenda, and in particular number 12, continue to represent one of the greatest challenges facing all countries, since collaborative work is required between organizations to encourage large companies and transnational companies to adopt sustainable practices (Gutiérrez, June 25, 2023).

One of the tools available to achieve this goal is *lean manufacturing,* also known as *lean production* or *lean manufacturing* , a strategy that helps reduce waste in the production processes of industries (Aruleswaran, 2009; Galgano, 2021; Hinojosa, 2010; Tanveer *et al.* , 2016). *Lean* manufacturing focuses on the identification and elimination of waste, as well as the reduction of downtime in unnecessary movements in order to drive continuous improvement (Hernández and Vizán, 2013).

In this process, the manufacturing flow constitutes a fundamental principle, since it consists of a method that is based on the time in which a material is moved through a production system in an uninterrupted manner (Andrue, February 22, 2023) . In this regard, various studies have shown that the improvement of these processes, combining *lean* and Six Sigma methodologies, maximizes value for all interested parties, since better results are achieved in terms of customer satisfaction, costs, quality, speed of process and return on investment (George *et al.* , 2005).

The International Organization for Standardization (ISO) develops standards covering a wide range of industrial aspects, from technology to food safety and occupational health. However, the relevance of the ISO is not limited only to the technical field since its standards can also be applied to social and work skills.

For example, the ISO 45001 standard seeks to serve as a tool to facilitate communication between the company and its clients, thereby guaranteeing reliability in the quality of products, processes, and compliance with social obligations. Due to these properties, the most important companies worldwide have adopted the ISO 9001 standard as part of their strategy to ensure long-term growth, profitability, and sustainability (Guido-Falcón and Roque, 2018). In fact, process mapping is an integral part of the ISO 9001:2015 strategy, which helps any company or organization to identify and group three different types of existing processes: operational, strategic and support in order to better understand their operations (López, 2015).

In the case of the sustainable recycling company where this research was carried out, the operations and services managed led to the identification of the causes and effects of the problems using various methods, such as research and action, which contributed to improvement. in the use of materials, production processes, product quality and safety (Thiollent, 2005).

In addition, the continuous improvement methodology was used, which seeks to optimize and increase the quality of processes, services, and products. This was applied directly in manufacturing companies and processing plants due to the constant need to minimize production costs and obtain the best quality of products. This methodology has its roots in the Kaizen method, whose name derives from the Japanese characters *Kai* (meaning 'change') and *Zen* (meaning 'improvement'), which could be translated as *change for improvement* (Alvarado and Pumisauno, 2017).

In this regard, Suárez-Barraza and Miguel-Dávila (2011) point out that the Kaizen method must be constantly carried out by all employees of the organization, in any area of the company. Likewise, it should be noted that this method must consider not only economic aspects, but also human factors to maintain a competitive position in the market, hence companies need to implement organizational changes supported by continuous improvements. In other words, Kaizen demands a process of activities implemented constantly to guarantee a continuous search for innovation (Suárez-Barraza and Miguel-Dávila, 2011).

Table 1 below shows the continuous improvement methodologies used by small and medium-sized companies:

Table 1. Continuous improvement methodologies used by small and medium-sized companies

Authors	Small and medium-sized companies using different methodologies
Alvarado and Pumisancho (2017) Caldas and Cueto (2019)	Small and medium-sized companies face the problem of excess waste, which negatively affects their results. For this reason, a small business performs diagnostic analysis using Ishikawa diagrams to identify root causes and measure them with metrics. Based on these results, a change management model was proposed, based on implementation (Caldas and Cueto, 2019).
Fortalvo and De la Hoz (2018)	Employee knowledge and experience serve organizations to redesign processes because they allow people to innovate and improve their work methods, so knowledge can lead to improvements in quality and efficiency, customer service, organizational culture, design scientific and engineering (Chávez, 2021; Fortalvo and De la Hoz, 2018)
Hernandez *et al.* (2018)	In a metallurgical company, the performance of its production lines was evaluated. 45% of the problems were found in quality defects in the welding of the final product. Diagnostic tools such as value chain mapping and 5 Ss were used to support the identification of other waste in the process: waiting times, transportation, customer complaints, finding important opportunities such as moving stations (H e rnández *et al* ., 2018).
Aldas *et al.* (2018)	The industry has become one of the most important things to require a qualified workforce in both operation and management, although there are currently problems in its process (for example, from consumption to production delay). If production is doubled it is an alternative to

	optimization to increase production efficiency. The products with the highest demand are studied through an ABC product segmentation analysis, it begins with the collection of information on all the activities that make up the die-cutting process, carrying out a time study, and then an analysis of the activities. in which there are preparation times to determine waste within the process (Aldás *et al.* , 2018).
Pérez and Rojas (2019)	*pull* systems and operations companies , SKU changeover time is a factor that directly affects cycle time, so reducing it directly affects service levels. The most common causes of delays are labor and work methods, the impact of which can be reduced by involving operators in the decision-making process (P é rez and Rojas 2019).
Pena (2019)	An experimental study is carried out to manipulate the independent variable of lean manufacturing to observe its effect on the dependent variable, reducing lean waste and that these are expressed in times through a pretest and posttest, which tools such as Layout were implemented to improve distribution. plant and reduce the process route, also the 5 S with the purpose of improving work areas and line balance to avoid overproduction in the process. By obtaining the results, it is concluded that with the application of lean manufacturing tools, waste measured over time in the production process is reduced (Pe ña, 2019).

Fountain: Own elaboration

Now, as is known, industrial companies generate waste, whether with or without added economic value, hence waste management requires the implementation of methods such as TPM, 5 S, SMED, Kanban, Deming Circle (PHVA). , Kaizen, Heijjunka, JIT, tactical timing, small yoke jidoka, simulation, Delphi technique and KPI indicators to evaluate their performance, as well as the use of *software* such as Arena 10.0 Trading Mode and Flex Sim (Piñero *et al* ., 2017; Reyes *et al* . *al.* , 2017).

In the specific case of the plastics recycling and reuse industry, a series of problems have been identified in business operations, such as downtime, waste, lack of standardization in processes, acceptance criteria for unknown products, poor communication between shifts and absence of clear objectives and goals for productivity.

Due to these difficulties, it was proposed to implement continuous improvements in production processes, although it should be noted that to establish objectives and methods in each area it is crucial to implement an organizational chart of functions to clarify dependencies and roles within the company. In addition, the process mapping must be represented, in accordance with the ISO 9001:2015 strategy, and a flow diagram provided to establish an understandable and clear order.

Having explained the above, continuous improvement must be implemented to optimize and increase quality, using strategies such as *lean manufacturing* to reduce waste; key performance indicators (KPIs); Six Sigma to define, measure, analyze, improve and control, and lean manufacturing to eliminate waste, along with the 5 S and Kaizen methodology.

In this research, various tools have been used that have been of great importance for the analysis and improvement of processes. Some of them are explained below:

1. Ishikawa Diagram: Also known as a cause and effect diagram, it is based on the premise that every problem has an underlying cause and helps determine where the behavior that is causing the problem comes from in the process (Acuña, 2004).
2. Flowchart: This tool makes it easier to understand the activities carried out in a process. Using arrows or lines, it shows how the activities are related to each other and in what order and sequence they are organized (Cuatrecasas and González, 2017).
3. Poka-yoke: It is a Japanese tool for checking errors, both human and automatic, which can be adjusted to solve problems and reduce risk through simple, economical and effective measures (Dudek-Burlikowska and Szewiwczek, 2009; Hernández, 2018).
4. Six Sigma: Attributed to Motorola quality engineer Bill Smith. It was introduced and implemented in 1987 by Bob Galvin, president of the company, with the purpose of reducing defects in electronic products. It is a tool that combines different techniques of the quality process, statistical control and experimental design. By measuring the performance of processes, it allows focusing on specific improvements or those of the entire organization, which can result in the reduction of operating costs and an increase in profitability (Fontalvo, 2009). The most relevant indicators include cycle, waiting and delivery times before orders are closed (Kumar *et al* . 2008; Rojas- Calva, 2018).

5. Organization Chart: It is a tool used to divide tasks and establish a hierarchical structure of areas of specialization in an organization. In this work, a company organization scheme was implemented and corresponding hierarchies were established (Boada and Ficapal, 2012).
6. Management indicators: They are of vital importance in companies, since they support the techniques and metrics that allow processes to be evaluated. Selected based on the organization's goals, objectives and vision, they should be quantitative and help ensure that resources and costs are used effectively. In addition, they are essential to adequately inform management about the results based on decision making (Team Asana , February 10, 2024; Chávez, 2022; Diez *et al.* , 2012; Flapper-Fortuin and Stoop, 1996; Tolosa, 2017).

Having explained all of the above, it can be said that the objective of this research is to implement continuous improvement to impact the fulfillment of the goals of a recycling company in Reynosa, Tamaulipas (Mexico) with the objective of proposing and implementing a productive process (Brand , 2019).

Materials and methods

The methodology used in this research was action research, an empirical genre whose conception and implementation is closely related to problem-solving activities, where researchers and actors collaborate in problematic situations (Thiollent, 2005). In this regard, it should be noted that the methods and tools that support the processes or activities that generate value are part of continuous improvement, which includes the creation of knowledge through practice and innovation (Pereira *et al.* , 2012).

The instrument used consisted of a list with 29 closed and multiple-choice questions. The criteria considered for the evaluation were organization, order, cleanliness, standardization and discipline, corresponding to the 5 S methodology. This instrument was applied to 62 operators, of which 42% were women and 58 % men, in a sustainable recycling company located in Reynosa, Tamaulipas.

The phases applied in the action research methodology are described as follows:

- In the first phase, corresponding to the diagnosis and data collection of the evaluation and organization, it was detected that the tools were not organized according to their importance and usefulness in the areas. Likewise, unnecessary objects were identified for the production process and the development of the activities of the corresponding area.

- In the second phase, the information feedback and analysis of the collected data occurred.
- In the third phase, the action plan was proposed and implemented to address the identified areas of improvement.
- Finally, in the fourth phase, the evaluation, monitoring and standardization of the implemented actions were carried out.

The implementation of action research follows a spiral model, where successive cycles are carried out that include the diagnosis and recognition of the current situation, the planning of an action plan, the action to put said plan into practice, and the observation of its results. effects in the context in which it takes place. Subsequently, a reflection is carried out on the observed effects, which serves as a basis for new planning (figure 1).

Figure 1. Steps of the action research methodology

Source: self made

The development of the action research methodology in the company was developed jointly between the members of the selected organization and the researchers, for which the perception of the members of the company was considered essential. In the implementation of the methodology from continuous improvement, applied to the production process of the recycling company, an evaluation diagnosis was carried out with emphasis on the use of specific tools, such as the 5 S method. This is based on five principles: organization, order , cleanliness, standardization and discipline (table 2).

Table 2. Evaluation of the 5 S methodology

	Organization evaluation		
		YES	NO
1	Are the objects considered necessary for the development of the area's activities organized?	☐	☐
2	Are there any damaged objects?	☐	☐
3	If damaged objects are observed, have they been classified as useful or useless? Is there an action plan to repair them or are they separated and labeled?	☐	☐
4	Are there obsolete objects?	☐	☐
5	If obsolete objects are observed, are they properly identified as such, are they separated, and is there an action plan to discard them?	☐	☐
6	Are there any extra objects observed, that is, those that are not necessary for the development of the area's activities?	☐	☐
7	If extra objects are observed, are they properly identified as such, is there an action plan to transfer them to an area that requires them?	☐	☐
	Order evaluation		
		YEAH	NO
1	Are the objects considered necessary for the development of the area's activities organized?	☐	☐
2	Are there any damaged objects?	☐	☐
3	If damaged objects are observed, have they been classified as useful or useless? Is there an action plan to repair them or are they separated and labeled?	☐	☐
4	Are there obsolete objects?	☐	☐
5	If obsolete objects are observed, are they properly identified as such, are they separated, and is there an action plan to discard them?	☐	☐
6	Are there any extra objects observed, that is, those that are not necessary for the development of the area's activities?	☐	☐
7	If extra objects are observed, are they properly identified as such, is there an action plan to transfer them to an area that requires them?	☐	☐
	Cleaning evaluation		
		YEAH	NO
1	Is the work area perceived as absolutely clean?	☐	☐
2	Are the workers in the area in accordance with their activities and their ability to clean themselves?	☐	☐
3	Have the sources of contamination been eliminated? Not just dirt	☐	☐
4	Is there a cleaning routine by the area operators?	☐	☐

5	Are there spaces and elements to dispose of garbage?	☐	☐
	Standardization evaluation		
		YEAH	NO
1	Are there standardization tools to maintain identified organization, order, and cleanliness?	☐	☐
2	Is visual evidence used regarding the maintenance of organization, order and cleanliness conditions?	☐	☐
3	Are molds or templates used to maintain order?	☐	☐
4	Is there a schedule for analyzing the usefulness, obsolescence, and status of elements?	☐	☐
5	During the evaluation period, have any improvement proposals been presented in the area?	☐	☐
6	Have any lessons or standard operating procedures been developed?	☐	☐
	Discipline evaluation		
		YEAH	NO
1	Is there a culture of respect for established standards and achievements in terms of organization, order and cleanliness?	☐	☐
2	Is there any perceived proactivity in the development of the 5 S methodology?	☐	☐
3	Are there known situations within the evaluation period, not necessarily at the time of filling out this form, that affect the 5 S principles?	☐	☐
4	Are the results obtained through the methodology visible?	☐	☐

Source: self made

Results

According to the data obtained in each of the phases developed during the implementation of the continuous improvement process, the following findings were identified:

1. Order evaluation: The lack of neat arrangement in the tools and work areas was detected, as there is a lack of visual identification and a designated area for each element, which makes it difficult for the elements to return to their place of disposition. Therefore, it is of utmost importance to implement a stipulated order plan.

2. Cleaning evaluation: It was observed that effective cleaning monitoring was not carried out, which resulted in dirty and messy work areas. In addition, residues of compliant and non-conformed materials were found distributed throughout the work area. Therefore, it is important to implement cleaning plans, monitoring or routines among operators.
3. Standardization evaluation: The lack of monitoring rules during the process in the areas of management and adaptation was evident. Consequently, standards must be established to help maintain order and cleanliness in these areas.
4. Discipline evaluation: It was found that there is no knowledge of the 5 S methodology in 100% of the cases, which translates into a lack of discipline in the aspects mentioned above (order, cleanliness, organization and standardization). .

In the second phase, referring to information feedback and data analysis, the following percentages were obtained:

- Evaluation and organization: 71% of the areas do not have adequate organization.
- Order evaluation: 85% of the areas lack order.
- Cleaning assessment: 60% of areas do not have an established cleaning protocol.
- Standardization evaluation: 83% of work areas lack standardization.
- Discipline evaluation: 100% of the areas do not have knowledge of the 5 S methodology.

Table 3. Results of information feedback phase and data analysis

AREA	START	THE INTENTION IS TO
Evaluation and organization	71%	100%
Evaluation and order	85%	100%
Evaluation and cleaning	60%	100%
Evaluation and standardization	83%	100%
Evaluation and discipline	100%	100%

Source: self made

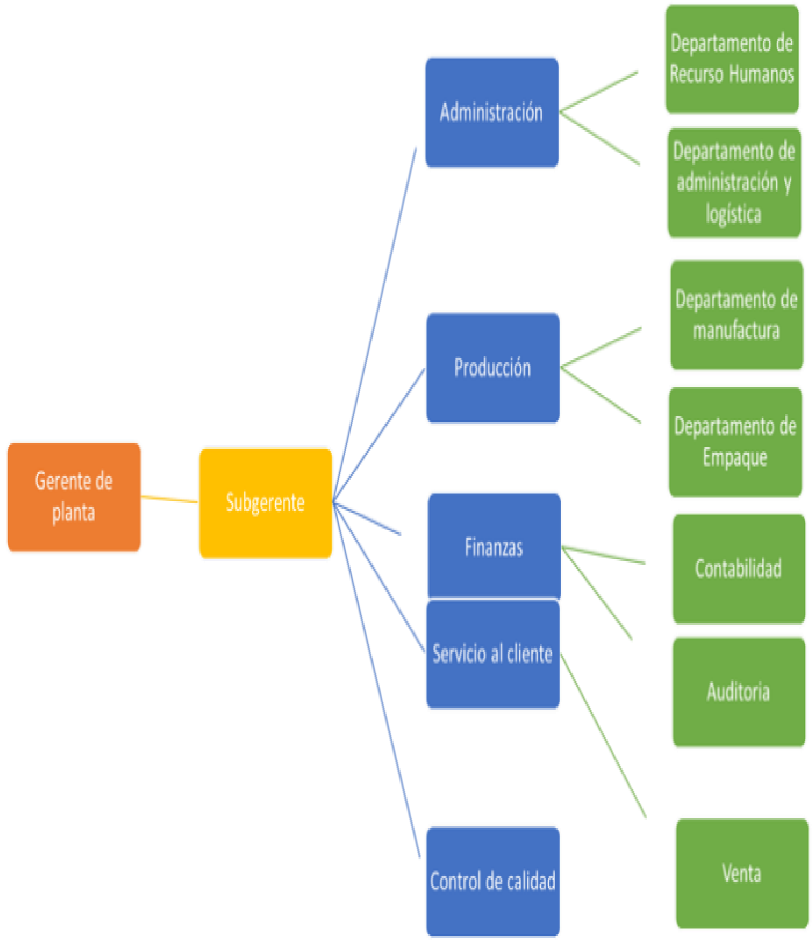
In the third phase, focused on the approach and implementation of actions, a detailed work plan was prepared that established the actions necessary to address the identified problems, as well as those responsible for each action. To achieve this, the company was encouraged to adopt the planned actions and carry them out collaboratively.

Subsequently, face-to-face courses led by managers and researchers were held in which topics related to the company's production, the importance of hierarchization between administrators and employees, as well as various methodologies and types of waste present in companies were addressed. During these courses, the observed failures were highlighted, and immediate improvements were proposed to optimize the operation of the company.

In this process, the general supervisor was assigned the responsibility of providing training to employees in the manufacturing area, which includes the separation and segregation area. In addition, workshops were implemented in which knowledge about the company's organizational structure was transmitted and shared, the person in charge of each department was introduced as a supervisor or leader, the materials, tools, and techniques used were explained, and the function was highlighted. and the importance of each area in the production process of the final product.

Likewise, employees were provided with information about the company's organizational chart, the production process and the areas that make up the company, including the separation areas and the production line.

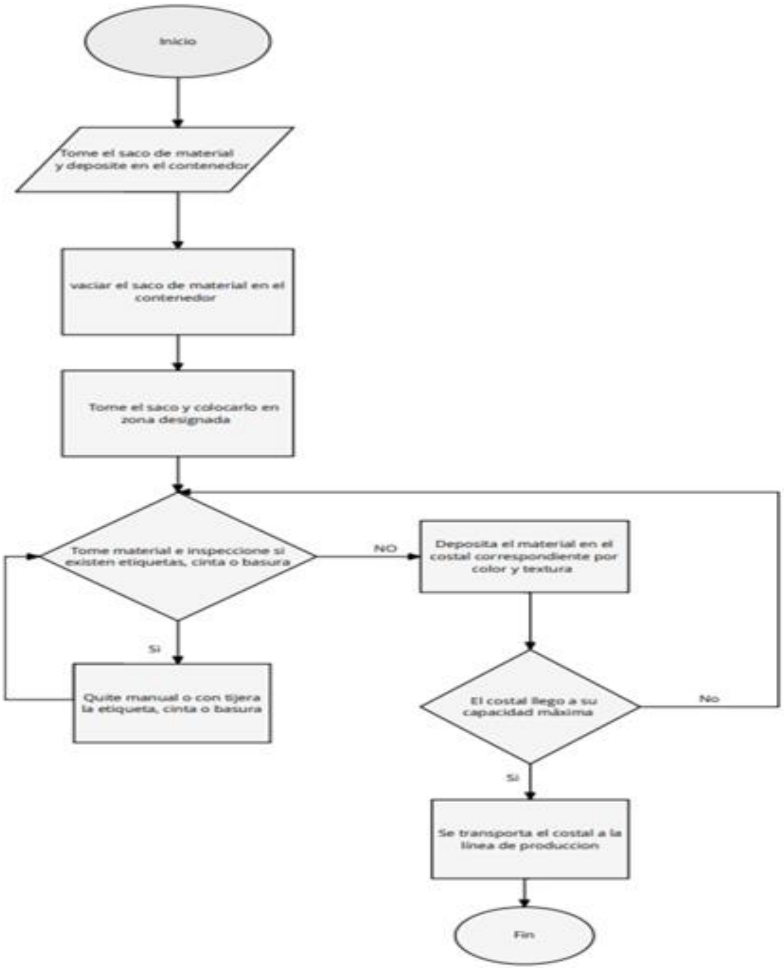
Figure 2. Company organization chart



Source: self made

Figure 3 shows the process of the production area, from when the material arrives and its processing to the transportation of the recycling.

Figure 3. Flowchart



Source: self made

Table 4. Development of training according to areas and action

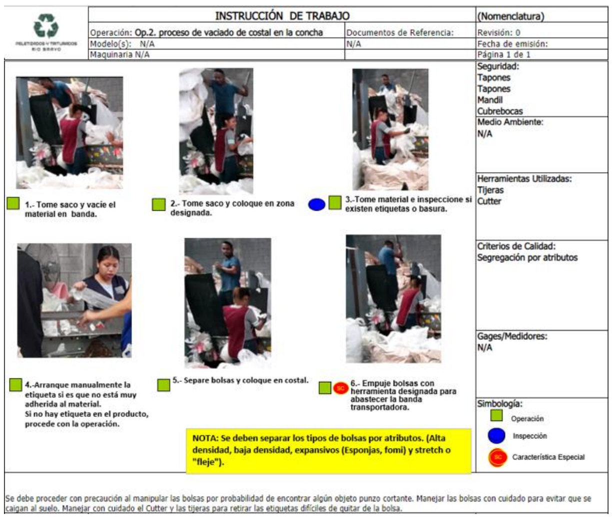
Areas	Training action
Job Description	Information about the position in each area and/or activity was generated in the training with the objective of their best performance and safety, and to follow up so that they know their competencies required to perform their functions.
Explanation of conforming and non-conforming materials	The operator is given training on the materials. Likewise, conforming materials are mentioned and made known to you, as well as the material physically so that you can see and feel its shape and texture. Likewise, non-conformed materials such as plastic bottles, tokens, cellophane, dirty material, tape, among others, are made known.
Regulation	The worker must know the company's internal regulations in order to have better work efficiency and an environment.
Implementation of control charts	Control charts are a visual aid found in the work area with the objective of guiding the operator in their functions. They describe in detail the process of the area, the activities and techniques that are implemented in each operation.
Bale selection and mill feeding	The bale is selected considering the customer's requests. In the raw material storage area there are pure bales, basic bales, colored bales, foam bales and mixed bales. In the segregation area, a worker must be chosen as a materialist, who will be in charge of selecting the bale that will be deposited in the container. At the beginning of the production line, 1 or 2 workers are placed for the final inspection of the material with the aim of preventing any non-conformed material from entering the pellet mill.
Excel	The supervisor is in charge of filling out the reports in the Excel application to have control of the production that was obtained for the day of each line, shift, as well as type of final product with the objective of keeping managers and supervisors up to date. of the production.
Input and output format	The input and output formats have the objective of having control of the movement of the material or product that has entered or left the plant to have administrative control.
Implement fault format.	The failure format is implemented to have a record and control of the deficiencies of the production lines. This record helps justify the decrease in production and implement improvement measures.
Logbook	The log is a communication tool between shifts. This is implemented to keep the supervisors of each shift informed about any failures or inconveniences that occurred. Subsequently, follow-up is carried out accordingly.
Layout diagram	The route diagram is the plan of the factory or work area and shows the correct position of the machines and workstations based on action methodology (Araya, 1988).
Path diagram description	It is a palletizing process. Once the bale has been chosen, it is transported with the forklift to the segregation area where it is placed in the segregation container. Then, the assigned operator is in charge

	of bursting the bale and feeding the belt so that the assigned operators can remove the tape and labels from the material and separate them into sacks by type of material (high, low, foamy, stretch, color). Once the bag is full of finished material (pellet), it is transported to the weighing machine and the bag is marked (date, type of natural or colored pellet, production line, kilograms, shift and tare weight). Finally, the sack is transported to the finished product storage area.

Fountain: Own elaboration

Figure 4 shows the information board so that the operators perceive what they must do in the process.

Figure 4. Information board



Source: self made

In the fourth phase, focused on evaluation, the results of the actions at the end of the cycle were reflected on. Furthermore, the results obtained were compared with the initial diagnosis results. This stage is crucial for the collective learning of the process since each of the main steps is monitored.

Additionally, during the implementation of this process, various areas were identified and analyzed, including the following: administration, operator movements, materials handling, machinery, storage, and service.

First phase

All the mentioned departments were observed and analyzed. In addition, areas of opportunity, their causes, and effects, were detected using different methods such as time taking, flow charts, routes, among others. Likewise, the bottleneck was identified through the action research methodology in the production processes in the recycling company.

On the other hand, immediate action plans were implemented to address or reduce the problems encountered in materials management, the production process and quality. Likewise, production control resources were used by area and weekly and monthly reports were generated.

This document presents the resources used to improve the company and the analysis carried out, company reports, actions, movements, and modifications that were carried out in the areas and activities.

Administration area

Various measures were implemented to promote continuous improvement. For example, a diagnostic evaluation of the 5 Ss, the 7 quality tools, process mapping, problem resolution and root analysis was carried out. In addition, the mission and vision of the company was proposed, as well as the development of a visible regulation for operators and administration. The detailed job description and the company's organizational chart facilitated communication between management and operators, ensuring that instructions were transmitted appropriately and that everyone involved in the area or process was known.

- Material identification. Training was provided to both administrators and operators, and the separation material that could be processed was presented. Likewise, a board was installed with photographs and descriptions of the materials that could enter the process for better understanding by staff.
- Movements. The movements of the operators were improved, which made it possible to optimize times and eliminate some unnecessary ones in the operation. In addition, the work area was facilitated, including a separation table prior to the production line.
- Material handling. It was identified that the separation of materials was not being carried out properly. Therefore, a training course on material separation was provided, resulting in an 80% improvement. Likewise, a board was installed with the

suitable materials and those that should be rejected for a clear visual reference by the staff.

- Storage. A notable decrease was achieved in the storage of products destined for the raw material transformation process, reaching an improvement of 80%.
- Operator. Greater clarity was expressed in the production process with all the improvements implemented, as well as with the courses and information provided on the boards with allowed and prohibited items.
- Service. A significant improvement was observed in customer satisfaction, who are happy with delivery times and the quality of the product they receive.
- Machinery. The performance in its use was identified and the factors that cause the interruption of the process due to the machinery were detected, mainly related to the use of inappropriate material. Even so, it is recommended to prepare a clear and precise list of the objectives that should not enter the process. Likewise, it is essential that this list is visible to all operators so that all staff understand it and integrate it into their daily work.

Based on the previous points, it is evident that all the improvements made in the company generated satisfaction by optimizing the key points to obtain better results.

Second stage

Table 5 presents the initial diagnosis and the results after applying the action research methodology, with an improvement of 98%, although the aim is to achieve 100% improvement in later stages.

Table 5. Diagnosis

DIAGNOSIS	START	METHODOLOGY-ACTION	THE INTENTION IS TO
Evaluation and organization	71%	98%	100%
Evaluation and order	85%	98%	100%
Evaluation and cleaning	60%	100%	100%
Evaluation and standardization	83%	100%	100%
Evaluation and discipline	100%	100%	100%

Fountain: Own elaboration

Third phase

Various actions were applied to implement the process. First, training was provided in several stages. Then, the detailed job description was entered, and the organizational chart was applied. In addition, process letters were prepared, and a system was implemented in Excel that includes the failure format and the output format.

Fourth phase

The action methodology served to close the cycle with monitoring:

Company researchers				
PHASE	STEPS	GUY	PARTICIPANTS	DESCRIPTION
1	Diagnosis	Meeting	Management, administrative and researchers	• Identify the current tax situation. • Present the results of the diagnosis. • Joint agreements.
2	Harvest	Visit to the company	Area managers	• Tour of the plant • Take photos. • Access to information • Application of methodologies
3	Feedback	Meeting	Management, administrative and researchers	• Analysis of the results • Implementation of actions
	Action planning	Meeting	Management, administrative and researchers	• 100% courses for the entire company • Job Description • Implementation of the regulation • Implementation of process alibis • Excel program • Input and output formats. • Machinery failure formats
4	Monitoring	Meeting	Management, administrative and researchers	• Check that everything I implement is working and detect some errors to correct them.

Fountain: Own elaboration

Discussion

In organizations, the implementation of various methods, especially in the engineering area, requires the integration of various departments and their functions to solve problems that lead to decision making. Logically, this integration is likely to lead to effective results in production systems, such as the step towards standardization of processes and customer satisfaction.

Now, when analyzing the results obtained in this research and implementing continuous improvement in the production processes, the administrative, operational and senior management personnel indicated that the lack of procedures in each of the functions or the overload of tasks did not allow them to have measurement metrics in each of the established areas, such as KPIs (key performance indicators), especially in a sustainable recycling company in its initial stage in the market. In fact, various situations arose that caused resistance to change among personnel, although some research highlights the importance of waste elimination in the efficiency of the production system. This allows for timely delivery to meet customer demand, hence the manufacturing process is a fundamental principle (Andrue, February 22, 2023).

Similarly, the results are consistent with those obtained by George *et al. (2005), who point out that lean and Six Sigma* process improvement methods have been used in a variety of studies to maximize stakeholder value by achieving better relationships in customer satisfaction, cost, quality, process speed. and capital investment.

Therefore, Marca (2019) encourages large companies and multinational corporations to adopt sustainable practices and integrate sustainability information horizontally with SDG 12, so that sustainable consumption and production strategies are guaranteed, and related processes are promoted. with continuous improvement of change. In short, and according to the review of the foundations of the literature, it can be stated that overloaded work and the lack of established functions, as well as limited development time are factors that influence continuous improvement processes.

Conclusions

The action methodology was a crucial process to collect information in this work, since its focus on observation allowed us to perceive the importance and positive impact of continuous improvement in manufacturing companies, especially in the industrial sector.

Likewise, an exhaustive analysis of the background of the industrial company was carried out, which made it possible to identify the objectives of the area and establish precise goals for the process. This stage is considered essential for all companies that focus on continuous improvement, as it involves the evaluation, improvement, and analysis of historical data within the processes, which provides a solid basis for decision making.

During the process, various diagrams were developed, such as flow and Ishikawa diagrams, as well as specific *layout designs.* In this sense, special attention was given to the 5 S methodology, which was implemented in all work areas. Additionally, widely recognized KPIs in the industry were used, which provided numerical data and quantifiable functions that could be easily represented in graphs or tables. This made it possible to clearly reflect the status of the process and convert the data into statistical tools that could be stored as historical data for later consultation. These tools turned out to be key for both evaluation and overall security, ensuring optimal operation of the company.

On the other hand, the positive results obtained were immediately analyzed to facilitate process management through quantitative measurement and transform them into continuous development that leads to an increasingly efficient company. Since the primary purpose of continuous improvement is to empower the workforce to make decisions, these must be specific and oriented toward a previously established goal, rather than general, to then be implemented effectively.

Finally, and for future research in this field, it is recommended to carry out interviews with collaborators to evaluate their satisfaction with the improvements implemented. The data collected could be used to make a diagnosis that evaluates the company's progress. The primary objective is to guarantee that employees experience continuous improvement in their production processes, which will allow the detection of factors that contribute to work performance. Based on this information, workshops specifically designed to improve processes can be proposed. Finally, the implementation of a pre-experimental or quasiexperimental design could be considered, using the results of systematic reviews as a starting point.

References

Acuña, J. (2004). *Mejoramiento de la calidad: un enfoque a los servicios*. Editorial Tecnológica.

Aldás, D., Portalanza, N., Tierra, L. y Barrionuevo, M. (2018). Análisis de los tiempos de preparación para la reducción de desperdicios en el proceso de troquelado. Caso aplicado industria de calzado. *Innova*, 3(10), 149-160.

Alvarado, K. y Pumisacho, V. (2017). Prácticas de mejora continua, con enfoque Kaizen, en empresas del Distrito Metropolitano de Quinto: un estudio exploratorio. *Intangible Capital*, 13(2), 479-497.

Andrue, I. (22 de febrero de 2023). Lean Manufacturing: ¿qué es y cuáles son sus principios? *APD*. https://www.apd.es/lean-manufacturing-que -es/

Araya, J. C. (1988). *Técnicas de organización y metodos* (II parte). UNED

Aruleswaran, A. (2009). *Changing With Lean Six Sigma*. LSS Academy Sdn. Bhd.

Boada, J y Ficapal, P. (2012). *Salud y trabajo. Los nuevos y emergentes riesgos psicosociales.* Editorial UOC.

Caldas, B. y Cueto, R. (2019). *Diseño y desarrollo de un modelo de reducción de desperdicios en una microempresa de confecciones aplicando la filosofía lean manufacturing – Umbrella Model* (trabajo de grado). Universidad Peruana de Ciencias Aplicadas.

Chavéz, E. (2022). Tablero de indicadores de desempeño académico en la carrera de ingenieria industrial. *RIDE Revista Iberoamericana para la Investigación y el Desarrollo Educativo*, 13(25), 1-26.

Cuatrecasas, L. y González, J. (2017). *Gestión integral de la calidad. Implementación, conltrol y certificación.* Profit.

Diez, M., Pérez, A., Gimena, F. y Montes, M. (2012). Medición del desempeño éxito en la dereección de preyectos. Perspectiva dfel manager público. *Revista EAN*, (73), 60-79.

Dudek-Burlikowska and Szewiwczek, D. (2009). The Poka-Yooke method as an improving quality tool of operations in the proces. *Journal of Achievements of Materials and Manufacturing Engineering*, *36*(1), 10-19.

Flapper, S., Fortuin, L. and Stoop, P. (1996). Towards consistent performane management systems. *International Journal of Operations & Production Management*, 16(7), 27-37. https://doi.org/10.1108/01443579610119144

Fontalvo, T. (2009). Un caso práctico del enfoque sistématico convergente de la calidad (ESCC) en vidrio templado. *Revista Escenarios*, *12*(2), 7-18.

Fortalvo, T., De la Hoz, E. y Morelos, J. (2018). La productividad y sus factores: incidencia en el mejoramiento organizacional. *Dimensión Empresarial*, *16*(1).

Galgano, A. (2021). *Los tres revoluciones.* Grupo Galgano.

George, M., Rowlands, D., Opton, M. and Maxey, J. (2005). *The Lean Six Sigma Pocket Toolbook: A Quick Reference Guide to Nearly 100 Tools for Improving Quality and Speed.* McGraw-Hill.

Guido-Falcón, W. y Roque, O. (2018). Las competencias laborales y la implementación de gestión de calidad ISO:2015. *Paideia XXI*, *8*(2)https://doi.org/10.31381/paideia.v8i2.2042

Gutiérrez, A. (25 de junio de 2023). *Objetivos de desarrollo sustentable*. www.un.org:https://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible/

Hernández, F. (2018). *Inspección automática con videovigilancia de software gratuito en la fabricación de autopartes plásticas* (tesis de maestría). CIATEQ.

Hernández, J. y Vizán, A. (2013). *Lean manufacturing. Conceptos, técnicas e implantación.* Escuela de Organización Industrial.

Hérnandez, V., Zarate, P. y García, A. (2018). Mejoramiento del área de manufactura de una línea aplicando la manufactura esbelta. *Jovenes en la Ciencia*, *4*, 38-48.

Hinojosa , S. (2010). *Un indicador de elegibilidad para seleccionar proyectos de asociaciones público-privadas en infraestructura y servicio*. BID.

Kumar, M., Antony, J., Madu, C., Montgomery, D., and Park, S. (2008). Common myths of Six Sigma demystified. *International Journal of Quality & Reliability Management*, *25*(8), 878-895. https://doi.org/10.1108/02656710810898658

López, P. (2015). *Cómo documentar un sistema de gestión de calidad según ISO 9001:2015*. Editorial Fundación Confemetal.

Marca, E. (2019). *El papel de las empresas medioambiente y sosteniblidad.* Multinacionales por Marca España.

Organización Internacional de Normalizacion (25 de abril de 2018). ISO:45001:2018. https://www.iso.org/obp/ui/#iso:std:iso:45001:ed-1:v1:es

Peña, J. (2019). *Aplicación de herramientas de manufactura esbelta en el proceso de producción para reducir los desperdicios lean en la empresa de calzado Casalian S.A.C, 2019* (trabajo de grado). Universidad César Vallejo. https://repositorio.ucv.edu.pe/

Pereira, C., Butista, J., Fernandes, A. y Fernandes, D. (2012). Pesquisa-ação na engenharia de produção: proposta de estruturação para sua condução. *Produção*, *22*(1), 1-13.

Pérez, I. y Rojas, J. (2019). Lean, seis sigma y herramientas cuantitativas: una experiencia real en el mejoramiento productivo de de la industria gráfica en Colombia. *Revista Procesos de Métodos Cuantitativos para la Economía y la Empresa*, *27*, 254-284.

Piñero, A., Vivas, E. y Flores, L. (2017). Programa 5S´s para el mejoramiento continuo de la calidad y la productividad en los puestos de trabajo. *Ingeniería Industrial. Actualidad y Nuevas Tendencias*, *6*(20), 99-110

Reyes, J., Aguilar, L., Hernández, J., Mejías, A., y Piñero, A. (2017). La metodología 5S como estrategia para la mejora continua en industrias del Ecuador y su impacto en la seguridad y salud laboral. *Polo del Conocimiento*, *2*(7), 29-41.

Rojas Calva, A., Reues, M., Salinas, E., Hernández, J. y Cerecedo, E. (2018). Caracterización y estudio de la composición de oro presente en la chatarra electrónica. *Pädi Boletín Científico de Cienecias Báicas e Ingenierías del ICBI*, *6*(11).

Suárez-Barraza, S. y Miguel-Dávila, M. (2011). Implementación del Kaizen en México: un estudio exploratorio de una proximación gerencial japonesa en el contexto latinoammericano. *Innovar. Revista de Ciencias Administrativas y Sociales*, *21*(41), 19-37.

Tanveer, M. Asif Khan, M. and Shyang Ho, S. (2016). *Rels*. Robust energy-based least squares twin support vector machines. *Appl Intell*, *45*, 174–186

Team Asana (10 de febrero de 2024). *Evaluación del desempeño: 15 modelos y plantilla gratuita*. https://asana.com/es/resources/employee-performance-review-template

Thiollent, M. (2005). *Metodología da pesquisa-acao*. Cortez Editora.

Tolosa, L. (2017). *Tecnicas de mejora continua en el trasporte.* Alfa Omega Editorial.

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