JPB REVIEW
INTERNATIONAL JOURNAL OF PROFESSIONAL BUSINESS REVIEW
ISSN: 2525-3654
OPEN ACCESS

KAIZEN: IMPROVING PRODUCTIVITY AND REDUCING WASTE IN A MANUFACTURING COMPANY: A PRACTICAL CASE STUDY

Juan Chávez Medina[A], Norma Angélica Santiesteban López[B], María Elena Pérez Terrón[C], José Víctor Manuel Vallejo Córdoba[D]

ARTICLE INFO

Article history:

Received 09 October 2023

Accepted 24 January 2024

Keywords:

Kaizen Methodology;
Improvement Plan;
Productivity;
Waste;
Maintenance.

PREREGISTERED
OPEN DATA
OPEN MATERIALS

ABSTRACT

Purpose: The goal of the research article is to reduce waste in the bandage winding machine. This is achieved through the application of the Kaizen methodology, which is based on continuous improvement and the participation of all employees by presenting a case study in a manufacturing company.

Theoretical Framework: The article presents a solid theoretical framework, including a review of the literature on Kaizen methodology and waste in production. The author cites well-known authors in these areas, such as J.A. García and J.L. Marín-García, who have researched the application of the Kaizen methodology in manufacturing companies.

Design/Methodology/Approach: The article uses a quantitative and descriptive approach. The author collects data by diagnosing the current situation, implementing strategies, applying the Kaizen methodology, and developing a preventive maintenance plan.

Findings: The results of the article are positive. The author manages to reduce the waste in the bandage winding machine by 1%. This is because the changes made in the speed of operation, the implementation of strategies, the application of the Kaizen methodology and the establishment of a preventive maintenance plan have all contributed to reducing machine downtime and defects in the bandages.

Research, Practical & Social Implications: The author demonstrates that the research is original and creative. The article presents a novel approach to reducing waste in production, which combines the Kaizen methodology with preventive maintenance. The results of the article have significant practical and social implications. Reducing waste in production can help improve efficiency, reduce costs, and increase product quality. In addition, the Kaizen methodology can be applied to other productive contexts, which could generate similar benefits.

Originality/Value: The item is original and valuable. The author presents a novel approach to reducing waste in production, which combines the Kaizen methodology with preventive maintenance. The results of the article are positive and have significant practical and social implications. Value in proposing concrete actions to address identified problems and improve the production process.

Doi: https://doi.org/10.26668/businessreview/2024.v9i1.4241

[A] *PhD in Strategic Planning and Technology Management. Universidad Politécnica de Puebla. Mexico. E-mail: juan.chavez.medina@uppuebla.edu.mx Orcid: https://orcid.org/0000-0002-1978-0620*
[B] *PhD in Food Sciences. Benemérita Universidad Autónoma de Puebla. Mexico. E-mail: asantiesteban2@hotmail.com Orcid: https://orcid.org/0000-0001-7700-4139*
[C] *PhD in Education. Benemérita Universidad Autónoma de Puebla. Mexico. E-mail: elena.prerron@correo.buap.mx Orcid: https://orcid.org/0000-0002-2417-0915*
[D] *PhD in Administration. Benemérita Universidad Autónoma de Puebla. Mexico. E-mail: victor.vallejo@correo.buap.mx Orcid: https://orcid.org/0000-0003-2224-4850*

KAIZEN: MELHORANDO A PRODUTIVIDADE E REDUZINDO O DESPERDÍCIO EM UMA FÁBRICA

RESUMO

Objetivo: O objetivo do artigo de pesquisa é reduzir o desperdício na máquina de enrolar curativos. Isto é conseguido através da aplicação da metodologia Kaizen, que se baseia na melhoria contínua e na participação de todos os colaboradores, através da apresentação de um estudo de caso numa empresa fabricante.
Referencial Teórico: O artigo apresenta um sólido referencial teórico, incluindo uma revisão da literatura sobre metodologia Kaizen e desperdício na produção. O autor cita autores conhecidos nessas áreas, como J.A. García e J.L. Marín-García, que pesquisaram a aplicação da metodologia Kaizen em empresas de manufatura.
Design/Metodologia/Abordagem: O artigo utiliza uma abordagem quantitativa e descritiva. O autor coleta dados diagnosticando a situação atual, implementando estratégias, aplicando a metodologia Kaizen e desenvolvendo um plano de manutenção preventiva.
Resultados: Os resultados do artigo são positivos. O autor consegue reduzir o desperdício na máquina de enrolar ligaduras em 1%. Isso porque as mudanças na velocidade de operação, a implementação de estratégias, a aplicação da metodologia Kaizen e o estabelecimento de um plano de manutenção preventiva contribuíram para reduzir o tempo de inatividade da máquina e defeitos nos curativos.
Pesquisa, Implicações Práticas e Sociais: O autor demonstra que a pesquisa é original e criativa. O artigo apresenta uma nova abordagem para reduzir o desperdício na produção, que combina a metodologia Kaizen com a manutenção preventiva. Os resultados do artigo têm implicações práticas e sociais significativas. Reduzir o desperdício na produção pode ajudar a melhorar a eficiência, reduzir custos e aumentar a qualidade do produto. Além disso, a metodologia Kaizen pode ser aplicada a outros contextos produtivos, o que poderia gerar benefícios semelhantes.
Originalidade/Valor: O artigo é original e valioso. O autor apresenta uma nova abordagem para reduzir o desperdício na produção, que combina a metodologia Kaizen com a manutenção preventiva. Os resultados do artigo são positivos e têm implicações práticas e sociais significativas. Valor em propor ações concretas para resolver os problemas identificados e melhorar o processo de produção.

Palavras-chave: Kaizen, Plano de Melhoria, Produtividade, Desperdício, Manutenção.

KAIZEN: MEJORANDO LA PRODUCTIVIDAD Y REDUCIENDO LOS RESIDUOS EN UN COMP DE MANUFACTURA

RESUMEN

Propósito: El propósito del trabajo de investigación es reducir el desperdicio en la máquina laminadora de aderezo. Esto se consigue a través de la aplicación de la metodología Kaizen, que se basa en la mejora continua y la participación de todos los empleados, a través de la presentación de un caso de estudio en una empresa manufacturera.
Marco Teórico: El artículo presenta un marco teórico sólido, que incluye una revisión de la literatura sobre la metodología Kaizen y los residuos en la producción. El autor cita a autores de reconocido prestigio en estas áreas, como J.A. García y J.L. Marín-García, que han investigado la aplicación de la metodología Kaizen en empresas manufactureras.
Diseño/Metodología/Enfoque: El artículo utiliza un enfoque cuantitativo y descriptivo. El autor recopila datos mediante el diagnóstico de la situación actual, la implementación de estrategias, la aplicación de la metodología Kaizen y el desarrollo de un plan de mantenimiento preventivo.
Resultados: Los resultados del artículo son positivos. El autor logra reducir el desperdicio en la máquina de bobinado de vendajes en un 1%. Esto se debe a que los cambios en la velocidad de operación, la implementación de estrategias, la aplicación de la metodología Kaizen y el establecimiento de un plan de mantenimiento preventivo han contribuido a reducir el tiempo de inactividad de las máquinas y los defectos de preparación.
Investigación, Implicaciones Prácticas y Sociales: El autor demuestra que la investigación es original y creativa. El artículo presenta un nuevo enfoque para reducir el desperdicio en la producción, que combina la metodología Kaizen con el mantenimiento preventivo. Los resultados del documento tienen importantes implicaciones prácticas y sociales. Reducir el desperdicio en la producción puede ayudar a mejorar la eficiencia, reducir los costos y aumentar la calidad del producto. Además, la metodología Kaizen puede ser aplicada a otros contextos productivos, lo que podría generar beneficios similares.
Originalidad/Valor: El artículo es original y valioso. El autor presenta un nuevo enfoque para reducir el desperdicio en la producción, que combina la metodología Kaizen con el mantenimiento preventivo. Los resultados del trabajo son positivos y tienen importantes implicaciones prácticas y sociales. Valor en proponer acciones concretas para resolver los problemas identificados y mejorar el proceso productivo.

Palabras clave: Kaizen, Plan de Mejora, Productividad, Desperdicios, Mantenimiento.

INTRODUCTION

Mexico has positioned itself as the eighth country worldwide in the manufacture and export of medical devices, surpassing technologically more advanced nations such as Japan, South Korea, France and Italy. This achievement has led Mexico to be recognized as the third largest medical importer globally and the main exporter of medical devices in Latin America [1] and [2]. In addition, the country stands out as the main supplier of medical devices to the United States, accounting for 92% of exports to that country [3].

In addition, productivity is a factor of utmost importance for companies, since it reflects their performance, innovation capacity and strategies. According to [4], high productivity implies greater competitiveness and organizational success.

The company in question is a Mexican organization headquartered in the city of Puebla, dedicated to the manufacture of hospital products and healing materials. Its product portfolio includes umbilical ligatures, belly compresses, cotton in different presentations, sterilized and non-sterilized gauze, and postpartum bandages in different sizes.

Motivated by the growing demand for surgical material, the company has decided to implement an additional winding machine in the bandage area in order to increase the number of pieces processed in less time and thus increase productivity. However, it has been observed that the machines produce around 150 defective bandages per shift, generating an economic loss of more than 550 pesos per shift. It is estimated that 1.2% of the production delivered by each machine is defective. Although the operators meet the established production goals, only 98.8% of the bandages manufactured meet total quality standards. Therefore, there is a need to control these waste rates by implementing the Kaizen or continuous improvement methodology and applying additional preventive maintenance to prevent failures and avoid interruptions in the process.

In this context, the general objective of the present research is to develop a continuous improvement plan in the bandage sewing and rolling process, through the application of the Kaizen methodology and the adoption of preventive maintenance, in order to reduce waste and increase productivity in the bandage area of the manufacturing company.

Theoretical Foundations

Kaizen methodology has been widely used in manufacturing companies to improve efficiency and reduce waste in production processes. In a case study on the implementation of Kaizen in an auto parts manufacturing company in Mexico, it was found that the methodology allowed improving product quality, reducing production time and reducing waste [5]. Another study in Colombia on the application of Kaizen in metal-mechanical companies found that the methodology allowed improving productivity, reducing costs and improving product quality [6]. In a theoretical study on technological design and work process, it is mentioned that Kaizen methodology is a useful tool to improve efficiency and quality in production processes [7].

Regarding the application of preventive maintenance, a study in Spain found that the implementation of a preventive maintenance plan resulted in reduced machinery downtime and improved production efficiency [8].

The Kaizen methodology has been widely used in manufacturing companies to improve efficiency and reduce waste in production processes. The application of preventive maintenance can also be a useful tool to improve production efficiency. In this sense, it is necessary to mention that the Kaizen methodology is based on the philosophy of continuous improvement, where the participation of employees at all levels of the organization is promoted to identify and eliminate waste, as well as to implement gradual improvements in the processes. The focus is on efficiency, quality and employee participation to achieve long-term sustainable improvements [9].

An outstanding example of the successful implementation of Kaizen can be found at Toyota, a company recognized worldwide for its Toyota Production System (TPS). Toyota has successfully adopted the Kaizen methodology in its manufacturing processes, encouraging employee participation and promoting continuous improvement. As a result, Toyota has managed to significantly reduce waste, improve product quality and increase efficiency in its production plants [10].

In addition to the above case, FANUC, a leading Company in the field of industrial automation equipment manufacturing, has successfully adopted the Kaizen philosophy in its operations with the aim of maximizing efficiency and minimizing waste. By implementing this methodology, FANUC has achieved remarkable advances in terms of productivity, quality and efficiency. In addition, it has fostered a culture of employee participation, encouraging employees to identify and solve problems collaboratively [11].

Table of research on the implementation of Kaizen in companies:

Table 1. Research on the application of Kaizen in companies.

Autor(es)	Año	Título de trabajo o investigación	Método de investigación	Principal resultado
Medina-López, C., Alfalla-Luque, R., y Marín-García, J. A. [12]	2011	The application of Kaizen in Mexican organizations. An empirical study.	Case study	The implementation of the Kaizen philosophy improved efficiency and reduced waste in manufacturing companies in Mexico.
Marín-García, J. A. [12]	2012	Kaizen implementation in Mexico: an exploratory study of a Japanese managerial approach in the Latin American context.	Exploratory study	The implementation of the Kaizen philosophy in multinational companies in Mexico has improved efficiency and reduced costs.
Suárez-Barraza, M. F. y Castillo-Arias, I. [13]	2013	The application of Kaizen in Mexican organizations. An empirical study.	Case study	The implementation of the Kaizen philosophy improved efficiency and reduced waste in manufacturing companies in Mexico.
Alfalla Luque, R., Marín García, J. A., y Medina-López, C. [12]	2012	Is worker participation related to Kaizen implementation success? An empirical study in Mexican organizations	Empirical study	The participation of workers in the implementation of the Kaizen philosophy in manufacturing companies in Mexico is related to the success of the implementation.
García, J. A. y Rodríguez, J. A. [5]	2015	Technological and productive trajectory of General Motors in Mexico, the case of the Silao Complex, Guanajuato - Automotive	Case study	The implementation of the Kaizen philosophy at General Motors in Mexico improved efficiency and reduced waste at its Guanajuato complex.
Cruz, A. [7]	2015	Technological design and work process	Theoretical Study	The Kaizen philosophy is a useful tool for improving efficiency and quality in production processes.
Brunet, A. P. y New, S. [14]	2003	Kaizen in Japan: An empirical study	Empirical study	The implementation of the Kaizen philosophy in Japanese companies has improved efficiency and reduced waste.
Oropesa Vento, M., Garcia Alcaraz, J. L., Maldonado, M., Aidé, A., y Loya, V. [15]	2016	The impact of managerial commitment and Kaizen benefits on companies	Empirical study	Management commitment and the benefits of the Kaizen philosophy positively affect companies.
Al-Najjar, A. M. y Rahman, M. A. [16]	2014	The implementation of Kaizen in the service industry: a case study	Case Study	The implementation of the Kaizen philosophy in a service company in the United Kingdom improved efficiency and reduced costs.

Source: Own elaboration.

MATERIALS AND METHODS

The methodological aspects of this quantitative, descriptive and conclusive research, which was carried out in the period from September 2020 to May 2021, are presented below. In this sense, it can be mentioned that one of the methods used in this research was Kaizen, which was used as part of a problem-solving process. In this methodology, any improvement must be standardized to reach the next level of improvement. The main focus of Kaizen is to improve the work system, which allows companies to produce large quantities of products in a shorter time while maintaining optimal quality. However, to obtain better results, it is necessary to involve not only people, but also the machinery and materials available, to achieve significant improvements as a whole.

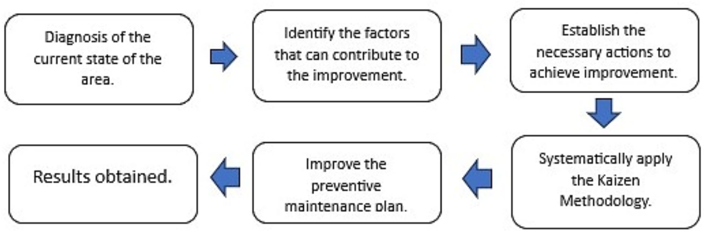
According to [17], the Kaizen approach generates process-oriented thinking, since processes must be improved before results can be obtained. This approach promotes the idea that a better method can always be found and is based on gradual progress with small innovations and improvements made by all employees, including managers. These cumulative improvements ensure quality, reduce costs, and allow the right quantity to be delivered to the customer on time, as they state [18].

Continuous improvement implies that when a problem arises, the production process is stopped to analyze the causes and take corrective action, which increases the efficiency of the system. This aligns with the Kaizen approach and reinforces the importance of addressing problems proactively to achieve continuous improvement.

In this research, an adapted methodology that integrated various existing tools and procedures was used to improve the system. Some of these tools include the Deming cycle or PDCA, total quality management (TQM) and Single Minute Exchange of Die (SMED), as mentioned in [19].

To carry out this continuous improvement research, the following schematic steps were established, which can be seen in Figure 1.

Figure 1. Improvement plan methodological scheme.



Source: Own elaboration.

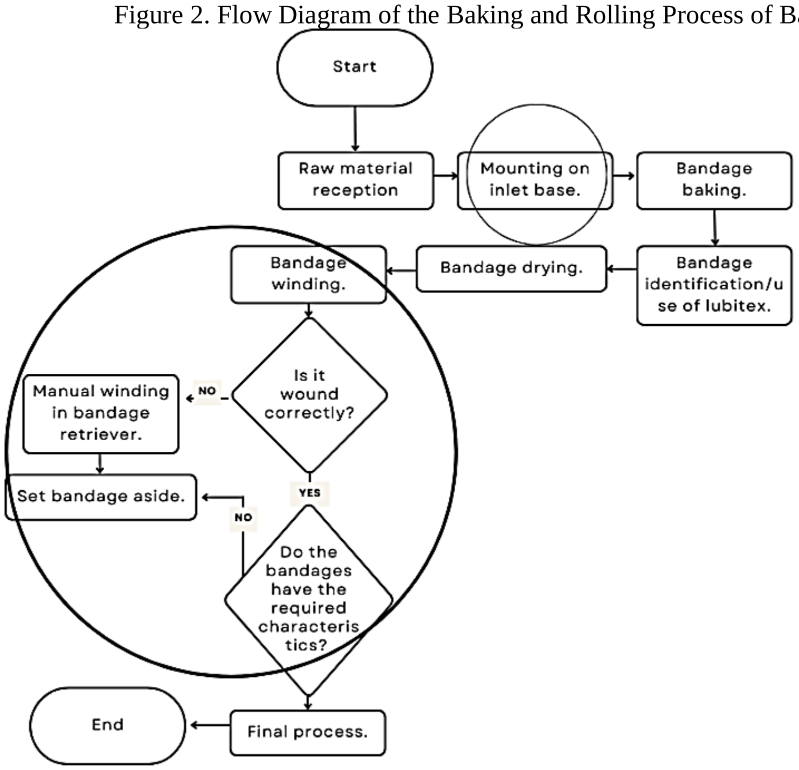
RESULTS

Diagnosis of the Area

To start the process of developing the improvement project, a diagnosis was carried out with the objective of evaluating the current situation of the "Sales Area". This area in particular has shown great potential for growth in the plant, especially after a recent expansion that took place months ago. As part of this expansion, a new bandage rolling machine was incorporated in order to increase production. It should be noted that these machines are considered semi-automatic, as most of the operations are performed by the machine itself.

The following flow chart (see Fig. 2) details the stages of the baking and bandage rolling process, highlighting the interventions made by the personnel by means of circles.

Figure 2. Flow Diagram of the Baking and Rolling Process of Bandages.



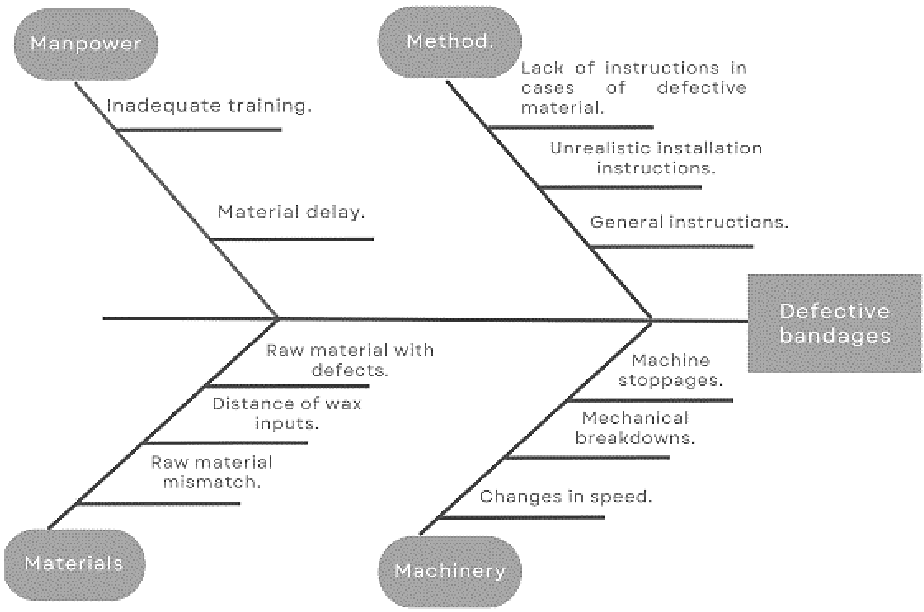
Source: Own elaboration.

In relation to the above, the operators have the responsibility to properly start the winding machines, following the specific operating parameters described in the Standard Operating Procedure (PNO) of each machine. However, there is considerable variation in the parameters according to the size of the bandages, and in addition, these parameters are not correctly identified in the PNO.

In addition, a high number of rejected bandages was detected due to non-compliance with quality standards. It was observed that each machine has a production goal per shift, calculated based on the adaptation of the machine to the size of the bands. However, during the process, operators face problems that result in approximately 1.2% of defective bandages per machine. These losses accumulate throughout the shift, reaching approximately 7.2% of bandages that cannot be recovered, since the elimination of defects is not easily achievable. Consequently, the rejected material must be destined for another use.

In order to accurately identify and understand this problem, an Ishikawa or cause-effect diagram was developed (See Fig. 3), which was generated using the information collected to highlight the main causes of the identified problem.

Figure 3. Ishikawa diagram.



Source: Own elaboration.

As reflected in the Ishikawa diagram, only four of the factors that stick more to obtain this problem were taken, which are: materials, labor, method and machinery where the causes are changes in speed, mechanical breakdowns and machine stoppages. This serves as a basis to know what are the causes of the problem obtained.

Identify factors that can contribute to improvement

An analysis of the previously mentioned factors was carried out to determinate their relevance to this problema. In this sense, the quality standars that must be met for a bandage to advance to the next process were identified. These standars cover aspects such as the number of wefts, color weight diameter normal lenght anf lenght of the bandage when stretched. The workers or quality inspectors themselves are responsable for making these measurements, and if any og the above parameters do not meet the required specifications, the workers adjust the machine parameters to ensure that the bandage meets the established quiality standars.

Table 2 presents the identified wastes, followed by the corresponding causes, in order to provide a clear view of the discrepancies encountered during the process.

Table 2. Main causes of waste found in the área.

Waste	Found case	Cause
Seams. Jumps in the product or material that do not comply with the specifications and that are generated by joints made in order to be able to continue production.	Bandages that have fabric bindings.	Raw material problems.
Prior approval. Waste of approval of standards.	Bandages with incorrect wefts Bandages under/over weight, stretch length and bandage diameter.	Changes in machine standards.
Shade and gloss approval. Waste due to approved shade and/or gloss that does not correspond to the standard. Raw bandages	Stained, raw or burnt bandages.	Operators are late in the final operation, the oven does not heat up enough or overheats during machine stoppages due to operation or maintenance.

Source: Own elaboration.

Raw material problem

It is important to note that this identified cause is not a controllable factor, since the defects found in the bandage rolls cannot be modified. Once a defect is detected in the bandage, it is not possible to make adjustments or corrections to fix the problem. It is essential to take this limitation into account when looking for solutions to improve the quality of the bands, focusing on the factors that can be controlled and adjusted during the production process.

Changes in standards

The operators adjust the parameters of the winding machine based on the "Standard Operating Procedure (PNO) for the handling and cleaning of the Baking and Winding Bandage machine". However, these parameters differ from the actual values used by operators, who adjust them according to their experience to achieve better performance. This discrepancy affects the quality of the bandages and generates loss of time. However, this cause is controllable and can be addressed with appropriate measures.

Defects identified due to improper handling of parameters include: bandages with incorrect wefts, low or overweight bandages, stretching of the bandage and incorrect diameter of the band. These problems are related to improper oven heating, fan speed, drying process, table configuration, and winding time. Addressing these causes and defects will improve the quality of the bands and optimize the production process.

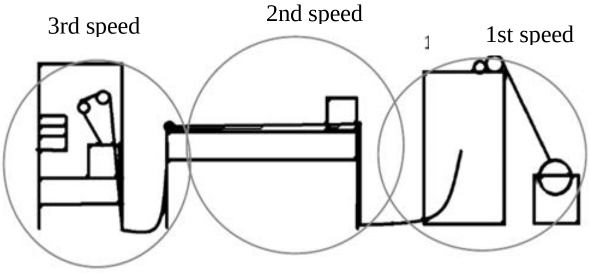
The operators are delayed in the final operation, the oven does not heat enough or is spent on heating, stops in the machine for operation or maintenance

On the machine, the speed of the rollers is predefined and can only be modified by authorized personnel, which causes delays for the operators, since the feeders move faster than their working pace. Operating times vary for each type of band, requiring adjustments in the parameters. In addition, proper heating of the furnace also involves changes in the parameters for proper operation.

Machine stoppages are due to two factors: operation and corrective maintenance. Stoppages occur when operators accumulate many bandages in the basket of material, causing disorder and forcing the machine to stop to retrieve the bandages. However, the oven cannot be turned off due to its cooling and heating time. As a result, the bandages left in the oven burn and generate waste.

Among the defects found, machine shutdowns had a significant impact. It was observed that the machines operate at specific speeds according to the authorized capacity, and this is represented in Figure 4, which shows the corresponding speeds.

Figure 4. Speeds found in the winding machine.



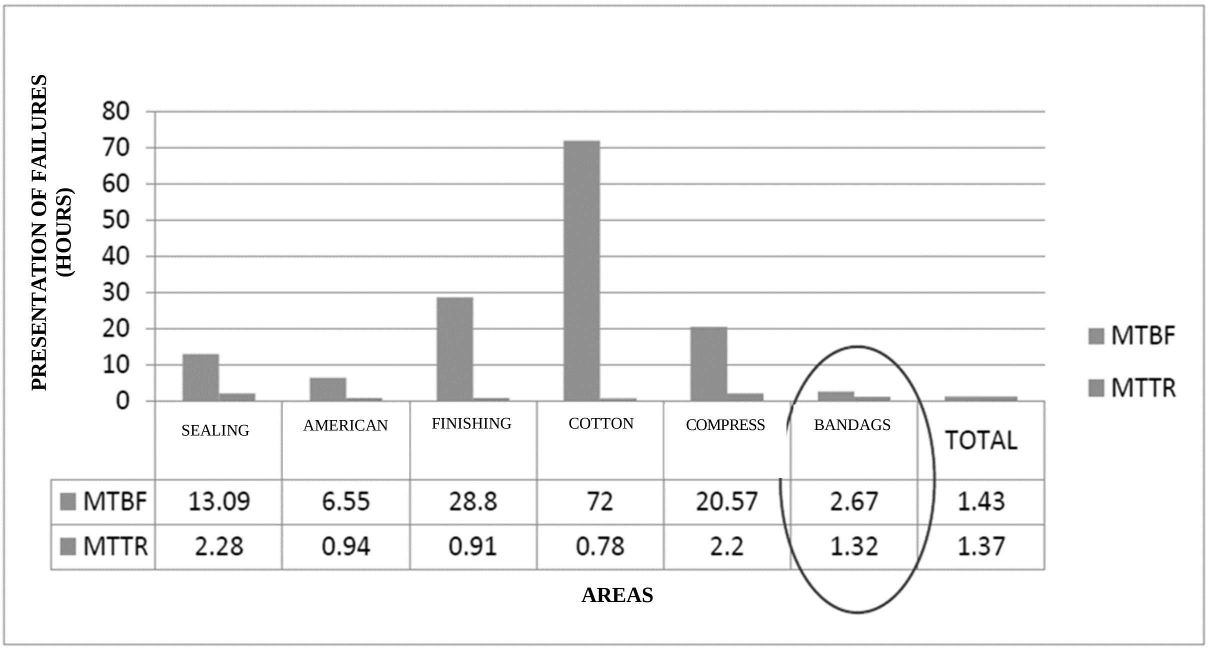
Source: Own elaboration.

In relation to the second factor of stoppages, it is important to note that the Maintenance area proposed indicators in September 2019 to measure performance in maintenance management. These indicators make it possible to analyse the results obtained. In the previous year, the following results were obtained (see Figure 6): the MTBF (mean time between failures) and the MTTR (mean time to repair).

In the last week of September, it was identified that the "Vendas" area is the one that experiences the highest frequency of failures, with an average of one failure every two hours and forty minutes. In addition, the average repair time for these faults is about one hour and nineteen minutes.

The indicators proposed by the Maintenance area provide a clear view of efficiency in maintenance management and help identify areas for improvement to reduce failure and repair times. This is essential to minimize machine downtime and optimize performance in the "Bandages" area.

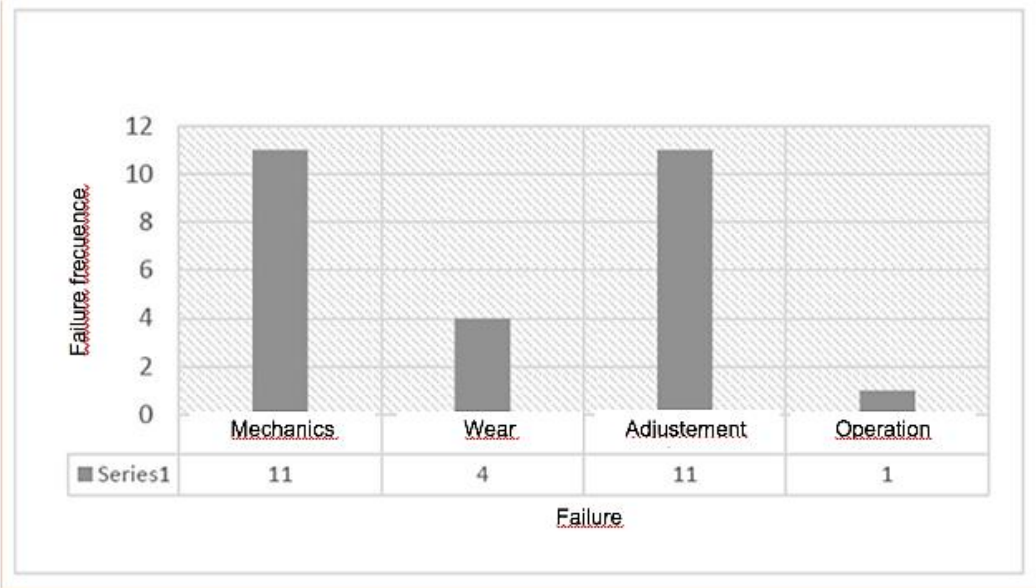
Figure 5. Corrective maintenance indicators week 39, year 2020.



Source: Own elaboration.

In week 11 corresponding to the month of March in the bandage area there was a failure every 6 hours and 16 minutes, and its repair time was 16 minutes. It can be seen that the repair time decreased but still has the same frequency of failures. Therefore, an analysis was made of the faults (see Figure 6) that were most frequently found in this area, of which the following were identified:

Figure 6. Types of failures found in the bandage area.



Source: Own elaboration.

- Mechanical failures were found: change of resistors, changes of arrows, among others.
- Failures due to wear and tear: changes of bands, bands, and blades, as well as the variation of others.
- Adjustment failures: adjustment of blades, diameter adjustment, etc.

Establish the necessary actions to achieve improvement

As previously mentioned, two of the causes mentioned in Table 3 are avoidable, therefore, actions will be proposed to address these causes. After identifying all the factors that contribute to the generation of bandage waste, we proceeded to identify the parameter changes recorded on the machine screens.

Table 3. Parameters of the rolling machine.

Parameter	Changes
Winding Speed	Increase winding speed
Dry stop distance	Increase or decrease weight
UV Cut offset	Stretching of the bandage
Fast rolled roller	Winding speed
Slow rolled roller	Sales delivery speed

Source: Own elaboration.

It has been confirmed that several defects are caused by stops generated by the operators. Sometimes, the operators do not consider the speed of the machine during the winding process, which results in an accumulation of bandages in the tray. To solve this problem, the bandages must be retrieved manually, which requires stopping the machine. Unlike the oven, which cannot be turned off due to its cooling and heating process, which takes approximately 30 minutes. This means that the bandages are stored in the oven during shutdowns, resulting in their burning.

In order to address this situation, the final winding times were recorded considering the participation of 2 operators and 3 repercussions, as shown in Table 4.

Table 4. Time taken for manual winding.

30 cm Sale				
Operator	**Time**	**Time**	**Time**	**Average**
Operator 1	**8:05 seconds**	**8:07 seconds**	**8:04 seconds**	**8:05 seconds**
Operator 2	**7:56 seconds**	**7:55 seconds**	**7:57 seconds**	**7:56 seconds**
			Average	**8:02 seconds**
15 cm sale				
Operator	**Time**	**Time**	**Time**	**Time average**
Operator 1	**7:45 seconds**	**7:40 seconds**	**7:42 seconds**	**7:42 seconds**
Operator 2	**7:34 seconds**	**7:36 seconds**	**7:42 seconds**	**7:34 seconds**
			Average	**7:38 seconds**

Source: Own elaboration.

According to the time study, an average time was obtained for the final winding of the bandages made by the operators, so this research will serve as a basis for balancing the machine, which is why the capacity of pieces of labor was calculated with the speed of the machine in one minute.

Systematically apply the Kaizen methodology

Once the variables for improvement were identified, pilot tests were carried out on winding machine 7, which is a new machine and will work with 30 cm and 15 cm bandages. Since it is a new machine, there were no working standards or established times. In the production area, it is estimated that 1,800 30 cm bandages will be produced in an 8-hour workday, without combining with other bandage sizes. For 15 cm bandages, the estimated production is 2500 bandages. In order to continue the study of the machine parameters, the participation of an operator designated by the bandage area coordinator was requested, who was able to make modifications to the machine parameters. This action facilitated the test, since the operator used her knowledge and experience to adjust the machine parameters, thus providing an initial basis for the study.

During the beginning of the process, problems were identified with the machine's quality standards, which are described in the following table

Table 5. Defects obtained.

Defects found in 30 cm bandage
Very open incorrect frames
Underweight and unstretched bandage
Correct bandage diameter
Bandage with brown color

Source: Own elaboration.

Table 5 shows the defects obtained in the test, which were modified according to the machine and its speed.

Improve the preventive maintenance plan

According to the previous analysis, it was possible to determine the faults in the machinery, as well as the maintenance that was performed, so according to the frequency of the corrective maintenance faults, the frequency of maintenance was determined (See table 6).

Table 6. Preventive maintenance in the bandage area with frequency.

Area	Machine	Preventive Maintenance	Frecuency
Sales	Sale 1	Compressed air cleaning	Monthly
		Review and, where appropriate, change elements of the pneumatic system	Yearly
	Sale 2	Compressed air cleaning	Monthly
		Review and, where appropriate, change elements tire	Yearly
	Sale 3	Compressed air cleaning	Monthly
		Review and, where appropriate, change elements tire	Yearly
	Sale 4	Compressed air cleaning	Monthly
		Review and, where appropriate, change elements tire	Yearly
	Sale 5	Compressed air cleaning	Monthly
		Review and, where appropriate, change elements tire	Yearly
	Sale 6	Compressed air cleaning	Monthly
		Review and, where appropriate, change elements tire	Yearly

Source: Own elaboration.

Based on the frequency of corrective maintenance and the identified failures, preventive maintenance was determined to avoid the repetition of failures. The annual frequency of preventive maintenance for the revision of the pneumatic elements was modified to quarterly, in order to improve its accuracy and reduce its incidence.

When changes are made to the machinery maintenance schedule and orders, the area's procedures and corresponding SOPs must also be updated. Therefore, preventive maintenance, its frequency and relevant descriptions should be attached to the preventive maintenance SOP of the bandage machines.

The implementation of changes in the parameters of winding machine 7 will benefit the operators, since they will work with standardized parameters and a more adequate speed. It was identified that the defects were related to the lack of material and bandage joining, which generated unevenness in the bandages. Before the improvement, no significant defects were obtained, only variations within the quality parameters. The initial speed of the machine generated 3 stoppages per hour due to the discrepancy between the winding speed and the table speed. After reducing the winding times to 6 pieces per minute, the machine was observed for 2 hours, with only 1 stop due to lack of material and 1 defective bandage.

In the case of 15 cm bandages, before the changes, 2 stoppages per hour were detected due to incorrect diameter of the bandages, which caused low weight. After adjustments were made, the weight and diameter of the bandages were checked, and 2 subsequent stoppages were observed due to folds in the material and lack of adaptation of the operator, but only cuts of wax burrs were found in the waste bag, which is normal. It is estimated that, by changing the bandage rolls 4 times a day, it will generate only approximately 5 defective bandages due to this factor, and only 2 due to weight problems. In addition, when changing bandage presentation, it is expected that the 5 defective bandages associated with the size change will not be generated. According to the quality productivity indexes (good parts/actual production), an estimated 0.28% of defective bandages, which represents a 1% reduction in machine-generated waste.

The preventive maintenance plan will reduce machine failures, decreasing downtime and increasing both machine productivity and bandage quality. This new maintenance plan will be implemented starting in May, which is expected to further reduce machine downtime and bandage waste.

CONCLUSIONS

The present research was able to reduce waste in the bandage rolling machine, thus fulfilling the general objective. By balancing the speed of the machine with the operator, less stoppages and waste were generated. This approach will also be applied to the other bandage winding machines for better results. In addition, a preventive maintenance system managed through maintenance orders (see Annex 3) was implemented to ensure execution and delivery.

Regarding the specific objectives of the project:

A diagnosis of the current situation in the "Bandage Area" was carried out to identify the factors affecting the production system and generating waste.

Strategies were implemented to reduce these factors and balance the baking and bandage rolling process. Relevant parameters were identified and adjusted, and a time and motion study was carried out to determine the operator's winding capacity.

Kaizen methodology was systematically applied to the bandage winding machine, allowing detailed studies on each parameter and factor. These changes were reflected in cost savings, reduced waiting and cycle times, and improved quality, as supported by the methodology of [17]. This will allow the company to increase production in less time while maintaining optimal quality.

A preventive maintenance improvement plan was developed to address shutdowns as a contributing factor to waste. Measures were implemented to avoid this problem, since maintenance, as pointed out by [20], is fundamental for the correct operation of the system. It is not necessary to wait for machines to fail in order to carry out repairs or corrective maintenance, but rather to establish a program before failures occur.

In conclusion, the project succeeded in reducing waste in the bandage rolling machine by balancing the operating speed, as well as through the implementation of strategies, the application of the Kaizen methodology and the establishment of a preventive maintenance plan. The results obtained support the achievement of the proposed objectives, which will allow the company to increase production, reduce costs and improve the quality of its products.

REFERENCES

[1] Rojas, L. (2019). El papel de México en la industria de dispositivos médicos: un análisis comparativo. Revista de Comercio Internacional, 25(2), 45-62.

[2] Rojas, R. (2019). Los 5 motivos por los que la industria de Dispositivos Médicos está en auge en México. Saludario. Recuperado de https://www.saludiario.com/los-5-motivos-por-los-que-la-industria-de-dispositivos-medicos-esta-en-auge-en-mexico/

[3] Solano, D. (2019). Indicadores de la industria de dispositivos médicos en México. Recuperado de https://dispositivosmedicos.org.mx/indicadores-de-la-industria-de-dispositivos-medicos-en-mexico/

[4] Morales, C. & Masis, A. (2014) La medición de la productividad del valor agregado. Recuperado de file:///C:/Users/Usuario/Downloads/Dialnet-LaMedicionDeLaProductividadDelValorAgregado-4808514.pdf

[5] Rodríguez, J. A., & García, J. A. (2015). Trayectoria Tecnológica y productiva de General Motors en México, el caso del Complejo Silao, Guanajuato - Automotriz. ResearchGate. https://www.researchgate.net/publication/287206088_Trayectoria_Tecnologica_y_productiva_de_General_Motors_en_Mexico_el_caso_del_Complejo_Silao_Guanajuato_-_Automotriz

[6] Del Castillo, J. A. (2014). Modelo de gestión tecnológica para las empresas metalmecánicas localizadas en la ciudad de Cartagena. Universidad Tecnológica de Bolívar. https://biblioteca.utb.edu.co/notas/tesis/0000726.pdf

[7] Cruz, A. (2015). Diseño tecnológico y proceso de trabajo. Academia.edu. https://www.academia.edu/74594791/Dise%C3%B1o_tecnologico_y_proceso_de_trabajo

[8] García, J. A., & Rodríguez, J. A. (2016). Plan de mantenimiento preventivo para minimizar el desperdicio y aumentar la productividad del área de vendas en una empresa manufacturera. ResearchGate. https://www.researchgate.net/publication/309791149_Plan_de_mantenimiento_preventivo_para_minimizar_el_desperdicio_y_aumentar_la_productividad_del_area_de_vendas_en_una_empresa_manufacturera

[9] Johnson, A. (2018). Kaizen methodology: A comprehensive overview. Journal of Operations Management, 36(1), 48-64.

[10] Brown, M. (2021). Successful implementation of Kaizen methodology in Toyota's manufacturing processes. International Journal of Lean Manufacturing, 27(3), 212-228

[11] Smith, J. (2019). Implementation of Kaizen methodology in the industrial automation sector. International Journal of Production Improvement, 25(2), 145-162.

Solano, M. (2019). Exportaciones de dispositivos médicos de México hacia Estados Unidos: análisis de la demanda y oportunidades de crecimiento. Revista de Economía Internacional, 40(3), 78-92.

[12] Alfalla Luque, R., Marín García, J. A., & Medina-López, C. (2012). Is worker participation related to Kaizen implementation success? An empirical study in Mexican organizations. International Journal of Production Economics, 140(2), 732-742.

[13] Suárez-Barraza, M. F., & Castillo-Arias, I. (2013). La aplicación del Kaizen en las organizaciones mexicanas. Un estudio empírico. Revista Internacional de Tecnologías en la Educación y el Conocimiento, 7(1), 1-16.

[14] Brunet, A. P., & New, S. (2003). Kaizen in Japan: An empirical study. International Journal of Operations & Production Management, 23(12), 1426-1446.

[15] Oropesa Vento, M., Garcia Alcaraz, J. L., Maldonado, M., Aidé, A., & Loya, V. (2016). The impact of managerial commitment and Kaizen benefits on companies. Journal of Industrial Engineering and Management, 9(1), 1-14.

[16] Al-Najjar, A. M., & Rahman, M. A. (2014). The implementation of Kaizen in the service industry: a case study. Total Quality Management & Business Excellence, 25(11-12), 1388-1402.

[17] Alvarado, K., & Pumisacho, V. (2017). Prácticas de mejora continua, con enfoque Kaizen, en empresas del Distrito Metropolitano de Quito: Un estudio exploratorio. OmniaScience, 13(2), 479-497. doi:10.3926/ic.901

[18] Lizarralde, E. & Ferro, E. (2014). Lean manufacturing Conceptos, técnicas e implantación. Madrid, España: Fundación EoI.

[19] 50Minutos.Es. (2016). La filosofía del Kaizen: Pequeños cambios con grandes consecuencias. Kindle.

[20] Alavedra, C., Gastelu, Y., Méndez, G., Minaya C., Pinedas, O., y Prieto, G., Krisley K., & Moreno C., (2016). Gestión de mantenimiento preventivo y su relación con la disponibilidad de la flota de camiones 730e Komatsu-2013. Ingeniería Industrial, (34) 11-26. Recuperado de: https://www.redalyc.org/articulo.oa?id=3374/337450992001