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Article

Optimization of production processes through the Kaizen philosophy to reduce time

Optimización de procesos productivos mediante la filosofía Kaizen para la reducción de tiempos

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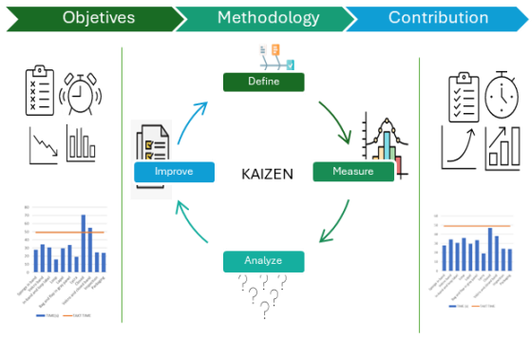
Abstract

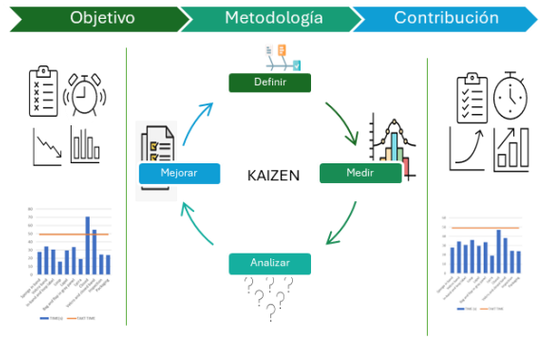
This work presents the results obtained from the design and implementation of the Kaizen philosophy in a maquiladora company, where downtime in the production line, machine failures and low production levels have been detected. The philosophy was implemented where the production line was analyzed through the implementation of continuous improvement tools that managed to eliminate downtime and thereby improve the company's productivity.



Kaizen, Continuous Improvement, Productivity

Resumen

Este trabajo presenta los resultados obtenidos del diseño e implementación de la filosofía Kaizen en una empresa maquiladora, en donde se ha detectado tiempos muertos en la línea de producción, fallas en las máquinas y bajos niveles de producción. Se implemento la filosofía en donde se analizó la línea de producción mediante la implementación de herramientas de mejora continua que lograron eliminar los tiempos muertos y con ello mejorar la productividad de la empresa.



Kaizen, Mejora Continua, Productividad.

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Introduction

Competitiveness plays a fundamental role in industrial and service companies because they seek to gain new customers or retain the customers they have.

One way to increase companies' competitiveness is through management strategies in which they seek to constantly improve their processes, thus becoming more efficient and having a higher performance.

This is thanks to the simplification and optimization of methods, which helps reduce or eliminate waste that the production system presents and thus increases the productivity of companies.

These management strategies are based on continuous improvement such as Lean Manufacturing, also known as world-class manufacturing, and Toyota production system. According to Ibarra-Balderas (2017), it consists of a continuous and systematic process that seeks to eliminate waste or activity that does not add value to the product, service, and processes and thereby increases efficiency increasing productivity, as reflected by Marmolejo et al (2016) the implementation for the reduction of downtime.

Arrieta Posada et al. (2010) in their study show that companies in the textile industry do not have great benefit in the implementation of Lean Manufacturing because they have not been able to develop the culture nor have, they implemented the philosophy consciously and comprehensively due to its complexity.

On the other hand, the Six Sigma philosophy, also of continuous improvement, seeks to increase quality and decrease variety in production processes to obtain zero defects. Tello Capa, J. R. T., & Aguirre, M. (2019) mention that the success of this depends on the dissemination of knowledge in statistical methods and above all on the willingness of its workgroup to promote change in the culture of the company.

Another philosophy for improvement is Total Quality Management (TQM), this philosophy focuses on the production of quality products and services to meet the needs of customers helping to improve employee productivity and thereby increase customer satisfaction to achieve a competitive advantage. Fuentes, M. D. M. F., & Torres, N. E. H. (2002), in their study, establish that the greatest problem presented by organizations that have TQM is the measurement of performance because subjective measurement predominates over objective measurement.

The Kaizen philosophy, like the philosophies, promotes continuous improvement in organizations according to Pin et al (2022), and is based on the improvement of the initial design by involving all personnel and training them to identify areas of opportunity, developing action plans for future improvements. In Moreno et al (2020), thanks to the implementation of Kaizen, there were savings in monthly investment and a reduction in manufacturing time.

This philosophy is not only implemented in production areas, in the study carried out by Gallegos (2007) it was implemented in administrative areas, and with it, a cost reduction was achieved thanks to the action plan that solves the areas of opportunity found. These philosophies bring with them many benefits since they help analyze the current situation of the company and measure and implement actions that reduce costs, time, and efforts to increase productivity and thus have greater competitiveness.

This work proposes the implementation of the Kaizen philosophy in a manufacturing company in the medical area, where there have been downtimes in the production line, machine failures, and low production levels. This implementation will help detect and analyse the production system. With this, implement improvement tools that allow eliminating downtime and problems that arise, optimizing the production line and increasing the productivity of the company.

Kaizen

Kaizen is a business management strategy that describes the improvement of organizational processes at all levels of hierarchy.

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Its objective is to implement improvements and reduce inefficiencies to build an efficient and productive environment that increases the competitiveness of companies. (Kasuga, 2021).

This strategy is implemented within companies where they seek to obtain profit through the motivation of ingenuity, and the creativity of the staff to identify the areas of opportunity that could be improved in the company, as well as find a way for them to have a better functioning and be more effective.

To guarantee the success of this philosophy, it is necessary to involve all the company's personnel, as well as to keep them motivated, always looking for possible improvements in all areas of the company. That is why it has as its pillars the commitment, perseverance, and discipline of both line operators up to the highest rank of the company.

This philosophy is immersed in a series of principles that guide the behavior of the personnel who apply the tools to improve their processes. Many authors describe different principles such as Boluda, M. Á. V., & Soler, V. G. (2016) who establish 10 such as:

- *Customer focus:* Ensuring that your products and/or services meet customer needs.
- *Make continuous improvements*: Constantly improve, once a task is completed, focus on improving that same task.
- *Openly recognize problems*: Promote a culture of communication to recognize problems and thus be able to solve them to improve, without looking for those responsible.
- *Promote openness:* Sharing, inter-functional communication, and visible leadership.
- *Create teams:* Teamwork promotes the creation of quality circles where we seek to solve detected problems.
- *Team project management:* Setting up projects within departments engages all employees to gain different points of view.
- *Encourage appropriate relationship processes:* Intervene in the relationship of your employees, managers, and leaders for the harmony of the company.
- *Develop self-discipline: Allow employees to adapt to situations that arise.*
- *Constant information to employees: Establishes understanding and acceptance of the company's vision, mission, values, practices, and plans.*
- *Promote the development of employees:* Train the members of the company to acquire knowledge and skills for decision-making.

With these principles, Kaizen allows reducing waste and consequently improving work performance, leading the organization in constant innovation according to Suárez-Barraza (2007). This optimization of the company is possible through the implementation of Kaizen tools.

Kaizen Tools

Quality Tools

These tools are common tools due to the simplicity of being able to implement them without having great statistical knowledge, apply at any level of the organization, and are very useful due to the collection and organization of useful information. According to Lemos, P. L. (2016) these tools are:

- *Control Sheet:* Also known as a checklist, this is designed to obtain information related to a process or project.
- *Control Chart:* A chart implemented to control and improve a process by analyzing its variation over time.
- *Cause and Effect Diagram:* Also known as the Ishikawa Diagram, this tool allows you to identify, know, and classify the information related to the causes of the problem.
- *Histogram:* A bar graph that shows the rate of data that a given category counts.
- *Pareto Chart:* It is an analysis method that allows discriminating and establishing priorities between the causes of the problem by defining categories, based on the Pareto principle where 80% of defects are caused by 20% of the causes.
- *Scatter Plot:* This graph allows you to identify the relationship between two variables.

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Box 1

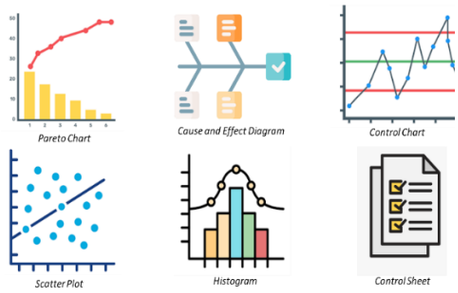

Figure 1

Basic quality tools

Source: Own elaboration

Deming Cycle

This philosophy uses the Deming circle, also called PDCA, as a tool to detect problems and optimize processes. Walter A. Shewhart is the creator of the PHVA Cycle, which was later renamed the Deming Cycle by the Japanese due to William Edwards Deming.

He was the one who taught the methodology in Japan in the 1950s. It should be noted that Shewhart was a friend and mentor of Deming. (Cuggia-Jiménez et al, 2020).

The Deming cycle is a method that companies use to continuously improve their processes, making them more efficient and of higher quality, in addition to solving problems and executing continuous improvement systems since its application helps companies to increase their productivity and constantly improve.

If implemented correctly, it allows the quality standards of a process to improve. But the most interesting thing is that, since it is a circle, it is possible to start the improvement system once again, as many times as necessary. (Costa et al, 2024)

This cycle is made up of 4 steps:

- *Planning:* an analysis of the problem is carried out and the action plan is decided. (improvement)
- *Execution:* The improvement is made, and a record is kept.
- *Verification:* After some time after the improvement has been applied, the results obtained are analyzed.
- *Action:* If necessary, another modification is made to achieve the expected results.

PDCA stands for Plan, Do, Check, Act. Benefits of the Deming Cycle:

- Reduces process times
- Increases productivity
- Decreases and prevents failures and errors.
- Optimize the use of the company's resources (materials, people, money, etc.)

The 5s

This is an activity that depends on the joint participation of all the company's personnel. Workers must be made aware that they will be able to improve their daily work environment. The 5s method consists of the following:

- *1st S – Classification (Seiri):* It is based on identifying and classifying the materials essential for the process, while the rest is considered unnecessary material and therefore will be removed or separated from the workplace. From that moment on, an inventory of each job will be made to have the essentials so that there are no longer elements that can hinder the work.

- *2nd S – Organization (Seiton):* The next thing is to organize the essential materials, for their easy location, use, and availability, as well as to replace these tools to eliminate non-productive times due to the search for materials and unnecessary displacements. To achieve this, the location of each material or tool must be marked with the help of labels, molds, drawings, signs, etc.

- *3rd S – Cleaning (Seiso):* It is very important to locate and remove dirt from the work area, as well as its correct maintenance of cleanliness and organization, as this has a direct impact on the motivation of the staff, in addition to considerably reducing accidents and work injuries.

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- *4th S – Standardize (Seiketsu):* The standard process simply tries to distinguish between "normal" and "abnormal" situations, i.e., personnel must be able to distinguish when the previous three S's are used correctly and when they are not. All plant personnel must have the appropriate training to identify this type of situation. With this, the staff feels more valued and increases their motivation to work, which in turn, operators are better able to detect small failures in their workplace that could trigger more serious problems in the future in the process.

- *5th S – Keep Improving (Shitsuke):* The 5S do not have a defined end. It is a cycle that repeats itself continuously and in which discipline must be maintained to achieve an orderly and clean workplace. The success in the implementation of the 5S provides a much more pleasant workspace with a good work environment where accidents are also reduced and the productivity and satisfaction of the company's personnel when working is increased. (Carreras, 2021) (Tomal Das, 2024).

5 Whys

The 5 Whys is a very simple continuous improvement tool, but at the same time very effective, because it shows the direct path to the root cause of the problem you have so that it can be implemented it is convenient to make a quality circle, that is, a group of people who are directly familiar with the problem and with the process to improve it.

The 5 whys consist of clearly defining the problem to be solved and questioning why it is generated and obtaining an answer from it, followed by another 4 whys that give an answer to why that situation is being carried out and in this way guide to the true root. (Oliveira 2021).

Methodology

According to the steps to be followed to apply continuous improvement based on the Kaizen methodology, it includes the use of statistical tools within a structured methodology increasing the necessary knowledge to achieve in a better way, faster, and at the lowest cost, products and services than the competition.

This methodology can be carried out through the phases as shown in Figure 2. (Tapias, Y. A. A., & Correa, J. H. R., 2010).

Box 2

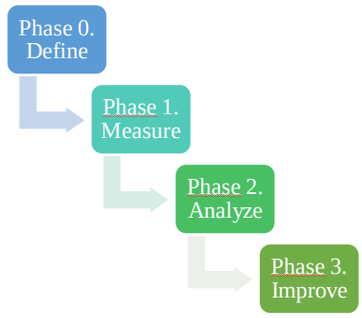

Figure 2
Methodology
Source: Own elaboration

Phase 0: Definition

In the Definition phase, the starting point is established, and the objective to be achieved is defined, where the reduction of downtime and line balancing due to the excess of downtime in certain process operations is proposed, which generates bottlenecks and affects the achievement of the production goal.

Phase 1: Measurement

In this phase, time was taken for each of the operations that make up the production system as shown in Table 1. This table shows how many traders each trade has, and the Takt Time it has.

Box 3

Table 1
Cycle time measurement

Operation	Description	Operators	Tim E(s)	Takt time	Difference
1	Sponge in band	1	27.82	48.96	21.14
2	Velcro band	1	34.49	48.96	14.47
3	In-band and loop label	1	30.74	48.96	18.22
4	Loop	3	15.85	48.96	33.11
5	Lapel	1	29.69	48.96	19.27
6	Bag and flap in gray panel	1	33.73	48.96	15.23
7	Lycra	2	19.08	48.96	29.88
8	Closed	1	70.7	48.96	-21.74
9	Velcro and closed band	1	54.7	48.96	-5.74
10	Inspection	1	24.37	48.96	24.59
11	Packaging	3	24	48.96	24.96
	Total	**16**	**365.17**		

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With these measurements, it can be seen that the closing velcro and banding operations in closed are those that exceed the Takt Time shown in Figure 3, being the operations that generate the bottleneck in the line.

Box 4

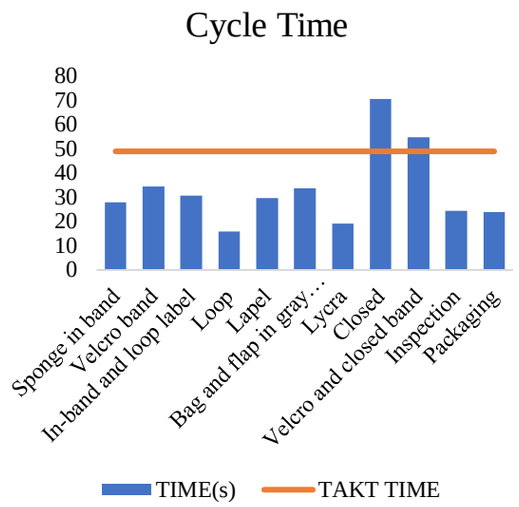

Figure 3
Cycle Time

Phase 2: Analysis

In this phase, the activities that occur within the operations that generate downtime and that in turn cause it to be the bottleneck of the line are analyzed.

The analysis is carried out using the tool of the 5 Why? To carry out this tool, a quality circle was made, made up of the workers of the area to find the root cause of the delay in each of the activities. Table 2-5 shows the causes and responses to each Why?

Box 5

Table 2
Answers of the 5 Why? of thread cutting

Cause	Thread cutting 
Why 1	Excessive wire tension
Why 2	Knots in the thread or damaged part where the thread passes
Why 3	Incorrect threading on the machine
Why 4	Lack of knowledge of the personnel to thread
Why 5	Lack of training

Source: Own elaboration

Box 6

Table 3
Answers of the 5 Why? of stitch mismatch

Cause	Stitch mismatch 
Why 1	Mismatched tension on the bobbin spool
Why 2	Reel failing on the spool
Why 3	Accumulation of dust or lint on the machine
Why 4	Lack of machine cleaning
Why 5	Lack of training

Source: Own elaboration

Box 7

Table 4
Answers of the 5 Why? of dirty machine

Cause	Dirty machine 
Why 1	Accumulation of dust and lint in the machine
Why 2	Lack of knowledge of the staff about the cleaning of the machine
Why 3	Lack of staff training
Why 4	Lack of cleanliness during the shift
Why 5	Lack of cleaning utensils

Source: Own elaboration

Box 8

Table 5
Answers of the 5 Why? of online operator imbalance

Cause	Online Operator Imbalance
Why 1	Poor organization of workstations
Why 2	Poor organization of operations
Why 3	Ignorance of the process
Why 4	Erroneous cycle times
Why 5	Non-continuous workflow

Source: Own elaboration

Phase 3: Improvement

In the improvement phase, proposals are established that eliminate or reduce the root causes found in the analysis phase, by the circle of quality. The proposals reached are the following:

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1. Training operators on the basic operation and adjustment of the tension in the machine's wire, thus eliminating the problem of automatic wire cutting.
2. Training of personnel on cleaning utensils for stitch misalignment.
3. Implementation of cleaning checklist TPM for the machine as shown in Figure 4.
4. Study of times and balancing of the line with the changes of the Takt Time, based on the client's demand.

Box 9

TPM/SEWING CHECKLIST

	Activity	Date									
		1	2	3	4	5	6	7	8	9	10
1	Verify that the machine has guards										
2	Verify that the machine has its accessories										
3	Clean the sewing area										
4	Check that there are no air leaks										
5	Check that the thread holder is clean and in good condition										
6	Check that there are no loose or disconnected electrical cables.										
7	Verify that the pedal chair and bench are in good condition										
8	Check that the lamp is working correctly										
9	Check that the machine does not present any strange noise										
10	Check that the ignition box is in good condition										
11	Carry out general cleaning of the machine										
12	Turn off the machine when not in use (change bobbin, or needle at rest)										

Mark with ✓ if the activity was carried out and no anomalies were found.

Mark with **X** if the activity was carried out and anomalies were found. Any anomalies detected should be repaired and reported to the department.

Mark **N/A** if the activity does not apply to your team

Figure 4

Cleaning checklist

Source: Own elaboration

Results

As a result of the training carried out, delays at the workstations were eliminated. Table 3 shows the times obtained and the line balancing. A rearrangement of operators was made since there were operations that required less time and had more operators than necessary (Green cells in Table 6).

On the other hand, operators were included in critical operations to reduce the workload and cycle time, so that it would adjust to the calculated takt time (Yellow cells in Table 6).

Finally, an operator was eliminated in the lycra operation, as it was not necessary, and the operation involved a minimum time (blue). The results shall be by section of the article.

Box 10

Table 6

Cycle time measurement

Operation	Description	Operators	TIME(s)	Takt time	Difference
1	Sponge in band	1	27.82	48.96	21.14
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3	In-band and loop label	1	30.74	48.96	18.22
4	Loop	2	36	48.96	12.96
5	Lapel	1	29.69	48.96	19.27
6	Bag and flap in gray panel	1	33.73	48.96	15.23
7	Lycra	1	19.08	48.96	29.88
8	Closed	2	47	48.96	1.96
9	Velcro and closed band	2	38.04	48.96	10.92
10	Inspection	1	24.37	48.96	24.59
11	Packaging	2	24	48.96	24.96
	Total	**15**	**344.96**		

Figure 5 shows the times for each operation and how, thanks to the improvements, they are within the Takt Time and thus eliminate the bottlenecks that the line presented.

Box 11

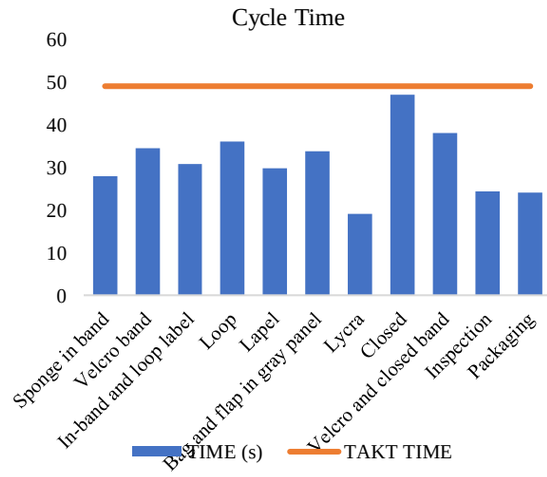

Figure 5

New cycle times

Source: Own elaboration

Conclusions

With the implementation of the Kaizen project in the production line, it was found that there was not good flow in the operations and excess cycle times, so it was necessary to make an analysis of operations and follow up on the balancing of the line (Figure 6).

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Box 13

Table 7

Comparison of the results obtained

	BEFORE KAIZEN	AFTER KAIZEN	
Cycle Time (Max)	70.7	47	itself
Pz x hour	50.9	76.60	Pcs
Available time	36720	36720	itself
Efficiency	85	85	%
Daily demand	750	750	Pcs
Pz produced	519.4	781	Pcs
Production efficiency	69.25	104.17	%
Goal	100	100	%
Time-out	33.5	4	%

Source: Own elaboration

Box 12

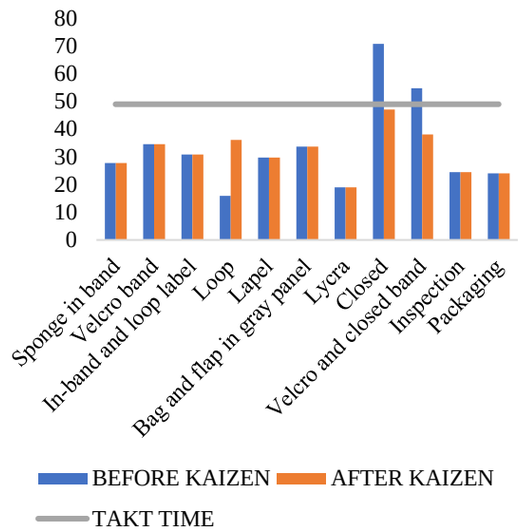

Figure 6

Comparison of cycle times

As a result of the analysis and improvements, the number of operators in certain stations was reduced, and with it the reduction of downtime, achieving a more efficient and optimized line that allows the established production goals to be achieved.

With this, it can be said that the Kaizen philosophy and the continuous improvement project obtained great benefits and good results for the company and its objective of customer satisfaction since the delivery times were met due to the increase in production obtained, the benefits obtained thanks to Kaizen can be reflected in Table 7 and Figure 6.

These results are a clear example of the great benefits of the implementation of the Kaizen philosophy generated within companies because it allows companies to increase productivity and be more efficient thanks to continuous improvement. Clearly explain the results and possibilities of improvement.

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Hernández-Anaya, Luisa Fernanda: contributed with the project idea, research, and implementation.

López-Garza, Esmeralda: Contributed to the idea of the project, research and state of the art. She contributed to the methodology and writing of the article.

Garza-Moreno, Jesús Cruz: Contributed to the idea of the project, the methodology, analysis of results and writing of the article.

Espíndola-Álvarez, Jorge Antonio: Contributed to conceptualization, analysis of results and writing of the article.

Availability of data and materials

The data presented for this research is available according to the sources consulted.

Funding

The project was carried out with its own financing.

Abbreviations

List abbreviations in alphabetical order.

PDCA	Plan, Do, Check, Act
PHVA	Planear, Hacer, Verificar, Actuar
TPM	Total Productive Maintenance

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