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Artículos científicos

Capacitación Profesional Para la Implementación de un Sistema Kanban-Tooling Para una Industria Automotriz

Professional Trainning for the Implementation of a Kanban-Tooling System for an Automotive Industry

Capacitação Profissional para Implantação de Sistema Kanban-Tooling para Indústria Automotiva

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Resumen

El proyecto que se presenta se basa en el diseño y la capacitación para la implementación de un sistema de organización y mejora denominado Kanban. En una empresa de productos automotrices se implementó el Sistema de Tarjetas Kanban con el objetivo de agilizar el proceso y facilitar tanto el manejo del herramental como el control de las células de producción. Dado que el uso del Kanban es ampliamente conocido para la gestión de materiales de producción, este artículo muestra el Sistema de Tarjetas Kanban-Tooling que se utilizó para administrar el uso del herramental en el montaje necesario para 55 modelos distintos de productos trabajados en diversas células de producción. Se tomaron tiempos de montaje antes y después de la implementación del Sistema Kanban-Tooling. Para el estudio, se seleccionó una de las células de ensamble con tiempos prolongados, de modo que los resultados de los cambios implementados fueran extrapolables a celdas con tiempos más cortos. El análisis estadístico de estos tiempos indica que se logró una reducción significativa en el tiempo de preparación de la célula de producción.

Palabras clave: Capacitación**,** Kanban, herramental, celdas manufactura, industria automotriz

Abstract

The project reported here is based on the design and training for the implementation of an organizational and improvement model called Kanban. In an automotive products company, the Kanban Card System was implemented, in order to speed up the process to facilitate: both tooling management and control of production cells. Since the use of Kanban is widely known for production material management, this article shows the Kanban-Tooling Card System that was used to manage the use of the tooling in assembly (set-up) required for 55 different product models, worked on various production cells. One of the longest assemble times cell was selected in order to replicate the results, after implementation of changes, to other cells with shorter assemble times. Set-up times were taken into account and after the Kanban-Tooling System was implemented. Statistical analysis of such times indicates that a significant reduction was achieved.

Keywords: Training, Kanban, tooling, manufacturing cells, automotive industry.

Resumo

O projeto que se apresenta assenta na conceção e formação para a implementação de um sistema de organização e melhoria denominado Kanban. Em uma empresa de produtos automotivos, foi implantado o Sistema Kanban Card com o objetivo de agilizar o processo e facilitar tanto o manuseio do ferramental quanto o controle das células de produção. Como o uso do Kanban é amplamente conhecido para o gerenciamento de materiais de produção, este artigo mostra o Kanban-Tooling Card System que foi usado para gerenciar o uso de ferramental na montagem necessária para 55 modelos diferentes de produtos trabalhados em várias células de produção. . Os tempos de montagem foram medidos antes e depois da implementação do Kanban-Tooling System. Para o estudo, foi selecionada uma das células de montagem com tempos longos, para que os resultados das alterações implementadas pudessem ser extrapolados para células com tempos mais curtos. A análise estatística desses tempos indica que foi alcançada uma redução significativa no tempo de configuração da célula de produção.

Palavras-chave: Treinamento, Kanban, ferramental, células de manufatura, indústria automotiva.

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Introduction

Kanban is an improvement and order tool; It is a manufacturing strategy that allows better inventory control and, thus, maximum use of the resources available for the production process.

This strategy was developed by Toyota in the 1950s, as part of a production system that would help to overcome the economic crisis caused by World War II. Kanban and other new strategies developed to the so-called Toyota Production System (SPT); In this way, they changed the traditional form of production for one that would help to have more efficiency and effectiveness in their production processes to compete in the changing global market. This article describes the way in which the application of a tool delivery route system was carried out, through the adaptation of a Kanban-Tooling system.

Background

For a long time, the Kanban methodology remained stagnant in production processes, that is, its application was only focused on improving the flow of materials in the production process. An example of this is relatively recent research where projects to apply this methodology are developed as something innovative (Rahman, Sharif and Esa, 2013); Adnan et al., (2013); Wakode, Raut and Talmale (2015), Arango, Campuzano and Zapata (2015). However, in the last decade, this methodology has been transferred to other areas of engineering, manufacturing and administration, obtaining excellent results.

Turner et al., (2012) describes how the application of the Kanban concept to engineering systems in aerospace areas has had a favorable impact on response speed in complex projects. They adapted the concepts of "push" in the master programming of activities and developed their own software based on this methodology, evidencing significant results. Similar results were found by Hofmann et al., (2018) in the area of project management, with the challenge of introducing new technologies. The application of the concepts and tools of the Kanban methodology helped to keep the workload levels of the elements involved in the development of these complex projects.

This methodology has even been applied to management systems for large databases in the cloud. Programs developed with these principles have shown a significant improvement in the speed of response to decisions in this type of complex environment, Krishnaiyer, Chen and Bouzary (2018).

Powell (2018) developed a Kanban system for a high-mix, low-volume production environment. Traditionally, relevant results are expected in environments where there is a very small mix (different part numbers) and a high volume of production. This work drew attention, mainly, due to the characteristics similar to the context of this research, where the movement of tools has the same conditions: many tools and low production volumes. Arteaga and Calvo (2019) developed the same application for a different product, but with the same mix/volume characteristics, finding the same benefits, primarily in reducing cycle times.

Training, Formation, Coaching

Siliceo (2004) defines three types of training. One is oriented to do; It is measurable and you can directly observe the results. In fact, this type of training is the most developed by the industry. Another training is that to become, that is, it seeks to develop the individual in terms of values, responsibility, appreciation for work, and so on. Finally, it defines the training to do and become simultaneously, an integral development of the individual in terms of his abilities and attitudes.

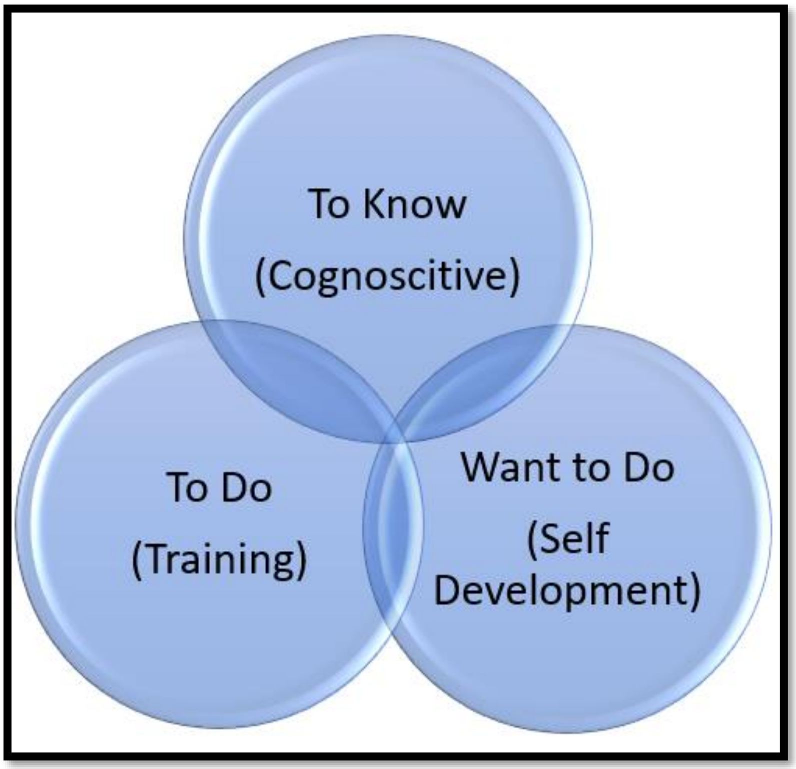
Some other authors use the term Training, such as Martínez et al (2017). This is raised from the perspective of a practical exercise of some activity, so that the subject develops the psychomotor skills to do something in particular.

On the other hand, Sánchez (2007) cites the definition of Training in the Federal Labor Law (México), article 153, paragraphs A to X, as the teaching of abilities and skills for the better development of one's own work.

Although the literature regarding these definitions is vast, it is possible to summarize these three concepts in figure 1. The training is aimed at developing the cognitive part of the individual, knowledge. The general training or particular training are programs aimed to develop skills to develop one or more activities, to do, in a general way (driving a vehicle, for example) or in a particular way (driving a forklift). An element that is less mentioned, but equally important, is what refers to the affective part of the individual, that is, what is the use of knowing how to do something, being able to do something if he does not want to do it?

This last conception is of the most importance, since, as mentioned by Martínez, Palos and Várgas-Fernández (2017), a comprehensive organizational development program must, invariably, include the personal development of the worker, that is, what is it that he wants to learn? Whether or not it has to do with his assigned activities, with the environment of his product or service, it must be included as part of the development of the organization. In many organizations there are well-developed and implemented programs in this regard: Painting, Aluminum Embossing, economical cooking, music bands, sports; programs ranging from basic education to high school, even. The tripartite nature of personal development is shown in figure 1.

Figure 1. Integral Development of the Individual



Source: Own Elaboration

Problem Statement

The Kanban technique is a tool that, within manufacturing, helps control material inventories, providing parts when needed. According to the Production Management of the plant under study, their problem lay in the levels of material waste and the loss of time in the assembly (set-up) required by each one of the 56 models produced in eight manufacturing cells (see Figure 2).

Figure 2. General View of a Manufacturing Cell

Source: Medrano (2019)

In each of the cells or manufacturing cells, the operations described in Table 1 are carried out in each model.

Table 1. Manufacturing Cell Operations

DESCRIPTION				
Insert Smooth Clamp to Looper Machine for Making Bends	Place the clamp on the welding machine to weld the component on the left side	Place clamp on welding machine to weld right side component	Insert the clamp to the rolling machine to make the circumference	Placement of accessories (bolt and stump)
Ct LOOPER	T Welder 1	Ct Welder 2	Ct Rolling Machine	Ct Assembly

Source: Own Elaboration

Considering the current situation, where there was no established process for the management of tooling, there was a lack of updated inventory of existing tooling. In fact, the very existence of some tooling inventory was unknown. Part of the tooling was in the production area, another part in the tool crib, and sometimes it was returned to the spare parts crib without grinding,

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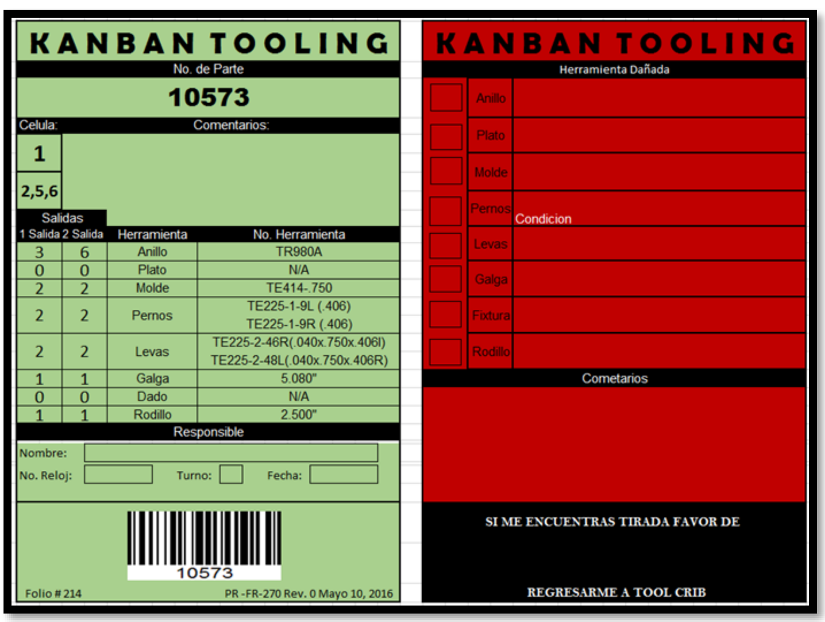
repairing, and/or adjusting. In other cases, the toolkit was returned incomplete or not at all. Management considered that by implementing a Kanban system, material supply and equipment assembly problems could be eliminated or minimized. This article only exposes the implementation of Kanban-Tooling to control the necessary tooling in the set-up, since, although there is a Kanban for the synchronization of the movement of productive material, there was no similar system to control and synchronize the movement of the tooling in the set-up or model change.

Methodology

For the design of the "Kanban-Tooling" or Kanban for the tools, we proceeded to design the necessary cards for the implementation of a control system of tools and parts required in the assembly (set-up). The objective was to comply in a timely manner with the tooling requirements in the production cells.

Figure 3. Kanban-Tooling Cards



Source: Medrano (2019)

Figure 3 shows the Kanban-Tooling cards designed for the control of the tooling and the necessary parts required for the assembly of each model in the eight manufacturing cells. The green card is used to identify tools and assembly parts, while the red card is used to identify damaged or missing tools or assembly parts.

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It is worth mentioning that a fundamental element in the implementation of this system was the general training and particular training of personnel. A deficiency in these aspects jeopardizes the success not only of projects like this, but of any project in general. As Guiñazú (2004) points out, training is no longer a secondary activity and now the organization must concentrate on maximizing human capital as a resource.

One of the main strategies used in this training process for the personnel involved in the Kanban-Tooling system was the use of information and telecommunications technologies (ICT). According to Abarca (2016), these technologies are an adequate resource for our current environment.

For the implementation of the Kanban-Tooling system, a work team was formed with personnel from various departments that would be involved in the process, such as production, planning, warehouse, machine tool room, and tool warehouse. Figures 4 and 5 show part of this work team.

Figure 4. Staff Involved in the Kanban-Tooling

Source: Medrano (2019)

Figure 5 Kanban Tooling Team

Source: Medrano (2019)

As part of the development of the project, a comprehensive training program was designed. 12 hours of training were given on the topics of the 5 S's and the design and calculation of a Kanban system. In addition, a workshop was held in which the team involved designed the route and performed the Kanban Tooling calculation. Once tested in pilot runs, it was implemented in this area. The training is considered comprehensive because in this organization there are well-defined and implemented programs for the personal development of the workers. All team members participate in one of these programs.

Measurement of Assembly Times

To quantify the problem of assembly times required for each model, a time study was carried out. Times were taken randomly in each of the work stations, considering all the different part numbers that are handled in this area. Results are shown in table 2.

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Table 2. Times Before Kanban-Tooling Implementation (Extract).

Model	Cell	DESCRIPTION				
		NSERT SMOOTH CLAMP TO LOOPEER MACHINE TO MAKE BENDS	PLACE THE CLAMP IN WELDING MACHINE TO WELD THE LEFT SIDE COMPONENT	PLACE THE CLAMP IN WELDING MACHINE TO WELD THE COMPONENT ON THE RIGHT SIDE	INSERT THE CLAMP TO THE ROLLING MACHINE TO MAKE THE CIRCUMFERENCE	PLACEMENT OF ACCESSORIES (PIN AND STUD)
		Ct LOOPER	T welder 1	Ct Welder 2	Ct Roller	Ct Assembly
002604-066	8	11.4	16.0	17.9	11.7	18.5
002603-065	8	7.1	18.6	19.2	16.7	23.4
002635-961	5	9.1	23.2	25.5	16.8	19.8
00365-785	5	10.1	19.5	21.8	19.5	19.9
521648-759	5	5.8	25.1	26.4	13.1	16.2
843655-96	1	5.3	10.3	11.8	8.5	14.4
00565-123	2	8.3	15.7	15.6	16.9	18.9
761355-532	1	6.8	20.6	22.3	15.8	29.7
1385485-562	5	10.2	23.5	18.8	19.6	25.9
134658-985	1	12.8	19.5	23.9	18.45	19.9
1236556-85	3	16.9	17.6	19.2	23.5	23.6
7625286-36	6	19.7	15.8	15.3	16.2	25.7
1356452-65	4	23.2	25.4	27.5	18.8	30.8
7913655-153	2	11.2	13.4	16.7	19.5	25.6
6452038-86	2	17.9	15.4	16.8	16.6	20.9
0000012-632	5	14.2	19.0	20.9	15.5	25.8
003564-789	3	8.5	15.2	17.9	17.5	39.0
002546-86	3	14.6	11.7	13.0	19.6	20.7
4364458-1	1	11.3	15.7	23.7	8.1	9.5
0032649-832	8	8.2	8.6	7.5	4.9	10.5
0007652-123	4	9.5	7.3	8.2	8.3	9.8
731658-516	3	8.6	9.7	6.7	9.8	8.7
19764536-456	2	8.9	9.5	9.7	8.1	10.5

Source: Medrano (2019)

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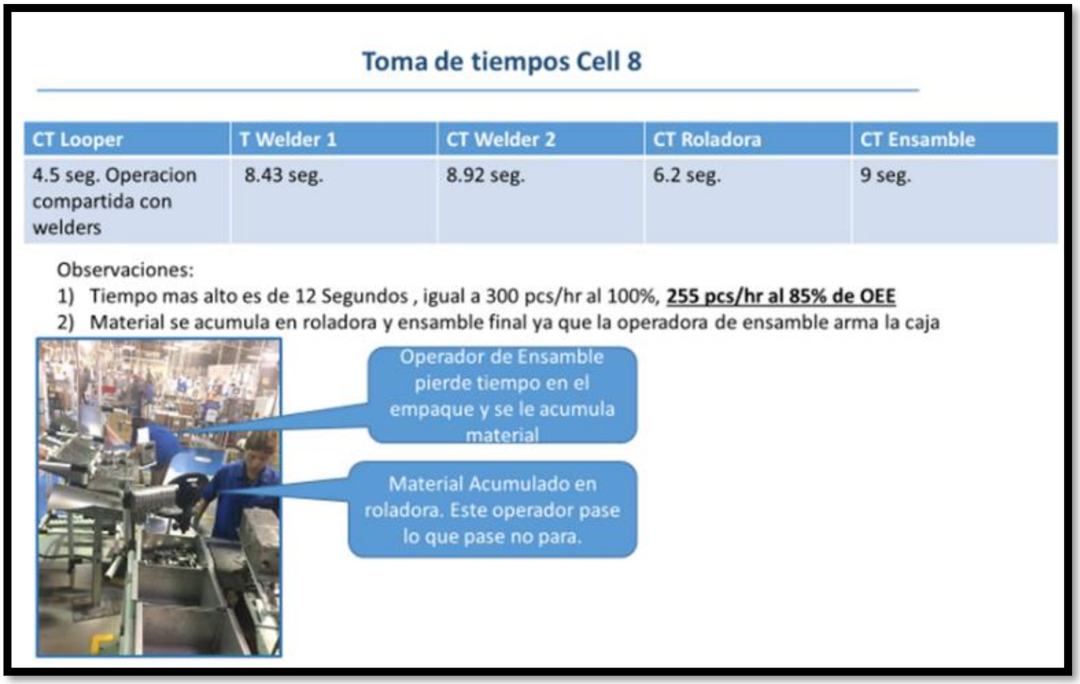
As in any project of this type, it is extremely important to consider that complementary fundamental activities must be carried out: Order, cleanliness and organization play a determining role in the implementation, control and maintenance of this type of system. A review and consideration of a 5 S's program is highly recommended. Figure 6 shows an example of taking times and observations in Cell 8.

Figure 6. Time Taking on cell 8



Source: Medrano (2019)

Analysis of current data

As a first step, normality studies of the data collected before implementation were carried out:
The hypotheses to be tested are:

$$H_0: Data\ is\ Normal$$
$$H_1: Data\ is\ Non\ Normal$$

If the probability of committing the alpha error is less than the preset value, generally 0.05 the null hypothesis should be rejected.

Normality test was applied to the data prior to implementation, the results are shown in Table 3.

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Table 3. Normality Test Results. Before Implementation.

P-values for Normality. Before Implementation Data				
Looper	Welder 1	Welder 2	Roller	Assembly
0.025	0.010	<0.005	<0.05	<0.005

Source: Own Elaboration

As can be seen, the data do not present sufficient normality, therefore, they were treated with a non-parametric test.

Once the points that can affect the System have been taken into account, the Project was started. Constant monitoring was carried out to ensure that the Kanban-Tooling was applied correctly. Once the system has been implemented, validated and monitored, the timing was taken after implementation. Table 4 shows these data.

Table 4. Times Taken After Implementation (Extract).

		Description				
Model	Cell	Ct LOOPER	T Welder 1	Ct Welder 2	Ct Roller	Ct Assembly
002604-066	8	4.5	8.2	7.2	6.2	9.0
002603-065	8	6.8	7.2	6.5	5.2	10.5
002635-961	5	4.5	6.1	7.5	4.5	5.6
00365-785	5	3.2	5.5	7.1	7.2	8.8
521648-759	5	4.9	6.5	7.7	8.1	8.2
843655-96	1	4.6	9.6	7.7	4.0	7.9
00565-123	2	5.7	5.6	6.7	4.7	7.3
761355-532	1	6.9	7.5	7.5	5.8	9.9
1385485-562	5	8.9	9.4	15.9	8.5	8.4
134658-985	1	9.0	4.8	8.4	7.6	9.8
1236556-85	3	6.5	6.5	9.5	8.4	8.7

Source: Medrano (2019)

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Data analysis

Again, the normality studies of the data collected after the implementation are made:

The hypotheses to be tested are:

$$H_0: Data\ are\ Normal$$

$$H_1: Data\ are\ not\ Normal$$

If the probability of committing the alpha error is less than the preset value, generally 0.05 the null hypothesis should be rejected. Table 5 shows the summary of results of these tests.

Table 5 Normalilty Test Results, After Implementation

Normality Test p-value. After Implementation				
Looper	Welder 1	Welder 2	Roller	Assembly
0.010	<0.005	<0.005	<0.005	<0.005

Source: Own Elaboration

Next, and since the data do not show sufficient normality, a non-parametric comparison is made. In this case, the Mann-Whitney test was used, where the hypotheses to be tested are:

$$H_0: \mu_{Before} = \mu_{After}$$

$$H_1: \mu_{Before \neq} \mu_{After}$$

If the probability of committing the alpha error is less than the theoretical allowable value (usually 0.05), then the null hypothesis must be rejected.

Figure 7. Minitab® Results, Median Difference for Looper

Mann-Whitney Test and CI: Looper Antes, LOOPER Después

N Median

Looper Antes 56 8.545

Looper Después 56 6.235

Point estimate for η1 - η2 is 2.170

95.0 Percent CI for η1 - η2 is (0.810,3.370)

W = 3743.0

Test of η1 = η2 vs η1 ≠ η2 is significant at 0.0008

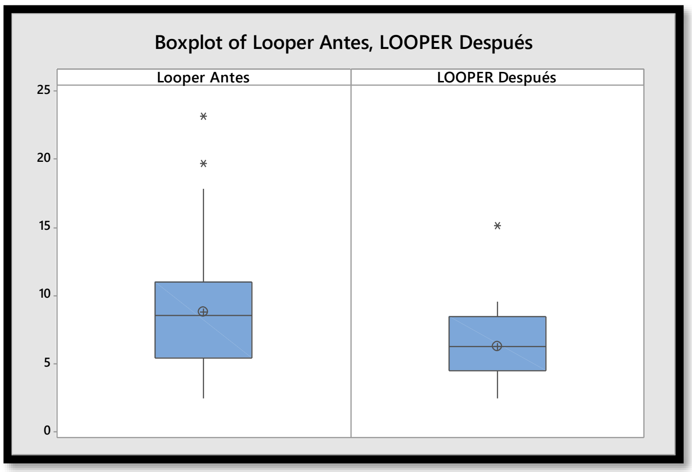
The test is significant at 0.0008 (adjusted for ties)

Source: Own Elaboration

The value p=0.0008, shown in Figure 7, indicates that the null hypothesis should be rejected, if there is a significant difference between the Looper's time before and its time after the changes introduced. As the confidence interval for the median difference is always positive, it is concluded that the Before Looper time is always greater than the After Looper time.

The reduction in the average time, as well as in the dispersion of the data, can be better appreciated in the corresponding box plot, Figure 8:

Figure 8. Box Graph Before and After for Looper



Source: Own Elaboration

Figure 9. Minitab® Results, Median Difference for Welder 1

Mann-Whitney Test and CI: Weld.1 Antes, T welder 1 Después

N Median

Weld.1 Antes 56 10.650

T welder 1 Después 56 7.200

Point estimate for η1 - η2 is 3.615

95.0 Percent CI for η1 - η2 is (1.890,5.911)

W = 3867.5

Test of η1 = η2 vs η1 ≠ η2 is significant at 0.0000

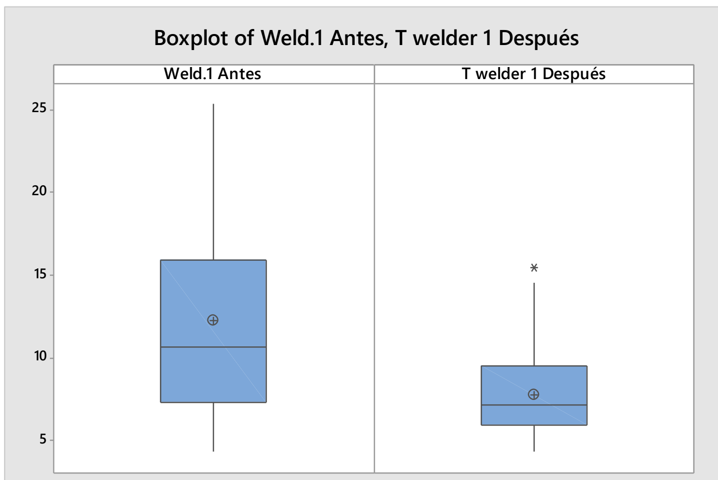
The test is significant at 0.0000 (adjusted for ties)

Source: Own Elaboration

The p=0.0000 value shown in Figure 9 indicates that the null hypothesis should be rejected if there is a significant difference between welder 1's time before and his time after the changes introduced. Since the confidence interval for the difference in medians is always positive, it is concluded that the time of welder 1 Before is always greater than the time of welder 1 After.

The reduction in the average time, as well as in the dispersion of the data, can be better appreciated in the corresponding box plot, Figure 10:

Figure 10. Box Graph Before and After for Welder 1



Source: Own Elaboration

Figure 11. Minitab® Results, Median Difference for Welder 2

Mann-Whitney Test and CI: Weld.2 Antes, Ct Welder 2 Después

		N	Median
Weld.2	Antes	56	12.105
Ct Welder 2	Después	56	7.645

Point estimate for $\eta1 - \eta2$ is 4.140

95.0 Percent CI for $\eta1 - \eta2$ is (1.600,7.640)

W = 3890.0

Test of $\eta1 = \eta2$ vs $\eta1 \neq \eta2$ is significant at 0.0000

The test is significant at 0.0000 (adjusted for ties)

Source: Own Elaboration

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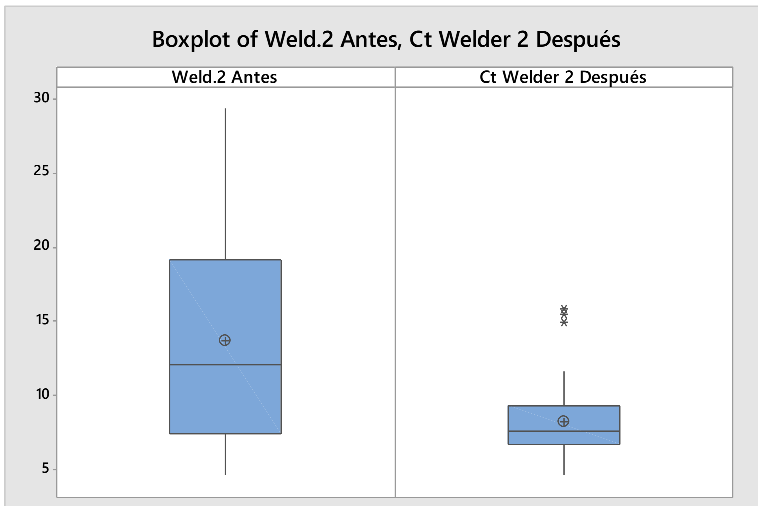
As can be seen in Figure 11, the p=0.0000 value indicates that the null hypothesis should be rejected if there is a significant difference between welder 2's time before and after the changes introduced. Since the confidence interval for the difference in medians is always positive, it is concluded that the time of welder 2 Before is always greater than the time of welder 2 After.

The reduction in the average time, as well as in the dispersion of the data, can be better appreciated in the corresponding box plot, Figure 12:

Figure 12. Box Graph Before and After for Welder 2



Source: Own Elaboration

Figure 13. Minitab® Results, Median Difference for Roller

Mann-Whitney Test and CI: Roladora Antes, Ct Roladora Después

N Median

Roladora Antes 56 9.485

Ct Roladora Después 56 7.650

Point estimate for η1 - η2 is 2.465

95.0 Percent CI for η1 - η2 is (1.079,4.091)

W = 3817.0

Test of η1 = η2 vs η1 ≠ η2 is significant at 0.0001

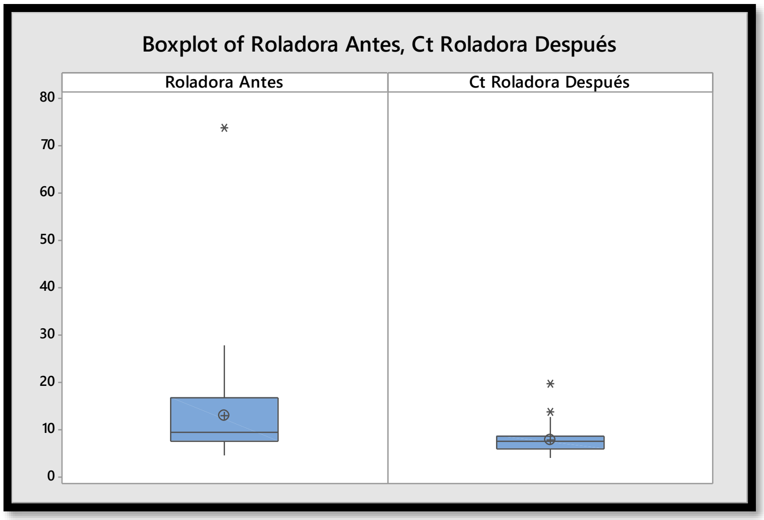
The test is significant at 0.0001 (adjusted for ties)

Source: Own Elaboration

Once again, it can be seen in Figure 13 that the value p=0.0001 indicates that the null hypothesis must be rejected, if there is a significant difference between the time of the Roller before and its time after the changes introduced. Since the confidence interval for the difference in medians is always positive, it is concluded that the time of the Before Roller is always greater than the time of the After Roller.

The reduction in the average time, as well as in the dispersion of the data, can be better appreciated in the corresponding box plot, Figure 14:

Figure 14. Box Graph Before and After for Roller



Source: Own Elaboration

Figure 15. Minitab® Results, Median Difference for Assembly

Mann-Whitney Test and CI: Ensamble Antes, Ct Ensamble Después

N Median

Ensamble Antes 56 18.320

Ct Ensamble Después 56 9.765

Point estimate for η1 - η2 is 6.385

95.0 Percent CI for η1 - η2 is (3.798,9.212)

W = 4049.0

Test of η1 = η2 vs η1 ≠ η2 is significant at 0.0000

The test is significant at 0.0000 (adjusted for ties)

Source: Own Elaboration

The p=0.0000 value, shown in Figure 15, indicates that the null hypothesis should be rejected if there is a significant difference between the time of the Ensemble before and its time after the changes introduced. Since the confidence interval for the difference in medians is always

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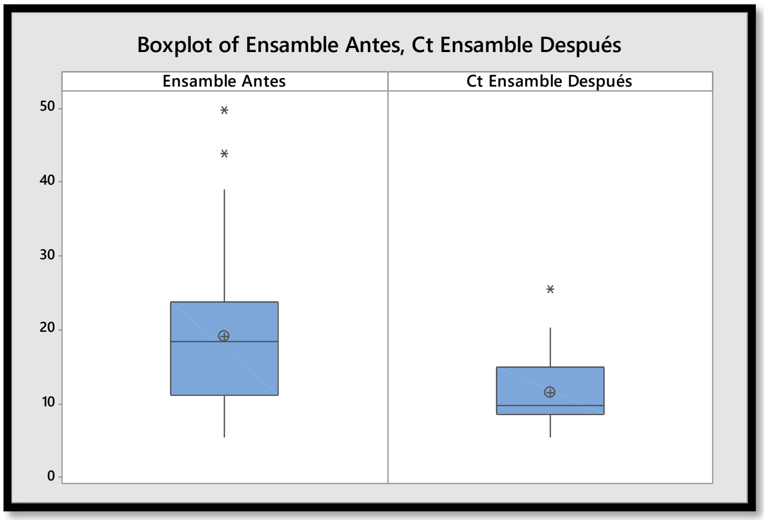
positive, it is concluded that the time of the Before Ensemble is always greater than the time of the After Ensemble.

The reduction in the average time, as well as in the dispersion of the data, can be better appreciated in the corresponding box plot, Figure 16:

Figure 16. Box Graph Before and After for Assembly



Source: Own Elaboration

Discussion

Documented research shows that the degree of employee satisfaction is substantially increased when working with material handling chains, through training and education. The application of this concept, beyond the classic one in manufacturing systems, demonstrates its universal effectiveness, since cases such as those documented by Aguilar-Escobar, Bourque and Godino-Gallego (2015) can be found in the nursing area. in a public hospital.

On the other hand, Muhammad, Markkula and Oivo (2016), applied a survey to 27 organizations, obtaining 126 responses from personnel involved in the use of Kanban. In the compendium of this information, they found, as one of the common factors, that training is a key success factor in the implementation of this methodology.

Finally, the use of this methodology is widespread in the transformation industry. The reviewed literature shows us that there are few cases in which this methodology is applied outside of production systems, so this research provides further evidence that it is possible to apply these principles outside of these systems, in alternative systems or support, since, with the proper training and training, equally favorable results can be achieved.

Conclusions

The research questions that gave rise to this project are: How is it possible to apply the Kanban principles to the management and control of tools for model change in a manufacturing cell? Will it be successfully applied in this manufacturing company?

Question for which the following hypothesis was established:

Using the Kanban-Tooling methodology, assembly times in manufacturing cells will be significantly reduced

To test this hypothesis, the Mann-Whitney test was used, where the hypotheses to be tested are:

$$H_0: \mu_{Before} = \mu_{After}$$

$$H_1: \mu_{Before \neq} \mu_{After}$$

If the probability of committing the alpha error is less than the theoretical allowable value (usually 0.05), then the null hypothesis must be rejected.

Comparing the data before and after for each of the five operations carried out in the cells, it was found that the p value indicates that the null hypothesis should be rejected (for all cases), which indicates that if there is a significant difference between the time before and time after the changes introduced. Since the confidence interval for the median difference is always positive, it is concluded that the Before time is always greater than the After time.

The statistical analysis positively validates that the research objective has been met: Reduce assembly times in the manufacturing cell, through the implementation of the Kanban Tooling method. This was achieved by adapting the traditional Kanban system to the cell start adjustment point and by effectively managing the training and training of all the personnel involved.

Traditionally, work-in-process management tools, such as Kanban, are done in the production process; This work demonstrates that it is possible to use this type of system at other points in the process, such as the moment of boot adjustments.

Future Research Lines

As demonstrated in this work, it is possible to implement this tool in other manufacturing areas, not necessarily in the production process. In any organization, endless activities are carried out outside of this process: purchasing, storage, maintenance, quality, etc.; How is it possible to use this methodology in those other areas?

Given that the results obtained show that the Kanban methodology can be implemented in areas other than those strictly related to production flow, which is traditional, management is proposed to develop and implement similar systems for other areas, such as: molding, stamping and punching. In these areas there are similar problems of disorder, inefficiency and loss of time, so the benefit would have a great impact on the manufacturing process in general.

Teaching and training in this type of methodologies is a necessity, for some years now, they cannot continue to be handled as a "plus" to the general knowledge of the first-line engineer. In this same sense, efforts should be resumed regarding the teaching of applied statistics. Whenever possible, statistical validation of research assumptions should be sought, since this gives a scientific meaning to any project, be it a thesis or an undergraduate research paper.

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