A Comparison of the Application of the SMED Methodology in Two Different Cutting Lines

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ABSTRACT

Purpose: This study was carried out in a cork company. Its purpose was to observe and analyse the practices and methods used during the tools/series change moments and to propose improvements to these same procedures so that the time needed to carry out the setup is reduced by 15% in both lines.

Methodology/Approach: The methodology included the following phases: 1st – historical data collection, 2nd – footage analysis and conduction of informal interviews with employees, 3rd – flow, Gantt, and spaghetti charts creation and making of an action plan based on the waste and improvement opportunities, 4th – validation with the line workers of the new operating mode created with the SMED tool, 5th – placement of plasticized cards on the cutting lines to ensure that new operating mode is followed in the action plan.

Findings: Throughout this project using observations, video recording and its subsequent analysis, as well as, interviews to the workers operating in the line, it was found the existence of several actions carried out by them during the setups which did not add value to the product and lack of work tools in general.

Research Limitation/Implication: The study was limited by the lines and products under study and by the duration of the curricular internship, which was about five months.

Originality/Value of paper: The article demonstrates the added value in terms of product quality and production output rate that SMED methodology can bring to companies that adopt the lean philosophy and in particular this continuous improvement tool.

Category: Research paper

Keywords: series change; time reduction; SMED; changeover; productivity

1 INTRODUCTION

In the last decades we have seen a significant change of the manufacturing sector. According Parwani and Hu (2021), companies focus on reducing non-value-add activities, eliminating wastage, and decreasing the setup time to remain competitive. Industries have to compete with manufacturing from other countries with relatively cheap labour. Thus, as technological advances happen, the end consumer is more informed and becomes more and more demanding with what he/she wants, seeking products with more quality, at more affordable prices and with very fast delivery times. As such, companies are currently under tremendous pressure to adapt and meet the quality needs of demand while reducing their response time and consuming less resources, thus ensuring their survival (Silva and Gouveia, 2020). One of the critical points of the industries is the setup changes, since they are activities that do not add value to the product, but are necessary for its production (Godina et al., 2018). As such, the challenge is to use the Single Minute Exchange of Dies (SMED) methodology to promote an improvement in product quality, productivity and reduction of setup times (Vieira et al., 2019; Rosa et al., 2017). The setup times are a typical example of waste, since they correspond to an activity that does not add value and that involves hidden expenses (Van Goubergen and Van Landeghem, 2002).

Before the Industrial Revolution, the existing productive activity was handmade and very manual, with the help of some simple machines and some helpers, the craftsman took care of almost the entire production process (Risatti, 2013; Murmura, Bravi and Santos, 2021). Henry Ford, founder of Ford Motor Company, a car manufacturing company, introduces after the end of World War I the assembly line, which will become the new industrial model (Bhagwat, 2005). Ford aimed to produce as much as possible with the minimum associated production costs (Machado et al., 2020), so that it could conquer the market with more attractive selling prices (Tomac, Radonja and Bonato, 2019). However, this model had a major disadvantage which falled in the fact that there was no variety and diversification of the product, only cars with black color were produced (Rosa, Silva and Ferreira, 2017). After the end of World War II, customers began to demand higher quality in the products and services provided, something that mass production had difficulties in providing (Jasti and Kodali, 2014; Araujo et al., 2019; Costa et al., 2019; Santos, Murmura and Bravi, 2019). In order to be able to respond to customer requirements, in the 1950s, Eiji Toyoda and Taiichi Ohno developed the Toyota Production System (TPS). This is an integrated socio-technical system, with the combination of the knowledge and skill of master craftsmen with the concepts of standardization and teamwork (Jasti and Kodali, 2014; Correia et al., 2018). Since they lacked the capacity to apply the philosophy of mass production, Toyota sought to offer what the other companies did not have: a wide variety of high quality products at low cost (Liker, 2004; Félix et al., 2019a). Thus, lean philosophy was born (Ribeiro et al., 2019; Santos et al., 2019b; Sá et al., 2020) at a time when new businesses are sought (Bravi, Murmura and Santos, 2018) and customers are increasingly demanding with product quality and also with environmental issues (Carvalho, Santos and Gonçalves, 2019; Talapatra et al., 2019). The Lean philosophy can be synthesized as the systematic pursuit of perfect value by eliminating waste in all aspects of organizations' business processes (Dahlgaard-Park and Bendell, 2006; Neves et al., 2018). Continuous Improvement is the element guided by management that promotes cultural change in the workplace (Sundar, Balaji and Kumar, 2014; Santos, et al., 2019a). This is based on people's inherent desire for quality and value (Berger, 1997). According to Dean and Bowen (1994), improvements in quality are widely recognized as having a competitive advantage in the global economy. Lean production identifies all types of waste in the value chain and implements the necessary tools for their elimination and consequent minimization of waiting times (Abdulmalek and Rajgopal, 2007; de Oliveira, Sá and Fernandes, 2017; Barbosa, de Oliveira and Santos, 2018). Anything that interferes with the continuous flow of production is defined as waste (Rosa et al., 2018; Pereira et al., 2019). Womack and Jones (2003) identified five basic principles for a Lean philosophy, namely: value identification, value stream identification, creating a continuous production flow, implementation of a pull system and pursuit of perfection.

Karim and Arif-Uz-Zaman (2013) explain the interconnection between the five principles as follows:

The customers create value for the organization based on needs, pricing, and timing for products or services. Thus, this customer information and value transformation create the value stream for the product demanded by customer. The value added steps for product creation identify the product flow for production. Customers pull products from producers through product order. The final principle integrates and perfects the system so the first four principles can be effectively implemented. These principles guide the elimination of waste and the simplification of all manufacturing and support processes.

The following Figure 1 shows the main benefits that organizations achieve through the five principles of lean thinking. Today, customers demand high quality products at reasonable prices and with a short response time (Costa, Silva and Campilho, 2017; Félix et al., 2019b).

Companies must implement a Lean philosophy and customer-based production in order to meet their requirements. Being able to evolve in the industry at different operating levels means that workers must be able to exceed expectations for their performance each day. For this, it is necessary to have a stable and viable structure to support these performances (Boran and Ekincioğlu, 2017). The Lean production practices and tools have been commonly used to reduce wastes, to meet the client's requirements in the desired quantity and at the right delivery time, leading to gain competitive advantages over their direct competitors (Rüttimann, 2017; Rodrigues, et al, 2019; Sá et al., 2019; Bravi, Murmura and Santos, 2019; Jimenez et al., 2019).

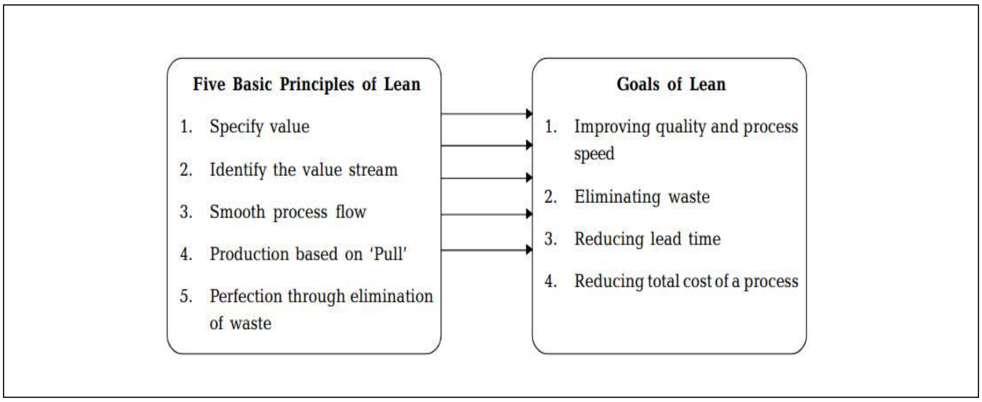

Figure 1 – The Five Principles of Lean and Their Respective Goals

The most effective way to achieve this is to increase flexibility by producing smaller lots (Costa et al., 2018; Bravi, Murmura and Santos, 2019), however this type of production tends to lead to an increase in setup frequency (Costa et al., 2013). For this reason, companies must find a way to reduce setup times, eliminate waste and limit non-value-added activities (Sousa et al., 2018; Santos et al., 2019c) where it is important a quality culture (Zgodavova, Hudec and Palfy, 2017) and control the risks (Ferreira, Santos and Silva, 2019). An efficient series change is, therefore, an important element that supports the control of the production process on the industrial shop floor, (Martins et al., 2018), proving to be even more important if the demand is complex (Allahverdi and Soroush, 2008; Bravi, Murmura and Santos, 2017).

The present work was carried out in a cork company and its goal was to observe and analyze the practices and methods used during the tools/series change moments and, with the help of Single Minute Exchange of Dies (SMED) methodology implementation in the cutting lines present in the final finishing areas of the process, propose improvements and alternatives to those same procedures, so that the time needed to perform the setup is reduced by 15% in both lines and the likelihood of errors on the part of employees and malfunctions on machines decrease.

2 THEORETICAL CONTEXTUALIZATION

The SMED methodology was developed in the 1950s by Shigeo Shingo, a Toyota industrial engineer, and its main goal was to reduce setup times (Ahmad and Soberi, 2018). SMED was the proposed solution to reduce the bottlenecks caused by Toyota's printing presses (Dillon and Shingo, 1985).

SMED is essentially a methodology for analyzing and improving time lost in manufacturing series changes due to the execution of setups (Pinto et al., 2019). In its original definition, it defends that the tool changes to be carried out in a production line must be completed in less than 10 min, thus guaranteeing its representation by only a single digit in the minutes field. It focuses on the analysis, systematization and normalization of tasks performed by the machine operator or line team. A correct implementation of SMED will ensure greater flexibility and result in improved product flow in the manufacturing area (Dave and Sohani, 2012; Azevedo et al., 2019; Doiro et al., 2019).

Setup time is defined as the period from the time when the last good product from the previous production order leaves the machine and the first good product from the next production order is produced (Coimbra, 2009). Changeover time is defined as the time needed to set up a given production system to run a different product with all the requirements (Díaz-Reza et al., 2016).

Current theory and practice regarding SMED techniques are still centered on the original concept developed by Dillon and Shingo (1985) in the 1950s and 1960s (Moxham and Greatbanks, 2001). The implementation of the SMED methodology involves the following steps:

- Study of the current situation,
- Classification of tasks into internal and external tasks,
- Transformation of internal tasks into external tasks,
- Optimization of internal tasks,
- Optimization of external tasks.

In the first stage, study of the current situation, it was sought to make an analysis of the current operating procedures and conditions in the work area. In the second phase, one then seeks to distinguish between what can be done before and what can be done after the change of series. Having differentiated between the two types of tasks, the next step is to transform, whenever possible, internal tasks into external tasks. The next point of the methodology has the internal activities as focus. This phase aims to reduce the time of internal tasks by simplifying, optimizing and standardizing them in order to reduce or eliminate internal work that could not be transformed into external in the previous step. Finally, the last stage of the methodology only deals with external activities (Vieira et al., 2019).

3 METHODOLOGY

The company where this study was developed is specialized in the manufacture of cork-floated floating floors. The research methodology used in this work was the action research methodology.

The methodology included the following phases:

- *Diagnosis* – collection of historical data and recording of configuration video. Filming was analyzed and informal interviews were conducted with employees and spaghetti diagrams were also drawn up to identify waste;

- *Action Planning* – elaboration of the action plan based on the residues and opportunities for improvement identified in the video analysis;
- *Action Taking* – Elaboration of new standard works with the objective of reducing the time for changing the machines;
- *Evaluating* – validation with workers who operate in line with the new procedures created with the aid of the SMED methodology and communication to the Maintenance department about their role in this project;
- *Specifying Learning* – making and placing plasticized cards on the cut lines to ensure the fulfillment of the new procedure and the execution of the actions identified in the action plan.

4 CASE STUDY

4.1 Data Collection

After the meeting with the person in charge of the final finishing area, where the objectives for this project were defined, as well as the products and lines that this project encompassed, the next step consisted of collecting historical data, namely the number and the duration of stops due to damage and setups.

Through the collected data, it became possible to verify the number of important setups for this project that occurred in each month, as well as their monthly average. After processing the data and creating bar graphs it was possible to observe that the number of setups performed, and their monthly average time is not constant. In AF2 the average time is decreasing while in AF3 the opposite occurs. AF2 averages 193.84 minutes per setup while AF3 averages 41.63 minutes per setup.

With the collected data it was also possible to verify the number of unplanned stops that occurred in the two plants, the number of hours that induce production to stop and the corresponding percentage. Pareto's diagrams were made to allow easy visualization and identification of the most significant causes with the most significant stops happening in AF2 due to the occurrence of setups and machine malfunctions, totalling 62% of the downtime on the line in analysis. As in AF2, also in AF3 the stops with the most impact on the cutting line are the stops happening due to malfunctions and setups, thus making it essential to promote measures that act in these two fields to reduce the number of non-productive hours.

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4.2 Introduction to the Cutting Lines

After knowing what lines this project was concentrating on and after the collection of data of said lines was done, the next step was to get to know the lines in question, observe the process that transforms material A in product B. This project focused on the final finishing areas 2 and 3, AF2 and AF3, more precisely on their respective cutting lines.

AF2's cutting line works in a regime of 3 rotating shifts, 8 hours per shift for 5 days a week. Each shift consisted of 3 workers, however, during this project it was passed to 2 workers. AF3's line works under the same regime, however, it is only operated by 1 employee.

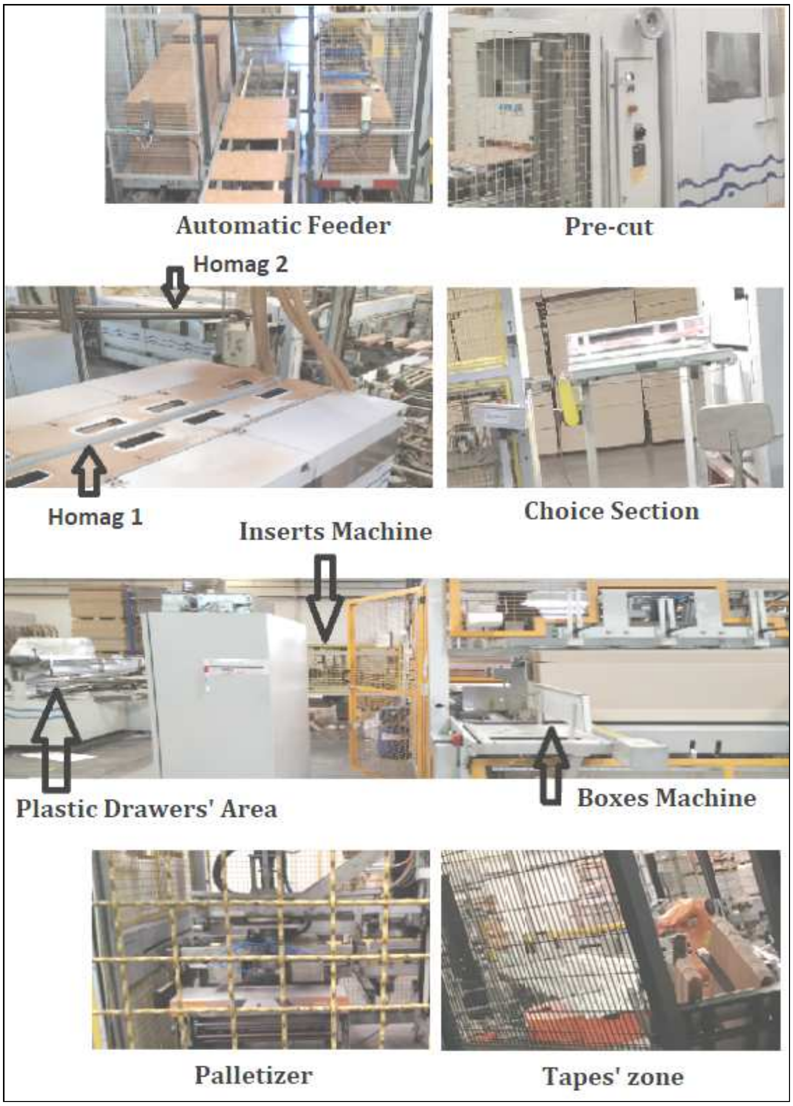


Figure 2 – AF2's Cutting Line

The entry of the boards into the cutting lines occurs with the automatic feeding of pallets, which then pass through a section called Pre-cut, where the boards are transformed into 2 or 3 tiles, then going to the Homag 1 machine that will make the longitudinal cut and then proceed to Homag 2 which will make the cross section of the tiles. In AF2 the process continues to the Choice Section, where a worker assigned to that post checks whether the tiles contain defects or are good to carry on the process. If they are without defects the tiles go to the Boxes Machine where they will be automatically deposited in a cardboard box that when it reaches its capacity frees it for the Inserts Machine where a pamphlet is placed according to the product and market in question and the box is subsequently packed in the Plastic Drawers' area.

Finally, in the palletizer's area, a robot organizes the packed boxes until they make up a pallet. When the dimensions of the pallet are reached, another robot surrounds and protects the pallet with plastic. In AF3, the cutting and packaging processes are separated. AF2's and AF3's cutting lines are shown in Figure 2 and Figure 3, respectively.

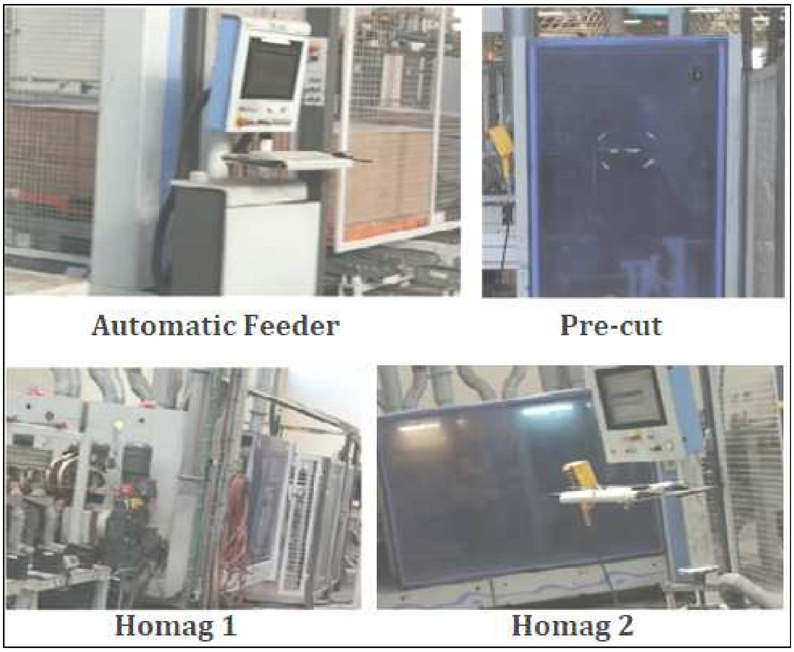


Figure 3 – AF3's Cutting Line

4.3 First Observations and Analysis of the Situation

The next step after the data collection phase and the introduction to the cutting lines was to try to involve the line workers in the project as they deal with the problems and situations of the lines on a daily basis. As such, informal interviews were conducted with them in order to understand what are their biggest difficulties during the setups.

During the data collection phase, Pareto's graphs were made to understand which events historically caused the most stops on the cutting lines. After the analysis of the graphs it was concluded that breakdowns and execution of setups were the most significant events, with the dirt and the lack of maintenance being points that contribute to that fact. After conducting the interviews and with permission of the employees, the execution of the setups under study was recorded on video for later analysis. Their analysis made it possible to identify the steps required to perform them, as well as the movements made by the workers during setups which were then passed to flowcharts and spaghetti diagrams, respectively, to facilitate their understanding and identify possible wastes.

The spaghetti diagrams created to visually represent the employees' movements during the setups in AF2 and AF3 are shown in Figure 4 and Figure 5, respectively.

As can be seen from the spaghetti diagram shown in Figure 4, all employees in AF2 show a certain level of waste during the execution of the setup, with the team leader (blue color) having the longest travel taking 258 seconds to make his journey. Product change settings actions took 59 minutes.

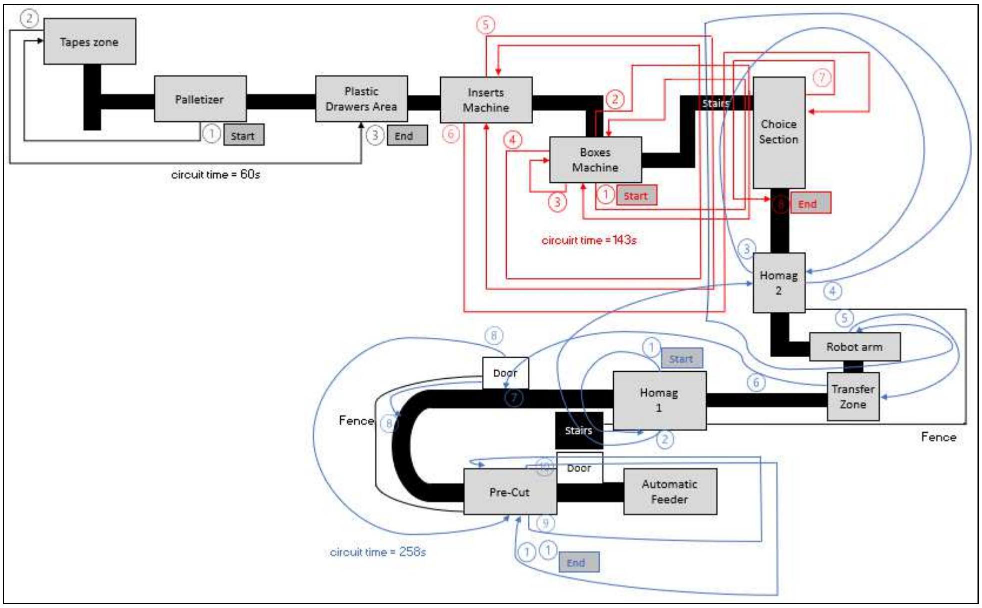


Figure 4 – Spaghetti Diagram of the Workers' Setup Movement in AF2

As can be seen in the spaghetti diagram in Figure 5, the employee responsible for the change in AF3 already uses an optimized procedure and there is no waste of movement. Product change settings actions took 26 minutes.

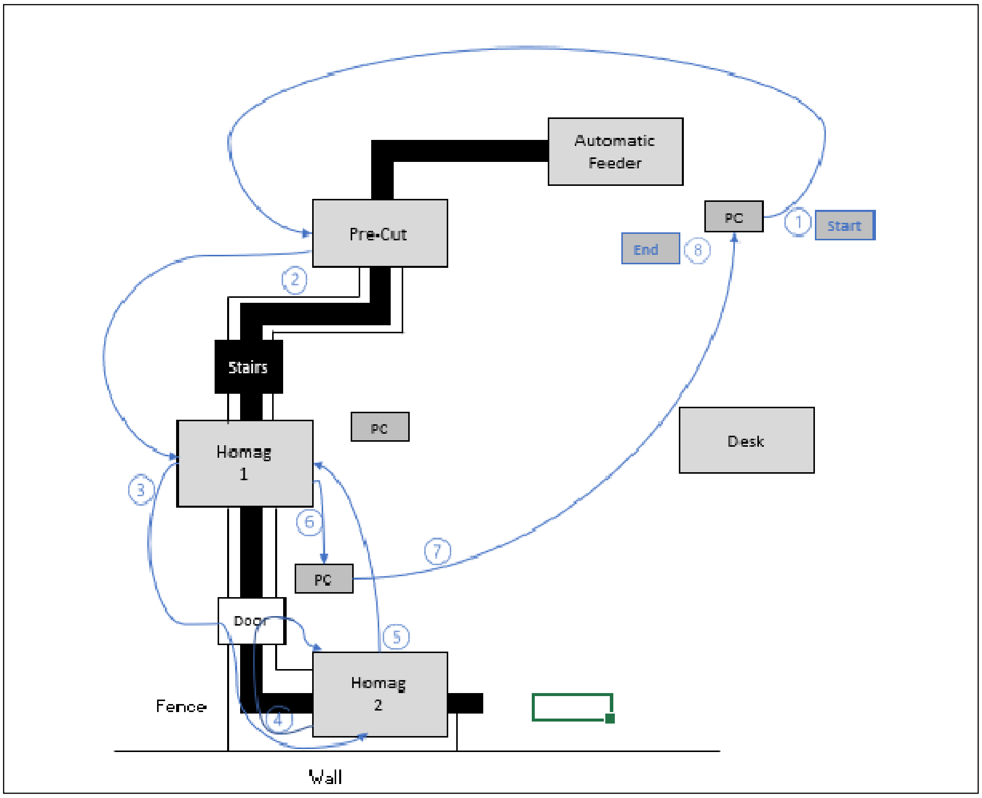


Figure 5 – Spaghetti Diagram of the Workers' Setup Movement in AF3

After the creation of the figures previously presented, two excel tables were created that synthesize the wastes which were observed during the execution of the setup tasks. Those two tables helped create an improvement action plan whose ideas would be implemented later.

Table 1 contain the wastes of time found in AF2 that is about 27 min and 52 sec. Table 2 contain the wastes do time found in AF3, that is about 6 min and 54 sec.

In Table 1, it can be seen that there is employees waste time in unnecessary situations, such as: looking for tools, disassembling and assembling suction cups, looking for a new funnel, assembling the new funnel among others. Like in AF2, the same table, that isTable 1, shows that workers also look for tools during AF3 setup, however, the largest amount of time is spent loading the material only when the setup time begins.

Table 1 – Waste Activities Found in AF2 and in AF3 When Executing Setups

To eliminate in AF2			*To eliminate in AF3*		
Activities	Time [min]	Time [sec]	Activities	Time [min]	Time [sec]
Searching for tools	00:30	30	Loading material into the feeding zone	05:13	313
Searching for and storing of tools	01:00	60	Checking the Material Information Sheet	00:20	20
			Checking the wrong saw	00:12	12
			Searching for a missing tool	00:09	9
Disassemble and assemble of suction cups	01:26	86			
Searching for new boxes	08:12	492			
Searching for tools	02:30	150			
Searching for new inserts	00:36	36			
Preparing a new film reel	07:25	445			
Preparing the Cardboard Box	01:36	196	Closing Homag 2 access door	01:00	60
Searching for the new funnel	00:22	22			
Mounting the new funnel	03:02	182			

Table 2 – Total Waste Time found in AF2 and AF3

AF2			*AF3*		
Total Time to eliminate (in seconds)	Minutes	Seconds	Total Time to eliminate (in seconds)	Minutes	Seconds
1672	27	52	414	6	54

4.4 Improvements Implemented

After analysing the videos and all the diagrams created, an action plan was carried out together with the maintenance department. The implemented measures are presented below.

4.4.1 Movement Modification and Task Reclassification

At the beginning of this project, the cutting line 4 was composed of 3 workers, however, throughout its development, the management decided that this line would be operated just by 2 workers. It was therefore necessary to balance tasks and movements for only 2 operators. The new path with the appropriate workforce reduction movements created for AF2 is shown in Figure 6.

Regarding employee movements, their starting points were changed and it was sought to ensure that employees travelled a direct path and did not travel the same path several times. With the new movement routes, it was possible to reduce the movement of the team leader from 258 to 161 seconds.

With 3 workers, the tasks during the setup took 59 minutes, plus 5 minutes of travel making a total of 64 minutes of setup. After task reorganization, the 2-worker setup takes now 62 minutes, the team leader finishes his tasks in 63 minutes resulting in a total setup time of 66 min after considering the time spent on employee travel.

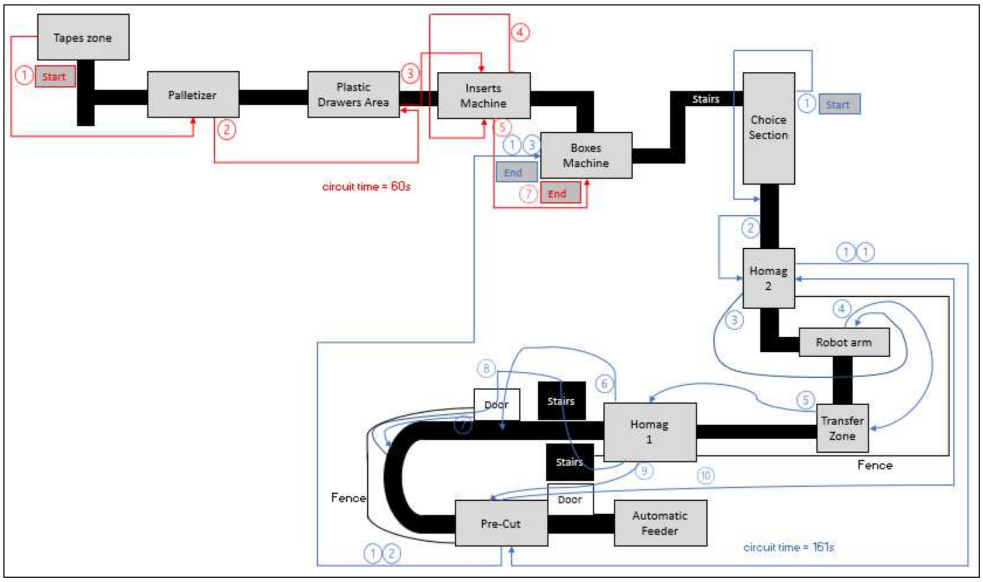


Figure 6 – Spaghetti Diagram of the Workers' New Procedure in AF2

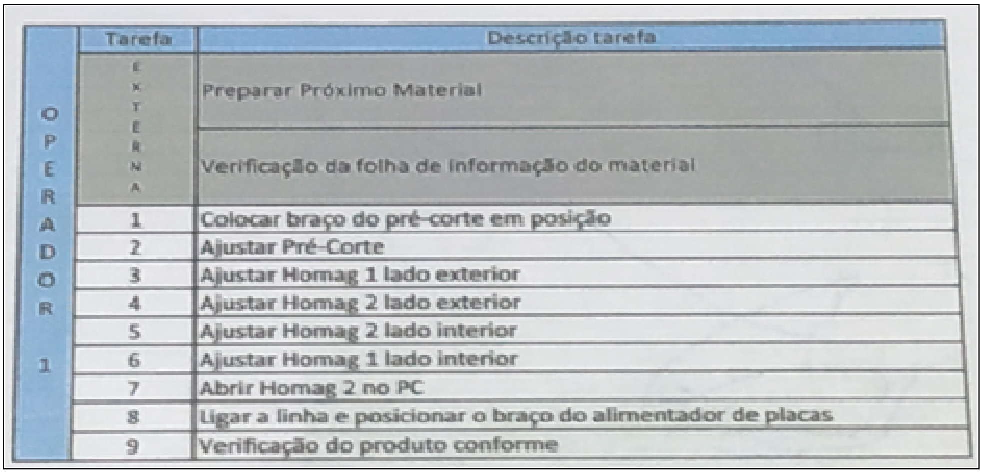
Since in AF3 the worker was already making an optimized route, only the order of tasks was changed. The preparation and checking activity of the next material to be cut is now done before the end of the last piece of the current product.

Previously, the setup took 29 minutes, 26 minutes for specific actions and 3 minutes spent traveling. Regarding the reorganization of tasks, the same setup done by the same collaborator now takes 22 minutes.

4.4.2 Creation of Operational Cards to deposit on the lines

The next step after the creation of these new procedures was the validation with the team leaders and then the creation of plastic cards to be always present in the lines for all employees to know their duties. The cards placed on the lines can be seen in the figures below.

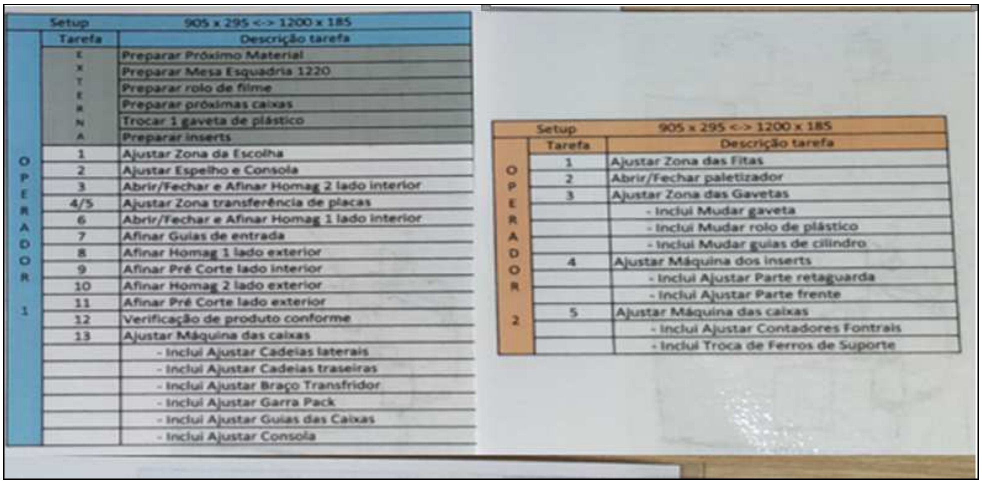
Figure 7 shows the front of the card placed in AF3, the back of the card was already show earlier in this document.



	Tarefa	Descrição tarefa
OPERADOR 1	EXTERNA	Preparar Próximo Material
		Verificação da folha de informação do material
	1	Colocar braço do pré-corte em posição
	2	Ajustar Pré-Corte
	3	Ajustar Homag 1 lado exterior
	4	Ajustar Homag 2 lado exterior
	5	Ajustar Homag 2 lado interior
	6	Ajustar Homag 1 lado interior
	7	Abrir Homag 2 no PC
	8	Ligar a linha e posicionar o braço do alimentador de placas
	9	Verificação do produto conforme

Figure 7 – Front of the card placed in AF3

Figure 8 shows the front of the card placed in AF2, this card show the new tasks and movements the workers must follow.



Setup		905 x 295 <-> 1200 x 185
	Tarefa	Descrição tarefa
OPERADOR 1	EXTERNA	Preparar Próximo Material
		Preparar Mesa Esquadria 1220
		Preparar rolo de filme
		Preparar próximas caixas
		Trocar 1 gaveta de plástico
		Preparar inserts
	1	Ajustar Zona da Escolha
	2	Ajustar Espelho e Consola
	3	Abrir/Fechar e Afinar Homag 2 lado interior
	4/5	Ajustar Zona transferência de placas
	6	Abrir/Fechar e Afinar Homag 1 lado interior
	7	Afinar Guias de entrada
	8	Afinar Homag 1 lado exterior
	9	Afinar Pré Corte lado interior
	10	Afinar Homag 2 lado exterior
	11	Afinar Pré Corte lado exterior
	12	Verificação de produto conforme
	13	Ajustar Máquina das caixas
		- Inclui Ajustar Cadeias laterais
		- Inclui Ajustar Cadeias traseiras
		- Inclui Ajustar Braço Transfridor
		- Inclui Ajustar Garra Pack
		- Inclui Ajustar Guias das Caixas
		- Inclui Ajustar Consola

Setup		905 x 295 <-> 1200 x 185
	Tarefa	Descrição tarefa
OPERADOR 2	1	Ajustar Zona das Fitas
	2	Abrir/Fechar paletizador
	3	Ajustar Zona das Gavetas
		- Inclui Mudar gaveta
		- Inclui Mudar rolo de plástico
		- Inclui Mudar guias de cilindro
	4	Ajustar Máquina dos inserts
		- Inclui Ajustar Parte retaguarda
		- Inclui Ajustar Parte frente
	5	Ajustar Máquina das caixas
		- Inclui Ajustar Contadores Fontrais
		- Inclui Troca de Ferros de Suporte

Figure 8 – Front of the Cards Placed in AF2

4.4.3 Tools Location Change

During the observation of the setups it was possible to verify that in both lines the employees spent too much time looking for tools, as such, one of the measures promoted was the change of location of some tools.

With this action, the workers no longer need to go to a shelf in the middle of the line and look in a metal box for the tools they need, neither need to go to the drawer storage area and collect the tools to change the plastic drawers. To avoid wasting time looking for tools, they have been placed exactly where they are needed as seen in Figure 9 and Figure 10.

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Figure 9 – Before and After Changing the Location of Some Tools

Figure 10 – Before and After Changing the Location of the Drawers

4.4.4 Placement of Toolkits in Strategic Locations

Small key tool kits were also introduced where they were most used, avoiding constant travel by the employees to the tool cabinet. Figure 11 shows the toolkit placed in the two most problematic areas of the line.

Figure 11 – Toolkits Used

4.4.5 Creation of a Missing Tools List

Another key point when observing setups and through informal conversations with employees was the fact that there was a lack of tools on the cutting lines, and it was often necessary to fetch tools from other lines.

A list of the missing tools was then drawn up and later sent to the person responsible for review and ordering what the responsible thought to be a valid request.

4.4.6 Tool Modification and Duplication

As for existing tools, a Homags (cutting machine) adjusting tool was duplicated as it was not always available, and another tool was stretched to increase its range.

Stretching the tool will mean that the worker no longer must position the crank in the starting position and will allow the working range of the handle to move from 180 to 360 degrees. The operator can now perform the operation faster and with less physical effort. The duplicated tool can be seen in Figure 12 and the elongated tool in Figure 13.

Figure 12 – Duplicated Tool

Figure 13 – Elongated Tool

4.4.7 Creation of Labels for Counters and Record Sheets with past references

Another change promoted was the creation and placement of labels in various locations, as shown in Figure 14. It was noticed that during the setups the workers were always checking the value because it was easy to forget and, in some places, they wrote on the machines. This measure promotes an improvement in the appearance of the workplace as well as decreases the probability of the occurrence of human errors. The labels appear as a memory aid and prevent rapid setup execution from relying on operator retention.

Figure 14 – Labels with the Value of the Counters

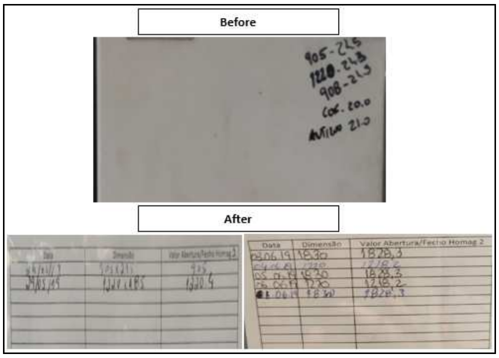

Figure 15 – Record Sheets

Record sheets were created and placed next to the cutting machines, Figure 15, to facilitate the process of opening and closing the machines by informing the last values used for certain dimensions. It is expected that with these forms and their history, product compliance will be achieved more quickly thus avoiding the need to reopen or close the machines.

Table 3 – Final Results in AF2

	min	*%*
Objective time (minutes)	120	100%
Historical average time (minutes)	194	162%
Expected reduction (minutes)	29	15%
Observed time (with 3 workers) (minutes)	64	100%
Time after task reorganization (with 2 workers) (minutes)	66	103%
Reduction achieved (minutes)	-2	-3%

Table 4 – Final Results in AF3

	min	*%*
Objective time (minutes)	120	100%
Historical average time (minutes)	194	162%
Expected reduction (minutes)	29	15%
Observed time (with 1 worker) (minutes)	64	100%
Time after task reorganization (with 1 worker) (minutes)	66	103%
Reduction achieved (minutes)	7	24%

The sheets placed on the lines prevent collaborators from writing on the equipment and allow them to see the opening and closing values used in previous setups, reducing the subsequent setting times.

Tables 3 and 4 show the above data clearly and precisely, thus allowing a quick analysis of the results obtained in this project. The objective time corresponds to the time in minutes the company set as the maximum allowed to complete the setup, the historical average setup time corresponds to the time logged on the company's production database, this average recorded time happened at a time when there were no guidelines for how the employees should act and each team had its own way of operating and includes moments where workers did not correctly registry in the system machine malfunctions, loss of power or lack of raw material. The two setup times observed included in the tables 3 and 4 for AF2 and AF3 respectively refer to the times observed before and after the proposed changes. Therefore, it can be said that the objective was met and exceeded the initial expectations of the project.

5 CONCLUSION

The steps taken to improve the setup procedure on the cutting lines were the following: make an effort to maintain an organized workplace with tools in the appropriate places, i.e. properly marked and where they were really needed, change the employees' movements and create and place on the lines cards with the new instructions. Internal tasks were transformed into external ones, record sheets were created and placed near the cutting machines with their historical opening and closing values in order to speed up the product compliance process. Another measure applied was the duplication of a tool and the modification of another, and a request was made for new tools to facilitate the work of the employees.

In AF2 the target time set in the past by the company management was 120 minutes. With the help of the company's database, it was possible to verify that the historical average since January 2018 was 194 minutes. The objective set for this project was to reduce the observed setup time by about 15%. The observed time recorded corresponded to 64 minutes of movements and actions performed by 3 workers. After the implementation of the previously mentioned measures, the setup time now takes 66 minutes, therefore there is an increase of 2 minutes in relation to the recorded time, however, it is important to highlight that this new setup time is reached with only 2 employees, one less that the situation that existed before the project started.

In AF3 the target time set in the past by the company management was 20 minutes. With the help of the company's database, it was possible to verify that the historical average since January 2018 was 42 minutes. As in AF2, the cutting line AF3 also aimed to reduce the setup time observed by 15%. The observed time recorded corresponded to 29 minutes of movements and actions performed by 1 worker. After the implementation of the previously mentioned measures, the setup time in AF3 performed by a single operator now takes 22 minutes, which corresponds to a reduction of 24%.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.