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KAIZEN Application to Improve Times in the Product Change Process - A Case Study: Automotive Manufacturing Company

C Solís-Peña, V Lara-Jiménez, JM Hernández-Ramos, J Cuellar-Celestino, and J Chi-Tapia

Area of Industrial Engineering and Management
School of Chemistry
Universidad Autónoma de Nuevo León,
San Nicolás de los Garza, Nuevo León, México

Corresponding author´s Email: Carolina.solispa@unal.edu.mx

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Abstract: Kaizen is a methodology for the continuous improvement of organizations, which implies incremental gradual improvements. KAI means change and ZEN means better. This research is the result of a case study developed in a chemical branch company located in northern Mexico. The problem presented in the case study is the long time caused by product changes. To achieve the improvement of the times, the current situation was first established through the use of Value Stream Mapping and SMED, subsequently, time and movements were taken to separate the phases of the work and the standardization of worksheets and time study was used, as well as the presentation of the updated SMED.

Keywords: SMED, KAIZEN, Value Stream Mapping, Standardization, Time Study

1. Introduction

Manufacturing is an economic activity that transforms a great diversity of raw materials into different articles for consumption. According to the products produced in them, the industries are classified into nine activity divisions: I. Manufacture of Food, Beverages and Tobacco, II. Textile, Wearing Apparel and Leather Industries, III. Manufacture of Wood and Wood Products, Including Furniture, IV. Manufacture of Paper and Paper Products, Printing and Publishing, V. Manufacture of Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products, VI. Manufacture of Non-Metallic Mineral Products, except Products of Petroleum and Coal, VII. Basic Metal Industries, VIII. Manufacture of Fabricated Metal Products, Machinery and Equipment and finally IX. Other Manufacturing Industries (INEGI, 2003). The problem presented in this research is the change of product in a machine of the production line, this will be discussed later, the methodology used for improvement in this project is Kaizen which means continuous improvement in personal, family, social life and work, in which all participants are involved in the process to be improved, for the context of this research they are managers and workers alike (Imai, 2014). Improvement is a mental fixation inextricably linked to the maintenance and improvement of standards. Kaizen goes hand in hand with innovation, where Kaizen maintains and improves the standard of work through small and gradual improvements, and innovation produces radical improvements as a result of large investments in technology and / or equipment. (Imai, 2014). Although Kaizen is a methodology for continuous improvement, it relies on techniques to achieve it, one of the techniques we use in this research is Value Stream Mapping, which is used for the analysis of all the activities developed in the product manufacturing process, this technique leads to improve the process through the reduction of non-value added activities (Antonelli & Stadnicka, 2018). Another of the techniques that will be used in this research is the SMED (Single-minute exchange of die), this technique was developed by Shigeo Shingo, a Japanese industrial engineer who indicates that the objective of this approach is to reduce the preparation time and reduce it to a single digit, in this case less than 10 minutes, SMED method is changing over as many sub-processes that were previously carried out simultaneously with the core process and carry them out externally. The other sub processes are then simplified and streamlined based on the core process to save time (Shingo, 1989). To obtain the data for the previous techniques, the current times were taken and later the times were taken with the improvements made during the analysis of the same with the aforementioned techniques.

2. Literature Review

Organizations seek to make their processes leaner, eliminating all activities that have unnecessary expenses for the organization. Lean Production refers to eliminate unnecessary steps, aligning all steps in an activity in a continuous flow, recombining labor into cross-functional teams dedicated to that activity, and continually striving for improvement, companies can develop, produce, and distribute products with half or less of the human effort, space, tools, time, and overall expense (Womack & Jones, 1994). To be able to say that we have lean production, it is necessary to check that the areas of development, supply, manufacturing, distribution are focused on working in such a way that improvement strategies are shared and developed throughout the organization's value chain, in this way to eliminate the expense and implement continuous improvement, creation of multifunctional teams, always seeking to pull rather than push to be functional, in addition to this it is necessary to involve the client and generate marketing campaigns that pull demand for the organization. All those non-value added activities to the product are considered as expenses (Resta, Powell, Gaiardelli , & Dotti, 2015), to determine if we have expenses in the company, it is advisable to ask the following questions in each of the organization's processes. Below are some processes with their respective questions.: Work in process, does having it really generate any value with respect to the client? Lot sizes, does making batches of products really help achieve the organization's goals? Set up times, is the change between products optimal? Machine down, Does the time lost due to not doing preventive maintenance harm the organization in any way? According to Liebetruth (2017), in his research he detected that the indicators that are carried in organizations are divided into operational, financial and strategic; in this research we will focus on operational indicators, We can highlight that the metrics associated with this item are On-time delivery, Over/Short/Damaged, Returns & allowances, Order cycle-time, Inventory account accuracy, Inventory Obsolescence, Finished goods inventory turns, Orders processed/labor unit, Product units processed per warehouse unit (Keebler, 2000).

If we talk about waste, it is necessary to indicate the three types of waste, in the first place we have the Muda which is that activity that consumes resources without adding value for the client; Mura, refers to having poorly balanced activities inside and outside the organization; and lastly, Muri, which means that the teams run at a higher level than requested (González, 2007). Arunagiri, Gnanavelbabu (2014) focused on evaluating the 7 wastes: Transport, Inventory, Motion, Waiting, Overproduction, Over-Processing, and Defects; using a survey that had been conducted in 91 automobile industries based on the 5 point Likert's scale, the results were concise. The order of the results was as follows transportation, waiting, unnecessary motion, inventory, over processing, over production and lastly defects, in this research we will focus on reducing waiting, which according to this study is in second place. Previously, other authors identified that doing a good analysis of waste and adopting the culture and lean techniques in their organizations has helped reduce their defects by 20%, delivery times have been reduced by 75%, floor occupancy (warehouses, factories) has been reduced by 80%, machines have increased their availability by 95%, product changeover times have been reduced by 80-90% and cycle times have been reduced by 60%, with these data and the study carried out, it can be concluded that focusing on those activities that do not add value, either for their reduction or elimination, brings numerous improvements for the organization (Hines & Rich, 1997).

The Lean Manufacturing implementation process begins from the mapping of the value chain, which can be done through the VSM, after this approach, 5S's is carried out to be able to expose those activities that can be improved by JIDOKA, SMED and standard work, these last two allow the Total Productive Maintenance (TPM) to be carried out which together with the JIDOKA allow to develop the Just in time in the organizations and the implementation of the Heinjunka, Kaizen is found in the entire Lean Manufacturing process (Dinas, Franco, & Rivera, 2009). The word Kaizen is derived from two Japanese words which mean Kai = change and zen = good, when joined it means good changes. The way to represent Kaizen is through an umbrella which under it are tools such as Total Quality Management (TQM), quality circles, automation, discipline, Total Productive Maintenance (TPM), Kanban, Just in time, zero defects , among others (Imai, 2014). To carry out a Kaizen event, it is necessary to have clarity in the data, an ambitious and properly formulated goal, with interdisciplinary teams and with the support of the management as can be seen in image 1 (Farris, Van, Doolen, & Worley, 2009).

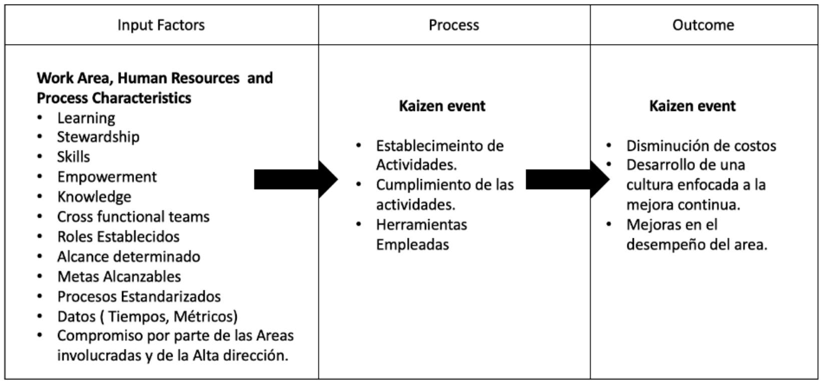

Figure 1**.** Kaizen development process

The 5S's is another technique that is generally used before making any type of modification on the workstations; this technique was developed by Deming, over forty years ago and is included in what is known as continuous improvement or Gemba kaizen. This concept refers to the creation of cleaner, more organized and safer work areas, that is, it is about adding quality of life to work. It is necessary to clarify that unlike Value Stream Mapping it does not see the process in a holistic way, as it focuses on workstations. The 5S's come from Japanese terms seiri which means to separate or discard what we don't need, seiton means order and identification of each thing, in many workstations we can notice how the tools are drawn or indicated where each thing goes, seiso means cleaning, seiketsu which means to standardize and lastly shitsuke which means discipline or standardization, is the generation of an habit (González, 2007) (Polancich, Pilon, & Treasa, 2019) (Kshitij & Surabhi, 2018). Empirical studies have been carried out on the 5S's, among which we can highlight the one developed in an automotive business where audits on the 5S's were carried out and subsequently it was reviewed that the areas of opportunity generated by these audits were corrected, in the study wanted to test how the 5S's affected productivity and through a simple linear regression it was determined that the 5S's helped reduce scrap, improve quality, reduce downtime (Veres, Liviu, Moica, & Al Akel, 2018).

Single minute Exchange of die (SMED) between the completion of manufacturing of one product and the start of another (Goubergen & Landeghem, 2002) (Gest, Culley, Mileham, & Owen, 1995), due to the great competition between companies, manufacturing processes have been forced to be effective and efficient, in such a way that any activity that makes the product more expensive or that makes it less competitive in terms of delivery times is eliminated, as a consequence they had to reduce their manufacturing times, which can be broken down into three phases: elaboration time, waiting time between successive processes as well as transport time; The purpose of the SMED is to increase flexibility and be available to react quickly to the needs of our customers and reduce inventories. The steps to perform the SMED are very simple, it highlights the fact of determining external and internal activities, where the external ones are activities that we can carry out when the machine is not stopped and the internal ones strictly require that the machine stop, from this, it should be noted that we can eliminate, combine, change or improve activities. (González, 2007). Studies have been carried out in which the VSM starts to establish the current situation and subsequently identify the process or activity in which the problem was, and determine which tool to use to improve it. In the study carried out by Rosa, Silva, Pinto, Campilho (2017), a data survey of 8 workstations was carried out, where the following problems were identified: lack of organization, identification and availability of tools to make the product change and poor processes to make the product change. Later, it was detected that the area had a weakness and tools such as 5S's, visual aids, and standard work were used to improve this weakness.

3. Methodology

The company where the research was developed, manufactures auto and motor-vehicle equipment such as differentials, transmissions shafts, crowns, and gears, among others. The main objective is to reduce the change model time in order to increase effectiveness and productivity. The specific goals are:

- To improve turning cell model change,
- To save time,
- To Avoid unwanted stops line
- 12% of production increase.

- Easy wat to operator model change,
- To Increase the flexibility of equipment and processes,
- To Reduce waste and rework
- To keep good operating condition equipment by PM routines.

The operation twenty has a GAP capacity, that means is the bottleneck and the main problem of the research. For this reason, is important to eliminate this bottleneck operation, to reach the demand of 71,000 annual transmissions, as can see in the Figure 2. There are two lathers model CTW beta 1250 4A, where the monitoring hour-by-hour was implemented. For this reason, a Pareto Diagram was made to determinate the causes of 6,000 transmissions deficit. It can be seen in the Figure 3 and 4 that the model change is one of the activities that takes more available time during the week.

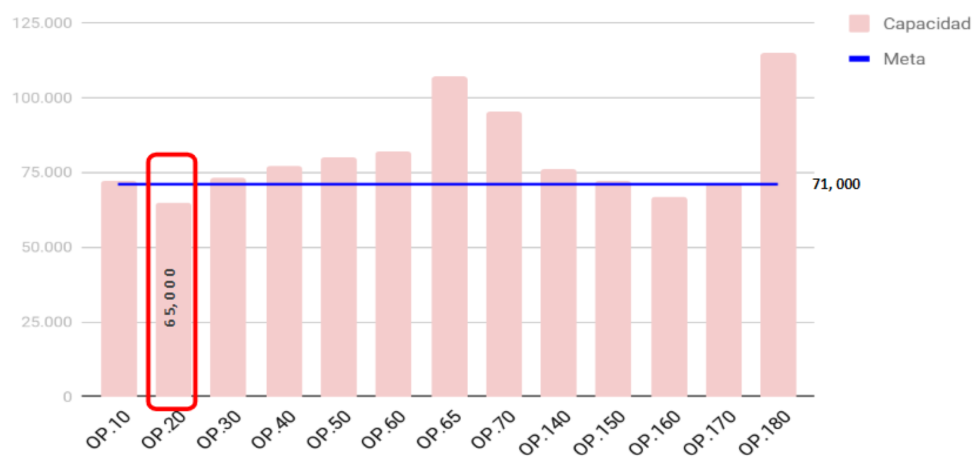

Figure 2. Capacity GAP

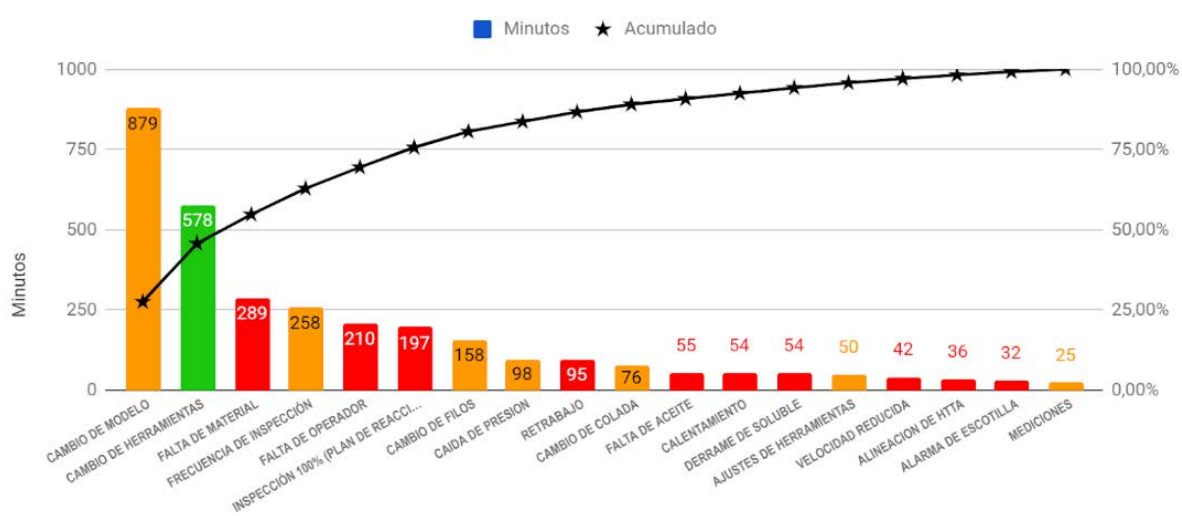

Figure 2. Pareto Diagram of shift 1

Figure 3. Pareto Diagram of shift 2

In order to solve the problem, a Kaizen event was made in the workstation. First, a plan career was made for the operators and workstations staff. Subsequently, a recording take time was made to found opportunity areas as:

- Marking Rool adjustment delay,
- Linearity adjustment in model change,
- Material lack in order to begin adjustment,
- Different jaws,
- Change of tailstock,
- Dead time due to tools lack,
- 5´s lack,
- Fist pieces variations adjustment,

The project development consisted in to reduce the model change from 300 minutes to 115 minutes following the next phases:

- Training: it was given to the staff and operational team.
- GEMBA analysis: using the take time recording and data collection previously made.
- Implementation:
  - The alignment adjustment was deleted,
  - Each model change adjustment was eliminated, and a reliability study was used instead. A 30 min reduction time was obtained.
- Marking Roll:
  - The Kanban was implemented in this part to avoid preparation and model change with the machine stopped. The reduction time was 7 min. See the Figure 5.

Figure 5. Marking Roll

- Independent chargers for each model: the charger's adjustment was eliminating each time of model change. 15 min was reduced with this improvement. See Figure 6.

Figure 6. Independent chargers for each model.

- Unique tailstock for all models: the checking and changing of the run-out was avoided. 8 min was reduced with this implementation. See Figure 7.

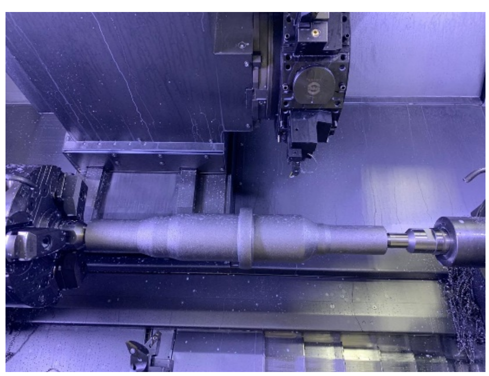

Figure 7. Tailstock for models.

- Table work standardization: using 5´s methodology, the looking for the tool was reduced by 10 min. (See Figure 8).

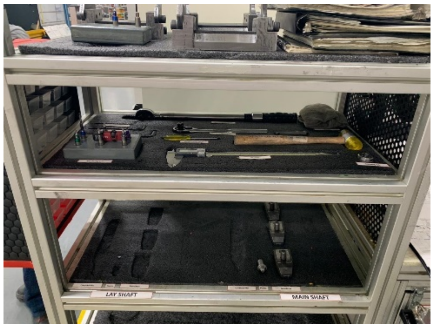

Figure 8. Table work Standardization.

- Control Drawing for adjustments roughing: an easy way to the machine releasing.
  - Tracing: at the end of each model change, a monitoring table will be filled with the time registered. It will allow measuring the project´s performance. (See Table 1).

Table 1. Monitoring Table

N° Máquina	DR-1004	Descripción	Torno DMG L1
Línea	Flechas de Transmisión Daimler	Responsable del seguimiento	Juan Angel Vela

	Cambio		Fecha	Tiempo							
N°	De pieza	A Pieza	(dd/mm/aa)	Turno	Cambio Fisico	Ajuste de R-O Alineación	Ajuste / Inspección	Piezas de Ajuste	Total Minutos	N° Nomina	Observaciones
1	DS G281	LS G281	09/08/2019	1/2	150	40	310	2	500	10251/700352	TERIAL POR FALLA DE CENTRADORA, 30 MIN CAMBIO D
2											
3	DSG211	DSG281	15/8/2019	2	35	15	180	3	230	700300	30MIN COMIDA
4											
5	LSG281	DSG281	21/8/19	2	80	60	145	2	285	10251	OK
6											
7	DS G281	LS G281	8/23/2019	3	60	38	122	2	220	700300	30 MIN COMIDA ,ALARMA DE Z3, PLATICA DE SEGURIDAD
8	LS G281	DS G211	26/8/19	1/2	60	30	455	3	545	718131/700352	INANDO Y AJUSTE EN 1005 LLENADO DE DOCUMENTOS
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4. Results

The results were:

- Saved time: 195 minutes.
- 1,300 new pieces.
- Increased 12% in productivity (See figure 9,10,11,12)

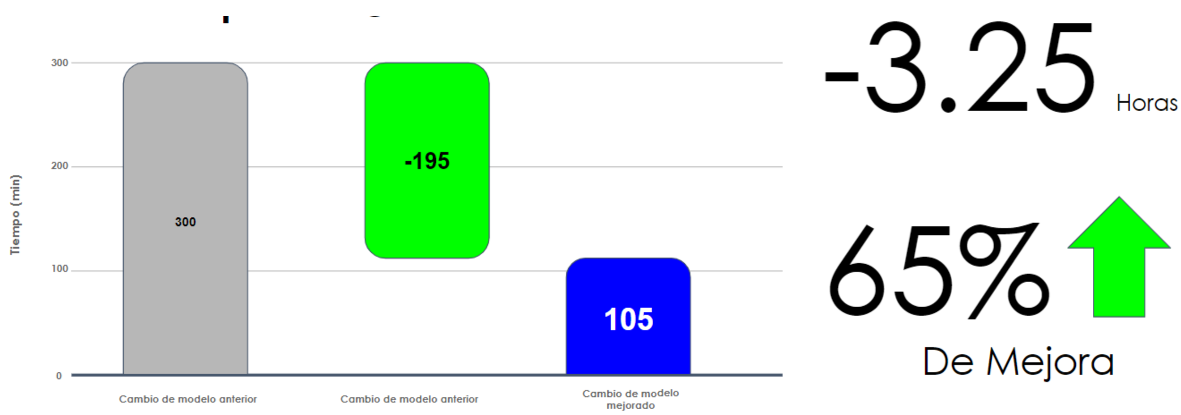

Figure 9. Model change times

PIEZAS ACTUALMENTE MAQUINADAS SEMANALMENTE	2,350 piezas
PIEZAS ACTUALMENTE MAQUINADAS MENSUALMENTE	9,400 piezas
PIEZAS ACTUALMENTE MAQUINADAS ANUALMENTE	112,800 piezas

TIEMPO GANADO POR CAMBIO DE MODELO	195 min
TIEMPO CICLO PROMEDIO	4.8 min
PIEZAS GANADAS POR CAMBIO DE MODELO X MAQUINA	40.62 piezas
PIEZAS GANADAS POR LÍNEA **(2 TORNOS: SMX-1061 / SMX-1062)**	81.25 piezas
CAMBIOS DE MODELO POR SEMANA	4
PIEZAS GANADAS SEMANALMENTE **(81.25 X 4)**	325 piezas
PIEZAS GANADAS MENSUALMENTE **(325 X 4)**	**1,300 piezas**
PIEZAS GANADAS ANUALMENTE **(1300 X 12)**	**15,600 piezas**

Figure 10. Production increase

	2018		2019	
	META	REAL	META	REAL
Enero	15,000	13312	16,500	16210
Febrero	15,000	12498	16,500	14552
Marzo	15,000	15070	16,500	16395
Abril	15,000	14153	16,500	16897
Mayo	15,000	15525	17,000	17271
Junio	15,000	14588	16,500	16301
Julio	16,000	15608	17,500	17630

Figure 11. Increase of pieces produced

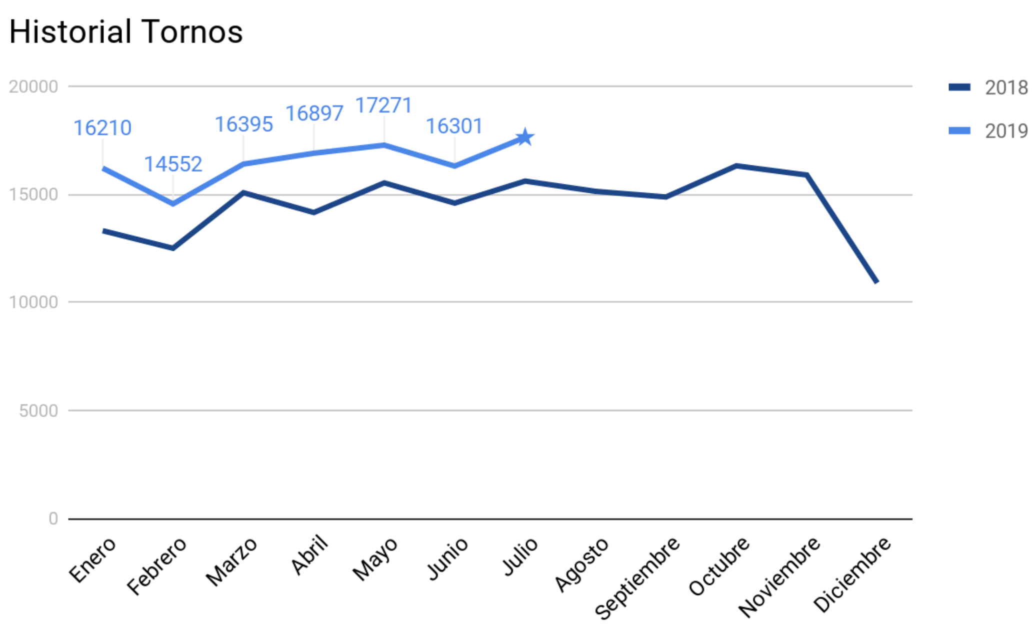

Figure 12. Lathes history

5. Conclusions

Through this project, a new working culture was implemented. It is important to involve workers in projects related to wasted time. This project will be replicated in the operation 160 where actually, it has the worse capacity GAP. The methodology SMED will be applied using the same steps. 50% improvement will be looking for and the elimination of capacity GAP

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