Application of the SMED method to increase the efficiency of the sealing process in a Peruvian company that produces flexible plastic

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Abstract

Currently, in the Peruvian industrial sector, most companies are affected by the low efficiency provided by the staff when carrying out their respective work. This arises because most companies are looking for the cheapest labor they can get and not all these people have the economic capacity to receive a good level of education. In manufacturing companies, it is almost always possible to observe "the law of minimum effort in the operators" which causes operations without added value to arise in the processes, unnecessary delays and all this translates into processes with low efficiency. What we want to demonstrate in the following investigation is how, with adequate training for the personnel, all these mentioned defects can be reduced and with a not very high investment for the company. There are many tools that we can use that the Lean Six Sigma methodology gives us depending on the objective to improve. This article mentions the implementation of the SMED tool in a flexible plastic production company where we were able to achieve an 8% increase in the efficiency of the sealing area with the reduction of product change over time.

Keywords

Flexible plastic, SMED, Set-up, Sealing process, Efficiency.

1. Introduction

In the last 60 years, plastic has been considered one of the best materials to use in different types of packaging. In addition to the properties it offers, the abundance and low price they have in the market are added. On the other hand, the excessive use of this has had a significant impact on environmental pollution. 40% of the plastic produced in the world is destined for packaging and the majority is for the food market (Muncke J. 2021). There are three types of polymers that are used to produce the different types of packaging: Polyethylene, Polypropylene and Pet. These contain different grades, either due to the different densities or their different properties (depending on the type of product to be packaged) (Marieke T., Eggo U., Kim R., Roland K., 2020). With the emergence of Covid-19, many sectors have been significantly affected due to the restrictions that countries decreed, but the plastics sector was one of the few that received a positive impact. The pandemic increased the use of household disposable plastic such as: bags, containers, containers to send food to homes or packaging for online purchases, a report by Ecoembes mentions that since the start of the pandemic the collection of plastic has increased by 15%. plastic material and this due to the greater use of it (Ethel E. 2020).

In the plastics industry, being a sector that produces on a large scale, the optimal use of resources is essential. The problem to be analyzed is directly related to this, specifically with the time resource, since a small change can make a big difference. There are cases, where the SMED methodology was implemented, which confirm the important changes in production times. One of them was a cutting production line in Greece, which managed to reduce the total time of the activities in the process by 15%, reducing from 194 to 120 minutes (A. Silva, JCSá, G. Santos, FJG Silva, LP Ferreira, MT Pereira, 2021). Another case was the implementation of SMED in a bottling company located in Peru, where they managed to reduce the downtime of the sanitation process by 10.29%, which represented $671,580 per year (B. Rivera, G. Ricaldi, 2019). Finally, a deodorant packaging company also located in Peru also implemented the methodology and managed to reduce the format change time from 20.77 to 9.12 minutes per batch, representing a saving of 41.09 hours per year (V. Huerta, S. Derek, 2017). On the other hand, the average utilization capacity in Peru is 71.45%, but in medium and small companies this indicator does not exceed 50% (Arroyo Huayta, 2020). Time in the industry is an extremely important factor, since the price difference with competitors is minimal and the added value is seen in timely deliveries to customers, because in many cases these are not met. In other words, a longer manufacturing time than the competition can reduce the number of customers. (Katarzyna Antosz, Andrzej Pacana, 2018).

The objective of the research is to implement the SMED methodology to improve the current service level of the company under study by reducing the set-up times in the plastic sealing process. During the investigation, it was possible to identify some main causes that generated delays in production and one of them alerted us to excessively high downtime. We were able to perform a time measurement, in the sealing area, before making the improvement and what was mentioned above was really observed. Finally, new times were taken with some of the established improvements and a decrease of almost 50 minutes per product was obtained, translated into production, generating 8% more production per shift. Other similar success stories confirm that the use of this methodology can generate very significant positive changes.

For purposes of presenting the case, this academic article is displayed as follows: State of the art, in which the theoretical framework of the problem to be treated is reviewed through previous cases reviewed by different authors. Contribution, showing the analysis of the model and its description accompanied by the corresponding indicators. Validation, in which the results of the executed tests, the implementation and simulations are shown. Discussion, in this part the conclusions and recommendations that are generated are a result of the model shown.

2. Literature Review

2.1 SMED

The SMED method had its beginnings in the Japanese industry and then it was expanding to the different countries of the world from the famous case of Toyota. This methodology is not only considered as a group of techniques, but also as a new ideology of production (Shingo S, 2000). The Single Minute Exchange of Die (SMED) aims to reduce the set-up time for product changes on a given production line to less than 10 minutes. The idea of the SMED methodology is to transform the largest number of internal activities into external ones to achieve the greatest efficiency of the machine. A successful case with the use of the aforementioned methodology was in a Peruvian carbonated beverage packaging company (Barrientos Rivera, Gamboa Ricaldi, 2019) where they managed to reduce the sanitation time by 10.29% (28 minutes and 7 seconds), which represented $671,580 a year. Another case that had good results was that of a company in the plastics sector in Indonesia. They had a very high set-up time in the injection machine (99.93 minutes) and after implementing the SMED method they managed to reduce it by 38% (38 minutes) and increase productivity by 3.17% (Uly Amrina, 2018). In India, a manufacturing company identified that, in the cutting area, where they used band saws, there was a great loss of time. The objective of this company was to reduce this time by 50% and with the help of the SMED it was possible to reduce the set-up time from 40 to 10 minutes. (Shashikant Mendhe, 2017)

2.2 TPM (Total Productive maintenance)

Total productive maintenance is a Lean Manufacturing tool, its objective is to increase the effectiveness and efficiency of the machines in an industrial plant using an indicator called OEE. The OEE measurement is categorized into three indicators: A) Availability, B) Performance, quality. (Zenithia Martomo, Pringgo Laksono, 2018) With these mentioned it is possible to carry out a good analysis of what happens in the machines and to be able to make decisions that increase their performance. There are many success stories for the implementation of the tool mentioned above. In Peru, a squid hydrobiological resource processing company (Gallesi-Torres, A., Velarde-Cabrera, A., León-Chavarri, C., Raymundo-Ibañez, C., & Dominguez, F, 2020), who implemented several methodologies in addition to the TPM. In this case, a 39% reduction in downtime was obtained, which increased production by 748 tons per year. Machine availability increased by 14% and mean time between failures improved by 40%. Another success story is that of a footwear manufacturing company located in Ecuador. With the analysis they carried out, it was observed that there were very high production times and low efficiency in the machines. They focused on the sewing process and decided to implement TPM. They managed to achieve a 5% increase in production, going from producing 410 pairs per shift to 429 pairs per shift (Jhon Reyes, Kevin Alvarez, Amanda Martinez, Juan Guaman, 2018). Finally, a case study in Romania of a company that used CNC machines confirms that the use of TPM is very feasible. The measurement of the OEE before the improvement resulted in 46.5% and after the implementation of the indicator it resulted in 55.9% (I C Gherghea, 2021)

2.3 Recruitment Policies

The personnel recruitment policies contemplate the strategies stipulated by the organization to hire the most qualified personnel and optimal performance. In the production divisions, the ability to handle the tools and machinery corresponding to the position is essential, (Kelly Meneses, 2019) therefore, these consist of doing a series of tests to confirm that the operator is in optimal conditions for be able to carry out their tasks and provide the training required by the position (Jose Flores, 2016). Research has shown that using the method properly reduces staff turnover and thus avoids training operators who will leave the organization in the short term. Regarding the optimization and reduction of downtime in production, selecting and training the right personnel is essential, since it will mainly depend on them that the processes are executed correctly. In addition, with adequate selection methods, absenteeism and frequent turnover are reduced. (Andrés Salas Vallina, Rafael Fernández Guerrero, Manuela Pozo Hidalgo, 2018) (Consuelo Zavala Villalon, 2015)

2.4 Work Standardization

The standardization of work is one of the principles of Six Sigma, as it aims to make processes as uniform as possible. It can be done in different ways, but it is based on the procedures being executed with a series of parameters to optimize them (Martín Calderón, Elsy Veronica, Cetina Lopez, Wendy Argentina, Erika del Carmen, 2019). For this, indicators must be used to calculate the efficiency of the process to be standardized and in this way be able to analyze whether the selected parameters are adequate. (Edward Randell, Garry Short, Natasha Lee, Allison Beresford, Margaret Spencer, Marina Kenell, Zoe Moores, David Parry, 2018). More than 60% of the operators agree that standardization determines an improvement in procedures. This tool generates speed in the processes, since once properly implemented there will be fewer unknowns or doubts for the operator when executing the corresponding tasks. (Alfredo Silva, Rosa Salas, 2017) (Carlos Arroyo, 2020)

2.5 Parameter control

In terms of production, a variety of controls are done through the evaluation of an operator. For this reason, it is of utmost importance that the worker in charge has full knowledge of the parameters that he is evaluating, since the quality of the products and the speed of the production line depend on this (Saul Cabezón Gutiérrez, 2014) (Maria Perez Gao Montoy, 2017). The time observation sheet is a tool that facilitates the control of parameters in the industry. It is necessary to choose a group of people who collect the times and characteristics necessary to know if the process is going correctly. On the other hand, documented standardized work is another tool that facilitates control since it allows operators to have a minimum margin of error in the process (Elaine J. Labach, Ph.D, 2010). Finally, a case study carried out in Indonesia on the improvement of the soymilk production process mentions that the standardization of parameters can greatly affect the quality of a product. In this case, poor temperature control during the milk heating process causes the protein, fat and Ph levels to be affected and as a consequence the product does not pass the standards implemented by the regulatory institution. They managed to adjust the parameters and standardize them so that the product can come out with the appropriate characteristics (E. Kristiningrum, 2021)

3. Methods

Our proposed model is based on a case study applied in a plastic injection company where they implemented the SMED methodology for mold changes (M. Kemal, L. Salum, 2017). In this, they were able to determine the internal and external activities that existed during the process, once determined they were separated and analyzed which internal activities could become external. Finally, they proposed some improvements to streamline these activities (internal and external) as much as possible. Unlike the case mentioned above and other cases where this methodology was implemented, the model proposed by us monetarily supports the benefit that this tool could generate if it is implemented correctly and the costs that could arise for said implementation.

The present investigation, together with the compilation of support in scientific articles, proposes an optimized model of time management in a plastic production plant through the SMED methodology as part of Six Sigma. This scenario is composed of the following 3 components. Collection of information, evaluation of scenarios, and implementation of improvements.

These components seek to reduce downtime in plastic manufacturing processes since compliance with batch delivery on time in the plastic production sector is essential to retain and win new customers. Figure 1 below shows all the details of the 3 components mentioned previously.

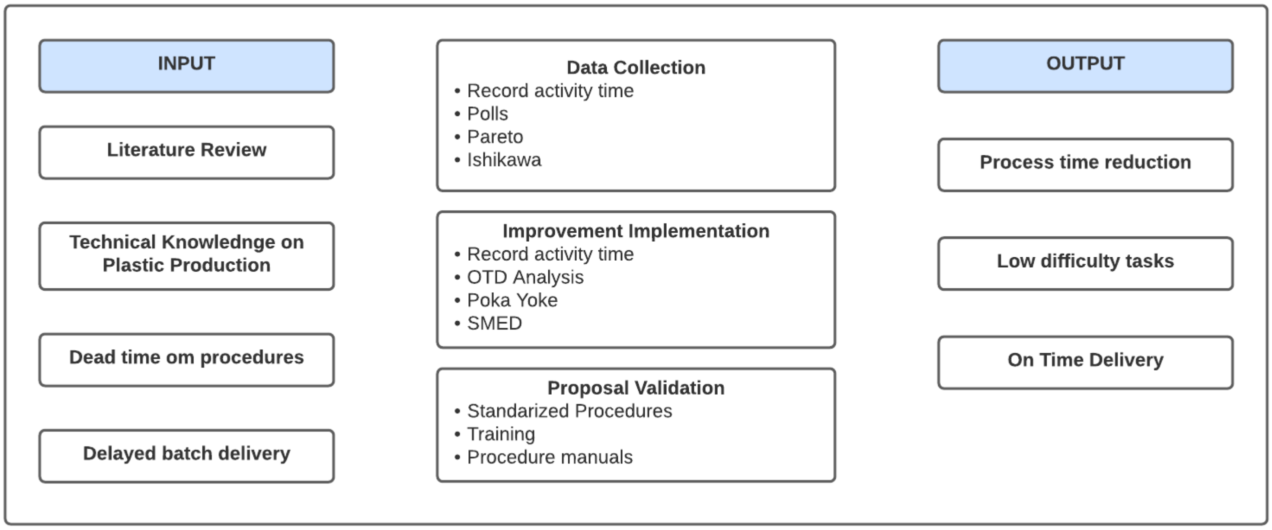

Figure 1: *Proposed model*

4. Data Collection

Data collection consists of obtaining the information that will allow the evaluation of the scenarios. For this, a series of tools were used. Surveys to receive first-hand information on whether downtimes have a substantial effect, time taking to confirm the above, Pareto to see the most important causes of delays and root cause diagrams to see exactly what the sequential effects of the delays are and other causes. Once all the information has been collected and it has been possible to determine if the use of SMED is feasible, the steps suggested by this tool will be followed until the results are obtained. Figure 2 shows all the steps we follow to obtain results.

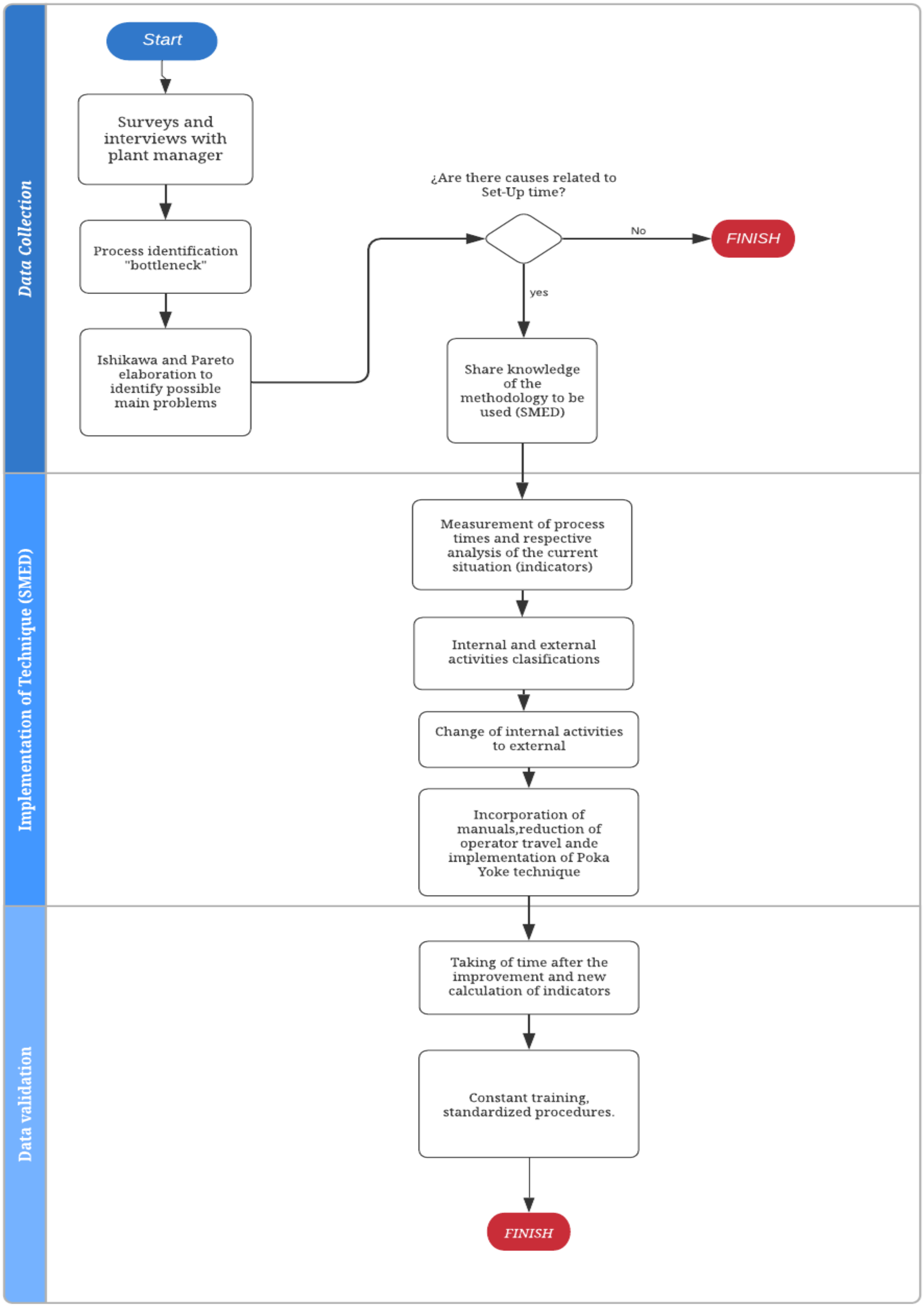

Figure 2: *Investigation process*

5. Company information

The pilot test was carried out in a company that produces flexible plastic bags located in the city of Lima (Peru). This company's main clients are textile and food companies. Most of the products sold are plastic bags, which are used to transport or protect food. On the other hand, in the textile sector, these bags have the objective of covering the fabrics to avoid their deterioration.

The sealing process is the last process. Hece (Brazilian) brand sealing machines are used, which with the help of rollers pull the coil and move it to the blade, which is responsible for cutting and sealing the bag according to the customer's specifications. This entire process is computerized and is carried out by a single operator. Figure 3 shows the plastic bags machine.

Figure 3: *Hece-700*

5.1 Implementation of SMED

a) Analysis of the current situation

In the first stage of the methodology, all the activities carried out by the operator when sealing a product were observed. Once this was done, 16-time samples were taken that allowed us to know the current time of the process. Next, the table with the times obtained and the respective indicators will be shown. The following table 1 shows the time for each activity before SMED implementation.

Table 1. *Times taken by a manager before SMED*

Locate production order	Search for coil	Transport coils	Place coil on machine	Arrange Coils	Place the coil sleeve on the machine until it meets the knife	Assemble dies	Glue bag bands	CLP coding	Size and appearance quality check on moving bags
Activity 1	**Activity 2**	**Activity 3**	**Activity 4**	**Activity 5**	**Activity 6**	**Activity 7**	**Activity 8**	**Activity 9**	**Activity 10**
1.4	8.18	3.15	8.11	0.5	1.4	21	1.7	10	1.5
0.6	9.21	4	9.3	0.3	0.9	16	1.9	9.37	1.3
0.8	14.13	2	9.57	0.5	0.8	4.4	2.5	15	1.5
0.5	12.23	4.56	7.1	0.4	1.7	73	1.3	14.1	1.8
0.4	5.38	1.42	8.3	0.4	1.5	10	2.1	8.5	1.5
0.7	15.15	5.2	9.05	0.6	1	18.08	1.5	19.6	1.5
0.9	8	2.1	9.45	0.8	1	17.21	2.3	18	1.7
0.4	10.17	1.45	9.5	0.9	0.8	34	1.5	16.42	1.5
0.3	11.4	8	8.2	0.4	0.5	18.08	1.7	20.54	1.2
0.8	17.1	1.3	7	0.6	0.9	34	1.9	6.08	1.5
0.7	8.4	2	7	0.4	0.9	5.13	1.5	11.3	1.5
1	7.07	4.08	8.27	0.8	1	15.23	2.1	9.27	1.3
0.2	15.15	4.46	4.4	0.7	0.7	3.45	2.3	13.35	2
0.7	7.5	2	4.28	0.5	0.9	8	1.5	17.1	1.9
0.2	11.3	3.42	2.23	0.4	1.8	7.3	1.8	25.3	1.1
0.3	6.6	4.56	6.13	0.4	1	22.41	2	12.9	1
AVERAGE									
0.62	10.44	3.36	7.37	0.54	1.05	19.21	1.85	14.18	1.49

To specifically observe how the improvement influences the process, two indicators will be considered. The improvement of these will have a significant impact on the main objective set. The indicators were measured before and after the implementation to compare the results and analyze the respective improvements. Table 2 shows the first indicator taken for the study and Table 3 shows the second indicator.

Table 2. *Efficiency in the sealing area*

$KPI = \frac{Thousands\ of\ units\ produced}{Thousands\ of\ units\ forecasted}\ x\ 100$	**Objective Before Improvements**	**Objective after improvement**
	75.3%	80%

- Objective: Achieve an increase in sealing efficiency of at least 80%.
- Interpretation: Measures the efficiency of the sealants with respect to the scheduled amounts studied by the engineers.

Table 3. *Set-up times*

$KPI = \frac{(Tsup1 - Tsup2)}{Tsup1}\ x\ 100$	**Objective Before Improvements**	**Objective after improvement**
	60.1 min	< 10 min

- Objective: To reduce downtime and set-up times to just one figure for each type of product.
- Interpretation: Measures the reduction or increase of time in the machine configuration.

b) <u>Classification and conversion of internal and external activities</u>

Once the times for each activity were calculated, the classification and conversion of internal activities into external ones was carried out. As can be seen in the matrix, the activities were listed, classified according to the type of work and according to its type (external or internal). Once this was done, the ECAS analysis was carried out to eliminate, combine, fi simplify each one of them and thus achieve the objective. Figure 4 shows the SMED matrix.

SMED MATRIX

Machine: Hece 700
Process: Seal
Operator: Miguel Papa

No.	Activity	Duration before changes [min]	Type: Tool change	Type: Transport	Type: Waiting time	Type: Setting	Type: Others	Analysis: Eliminate	Analysis: Combine	Analysis: Arrange	Analysis: Simplify	Improvement	Duration after changes [min]
1	Check production order	0.62					x					-	0.62
2	Serch and Select coil	10.44			x			x				Operator locates coils before finishing a batch	0.00
3	Transport coil from warehouse to machine	3.36		x				x				Operator puts coil to the side of the machine	0.00
4	Insert coil on machine	7.37					x				x	Implement Tool Panel	1.50
5	Combine new coil with the remains of the previous one	0.54					x					-	0.54
6	Place the coil sleeve on the machine until it meets the knife	1.05					x					-	1.05
7	Asseble dies and accessories	19.21	x							x	x	Include a shelf for dies and knifes	2.00
8	Glue bag bands	1.85					x				x	Operator leaves bands ready for the next batch	0.50
9	CLP coding	14.18				x					x	Standarize procedures	3.00
10	Size and appearance quality check on moving bags	1.49				x						-	1.49

Figure 4: *SMED matrix*

c) Reduce activity times

As previously mentioned, it was possible to eliminate and reduce the time of many activities, resulting in a reduction of almost 50 minutes for each product change. Table 3 shows the result after SMED

Table 3. *Timing Results*

	Before Implementation	After Implementation
Total Time (Minutes)	60.1	10.7
Total Time (Hours)	1.00	0.18

5.2 Results

With the previously shown data we can observe the improvement in the set-up times in the sealing area. Before the upgrade, 47,993 bags could be produced in one shift with set-up times of 1 hour. Now after the improvement, 51,945 bags were produced with the same parameters and characteristics but with a set-up time of 0.18 hours. Production increased by 8% after implementation. Figure 5 represents the numbers of bags produced before and after the implementation.

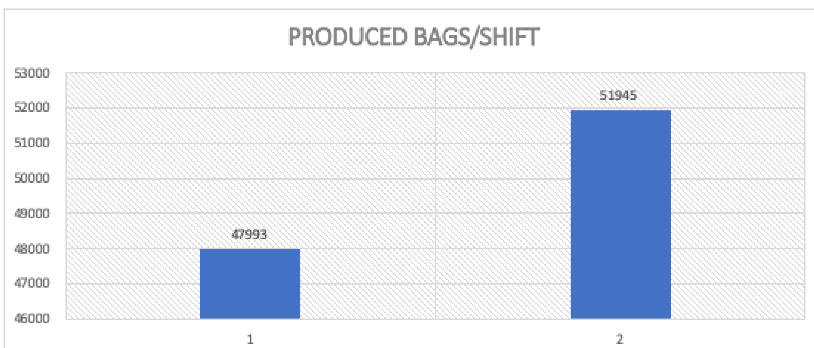

Figure 5: *Numbers of bags before vs after*

In addition, the indicators that had been previously proposed were recalculated to corroborate the impact of the time reduction and the possible increase in the efficiency of the area. From the month of June to December 2020, it was estimated that 16,229 thousand bags were sealed, of which 12,220 thousand were sealed, but with the proposed improvement they would become 13,198 thousand bags in the same period.

5.3 Cost analysis

With the analysis of the data obtained, the cost benefit is $146. This result is high, since the investment proposed for the necessary changes in the process is low compared to the profits that the organization would have annually. The investment is $10,812, this amount refers to the purchase of tools and personnel that will facilitate our work at each stage of the SMED implementation. These tools are: Chronometer, tapes, video camera, Set-up conversion matrix checkbook, pencils, steel shelf to organize the machine accessories, symbolized tool panel, highlighting labels, files and filing cabinets and finally the hiring of 2 people in charge of supervision (1 for each shift).

5.4 Validation

With the new data obtained after the implementation, the proposed indicators were calculated (in the analysis stage), giving us the following percentages as a result:

Efficiency: Efficiency went from 75.3% to 81.3% due to the increase in sealed bags over sealed bags estimated for the same period (12,220 vs 13,198). The proposed objective was achieved and there is the possibility of improving it even more with the help of different engineering tools.

Set-up time: On the other hand, the set-up time decreased by 82%, going from 60 minutes to 10.7 minutes for each product change. With this indicator we came very close to the stated objective and a significant amount of downtime was transformed into production time.

6. Conclusion

The analysis carried out on a Peruvian company that produces flexible plastic fulfilled the general objective that we had set at the beginning of this study, which had as its main task to reduce the unproductive times that were generated during the sealing process. This could be achieved thanks to the SMED methodology, which helped us to identify and classify the different types of activities and consequently to be able to reduce the time they took to carry out. To carry out the above, the list of actions to be taken must be detailed to be able to follow up on them and modify the new scenario if necessary, so that the optimization is adequate. In addition, it is important to assess the magnitude of the improvement to know if it is appropriate to apply the improvement.

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Biography

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