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Case Study

Using the Single Minute Exchange of Die (SMED) Method to Minimize Machine Setup Time: A Case Study

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ABSTRACT

PT. GTC is a company that produces automobile tubes facing problems with an increase in demand of up to 20% from the previous year. From 4 existing divisions named mixing, extruding, splicing, and curing, it was found that the extruding division was unable to meet the production targets set by the company. There are several causes, including high setup time. This research aims to reduce setup time by applying the Single Minute Exchange of Die (SMED) method to the production process in the extruding machine-1 that produces automobile tube sizes 5.50-13 and 7.00-14. Converting activities no. 2, 3, and 14 from internal activities to external activities, changing the layout of the die, core, and adjuster key storage table, dies unification, and installing a Temperature Control Unit to control steam to the extruder head can reduce setup time from 45 minutes to 22 minutes or 51% from the initial setup time. These improvements succeeded in increasing the productivity of the extruding division up to 93.9% in January 2023.

Keywords: *single-minute exchange of die, SMED, setup time, production achievement, unification*

INTRODUCTION

Tight competition in this era of globalization, forces manufacturing companies to continuously improve efficiency and effectiveness to reduce production costs and maintain product quality for the company's sustainability). Manufacturers must find new and innovative ways to increase efficiency and reduce waste **(1-3)**.

PT GTC is a manufacturing industry that produces four-wheeled vehicle tires known as automobile tubes with an average demand of 305,000 units/month in 2021. However, from January to November 2022, demand increased by up to 20% or 365,000 units/month. This extraordinary growth has not been able to be followed by the production capacity of each division, which consists of mixing, extruding, splicing, and curing. The extruding division was unable to achieve the production target of 90% while other divisions were able to achieve more than 90%. The extruding division carries out the process of forming compound sheets which produce green stick tubes for Light Truck (LT) and Truck bus (TB) products which have various types sizes and specifications so it requires more setup time to adjust the tools and dies that cause unavoidable delays. Process delays in the extruding division raise bottlenecks due to the inability to keep up with the work speed of the mixing division and subsequently affect the achievement of overall production targets.

This research aims to find a solution to reduce setup time on extruding division to prevent bottlenecks while increasing the effectiveness of the extruding division using the Single Minute Exchanges of Dies (SMED) method.

LITERATURE REVIEW

To maintain the high demand for smaller lot sizes and satisfy consumers' expectations Shingo Shigeo proposed the SMED (Single Minute Exchanges of Dies) method that requires reducing setup time to single-digit minutes or less than ten minutes **(4-5).** The primary objective of SMED is to convert the internal operations of the setup process, which are typically performed when the machine is stopped, into external operations that can be carried out while the machine is running **(6)**. This method has been used in previous research and has proven capable of reducing the setup time **(7-8)**. SMED method is used as a tool to reduce setup time to improve productivity in many competitive companies **(9-10)**.

MATERIALS & METHODS

The percentage of achieving production targets in the mixing, extruding, splicing, and curing division at PT GTC in 2022 is presented in Table 1, where it can be seen that the lowest achievement was in the extruding division, below the average determined by the company of 90%. Therefore, this research will focus on the extruding division.

Table 1. The Percentage of Production Achievements for January – October 2022

No	Month	Mixing	Extruding	Splicing	Curing
1	January	93.1%	90.2%	90.5%	91.4%
2	February	93.5%	90.2%	90.8%	91.6%
3	March	92.4%	88.9%	89.7%	90.6%
4	April	93.0%	88.4%	89.1%	89.9%
5	May	90.9%	88.7%	89.4%	90.2%
6	June	92.4%	90.1%	90.8%	91.6%
7	July	90.6%	88.6%	89.3%	90.1%
8	August	91.7%	88.6%	89.4%	90.1%
9	September	90.8%	89.9%	90.7%	91.6%
10	October	91.1%	90.0%	90.8%	91.6%
	Average	**92.0%**	**89.3%**	**90.1%**	**90.9%**

The production process at PT. GTC is divided into 3 shifts and the extruding division has 2 machines. The average setup frequency occurred the most on extruding machine-1 (11 times) compared to extruding machine-2 (8 times). Data on die usage on both machines shows that the most produced product sizes are type 5.50-13 (56,500 pcs or 16%) and type 7.00-14 (49,400 pcs or 14%) on extruding machine-1. The high demand for these two types requires production to be carried out daily with a fairly high intensity of die changes. This is the reason why this research focused on the extruding machine-1.

Data Analysis

Detailed observation of activities to separate internal and external activities is the initial stage of implementing the SMED method. 14 internal activities were analyzed to separate them into external activities. The results are shown in Table 2.

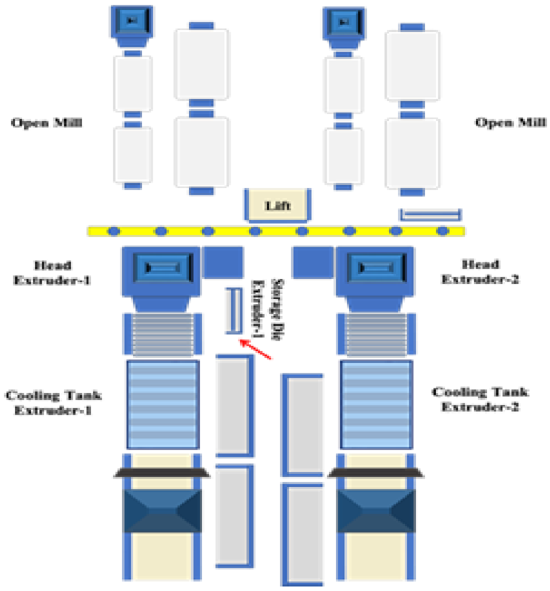
Table 2. List of Setup Activities on the Extruding Machine-1

No	Activities	Time (minutes)	Category
2	Wire cutting with sizes 40 and 10 mesh	2	External
3	Setting wire sizes 40 and 10 to the strainer	5	External
14	Installation of letter marking (branding)	2	External
1	Moving the compound sheet pallet to the front of the open mill 1	2	Internal
4	Picking the die, core, and adjuster key	3	Internal
5	Installing the die and core on the extruding machine head	7	Internal
6	Turning on the machine and setting process parameters	2	Internal
7	Grinding compound in open mill 1	6	Internal
8	Grinding compound in open mill 2	4	Internal

9	Grinding compound in open mill 3	2	Internal
10	Grinding compound in open mill 4	2	Internal
11	Waiting for the temperature stabilized of the product output	5	Internal
12	Taking samples of the product	1	Internal
13	Measuring the dimensions of the product	2	Internal
	Total	**45**	

The second step is to analyze the layout. Conversion of internal activities into external activities can be carried out in activity number 4 (picking up dies, cores, and adjuster keys) by changing the layout of the storage table to make it closer to the position of the Extruding machine head -1. Therefore the picking process can be carried out simultaneously during the die installation process as shown in figure 1.

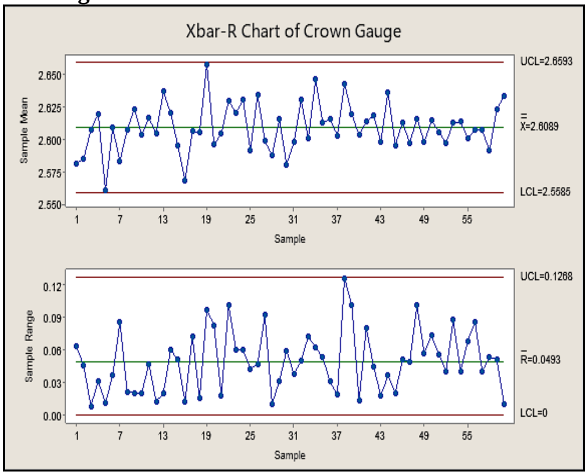
Figure 1. Layout Changing of Dies, Cores, and Adjuster Keys Storage Table



The next step is to analyze the possibility of unification of the dies or tools. There are two automobile tube sizes with high demand which are sizes 5.50-13 (56,500 pcs) and 7.00-14 (49.400 pcs) so they must be produced every shift every day. Of 14 types of products produced in extruding machine-1, there are 3 products used die no 100 (included product size 5.50-13) and others 4 products used die no 110 (included product size 7.00-14). For this reason, a unification process was carried out by testing the use of die number 110 to produce an automobile tube of size 5.50-13. Tests were carried out on several product dimension items to ensure that the quality of the product remains within the control chart. The result of the crown thickness dimension and process capability of the product testing is shown in Fig. 2 and Fig. 3.

The results of the crown thickness dimension are within control limits, none of the dimensions are out of the upper or lower control limits as seen in Fig. 2. Process capability or the ability of the Extruding machine-1 to produce crown green stick size 5.50-13 by using the die number 110 showed values of Cp = 1.81 and Cpk = 1.65 as shown on Fig.3. Using the same process, tests were carried out for the dimensions of base thickness, side thickness, and width, where all tests showed satisfactory results, all dimensions were within control limits, so that the unification process was acceptable.

Fig. 2. Control Chart of the Crown Thickness



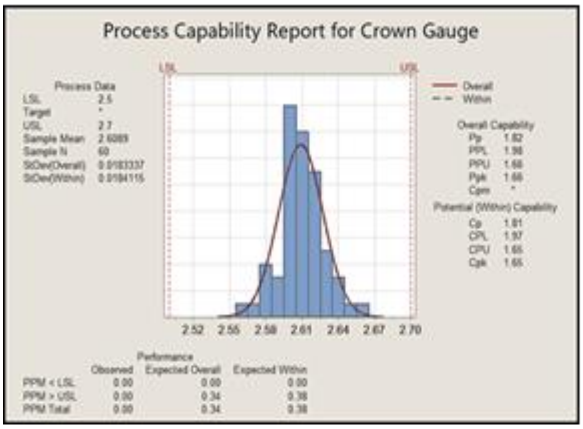


Fig. 3. Process Capability for Crown Gauge Dimension

Streamlining activities during setup, to make sure the product output temperature was stable by installing a Temperature Control Unit (TCU), to reduce the time consumed

Fig. 4. Installing Temperature Control Unit (TCU)

Another possibility to reduce setup time is adding tools to speed up the cooling process. The minimum standard product output temperature is 100^0C. Before installing TCU (see Fig.4), the waiting time to reach stable temperature was 5 minutes and after installing TCU, the waiting time was reduced to 59.97 seconds ≈ 1 minute, with an average product output temperature of 102.4^0C. This result shows that installing a Temperature Control Unit (TCU) can help to reduce the time for set-up activities in terms of waiting to achieve a stable temperature for the product.

RESULT

The application of the SMED method to the setup process on the Extruding machine-1 succeeded in making several improvements, as follows:

1. Conversion of activities no. 2, 3, and 14 from internal activities to external activities (carried out when the machine starts operating) with a clear task for the leader, operator 1, and operator 2 can reduce setup time up to 9 minutes. These results are in line with the results of research conducted by Sousa succeeded in reducing average changeover time by up to 43% from existing by implementing the SMED method **(11)**. Classifying activities into individual activities can help standardize the average time an operator requires to complete his work. In addition, the application of motion time study can help identify and reduce waste and non-value-added tasks **(6)**. A comparison between the setup activities of the extruding ma-chine-1 before and after improvements using the SMED method is shown in Table 3.
2. The layout changing of the die, core, and adjuster key storage table can

eliminate the activity of picking up dies, cores, and adjuster keys. This change can reduce setup time by up to 3 minutes. This result supports the research conducted by Martins by inducing layout changes production sequences can reduce setup time by up to 50% from existing **(12)**. A thorough observation of the layout and production flow will help to find waste and solutions to solve it.

3. The application concept of unification of dies could be an alternative to reduce setup time. Using the same die (die no. 110) for 2 different products (automobile tube sizes 5.50-13 and size 7.00-14) can save up to 7 minutes of setup time. Recognizing the characteristics of each product will help to identify the possibility of implementing the unification concept without changing the quality of each product. In cases where design changes are a viable option, the SMED model can provide an optimized list of workforce activities **(1)**. On the other hand, increasing productivity does not mean buying new machines which requires large investments.
4. Installation of a Temperature Control Unit to control steam to the extruder head and to make sure the temperature of the product output (green stick) is stable can reduce setup time by up to 4 minutes.

Table 3. The Comparison of Setup Time Activities Before and After Improvements

No.	Activities	Time (minutes)	
		Before Improvement	**After Improvement**
1	Moving the compound sheet pallet to the front of the open mill 1	2	2
2	Wire cutting with sizes 40 and 10 mesh	2	0
3	Setting wire sizes 40 and 10 to the strainer	5	0
4	Picking the die, core, and adjuster key	3	0
5	Installing the die and core on the extruding machine head	7	0
6	Turning on the machine and setting process parameters	2	2
7	Grinding compound in open mill 1	6	6
8	Grinding compound in open mill 2	4	4
9	Grinding compound in open mill 3	2	2
10	Grinding compound in open mill 4	2	2
11	Waiting for the temperature stabilized of the product output	5	1
12	Taking samples of the product	1	1
13	Measuring the dimensions of the product	2	2
14	Installation of letter marking (branding)	2	0
TOTAL		**45**	**22**
% Time Reducing			**51%**

The implementation of the four improvements mentioned above was tested in January 2023 and the results are shown in Table 4.

Table 4. Production Achievement on January 2023 after Improvements

Production Target (units)	Production Actual (units)	Achievement (%)
398.950	374.450	93,9

CONCLUSION

Application of the SMED method in the extruding division of PT. GTC was able to reduce setup time from 45 minutes to 22 minutes (51%) and at the same time increase productivity, from the previous average of 89.3% to 93.9% based on the results of the trial implementation of the proposed improvements in January 2023 (see Table 4). These results prove that the application of SMED can reduce setup time by up to 30% or even more **(11)** and is successfully applied in various industries including manufacturing **(13)**.

Proper analysis and application of the SMED method can give a solution to increasing production line productivity. As the product lifecycle of the products decreases, companies often use a single machine to produce different parts/products to increase flexibility and maintain high-volume production to reduce production costs **(1)**, making SMED imperative in any organization **(14)**.

Further research can be carried out on the production of automobile tubes in other sizes and can be applied to other divisions. The combination SMED method with other methods such as Lean Manufacturing, 5S, etc. may provide more comprehensive results. Considering the financial aspects will indicate the savings gained by reducing setup time.

Declaration by Authors

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