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REDUCING THE PRODUCT CHANGEOVER TIME USING SMED & 5S METHODS IN THE INJECTION MOLDING INDUSTRY

Daniel Agung[1], Hasbullah Hasbullah[2]
[1]Manufacturing Department, P.T. Bumimulia Indah Lestari
Jl. Jababeka, Bekasi, Jawa Barat 17550, Indonesia
[2]Department of Industrial Engineering, Universitas Mercu Buana
Jl. Raya Meruya Selatan, Kembangan, Jakarta 11650, Indonesia
Email: danielagung0508@gmail.com hasbullah@mercubuana.ac.id

Abstract -- *Along with the increasing market of plastic packaging products resulting from the injection process and the rapid development of existing technology, we need a strategy to be able to continue to meet the customer's needs and to be able to compete in the industry. One of the strategies that may be employed is Lean. Lean is a concept aimed at eliminating existing waste. One of the implementations of Lean's concept is the SMED (Single Minute Exchange of Dies) concept. SMED is a concept aimed at reducing the changeover time, so the eliminated time can be used in the production process. P.T. BIL is one of the companies engaged in the production of plastic packaging with an injection process. Problems occurring at P.T. BIL was the absence of a measurement process for changeover time. The Operation Analysis Chart concept was used to analyze the carried-out activities. To optimize activities employing the SMED concept, Analytical Cards were used so that the change over time can be reduced. The 5S concept was applied to support the SMED concept, so the waste in the work area could be eliminated. By implementing the SMED concept, we reduced 18% of the change over time.*

Keywords: *SMED; Injection molding; Changeover; 5S; Lean*

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INTRODUCTION

In 2019, the market for plastic injection products amounted to US$ 8940 million, and It was predicted to continue to increase due to its technological advancement. The market for plastic injection products is expected to grow at roughly 2.1% for the next five years, and it is predicted to have reached US$10100 million by 2024. This increasing opportunity of the plastic industry makes the injection molding industry a promising sector. To be able to keep up with the global competition, we need competitiveness strategies, one of which commonly used is Lean's concept.

Lean is a strategy used to make the manufacturer able to stay competitive. Moreover, its principle is to increase productivity by reducing waste. Wahab et al. (2013) explained that the lean concept used everything with fewer resources in the mass production manufacture. Besides, fewer labors in the production line, less space needed for the manufacturing processes, less investment in equipment, fewer hours used in the development. Moreover, it may also produce much more inventory capacity by providing fewer defects. Lean is not limited to the production process; in fact, it deals with all activities starting from product development, purchasing tools, manufacturing processes, and distribution processes. Lean is aimed at increasing productivity, improving quality, reducing waiting time, and reducing costs. Activities in Lean are classified as activities that provide added values and activities that do not offer added values. Regarding Lean's principles, waste is defined as a source of 8 activities that do not offer added values such as Defect, Overproduction, Waiting, Non-Utilized Talent, Transportation, Inventory, Motion, and Extra Processing.

Sundar et al. (2014) explained that one pillar in Lean's concepts was the Just-in-Time (JIT) concept. The Just-in-Time concept was a concept aimed at producing and delivering the right product, in the right amount, at the right time using the minimum resources. The JIT concept quickly identified any problems due to its reduction in inventory in the production system. Inventory reduction will bring up any issues that are produced quickly, so immediate improvements could be made to overcome these problems.

The SMED concept is one of Lean's concepts supporting the Just-in-Time principle. Gaikwad et al. (2015) explained that SMED focused on reducing unproductive time by increasing and standardizing the operating process to replace equipment using simple and easy application techniques. Companies were required to produce products with small quantities but with a large variety by the JIT concept. Based on these needs, the time of product change settings became a significant effect.

When the product change setting was the measured time interval of the last product of the previous type with good quality, the first product of the next type was produced with good quality. Shingo (1985) classified of changing the product settings activities into two types, namely internal activities, and external activities. Internal activities were activities that could only be done when the engine was not operating, while external activities were activities that can be done out even though the engine was operating. The basic idea of the SMED concept was to do as many activities as possible from the internal activities to external activities.

Ferradas & Salonitis (2013) suggested that there were five steps in the implementation of SMED, as shown in Fig. 1, namely:

1. Identifying internal activities and external activities
2. Separating internal activities from external activities and eliminating unnecessary activities
3. Changing internal activities into external activities
4. Focusing on reducing internal activities
5. Focusing on reducing external time

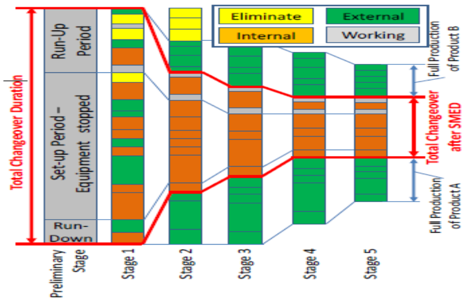

Figure 1. Stages in the implementation of SMED (Ferradas & Salonitis, 2013)

SMED concepts positively impact on the industry. Moreover, by applying SMED, we can reduce changeover time, so we will make the industry better respond to the customer's demand. Heriansyah & Ikatrinasari (2017) conducted a study on SMED, where changes in internal activities to external needed to be supported by the system improvements and work methods. With these changes, they expected that some internal activities could be done when the production machine was still operating or turning into an external activity. After SMED was implemented, the changeover time could be reduced by 52%. Arief (2015) implemented a SMED concept in a pharmaceutical company that could optimize the changeover by reducing 26% of the total changeover time. Mulyana & Hasibuan (2017) argued that one of the causes of the length of changeover time was many internal processes carried out when the engine was off and that there was no division of labors among the operators. A study conducted by Mulyana & Hasibuan (2017) showed that it was able to reduce the changeover time by 75.59%. Hendri (2015) also conducted a study on SMED. He found out that if SMED was implemented, it could reduce the changeover time by 21.29%, where the reduction was made possible by optimizing the external time and reducing the internal activities.

SMED now becomes more and more needed due to the increasing variability of the products, the reduced product life cycles, and the increased market requirements. SMED increases the flexibility of the existing process, where the product change setting process can be done more quickly so that the product can be made in the right amount and on time by the customer's demand. To ensure that SMED will be well implemented, we can also apply the 5S concept to regulate the work area so that operators can work more effectively. With the 5S concept, some occurring waste can be eliminated.

Hindoliya & Sarathe (2017) suggested that 5S was a technique to regulate workplaces in order that the quality of work, workability, and productivity of workers could be enhanced. Hindoliya & Sarathe (2017) suggested that 5S consisted of 5 main points that meant as follows:

- Seiri (Sort): regulating all existing items, where the required items would be stored, while removing items that were not needed.
- Seiton (Set in Order): arranging the layout of the goods and giving identity to each object. Everything had to be in its place to eliminate the potential for searching products and to eliminate waste.

- Seiso (Shine): keeping every item clean and tidy. The cleaning process was an inspection process to detect any abnormal or potential failure.
- Seiketsu (Standardize): documenting each work method and making 5S a part of the corporate culture in addition to developing systems and procedures for maintaining and monitoring the first 3S.
- Shitsuke (Sustain): establishing the habits of continuous improvement procedures, so the continuous improvement process could be maintained and repairs that had been made previously remained at the predetermined standards.

Hindoliya & Sarathe (2017) suggested that by implementing 5S, we could enjoy benefits as follows:

- Transparent work process flow
- Clean and well-maintained work environment
- Reducing changeover time
- Reducing cycle times
- Adding space available at work
- Reducing the potential for workplace accidents
- Reducing waste time carried out by workers
- Increasing the effectiveness of the use of equipment

In the implementation of SMED, we often combined it with the 5S concept, since a reduction in the changeover time could also be affected by the workplace environment. Bevilacqua et al. (2015) combined the SMED concept with the 5S concept, where the method that was used could reduce the changeover time by 61.5%. Roriz et al. (2017) integrated and implemented the SMED concept with the 5S concept and got a 47% reduction changeover time. Rosa et al. (2017) integrated and implemented the concepts of SMED and 5S, resulting in a reduction in the changeover time by 58.3%.

Plastic injection is a process most commonly used to produce plastic components. The injection process cycle starts from melting the material, the injection process by filling the material into the mold, and ends with the process of cooling and releasing the product. Plastic raw materials, usually in the form of granules or powders, are melted in the injection unit at a working temperature ranging from 200 to 250^{0}C. The melted material will be entered by being injected into a plastic mold with a certain pressure and speed. Molds that are injected with a certain pressure will be held back by the engine pressure, commonly called the clamping force. The advantage of the injection process is that this process is a process to produce plastic products in bulk economically. Besides, the products can be produced with high precision and good accuracy. The products that are produced do not require additional processing or workmanship, and they can be directly used by the customer. Bharti & Khan (2010) classified factors affecting the quality of plastic injection products into four categories, namely product design, mold design, engine performance, and process parameters. To print a plastic product, we need a mold to be formed in accordance with the desired product. The injection mold consists of 2 main parts, namely core, and cavity. A core is a mold part forming the inside of a product, while a cavity is a mold part forming the outside of the product. Injection mold can be made with a multi-cavity system. The multi-cavity is in 1 mold that has more than one cavity, so in one cycle of the injection process, more than 1 product can be produced.

PT BIL is a company located in Cikarang that engaged in the production of plastic packaging products using the injection process. PT BIL experienced a problem, namely the absence of a measurement process for changeover time. Without measuring the change over time, they would not know what potential improvements could be made to reduce changeover time. SMED is a method aimed at reducing the changeover time by eliminating the occurring waste, where it could detect by first measuring the change over time. Moreover, they found out that the work equipment was not properly sorted, and the equipment identity was not available. The waste potentially created in the work environment could be overcome with the 5S method, which, in this study, focused on the first 2S, namely seiri and seiton. This study was aimed at reducing the changeover time by eliminating wasteful activities and irregularities in the work area that could create waste. The SMED concept, combined with the 5S concept, was implemented to reduce the changeover time.

MATERIAL AND METHOD

Material

The data used as the materials in this study included:

- Type of injection mold used on P.T. BIL
- Duration of the changeover before the implementation of SMED & 5S
- Types of activities done during the changeover process

- Observation of the work area before it was improved with the 5S method
- Observation of the work area after it was improved with the 5S method
- Duration of changeover after SMED & 5S were applied

Types of injection mold on P.T. BIL were used as the data to divide mold types into several types. Distribution of the types was made based on mold, the dimensions and the type of accessories used in the mold. Mold dimensions and types of accessories used in the mold would affect the changeover time that was required.

The duration of the changeover time before SMED & 5S was applied was required as the initial changeover duration data. The whole process of both the value-added process and the non-value-added process was accumulated as the time of changeover on injection mold.

The types of activities done during the changeover process were classified into external activities and internal activities. An external activity was a changeover activity that could be done while the machine was operating, while an internal activity was a changeover activity done while the machine was stopped. Moreover, the activities were also classified as value-added activities and non-value-added activities in order that we could prioritize non-value-added activities to be eliminated or reduced.

We also observed the work area to analyze the waste occurring in the work area. All waste that was found would be used as a standard reference for improvement in the working area.

The duration of changeover after the SMED and 5S were implemented was required as the data compared to change over time before SMED, and 5 S was implemented.

Method

This study was aimed at measuring the change over time and identifying the occurring waste, so when the available waste was reduced, it would reduce the change over time of the injection mold. The study was conducted as follows:

1. Collecting changeover schedule data of the injection mold
2. Measuring the change over time of the injection mold using a stopwatch and recording it on the Operation Analysis Chart. The data collection period was October - November 2018
3. Analyzing the work elements and potential waste that occurred using the Operation Analysis Chart
4. Separating the internal activities from the external activities in the changeover process using Analytical Cards
5. Conduct 5S in the workplace to support the SMED concept
6. Measuring the change over time of the injection mold after being done at the workshop

In displaying observational data, we could use the Operation Analysis Chart, as Simoes & Tenera (2010) stated. Fig. 2 shows five types of activities, namely: Processing, Inspection, Transportation, Storage, and Waiting. By using the Operation Analysis Chart, we could analyze the processes that occurred and the waste that took place during the changeover process. When we separated the internal activities from the external activities as SMED was applied, we could employ a tool called the Analytical Card. The Analytical Card contains tables that classify which activities are internal activities and external activities. Analytical Cards can be made in several periods, namely analyzing the conditions of the current product change settings, analyzing internal activity activities and external activities that have been separated, analyzing the conversion of internal activity activities into external activities, and analyzing the results of improvements in internal activities and external activity.

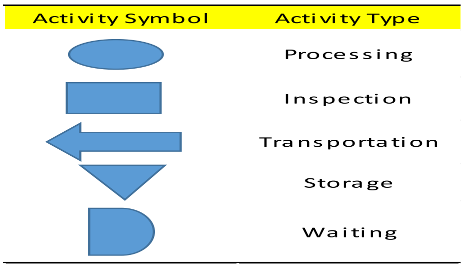

Figure 2. Activity on Operation Analysis Chart (Simoes & Tenera, 2010)

Fig. 3 shows the study's steps. Changeover time that had been analyzed with the Operation Analysis Chart would be converted to Analytical Cards to see any potential activities that could be used as the external activities. Improvements would be made based on the SMED concept and the 5S concept. The SMED concept would optimize the internal activities that could be converted to external activities, while the 5S concept would improve the organization of workplaces; thereby, its enhanced work productivity.

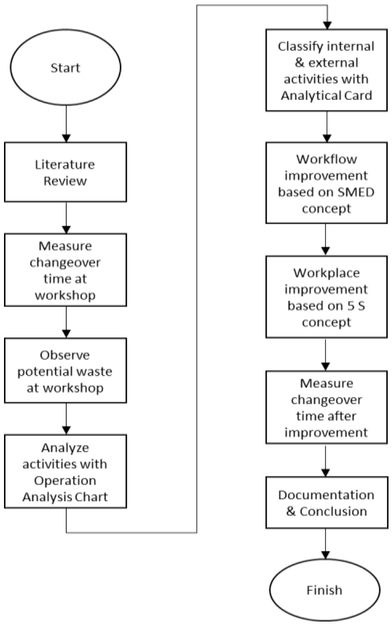

Figure 3. Research flowchart

RESULTS AND DISCUSSION

General data on the injection molds that would be elaborated were data of the classification of plastic molds at P.T. BIL. The classification of plastic molds was based on the volume of plastic molds and the accessories used in the injection molds. The greater the volume of injection molds, the more injection molds would have to be used in the injection machines. The greater the engine capacity that was used, the more coolant hoses, nipples, and other components that had to be installed on the mold, so it would result in longer changeover time. Accessories used in the injection molds affected the classification of injection molds. Injection molds that had accessories that had to be employed would result in longer changeover time. Based on the classification, the data was collected in regard to the general data of injection molds, as showed in Fig. 4 showed.

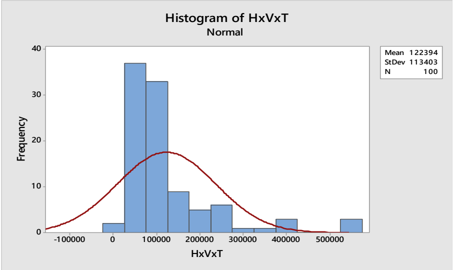

Figure 4. Distribution of the average volume of injection mold

Fig. 4 shows the volume of all plastic molds on P.T. BIL, where the average volume of injection molds available is 123000 cm3.

Table 1. Classification of plastic molds for injection of P.T. BIL

	Injection Mold	
Category	**Information**	**Quantity**
A	Volume < 123000 cm^3 with accessories	29
B	Volume < 123000 cm^3 without accessories	38
C	Volume > 123000 cm^3 with accessories	23
D	Volume > 123000 cm^3 without accessories	10
	Total	100

Based on Table 1, there were four categories, namely categories A, B, C, and D, with 100 plastic injection molds in total. In the data collection period of October - November 2018, the data was obtained for the purpose of the changeover time for each category, and they were presented in the average value below. Table 2 showed examples of the Operation Analysis Chart. The Operation Analysis Chart shown as the example was category A.

Table 2, as an example of Operation Analysis Chart, showed that some wastage occurred, where the waste could be eliminated or moved into an external activity. The analytical Card was used as a tool to separate and analyze which activity could be categorized as external activities and internal activities. Table 3 – Table 6 showed the Analytical Card of each category.

Table 2. Operation Analysis Chart Category A

No	Job description	●	■	⇦	▼	◗	Duration (minute)	Category	Setup type
1	Remove the cooling hose	16					16	Added Value	Internal
2	Remove the auto close sensor	13					13	Added Value	Internal
3	Remove auto close	13					13	Added Value	Internal
4	Remove the side grip	9					9	Added Value	Internal
5	Set down mold	7					7	Added Value	Internal
6	Bring mold to the mold maintenance			10			10	Non-Added Value	Internal (convert to external)
7	Looking for an eye bolt			6			6	Non-Added Value	Internal (convert to external)
8	Waiting for the next product's mold preparation					10	10	Non-Added Value	Internal (eliminate)
9	Looking for the next mold product			7			7	Non-Added Value	Internal (convert to external)
10	Replace mold's nipple	11					11	Non-Added Value	Internal (convert to external)
11	Bring mold to the production line			8			8	Non-Added Value	Internal (convert to external)
12	Waiting for production information					20	20	Non-Added Value	Internal (eliminate)
13	Looking for a spanner			6			6	Non-Added Value	Internal (eliminate)
14	Set up mold	7					7	Added Value	Internal
15	Install side grip	10					10	Added Value	Internal
16	Look for allen spanner			4			4	Non-Added Value	Internal (eliminate)
17	Looking for auto close			9			9	Non-Added Value	Internal (eliminate)
18	Install auto close	14					14	Added Value	Internal
19	Install the auto close sensor	13					13	Added Value	Internal
20	Install the cooling hose	17					17	Added Value	Internal
21	Look for additional hoses			17			17	Added Value	Internal (eliminate)
22	Turn on machine heater	21					21	Added Value	Internal
23	Purge material	21					21	Non-Added Value	Internal
24	Run In	50					50	Added Value	Internal
25	QC Approval		28				28	Non-Added Value	Internal
Total Time (min)		219	28	68	0	30	345		

Table 3. Analytical Card of Category A before SMED Improvement

		Current Condition of A Category					
	Work element	**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description		Remove the cooling hose	Waiting for the next product's mold preparation	Turn on machine heater		
	Work element duration		16	10	21		
2	Work element description		Remove the auto close sensor	Looking for the next mold product	Purge material		
	Work element duration		16	10	21		
3	Work element		Remove auto	Replace	Run In		

	description	close	mold's nipple		
	Work element duration	13	11	50	
4	Work element description	Remove the side grip	Bring mold to the production line	QC Approval	
	Work element duration	9	8	28	
5	Work element description	Set down mold	Waiting for production information		
	Work element duration	7	20		
6	Work element description	Bring mold to the mold maintenance	Looking for a spanner		
	Work element duration	10	6		
7	Work element description	Looking for an eye bolt	Set up mold		
	Work element duration	6	7		
8	Work element description		Install side grip		
	Work element duration		10		
9	Work element description		Look for Allen spanner		
	Work element duration		4		
10	Work element description		Looking for auto close		
	Work element duration		9		
11	Work element description		Install auto close	11	
	Work element duration		14		
12	Work element description		Install the auto close sensor	12	
	Work element duration		13		
13	Work element description		Install the cooling hose	13	
	Work element duration		17		
14	Work element description		Look for additional hoses	14	
	Work element duration		17		
Internal Activities Duration		73	153	120	345
External Activities Duration					
Total Time (min)		345			

Table 4. Analytical Card of Category B before SMED Improvement

Current Condition of B Category							
Work element		**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description		Remove the cooling hose	Looking for a nipple	Turn on machine heater		
	Work element duration		11	8	21		
2	Work element description		Remove the side grip	Looking for an eye bolt	Purge material		
	Work element duration		8	3	18		
3	Work element description		Set down mold	Waiting for the next product's mold preparation	Run In		
	Work element duration		7	8	45		
4	Work element description		Bring mold to the mold maintenance	Replace mold's nipple	QC Approval		
	Work element duration		9	9	21		
5	Work element description			Bring mold to the production line			
	Work element duration			7			
6	Work element description			Looking for a spanner			
	Work element duration			2			
7	Work element description			Set up mold			
	Work element duration			9			
8	Work element description			Install side grip			
	Work element duration			10			
9	Work element description			Install the cooling hose			
	Work element duration			14			
10	Work element description			Look for additional hoses			
	Work element duration			4			
Internal Activities Duration			35	73	105		213
External Activities Duration							
Total Time (min)				213			

Table 5. Analytical Card of Category C before SMED Improvement

Current Condition of C Category							
Work element		**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description		Remove the cooling hose	Waiting for the next product's mold preparation	Turn on machine heater		
	Work element duration		21	14	23		
2	Work element description		Remove hydraulic hose	Looking for the next mold product	Purge material		
	Work element duration		12	9	20		
3	Work element description		Remove the auto close sensor	Bring mold to the production line	Run In		
	Work element duration		18	10	54		
4	Work element description		Remove auto close	Looking for a spanner	QC Approval		
	Work element duration		16	5	26		
5	Work element description		Remove the side grip	Set up mold			
	Work element duration		12	14			
6	Work element description		Set down mold	Install side grip			
	Work element duration		14	14			
7	Work element description		Bring mold to the mold maintenance	Look for Allen spanner			
	Work element duration		10	8			
8	Work element description			Looking for auto close			
	Work element duration			3			
9	Work element description			Install auto close			
	Work element duration			11			
10	Work element description			Install the auto close sensor			
	Work element duration			18			
11	Work element description			Install hydraulics hose			
	Work element duration			19			
12	Work element description			Install the cooling hose			
	Work element duration			25			
13	Work element description			Look for additional hoses			
	Work element duration			9			
Internal Activities Duration			73	153	120		345
External Activities Duration							
Total Time (min)		345					

Table 6. Analytical Card of Category D before SMED Improvement

Current Condition of D Category							
Work element		**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description		Remove the cooling hose	Waiting for the next product's mold preparation	Turn on machine heater		
	Work element duration		17	12	25		
2	Work element description		Remove hydraulic hose	Looking for the next mold product	Purge material		
	Work element duration		14	6	27		
3	Work element description		Remove the side grip	Bring mold to the production line	Run In		
	Work element duration		13	7	46		
4	Work element description		Set down mold	Set up mold	QC Approval		
	Work element duration		9	11	29		
5	Work element description		Bring mold to the mold maintenance	Install side grip			
	Work element duration		8	15			
6	Work element description		Looking for an eye bolt	Install the cooling hose			
	Work element duration		5	24			
7	Work element description			Look for additional hoses			
	Work element duration			12			
Internal Activities Duration			66	86	127		279
External Activities Duration							
Total Time (min)		279					

Based on Tables 3 through Table 6, before the implementation of the SMED, all activities were carried out internally or waiting until the machine was not operating. This is a waste because it can be optimized when the machine is still operating. To reduce the change over time, we needed several improvements, including changes in the workflow by referring to the SMED concept, converting internal activities to external ones.

Table 7. Analytical Card of Category A after SMED Improvement

Work Element Conversion of A Category							
Work element		**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description	Looking for an eye bolt	Remove the cooling hose	Set up mold	Turn on machine heater	Bring mold to the mold maintenance	
	Work element duration	9	21	14	23	8	
2	Work element description	Bring mold to the production line	Remove hydraulic hose	Install side grip	Purge material		
	Work element duration	10	12	14	20		
3	Work element description		Remove the auto close sensor	Install auto close	Run In		
	Work element duration		18	11	54		
4	Work element description		Remove auto close	Install the auto close sensor	QC Approval		
	Work element duration		16	18	26		
5	Work element description		Remove the side grip	Install hydraulics hose			
	Work element duration		12	19			
6	Work element description		Set down mold	Install the cooling hose			
	Work element duration		94	100	123		318
Internal Activities Duration			53				
External Activities Duration		19					19
Total Time (min)				336			

Table 8. Analytical Card of Category B after SMED Improvement

Work Element Conversion of B Category							
Work element		**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description	Looking for an eye bolt	Remove the cooling hose	Set up mold	Turn on machine heater	Bring mold to the mold maintenance	
	Work element duration	8	11	9	21	9	
2	Work element description	Looking for an eye bolt	Remove the side grip	Install side grip	Purge material		
	Work element duration	3	8	10	18		
3	Work element description	Replace mold's nipple	Set down mold	Install the cooling hose	Run In		
	Work element duration	9	7	14	45		
4	Work element description	Bring mold to the production line			QC Approval		
	Work element duration	7			21		
Internal Activities Duration				25	32	105	
External Activities Duration		27				9	36
Total Time (min)				199			

Table 9. Analytical Card of Category C after SMED Improvement

Work Element Conversion of C Category							
Work element		**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description	Looking for an eye bolt	Remove the cooling hose	Set up mold	Turn on machine heater	Bring mold to the mold maintenance	
	Work element duration	9	21	14	23	8	
2	Work element description	Bring mold to the production line	Remove hydraulic hose	Install side grip	Purge material		
	Work element duration	10	12	14	20		
3	Work element description		Remove the auto close sensor	Install auto close	Run In		
	Work element duration		18	11	54		
4	Work element description		Remove auto close	Install the auto close sensor	QC Approval		
	Work element duration		16	18	26		
5	Work element description		Remove the side grip	Install hydraulics hose			
	Work element duration		12	19			
6	Work element description		Set down mold	Install the cooling hose			
	Work element duration		94	100	123		318
Internal Activities Duration			53				
External Activities Duration		19					19
Total Time (min)		336					

Table 10. Analytical Card of Category D after SMED Improvement

Current Condition of D Category							
Work element		**External Activities**	**Internal Activities**			**External Activities**	**Total Duration (min)**
		1. Start Activities	**2. Set Down Procedure**	**3. Set-Up Procedure**	**4. Run In Procedure**	**5. Finish Activities**	
1	Work element description	Looking for an eye bolt	Remove the cooling hose	Set up mold	Turn on machine heater	Bring mold to the mold maintenance	
	Work element duration	5	17	11	25	8	
2	Work element description	Looking for the next mold product	Remove hydraulic hose	Install side grip	Purge material		
	Work element duration	6	14	15	27		
3	Work element description	Bring mold to the production line	Remove the side grip	Install the cooling hose	Run In		
	Work element duration	7	13	24	46		
4	Work element description		Set down mold		QC Approval		
	Work element duration		9		29		
Internal Activities Duration			53	49	127		229
External Activities Duration		18				8	26
Total Time (min)		255					

Based on Table 7 - Table 10, the results of workflow changes are based on the SMED concept, where internal activities are converted to external activities, so the change over time will be shorter.

In addition to the workflow, improvements are carried out in the work area, where improvement is carried out based on the 5S concept so that waste resulting from irregularities in the work area can be eliminated.


Figure 5. Seiri implementation


Figure 6. Seiton implementation

Fig. 5 showed a Seiri implementation wherein the grouping of work equipment needed for the changeover was applied, while Fig. 6 shows a Seiton implementation giving the identity to the plastic molds. Seiri's implementation was carried out to eliminate waste that occurred due to incomplete equipment, while Seiton's implementation was carried out to eliminate waste that occurred due to the absence of identity in both injection molds and injection mold's accessories.

After being improved with the SMED and 5S concepts, the changeover time was measured again, and based on the results of the improvement, the results of the change of product change settings were obtained. Table 11 showed the results. Table 11 showed that there was a 16-percent reduced time for category A, a 22-percent reduced time for category B, a 12-percent reduced time for category C, and a 24-percent reduced time for category D. Based on these calculations, on the average of all categories, there was a decrease in the time of product change settings amounting to 18%. Moreover, Table 12 showed that there were reduced activities in all categories, where a reduced activity is an activity resulting in waste in the process of product replacement settings, as well as an activity that could be done when the machine was operating, or it was commonly called an external activity.

Table 11. Comparison of the average change over time before and after SMED implementation

Category	**Quantity**	**Average change over time (minute) before SMED implementation**	**Average change over time (minute) after SMED implementation**	**Percentage reduction for changeover time after SMED implementation**
A	10	268	225	16%
B	12	192	149	22%
C	6	310	274	12%
D	4	246	188	24%
		Average		18%

Table 12. Comparison of total activities before and after SMED implementation

Category	**Total activities before SMED implementation**	**Total activities after SMED implementation**	**Total reduced activities after SMED implementation**	**Total reduced activities after SMED implementation (%)**
A	25	14	11	44%
B	18	10	8	44%
C	24	16	8	33%
D	17	12	5	29%
	Average		8	38%

CONCLUSION

Based on all of the data that were obtained and analyzed, we could draw several conclusions. Implementation of SMED could reduce the changeover time by 18% with an average time amounting to 44 minutes. The most significantly reduced changeover time was 24% that took place at the D mold category. Implementation of SMED could also reduce total activities by 38% with an average of 8 activities. The most significantly reduced changeover activities were 11 activities accounting for 44% that took place at the A mold category.

In order to make this study more perfect, there we suggest things that may be used in further studies. The reduction of changeover time may significantly increase if we invest in mechanical tools, especially used for internal activities. The impact of a reduced changeover time can be investigated further, especially saving the costs in the fields of processing time, speed of delivery, quality of delivery, and the customer's satisfaction.

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