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Application of Single Minute Exchange Die (SMED) Method to Minimize Setup Time on 350T Capacity Molding Machine

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ABSTRACT

This study aims to apply the Single Minute Exchange of Die (SMED) method in reducing setup time on a 350T capacity molding machine at PT HMG. The data collection results showed that the frequency of mold changes reached 70 times a month, with the average time required for mold changes before the implementation of SMED 173 minutes. After the implementation of SMED, the mold change time was successfully reduced to 64 minutes, reflecting a decrease of 63%. The implementation of SMED was carried out through several stages, including converting internal activities to external ones, which aimed to reduce machine downtime. Optimization of the remaining activities was also carried out, such as reducing the temperature drop time on the barrel and hot runner, which previously took 15 minutes, now only 5 minutes. The final results showed that machine downtime cost savings reached Rp11,200,000 per month after the implementation of SMED, with total downtime costs decreasing from Rp30,274,999 to Rp19,074,999 per month. This study proves that implementing the SMED method can significantly improve time efficiency, reduce production costs, and create more efficient operational standards. The findings provide a solid basis for further development in industry manufacturing practices.

I. Introduction

In the manufacturing industry, especially in sectors that produce a large number of components, the efficiency of the production process is a critical factor in maintaining the company's competitiveness. One of the main challenges often faced is the high downtime during the machine setup process. This setup time, which often includes changing tools or dies on the machine, can negatively impact overall productivity [1]. In this regard, the Single Minute Exchange of Die (SMED) method was introduced as an effective solution to minimize setup time and improve operational efficiency.

SMED is an improvement method developed by Shigeo Shingo as part of the Toyota Production System. The goal is to reduce the time required to change a tool or mold on a production machine to less than ten minutes [2]. The main concept of SMED is to separate setup activities into two categories: internal setup, which can only be done when the machine is stopped, and external setup, which can be done when the machine is running. By converting as many internal setup activities as possible into external setup, downtime can be significantly reduced [3][4].

In the molding industry, especially with large-capacity machines such as the 350T molding machine, the mold change process often takes a long time due to the size and complexity of the tools used. This long setup time not only wastes valuable production time but also increases operational costs because the machine cannot produce optimally during mold changeovers [5][6]. Therefore, the implementation of SMED is crucial to improving efficiency and reducing setup time on these large-capacity machines.

This study explores how the SMED method can effectively reduce setup time on a 350T capacity molding machine. It also aims to identify specific steps that can be taken to separate internal and external setup activities and assess the impact of SMED implementation on improving productivity and reducing downtime in the production environment. Thus, the results of this study can make a practical contribution to manufacturing companies facing similar problems related to long setup times.

II. Literature Review

Shigeo Shingo introduced the Single Minute Exchange of Die (SMED) method as part of the Toyota Production System. SMED focuses on reducing setup time by converting internal activities, which must be performed while the machine is stopped, into external activities that can be performed while the machine is running [2][7]. This approach helps improve efficiency by reducing unproductive time during tool or mold changeovers and enables faster transitions between the production of one product to another. SMED also allows small quantities with shorter lead times without affecting productivity, making it an ideal method in flexible manufacturing systems [1][3].

Theoretically, SMED consists of three main stages: separating internal and external activities, converting as many internal activities to external as possible, and simplifying the remaining internal activities [8][9]. The first step is an in-depth analysis of the setup process to identify which activities can be converted to external. The second step is to implement physical and procedural modifications to allow most activities that previously could only be performed during downtime to be performed while the machine is still running. The final step is simplifying or eliminating non-value-added activities during internal setup and ensuring these steps are applied consistently.

Case studies regarding the implementation of SMED have shown significant results in reducing setup time in various manufacturing sectors. [1][4][6][10] outlined the implementation of SMED in the automotive industry, successfully reducing setup time by 50%. The study highlights that successful SMED implementation relies heavily on cross-functional collaboration, operator training, and regular evaluation of the setup process. In addition, machine technology improvements, such as using automatic sensors to detect the position of molds and tools, can also help speed up the setup process [6][11][12].

In the molding industry, especially those using large-capacity machines such as 350T, implementing SMED has its challenges due to the complexity of mold changeovers and large equipment size. [13] found that in this industry, SMED implementation often requires physical modifications to equipment and layout adjustments to enable faster tool changeovers. In addition, developing clear operational standards and implementing process visualization methods such as visual management can assist operators in performing setup steps more efficiently.

Further research also underscores the importance of applying SMED in an industrial context that is oriented towards improving the overall efficiency of the production process. Reducing setup time not only increases production capacity but also enables companies to respond faster to changes in market demand [6][14]. Therefore, SMED has become highly relevant in various manufacturing sectors, including the mold industry, which has large-capacity machines.

III. Method

This study uses the Single Minute Exchange of Die (SMED) method to minimize the time spent on the mold change process in a 350T capacity injection molding machine (Fig. 1). SMED is one of the techniques in lean manufacturing that focuses on converting internal setup activities into external ones, thus allowing the changeover process to be performed without stopping operations completely [2][7]. The steps of the SMED method applied in this study begin with identifying internal and external activities during the changeover process, followed by process simplification to improve overall efficiency.

The data collection process in this study was carried out by directly observing the changeover activities on the injection molding machine. The data collected includes the time required for each stage of mold changeover, which involves production stoppage, component replacement, and machine parameter reset. The first stage in applying SMED is to identify all internal activities that occur when the machine stops, which have the potential to be converted into external activities. After identifying the steps, we analyze which can be taken without stopping production. These steps allow the company to keep producing while making some preparations for the mold change process [1][15]–[17].

Fig. 1. Toshiba 350T (Source: PT HMG)

The implementation of SMED is focused on three main strategies: (1) converting internal activities to external ones, (2) simplifying internal activities, and (3) standardizing the new changeover procedure. The conversion of internal activities reduces the time spent on stages that can be prepared before the machine is stopped, such as material and equipment preparation. In addition, internal activities that cannot be converted to external ones are simplified by reducing the time spent on each step, such as speeding up the material heating process or reducing the time for adjusting machine parameters. With this approach, the time required for the changeover process can be significantly reduced [2][17][18].

The results of applying the SMED method show a substantial increase in efficiency. With the reduced setup time, companies can increase machine productivity and reduce downtime costs. In addition, the implemented SMED measures also provide a basis for continuous improvement in the future through a standardization process that allows the execution of changeovers to be more consistent and controlled. Thus, the SMED method is proven effective in improving overall production performance and providing significant economic benefits [16][18].

IV. Result and Discussion

This research focuses on applying the Single Minute Exchange of Die (SMED) method in reducing setup time on a 350T capacity molding machine. Based on the data collection results, this machine has a high frequency of mold changes, which is 70 times in one month (Table 1.). Before the implementation of SMED, the average time required for mold change reached 173 minutes. However, after the implementation of SMED, the changeover time can be reduced to 64 minutes, representing a 63% decrease in changeover time.

Table 1. Mold change machine setup time frequency per month

Machine	Number of Machine	Capacity of Machine (Tonage)	Number of Mold changes in a month
1,2	2	800T	58
3-7	5	650T	66
8,9	2	600T	26
10,11	2	400T	41
12-14	3	450T	39
15,16,20	3	350T	70
17	1	1400T	9

18,28,29	3	1600T	55
19,27	1	1300T	24
21,22	2	220T	19
23,25	2	200T	30
24,26	2	140T	18

This reduction in setup time is achieved through several stages in the SMED method. One crucial step is the conversion of internal activities to external ones. Activities such as setting machine parameters and material preparation, which were previously performed after the machine had stopped, are now moved to external processes so that they can be performed while the machine is still operating (Table 2. and Table 3.). This aligns with SMED principles that emphasize reducing machine downtime by converting as many internal activities as possible into external ones (Shingo, 1985). This implementation significantly reduced unproductive time, resulting in improved machine operational efficiency.

Table 2. Mold change activity

Step	Activity	Time (Minutes)
1	Production stop preparation	5
2	Stopping the production process	5
3	Spend material in the hopper	15
4	Turning off barrel and hot runner temperatures	15
5	Waiting for hot runner temperature to drop	5
6	Unscrewing the fastening bolts of the ejector rod unit	3
7	Remove the ejector rod unit from the machine	2
8	Taking the key to remove the mold bolt	1
9	Unscrew the mold fastening bolts	5
10	Lift the mold and take it to the mold storage area	20
11	Bringing the new mold to the machine	20
12	Installing the injection cavity and hot runner	10
13	Installing mold core and mold cavity	10
14	Installing the heating pot, heating core and lip cavity	3
15	Tightening all mold fastening bolts	2
16	Inputting new product setting parameters	2
17	Running the machine without material	2
18	Retrieve material from the material warehouse	3
19	Load material into the hopper	2
20	Warming up the material	5
21	Raise the temperature of barrel, heating pot and hot runner	3
22	Write report on change mold check sheet	2
23	Make start up sample	3
24	QC Approval	10
25	Perform 5S in the work area	5
26	Run production after judgment part OK	10
	Total Changeover	173

Table 3. Classification of Internal and External Activities

Step	Activity	Time (Minutes)	Internal	External
1	Production stop preparation	5		√
2	Stopping the production process	5		√
3	Spend material in the hopper	15	√	
4	Turning off barrel and hot runner temperatures	15	√	
5	Waiting for hot runner temperature to drop	10	√	

6	Unscrewing the fastening bolts of the ejector rod unit	3	√	
7	Remove the ejector rod unit from the machine	2	√	
8	Taking the key to remove the mold bolt	1		√
9	Unscrew the mold fastening bolts	5	√	
10	Lift the mold and take it to the mold storage area	20	√	
11	Bringing the new mold to the machine	20	√	
12	Installing the injection cavity and hot runner	10	√	
13	Installing mold core and mold cavity	10	√	
14	Installing the heating pot, heating core and lip cavity	3	√	
15	Tightening all mold fastening bolts	2	√	
16	Inputting new product setting parameters	2	√	
17	Running the machine without material	2	√	
18	Retrieve material from the material warehouse	3	√	
19	Load material into the hopper	2	√	
20	Warming up the material	5	√	
21	Raise the temperature of barrel, heating pot and hot runner	3	√	
22	Write report on change mold check sheet	2	√	
23	Make start up sample	3	√	
24	QC Approval	10	√	
25	Perform 5S in the work area	5	√	
26	Run production after judgment part OK	10		√
	Total Changeover	173	152	21

In addition, the remaining internal activities were also successfully optimized (Table 4.). For example, lowering the temperature on the barrel and hot runner, which previously took 15 minutes, was successfully cut to only 5 minutes using a gradual temperature reduction technique. This optimization reduced mold changeover time from 55 minutes to 21 minutes, or 61.80%. These steps show that not only the conversion of internal activities has a significant impact but also the simplification of the remaining activities (Table 5.).

Table 4. Change of Internal Activity to External

Step	**Activity**	**Time (Minutes)**	**Change**	**Improvement**
3	Spend material in the hopper	15	Internal to External	Unloaded material 10 minutes before machine stop
16	Inputting new product setting parameters	2	Internal to External	Input and stored in the machine monitor
18	Retrieve material from the material warehouse	3	Internal to External	Inform the material department 30 minutes in advance
19	Load material into the hopper	2	Internal to External	At the time of the changeover process, the material has already started to be input and heated up
20	Heating the material	5	Internal to External	Material is heated in the spare hopper before changeover.
21	Raising the temperature of barrel, heating pot and hot runner	3	Internal to External	After all parts are installed,

	Total Chageover	30

Table 5. Reduce Internal activity time

Step	Activity	Before	After	Improvement
4	Turning off barrel and hot runner temperatures	15	5	Partial temperature drop setting is performed
5	Waiting for hot runner temperature to drop	10	3	Faster Achieving cooling with partial temperature drop
12	Install the injection cavity and hot runner	10	5	Performed parallel work by operator 1 and operator 2
13	Installing mold core and mold cavity	10	5	
24	QC Approval	10	3	Inspector standby at machine with equipment and product specifications
	Total Changeover	55	21	

Overall, the results of this study show that the implementation of SMED significantly reduces molding machine setup time. With a mold change frequency of 70 times per month, reducing setup time from 173 to 64 minutes enables significant production cost savings. Based on calculations with machine costs when producing products at Rp150,000/hour, the cost of machine downtime before the implementation of SMED reached Rp30,274,999 per month. After the implementation of SMED, there was a cost savings of Rp11,200,000 per month, so the total downtime cost dropped to Rp19,074,999 per month. This impact shows that SMED is efficacious in improving time efficiency and significantly reducing production costs. Table 6. compares setup time and cost before and after the implementation of SMED.

Table 6. Comparison of Changeover Time and Production Cost Before and After SMED Implementation

Parameter	Before SMED	After SMED	Reduction (%)
Average Changeover Time (minutes)	173	64	63%
Internal Time (minutes)	55	21	61.80%
Downtime Cost (Rp per month)	30,274,999	19,074,999	37.06%
Mold Changeover Frequency per Month	70	70	-
Downtime Cost Savings (Rp/month)	-	11,200,000	-

The results of this study provide strong evidence that applying the SMED method to molding machines can effectively reduce setup time and production costs. In addition, the application of SMED provides additional benefits in creating more efficient operating standards and improving overall productivity [2].

V. Conclusion

This research applies the Single Minute Exchange of Die (SMED) method to reduce setup time on a 350T capacity molding machine. Data collection showed that the machine experienced a high frequency of mold changes, as many as 70 times a month, with an average mold change time of 173 minutes before the application of SMED. After applying this method, the mold change time could be reduced to 64 minutes, a significant decrease of 63%. These findings show that SMED can improve the machine's operational efficiency and substantially reduce unproductive time.

The research methodology involved identifying internal and external activities during the mold change process and optimizing the remaining activities. Machine downtime can be minimized by transferring internal activities to external ones, such as machine setup and material preparation. The analysis showed that these changes reduced setup time and resulted in significant production cost savings. Before the implementation of SMED, the cost of machine downtime reached Rp30,274,999 per month, while after implementation, the cost dropped to Rp19,074,999, resulting in a monthly savings of Rp11,200,000.

This study proves that implementing the SMED method on molding machines can effectively reduce setup time and production costs. In addition, applying SMED helps create more efficient operational standards and improves overall productivity. Applying SMED principles, such as maximizing external activities and simplifying internal activities, has impacted machine performance and reduced costs.

For future research, further studies are recommended on implementing SMED methods in different machines and industrial sectors to identify a broader range of potential time and cost savings. In addition, more profound research can be conducted to explore the influence of other variables, such as employee training and automation technology, in supporting SMED implementation. Longitudinal research is also recommended to analyze the long-term impact of SMED implementation on productivity and cost efficiency. This more comprehensive approach will provide deeper insights into best practices in SMED implementation in the manufacturing industry.

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