Reduction of Changeover Time by Using the SMED Technique with the Assistance of Lean Manufacturing Tools in a Plastic Company

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Abstract

The expanding manufacturing sector of plastic items is coming about because of the injection molding process and the quick advancement of existing innovation. One of the most time-consuming, non-value-added tasks in a manufacturing process is setup, or changeover. The study was conducted at a plastic product manufacturing company in Bangladesh. This study's goal was to demonstrate how changeover time reduction approaches may be used in a medium-sized production facility to cut down on total process lead time with the assistance of lean manufacturing tools. The analysis of numerous factors, including non-conformities, complaints, and delivery delays, revealed improvement prospects. In this research, three cases were considered for reducing overall changeover time: one is Reduce 7 Wastes (Case 1), the second is Improve SMED with 5S and 7 Wastes (Case 2), and the third is Total Change Over Works, which can be classified into external and internal works (Case 3). After implementing improvement measures, changeover time was reduced by 18%–33%. The most essentially decreased changeover time was 33% compared to the result for case 2, and they improved their main manufacturing line's output capacity by 10% by focusing on lean tools (5S, SMED, 7 waste). The company was able to avoid using temporary workers due to this development since it allowed employees to work longer hours during peak times. The study also explores how these techniques may be used in other major manufacturing industries that engage in mass production at several worldwide locations, in addition to a medium-sized facility.

Keywords
Changeover Time, SMED, 5S, 7 waste, Lean Manufacturing

1. Introduction
This study was developed out of the requirement for improving specific processes in a plastic manufacturing plant because of the greater expectations from their main customer. The majority of the items we use in our day-to-day lives require a few segments or even themselves to be created by the extruding process. That is the reason it additionally requires a generous amount of time to get the primary, great-quality item in its original shape after a changeover. Due to these troubles, there is an inclination to pick enormous clump creation with fewer changeovers, in actuality. Improvement of changeover times, supporting accomplishments, and doing this in a precise and normalized way are pivotal for the productivity of the firm (Cakmakci and Karasu 2007). Till now, the most renowned instrument for changeover time decrease is the SMED. Yet, this approach appears to be open for additional improvement of the longest piece of a changeover activity, "preliminary attempts; furthermore, changes" where another insightful strategy needs to be locked in to limit the time required for boundary changes (Karasu et al. 2014). The considerations that are being provided focus on the optimization of the manufacturing approach by applying the SMED (Single Minute Exchange of Die) technique to a chosen spare component. By reducing production delays and responding to changing orders more quickly, the SMED approach aims to strengthen the ability to quickly adjust to changing customer demands from the perspective of the Lean Manufacturing philosophy (Niekurzak et al. 2023). The goal of lean manufacturing is to find and remove waste at every stage of a product's manufacturing cycle (Saha and Mahmud 2022). A manufacturing system with short changeover times may help reduce the lot size. It has various advantages, including decreased costs, accelerated production, greater productivity, decreased lead times, smooth process flows, a wider variety of lot sizes, less inventory, and decreased waste (Ahmad and Soberi 2018). SMED, a quality-control concept, has been extensively

applied to lessen turnover. Time spent performing changeover activities is a crucial component of this strategy (Garcia-Garcia et al., 2022). SMED allows changes in production to be made in the minimum amount of time. Internal operations and external operations are the two categories of setup operations. External operations are those that can still be performed while the machine is running, whereas internal operations can only be performed after the machine is stopped (Ribeiro et al. 2019). The use of 5S to shorten operational lead times The majority of businesses currently employ 5S not only as a tool for cleaning, sorting, organizing, and operating but also to decrease downtime and non-value-added tasks in the manufacturing process (Shahriar et al. 2022). This problem has been addressed using 5S, which aims to minimize the number of motions that a worker must carry out throughout an operation (Randhawa and Ahuja 2017). For instance, the use of a number of lean tools and techniques is likely to be constrained in manufacturing environments with highly changeable demand, a wide range of products, low quantities, and variable order processing times (Slomp et al. 2009).

This investigation was focused on decreasing the changeover time by dispensing with inefficient exercises and anomalies in the work region that could make squander. The SMED idea, joined with the 5S idea, was carried out to diminish the changeover time. The main objectives of this research were the reduction of die change time, the identification of 7 wastes, and the increase in the output of the production lines. To accomplish these goals, we began by investigating the factory's production process, and then we determined the key problems and possibilities for improvement. Finally, lean methodology-based modifications were suggested, and their impact was analyzed.

1.1 Objectives
The objective of this research is to significantly decrease changeover time in a plastic company by implementing the Single-Minute Exchange of Die (SMED) technique, synergized with lean manufacturing tools. This study aims to identify and eliminate inefficiencies in the changeover process, streamline procedures, and enhance overall operational efficiency. The primary goals are to reduce downtime, increase production capacity, lower costs, and improve responsiveness to customer demands. By assessing the current changeover practices, implementing SMED principles, and integrating lean manufacturing tools such as 5S, seven waste, and standardized work, the research intends to quantifiably measure the reduction in changeover time, assess its impact on production efficiency and quality, and provide actionable recommendations to empower the Plastic Company with the tools needed to excel in a competitive industry.

2. Methodology
The methods used in the current improvement project are presented in this section. The phases of the methodology covered in this part utilized fundamental methods of process improvement using lean tools. Applying numerous principles for process improvement follows next, as do instruments like manufacturing SMED, 5S, and 7 wastes. In this research, three cases were considered for reducing overall changeover time: one is Reduce 7 Wastes (Case 1), the second is Improvement of SMED with 5S and Seven Wastes Technique (Case 2), and the third is Total Change Over Works, which can be classified into external and internal works (Case 3). In order to reduce the amount of available waste, this study evaluated the evolution of the injection mold over time and pinpointed waste generation. This is how the research was conducted, as shown in Figure 1 by a flowchart, and details are below:

- Gathering injection mold changeover timetable data
- Using a timer to time how the injection mold changes over time and documenting that information on the operation analysis chart
- Using the Operation Analysis Chart, examine the work components and any possible waste that may have occurred.
- Using analytical cards to separate internal and external activity throughout the switchover procedure
- Implement 5S, 7 waste, and 5 Why in the workplace to support the SMED approach.
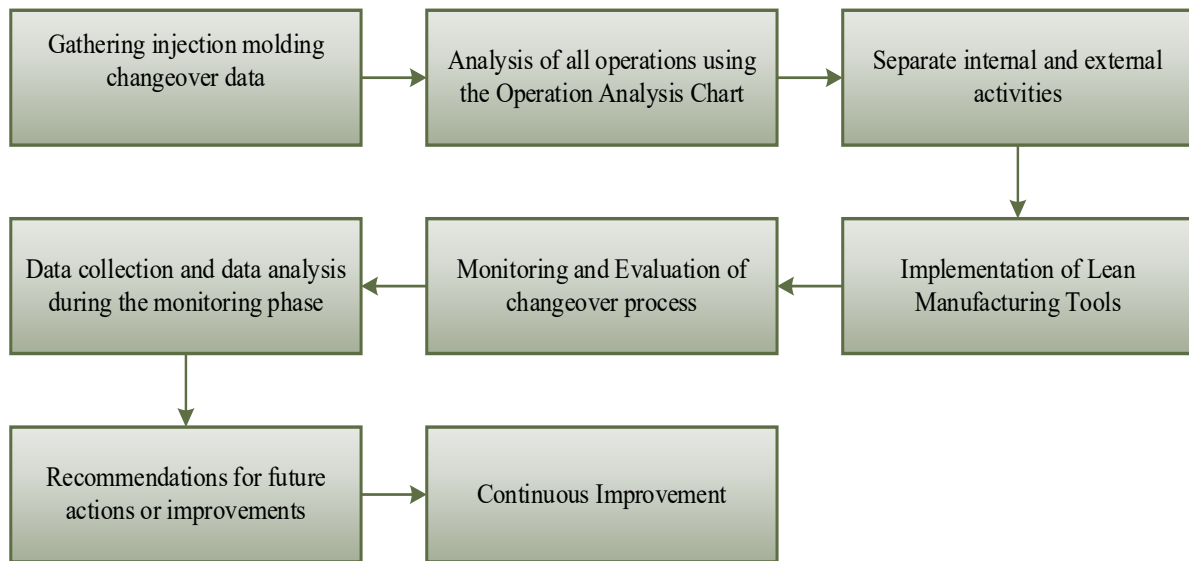- Monitoring evolution throughout time.

Figure 1. The flowchart of the proposed methodology

2.1 Concept of 5S

The goal is to be able to identify waste and abnormalities right away and make sure that anything that is superfluous or unnecessary in the workplace is taken out, and 5S ought to bring emphasis to and make waste visible (Chapman 2005). For instance, applying the 5S system will result in less walking and motion, a smaller number of errors, and more utilization of space. These are the five pillars of sorting, setting in order, shining, standardizing, and maintaining the 5S system. All of the aforementioned wastes need to be removed in order to operate a really lean storage facility.

2.2 Seven types of waste

The concept of the seven types of waste highlights inefficiencies in processes. Overproduction, defects, and waiting lead to resource waste. Inefficient transportation, excessive inventory, and unnecessary motion add to inefficiencies. Overprocessing consumes more resources than needed. Identifying and mitigating these wastes improves operational efficiency and sustainability in various industries, including plastics (El-Namrouty and Abushaaban, 2013). Unnecessary movement of people or machinery in plastic production, called motion waste, adds inefficiency. Moreover, overprocessing, involving excessive energy and resources for plastic products beyond required standards, contributes to waste generation.

The plastics industry contends with several types of waste that hinder efficiency and sustainability. Overproduction, characterized by excessive plastic manufacturing without corresponding demand, results in surplus and waste. Defects, such as flawed plastic items, lead to disposal due to quality issues. Inefficient transportation logistics cause the unnecessary movement of plastic goods, squandering resources. Delays in production or processes, known as waiting, lead to resource waste. Excessive accumulation of plastic materials or products, termed inventory waste, ties up resources needlessly. Unnecessary movement of people or machinery in plastic production, called motion waste, adds inefficiency. Moreover, overprocessing, involving excessive energy and resources for plastic products beyond required standards, contributes to waste generation. Table 1 shows the various kinds of waste inside a commonplace extruder die change and groups them into these seven wastes.

Table 1. The various kinds of waste and impact for extruder die change

Types of Waste	Description	Impact on Injection Molding
Overproduction	• Overproducing components beyond the current customer demand. • Increasing part production in expectation of additional orders. • Generating an excess of parts in response to scheduling issues.	Leads to surplus inventory, ties up resources, and increases costs.

Defects	• Manufacturing incorrect parts, which could involve deviations in specifications, color, or the use of incorrect raw materials. • Incorrect equipment setup. • Producing parts with either missing documentation or documents containing errors. • Mixing two various parts while shipping.	Wastes materials, labor, and time, impacting product quality.
Transportation	• Transferring a die from storage to an extruder. • The transfer of raw materials from the warehouse to the hopper of the extruder. • The transportation of ancillary equipment and tools.	Increases lead times, consumes energy, and hampers efficiency.
Waiting	• Downtime due to machine-related factors such as waiting for die heating or cooling, machine failures, or machine maintenance. • Delays caused by waiting for the arrival of materials. • Hold-ups stemming from personnel-related issues, like papermaking for quality inspection and approval or deviations from the production schedule. • Waiting for die availability, including time spent on tool repairs and adjustments when they are out of tolerance.	Results in idle machines, reduced throughput, and inefficiency.
Inventory	• Excess raw materials stockpiling - Holding an excessive quantity of resin in inventory. • Additional die inventory. • Redundant parts inventory - Manufacturing more parts than the required amount. • Additional spare/expendable machine items/tools.	Ties up capital, occupies space, and can lead to obsolescence.
Motion	• Manually operating security gates to extract parts from the mold, instead of employing sprue robots. • Wandering in search of tools. • Delays in the process of removing nuts, bolts, and clamps due to slow-paced actions.	Increases wear and tear, contributes to inefficiency, and fatigue.
Overprocessing	• Making many processing operations. • Using more resources than required for production.	Wastes energy, materials, and time, increasing production costs.

2.3 SMED (Single-Minute Exchange of Dies)

SMED (Single-Minute Exchange of Die) is a lean manufacturing technique designed to minimize equipment setup times. By streamlining and simplifying the changeover process, SMED reduces downtime between different production runs, enhancing productivity and flexibility (Agung and Hasbullah, 2019). The method focuses on separating internal and external setup tasks, converting them into parallel activities, and standardizing processes (Godina et al. 2018). SMED improves efficiency by allowing manufacturers to quickly switch between different tasks or products, thus optimizing production and resource utilization (Pellegrini et al. 2012). Figure 1 shows an extruder die change from an injection molding machine.
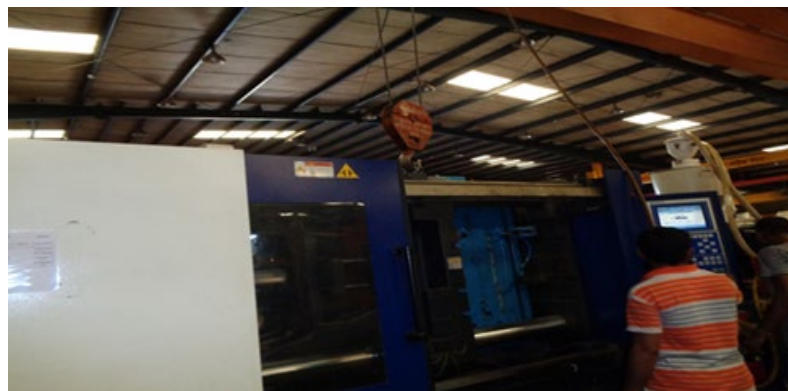

Figure 2. Extruder Die Change from machine

In the Bangladeshi plastics industry, SMED (Single-Minute Exchange of Die) holds significant potential for enhancing operational efficiency. By streamlining setup processes for molding and extrusion, SMED reduces downtime between production runs, allowing manufacturers to swiftly adapt to changing market demands. Through careful analysis and reorganization of tasks, like mold changes and material adjustments, the industry can minimize wasted time and resources. Implementing SMED techniques, such as standardized procedures and specialized tools, empowers Bangladeshi plastic manufacturers to achieve quicker changeovers, optimize production capacity, and stay competitive in a dynamic market while effectively managing costs. When the die of the extruder machine is changed, there are 13 works performed in a sequence. The works are: preheating the machine, cooling the water line open, cutting the unit open, printer removal, Take the die, heater open, die open, die close, Set the Heater, Start Heating, Cutting Unit Set, Printer Reset, Set Cooling Water Line.

Ten samples are taken to determine the required average time to change the die. The average time for each work is mentioned in the three tables. We are analyzing three sizes of dies for injection molding operations. The total time required for sizer-8 is 46.33 minutes, as shown in Table 2. Here we considered 13 operations in this process: preheating the machine, cooling the water line open, cutting unit open, printer removal, taking the die, heater open, die open, die closed, setting the heater, starting heating, cutting unit set, printer reset, and setting cooling water line time. On the other hand, a total of 35.05 minutes is determined for size 9 as shown in Table 3, and the total time required for size 10 is 25.10 minutes, as shown in Table 4.

Table 2. Total operational time for sizer-8

Analytical chart of Extruder Die before SMED implemention													
Model No. and Name (Sizer-8)													
	Description of Operation												
Work Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	
Sample No.	Preheating the Machine	Cooling Water Line Open	Cutting Unit Open	Printer Remove	Take the Die	Heater Open	Die Open	Die Close	Set the Heater	Start Heating	Cutting Unit Set	Printer Reset	Set Cooling Water Line	Average
1	6.92	1.15	1.15	1.15	1.15	2.31	3.46	3.46	3.46	13.85	2.31	2.31	2.31	44.99
2	6.80	1.50	1.62	1.90	1.30	2.50	3.50	3.60	3.45	14.30	2.15	2.15	2.20	46.97
3	6.85	1.90	1.70	1.70	1.25	2.70	3.70	3.80	3.65	14.10	2.60	2.20	2.50	48.65
4	7.20	2.30	1.90	1.50	1.15	2.90	3.90	3.92	3.60	12.85	2.50	2.10	2.60	48.42
5	6.50	1.20	2.10	2.10	1.10	1.90	2.95	3.50	3.20	14.15	2.10	2.30	2.10	45.20
6	6.40	2.10	1.20	1.30	2.10	1.85	3.10	3.10	3.30	13.50	2.40	2.60	2.25	45.20
7	6.20	1.10	1.30	1.60	1.90	2.10	3.20	3.30	3.10	13.90	2.15	2.40	2.35	44.60
8	7.80	1.70	0.90	2.10	1.70	2.60	3.40	3.20	3.25	13.60	2.60	2.20	2.45	47.50
9	8.40	1.90	1.50	0.90	1.50	2.30	3.50	3.25	3.60	13.40	2.20	1.95	2.55	46.95
10	5.60	1.40	2.10	1.10	1.00	2.20	3.10	3.40	3.90	14.20	2.25	2.50	2.10	44.85
Average	6.87	1.63	1.55	1.54	1.42	2.34	3.38	3.45	3.45	13.79	2.33	2.27	2.34	46.33

Table 3. Total operational time for sizer-9

Analytical chart of Extruder Die before SMED implemention													
Model No. and Name (Sizer-9)													
	Description of Operation												
Work Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	
Sample No.	Preheating the Machine	Cooling Water Line Open	Cutting Unit Open	Printer Remove	Take the Die	Heater Open	Die Open	Die Close	Set the Heater	Start Heating	Cutting Unit Set	Printer Reset	Set Cooling Water Line	Average
1	5.38	0.90	0.90	0.90	0.90	1.80	2.70	2.70	2.70	10.77	1.80	1.80	1.80	35.05
2	5.20	0.95	0.95	0.91	0.88	1.58	2.50	2.60	2.90	10.50	1.80	1.50	1.65	33.92
3	5.40	0.80	0.91	0.92	0.85	1.60	2.80	2.80	2.60	10.90	1.50	1.60	1.95	34.63
4	5.25	0.75	0.80	0.87	0.82	1.90	2.90	2.90	2.80	10.85	1.60	1.65	1.57	34.66
5	5.70	0.99	0.85	0.85	0.95	1.70	2.95	2.50	2.55	10.65	1.90	1.95	1.85	35.39
6	5.90	0.85	0.83	0.93	0.91	1.85	2.85	2.55	2.64	10.80	1.40	1.93	1.98	35.42
7	5.30	1.10	0.92	0.84	0.86	1.80	2.70	2.85	2.70	10.70	1.70	2.10	2.10	35.67
8	5.50	1.15	0.75	0.82	0.91	1.95	2.65	2.75	2.75	10.75	1.65	2.20	1.95	35.78
9	5.60	0.96	0.80	0.88	0.92	1.94	2.75	2.65	2.80	10.90	1.95	1.56	1.60	35.31
10	4.95	0.94	0.88	0.89	0.96	1.85	2.60	2.75	2.65	10.95	1.92	1.80	1.55	34.69
Average	5.42	0.94	0.86	0.88	0.90	1.80	2.74	2.71	2.71	10.78	1.72	1.81	1.80	35.05

Table 4. Total operational time for sizer-10

Analytical chart of Extruder Die before SMED implemention													
Model No. and Name (Sizer-10)													
	Description of Operation												
Work Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	
Sample No.	Preheating the Machine	Cooling Water Line Open	Cutting Unit Open	Printer Remove	Take the Die	Heater Open	Die Open	Die Close	Set the Heater	Start Heating	Cutting Unit Set	Printer Reset	Set Cooling Water Line	Average
1	3.85	0.64	0.64	0.64	0.64	1.28	1.92	1.92	1.92	7.70	1.28	1.28	1.28	24.99
2	3.82	0.65	0.67	0.63	0.63	1.30	1.97	2.00	2.30	7.75	1.30	1.26	1.26	25.54
3	3.60	0.67	0.68	0.62	0.68	1.35	1.95	2.11	2.50	7.88	1.35	1.29	1.33	26.01
4	3.95	0.69	0.61	0.67	0.62	1.50	1.96	2.15	1.80	7.20	1.47	1.24	1.35	25.21
5	3.85	0.70	0.63	0.68	0.65	1.20	1.85	1.94	1.96	7.25	1.25	1.55	1.40	24.91
8	3.92	0.72	0.66	0.61	0.69	1.45	1.80	1.97	1.97	7.36	1.15	1.45	1.15	24.90
7	3.87	0.56	0.68	0.65	0.67	1.50	2.00	1.96	1.68	7.25	1.18	1.15	1.20	24.35
8	3.98	0.55	0.63	0.63	0.56	1.35	2.15	1.65	1.75	7.88	1.36	1.22	1.15	24.86
9	3.99	0.72	0.65	0.68	0.52	1.35	1.80	1.82	1.99	7.85	1.34	1.14	1.18	25.03
10	3.75	0.66	0.69	0.67	0.70	1.29	1.70	1.86	1.86	7.95	1.36	1.40	1.35	25.24
Average	3.86	0.66	0.65	0.65	0.64	1.36	1.91	1.94	1.97	7.61	1.30	1.30	1.27	25.10

3. Results and Discussion

In this part, the changeover process is compared to how it was before and after the changeover optimization project was implemented. The team focused on three lean manufacturing techniques: minimizing changeover time, decreasing waste, decreasing handling time, and leveling production through minimizing process WIP. Implementing 5S in injection molding streamlines operations: removing clutter, organizing tools, maintaining cleanliness, standardizing processes, and ensuring continuous improvement. This fosters efficiency, safety, and quality in plastic manufacturing, enhancing productivity and reducing waste.

| (a) | (b) |

Figure 3. (a) Seiri implementation and (b) Seiton implementation

A Seiri implementation with the grouping of work equipment essential for the change is shown in Figure 2 (a). A Seiton implementation identifying the plastic sizers is shown in Figure 2(b). The implementation of Seiton was done to reduce waste caused by a lack of identification in both the extruder die and its attachments.

Model No. and Name (Sizer-8)			Operation working time (sec)											
Work Sequence Step No.	Description of Operation	Time (min)	0-100	100-200	200-300	300-400	400-500	500-700	700-900	900-1100	1100-1300	1300-1500	1500-1700	1700-1900
1	Preheating the Machine	6.87 (~410sec)	■	■	■	■								
2	Cooling Water Line Open	1.63 (~100sec)		■										
3	Cutting Unit Open	1.55 (~90sec)			■									
4	Printer Remove	1.54 (~90sec)			■									
5	Take the Die	1.42 (~85sec)				■								
6	Heater Open	2.34 (~140sec)				■								
7	Die Open	3.38 (~205sec)					■							
8	Die Close	3.45 (~210sec)						■						
9	Set the Heater	3.45 (~210sec)							■					
10	Start Heating	13.79 (~825sec)								■	■			
11	Cutting Unit Set	2.33 (~140sec)										■		
12	Printer Reset	2.27 (~135sec)										■		
13	Set Cooling Water Line	2.34 (~140sec)											■	
	TOTAL	46.33 (~2770sec)												1860

Figure 4. Standard work combination sheet after SMED for Sizer-8

The Standard Work Combination Sheet (SWCS) takes center stage post-SMED implementation for Sizer-8 in the plastic industry. This document precisely delineates the optimized sequence for setup, encompassing disassembly, tool changes, material adjustments, and quality checks. Allocated responsibilities and timeframes ensure smooth transitions between production runs, diminishing downtime. The SWCS, an evolving reference, bolsters the gains from SMED, perpetuating streamlined practices. Through continuous review, it propels operational efficiency, minimizes waste, and reinforces competitiveness in plastic manufacturing.

The normal change over time for sizer-8 is 2770 second. By rearranging for preceding the works we can set sizer-8 at 1860 second shown in figure 4. Focus step-1, 410sec is required for preheating the machine. Within this time, we can perform step-2,3,4,5 and 6. . Here we considered 13 operations in this process: preheating the machine, cooling water line open, cutting unit open, printer removal, taking the die, heater open, die open, die closed, setting the heater, starting heating, cutting unit set, printer reset, and setting cooling water line time. Similarly for sizer-9 and sizer-10 we can preceding the works shown in figure 4 and 5. The normal change over time for sizer-9 is 2100 second. By rearranging for preceding the works we can set sizer-9 at 1520 second shown in figure 5. Similarly, the normal change over time for sizer-10 is 1500 second. By rearranging for preceding the works we can set sizer-10 at 1120 second shown in figure 6.

Figure 5. Standard work combination sheet after SMED for Sizer-9

Model No. and Name (Sizer-10)		Operation working time (sec)												
Work Sequence Step No.	Description of Operation	Time(min)	0-100	100-200	200-300	300-400	400-500	500-700	700-900	900-1100	1100-1300	1300-1500	1500-1700	1700-1900
1	Preheating the Machine	3.86 (~240sec)												
2	Cooling Water Line Open	0.66 (~40sec)												
3	Cutting Unit Open	0.65 (~40sec)												
4	Printer Remove	0.65 (~40sec)												
5	Take the Die	0.64 (~40sec)												
6	Heater Open	1.36 (~80sec)												
7	Die Open	1.91 (~120sec)												
8	Die Close	1.94 (~120sec)												
9	Set the Heater	1.97 (~120sec)												
10	Start Heating	7.61 (~460sec)												
11	Cutting Unit Set	1.30 (~80sec)												
12	Printer Reset	1.30 (~80sec)												
13	Set Cooling Water Line	1.27 (~80sec)												
	TOTAL	25.10 (~1500sec)									1120			

Figure 6. Standard work combination sheet after SMED for Sizer-10

Total change over works can be classified into external and internal works. Here external works mean the works that can be performed before shutdown the production system for die change. The external works in this process are take the die and preheating the machine. On the other hand, internal works means which works that are done during nonproduction time. We needed a number of modifications, such as improvements to the workflow using the SMED idea and changing internal tasks to external ones, to decrease the change over time. Table 5 to Table 7 shown the outcomes of workflow modifications based on the SMED idea, where internal tasks are changed to external activities, resulting in a quicker change over time. By rearranging the preceding works, we found the total time for sizer 8 is 46.36 min, and after improvement, it is 38.07 min, as shown in Table 5. Similarly, the total time for sizer 9 is 35.07 minutes, and after improvement, it is 28.75 minutes, as shown in Table 6, and total time for sizer 10 is 25.12 minutes, and after improvement, it is 20.62 minutes, as shown in Table 7.

Table 5. Analysis of work category sheet for sizer-8

Opreation Analysis Chart					
Model No. and Name (Sizer-8)					
Sl. No.	Job description	Time (min)	Category	Setup type	Improvement Time (min)
1	Preheating the Machine	6.87	Non-Added Value	External	0
2	Cooling Water Line Open	1.63	Added Value	Internal	1.63
3	Cutting Unit Open	1.55	Added Value	Internal	1.55
4	Printer Remove	1.54	Added Value	Internal	1.54
5	Take the Die	1.42	Non-Added Value	External	0
6	Heater Open	2.34	Added Value	Internal	2.34
7	Die Open	3.38	Added Value	Internal	3.38
8	Die Close	3.45	Added Value	Internal	3.45
9	Set the Heater	3.45	Added Value	Internal	3.45
10	Start Heating	13.79	Added Value	Internal	13.79
11	Cutting Unit Set	2.33	Added Value	Internal	2.33
12	Printer Reset	2.27	Added Value	Internal	2.27
13	Set Cooling Water Line	2.34	Added Value	Internal	2.34
	Total Time (min)	46.36			38.07

Table 6. Analysis of work category sheet for sizer-9

Opreation Analysis Chart					
Model No. and Name (Sizer-9)					
Sl. No.	Job description	Time (min)	Category	Setup type	Improvement Time (min)
1	Preheating the Machine	5.42	Non-Added Value	External	0
2	Cooling Water Line Open	0.94	Added Value	Internal	0.94
3	Cutting Unit Open	0.86	Added Value	Internal	0.86
4	Printer Remove	0.88	Added Value	Internal	0.88
5	Take the Die	0.90	Non-Added Value	External	0
6	Heater Open	1.80	Added Value	Internal	1.8
7	Die Open	2.74	Added Value	Internal	2.74
8	Die Close	2.71	Added Value	Internal	2.71
9	Set the Heater	2.71	Added Value	Internal	2.71
10	Start Heating	10.78	Added Value	Internal	10.78
11	Cutting Unit Set	1.72	Added Value	Internal	1.72
12	Printer Reset	1.81	Added Value	Internal	1.81
13	Set Cooling Water Line	1.80	Added Value	Internal	1.8
	Total Time (min)	35.07			28.75

Table 7. Analysis of work category sheet for sizer-10

Opreation Analysis Chart					
Model No. and Name (Sizer-10)					
Sl. No.	Job description	Time (min)	Category	Setup type	Improvement Time (min)
1	Preheating the Machine	3.86	Non-Added Value	External	0
2	Cooling Water Line Open	0.66	Added Value	Internal	0.66
3	Cutting Unit Open	0.65	Added Value	Internal	0.65
4	Printer Remove	0.65	Added Value	Internal	0.65
5	Take the Die	0.64	Non-Added Value	External	0
6	Heater Open	1.36	Added Value	Internal	1.36
7	Die Open	1.91	Added Value	Internal	1.91
8	Die Close	1.94	Added Value	Internal	1.94
9	Set the Heater	1.97	Added Value	Internal	1.97
10	Start Heating	7.61	Added Value	Internal	7.61
11	Cutting Unit Set	1.3	Added Value	Internal	1.3
12	Printer Reset	1.3	Added Value	Internal	1.3
13	Set Cooling Water Line	1.27	Added Value	Internal	1.27
	Total Time (min)	25.12			20.62

The examination of the information and data assembled prompted huge improvements to be completed in three classes, to be specific: procedural, mechanical, and organizational, to carry out mold setup time reductions. Procedural improvements are intended to examine the effectiveness of the strategies utilized to complete an arrangement. Tables 8 and 9 show the outcomes of workflow modifications based on the SMED idea, where internal tasks are changed to external activities, resulting in a quicker change over time. By using this approach, we can reduce die change over time by approximately 26% to 33% in the extrusion time. According to Case 2, it is a very time-reducing method, and by using this approach, we can reduce die change over time by approximately 18% in the extrusion time for each overall die changeover time.

Table 8. Comparison of result for case- 2

Comparison of the average change over time before and after SMED implementation			
Style	Before SMED	After SMED	Improvement (%)
Sizer-8	46.33	31	33%
Sizer-9	35.05	25.33	28%
Sizer-10	25.1	18.66	26%

Table 9. Comparison of result for case -3

Comparison of the average change over time before and after SMED implementation			
Style	Before SMED	After SMED	Improvement (%)
Sizer-8	46.36	38.07	18%
Sizer-9	35.07	28.75	18%
Sizer-10	25.12	20.62	18%

4. Conclusion

The aims of this project were to decrease the changeover time, increase production, reduce inventory, and deliver products on schedule. The plastic manufacturing process, flow injection molding, and the accepted standards Procedures must be completely comprehended. Execution of SMED could decrease the changeover time by 18%-33%. The most essentially decreased changeover time was 33% comparison of result for case- 2. To make this examination, there we propose things that might be utilized in further examinations. The decrease of changeover time may altogether increment on the off chance that we put resources into mechanical apparatuses, particularly utilized for inward exercises. The effect of a decreased changeover time can be examined further, particularly

saving the expenses in the fields of preparing time, speed of conveyance, nature of conveyance, and the consumer loyalties. The conditions that have restricted the accomplishment of this execution hitherto can happen in any association, however persistence is fundamental for proceed with the drive towards more noteworthy adaptability and more effective assembling.

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