Chapter 13
Optimization of Changeover Time in a Manufacturing Enterprise Using Single Minute Exchange of Dies (SMED): A Case Study

Aditya Bassi, Harkrit Chhatwal, Nishant Bhasin, Shubham Sharma, and Ruchika Gupta

Abstract This paper presents a case study where the implementation of lean techniques in the changeover time of stereo in a Flexo printing machine were investigated to study its impact. During this study, the problem with high changeover time during printing were investigated through SMED (Single minute exchange of dyes). The research includes the analysis of current system depicting the existing problems within the company. The methodology aims to analyse the root cause of existing problems and thus provide implementation of improvement plan. At the end of the investigation, a few solutions were successfully implemented. The results demonstrates the steps taken to optimize the changeover time which was reduced to around 29 min. Thereby, an improvement of 10% was achieved. Hence, decreasing the changeover time resulted in increased productivity and processing time in the manufacturing unit.

Keywords SMED · Quick change over time · Internal and external activities · 5S

13.1 Introduction

Lean management was originated from Toyota production house and as stated by many authors it works on exaggerating the products value by streamlining the operations in a production setup. Lean methodologies can be enforced in the manufacturing sector in various ways such as reduction in defects, shortening of the lead time and reducing the changeover time. There are variety of lean methodology tools like identifying and sorting of Value Added and Non-Value-Added activities, 5S, SMED (Single Minute Exchange of Dies), Kaizen, Standardized Work and JIT (Just in time).

In these modern times, application of lean six sigma has spread all around the globe. These techniques are often implemented in the manufacturing industry in order to reduce the cost of production, maintain the product quality and sustaining a

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good customer relation. One of the tools which we used in our research project was SMED. It is an approach to reducing output and quality losses due to changeovers. C/O (Changeover) time is the amount of time consumed between the last piece of present product and the first piece of the next product. Reducing the changeover time helps the big, medium-sized and small-scale industries to meet the customers demand and thus leads to increase in their profits. In this method the process is studied by doing videography and examined on multiple occasions. After this process, all the activities are listed down and are segregated into internal (when the machine is running) and external activities (when the machine is stopped). The aim is to convert as many internal activities to external ones in order to reduce the overall time of production and hence meet the customers demand. 5S (Sort, set in order, Shine, Standardize and sustain) is a method that consists of five Japanese words which focuses on setting everything in order and sustaining the workplace clean. This eventually allows the workforce perform their job in a systematic manner without risking their life.

This paper aims to present the implementation sequence and level of importance regarding Lean-SMED techniques at a non-woven bag manufacturing firm.

13.2 Research Background

These days, organizations need to make the products as indicated by the necessities and prerequisites of their customers. Apart from that, customers also desire their product to be delivered on time and for that the lead time for the production is the key. For that, lean production system must be in place as it gives an edge to the companies who implement them in this highly competitive market. For a lean system, the removal of non-value adding activities and wastes is very imperative. Ohno [1] describes waste as any activity that does not value to the product from the customer's point of view. To reduce such non-value activities or wastes, there are a variety of tools that can be used like 5S, Value Stream Mapping and SMED.

Single Minute Exchange of Dies, or simply SMED assures a less changeover time and efficient transition of the machine setup usually less than ten minutes as explained by Shingo [2]. The Changeover time is the total amount of time elapsed between the last product produced in the previous run of the machine to the first different product produced in the next run. This amount of time is spent on cleaning and altering preparing the machine setup for next product. A setup can be defined as the transitioning of a machine to produce a product to a different product. Sousa et al. [3] describes that implementation of SMED involves a deep analysis of each and every setup operation. Setup operations can be characterized as Internal and External Setup. A literature review by Yash and Nagendra [4] covers the implementation of SMED by saying that it may represent the key factor for providing more flexibility and enhanced product flow in the manufacturing unit. Moreover, the main steps for implementing SMED includes judging the current state process, separating the internal and external activities and streamlining the process of changeover.

Goubergen and Landeghem [5] categorized three reasons for reducing setup times which includes Flexibility, Bottlenecks and Costs minimization. Flexibility is due to the large variety of products and any manufacturing company should react quickly according to the customer needs in order to maintain its reputation in the market. Bottlenecks should be minimized to maximize the availability for producing more. Costs minimization is very important as in any manufacturing unit, the production costs are directly proportional to the machine performance.

A critical evaluation of Shingo's methodology on SMED by McIntosh et al. [6] argues that the application of improvement techniques in some of the stages of SMED does not always prove to be effective. Whereas, a study by Abraham et al. [7] demonstrated the effectiveness of SMED by reducing the setup time of a press machine by 75%. This was achieved by identifying the bottlenecks and eliminating the non-value-added activities from the existing process leading to significant improvement in productivity.

SMED is one of the ideal methods to strengthen the output and minimize the quality loss in any manufacturing process as said by Prof. Nagaraj A. Raikar [8]. Apart from the value-added benefits, decreasing the changeover time results in additional advantages such as cost reduction, standardization, and better workload as showed by Ribeiroa et al. [9]. The Overall Equipment Efficiency (OEE) increases by decreasing the equipment downtime with Changeover as explained by Rahul and Naik [10] in a case study.

There are many more examples of the application of SMED that can be found to prove that this tool can be applied in a plethora of industries. One such example can be of a pharmaceutical company by Gilmore and Smith [11] where the setup time was reduced from 28.8 to 8.25 h with the help of SMED.

13.3 Methodology

The Lean six sigma project being reported here was carried out Planet Green Innovations which is part of Sterimed Group of companies. The company was recently facing major problems in the management of their inventory specifically the maintenance of their inventory levels. During the operations of the ongoing project, Changeover times were considered as the scope for improvement where some Lean Six-Sigma tools were applied and appropriate suggestions were given for improvement. The technique which was used is called SMED. The steps taken in the project are explain below.

13.3.1 Data Collection

Data collection is the initial phase of any Lean Six Sigma project. It is that phase where we are able to identify the customer and the requirements for the product and

Table 13.1 Translation matrix

V.O.C	CTQ	CTQ measure	CTQ specification
Huge pending orders	Change over time	Overall production rate	Reduction in change over time by 22%

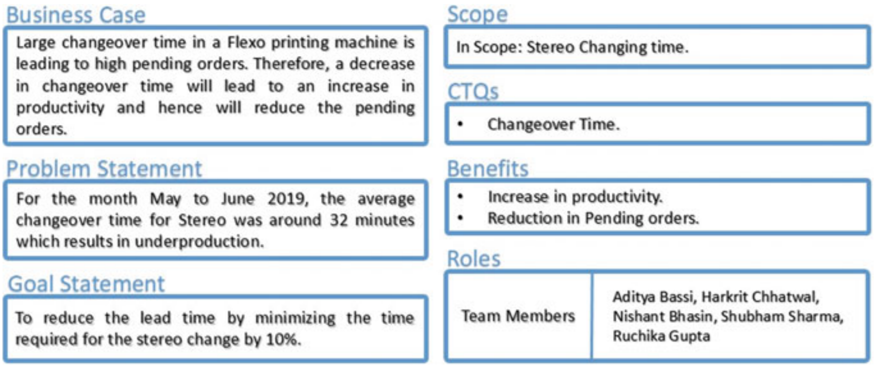


Fig. 13.1 Project charter

services. This phase plays a vital role as it helps in identifying the goals and aligns the project by laying the groundwork that will allow the team to remain focused.

One of the first phases of data collection is to identify the VOC (Voice of Customer) and the various steps required to convert it into CTQ (Critical to Quality). The conversion of VOC to CTQ is depicted below in Table 13.1. The table showcases the company's demand to increase the Overall Production rate to complete the huge existing and Pending orders and aims at achieving it by reducing the changeover time by approximately 22%.

Once the translation matrix is generated, next step is to construct a project charter which will exhibit the Problem Statement, Goal Statement and the benefits of carrying the project. The project charter shown in Fig. 13.1 displays the problem statement which mentions a large changeover time in the manufacturing, consequences of which are reduction in productivity and decrease in company's revenue. Furthermore, the goal statement defines minimization of stereo changeover by 10% in order to increase the operation productivity.

13.3.2 Data Analysis

Often many tend to avoid the analyse phase as we are able to identify the problems earlier only in our project. But this phase is important because it clearly defines how well the process is currently performing and identifies how much the process can be improved. We are able to develop hypotheses which helps us to validate and identify vital root causes of the problem in hand (Fig. 13.2).

One of the prime Lean six sigma tools used to find the root cause of the problem is the Ishikawa or the Fishbone diagram. It is a drill down process which enables us to point out the factors, causes and sub causes of the desired problem. In other words, we can say it helps in identifying the root cause of the given problem we look to find solutions for.

The cause and effect diagram depicted factors which effected the most on the inaccurate inventory levels. The major factors are:

- **Material not available**—one of the problems the operators tends to face is the unavailability of the material (cloth roll) at the appropriate time. This leads to increase in the non-value-added time and decreases the productivity.
- **Operator Training**—Lack of training plays a vital role as an unskilled worker will obviously take more time for setting up the new stereo and the roller on the machine.
- **Unavailability of tools**—During the setting up of the new stereo and the roller there are certain tools which are required. Often, they are not found because of misplacement. This causes delay and increase in change over time (Fig. 13.3).

Furthermore, in the analysis phase of the project we noted down the changeover time for stereo change for the month of June. The above table represents the data that was collected for the month of June. Every day the number of changeovers used

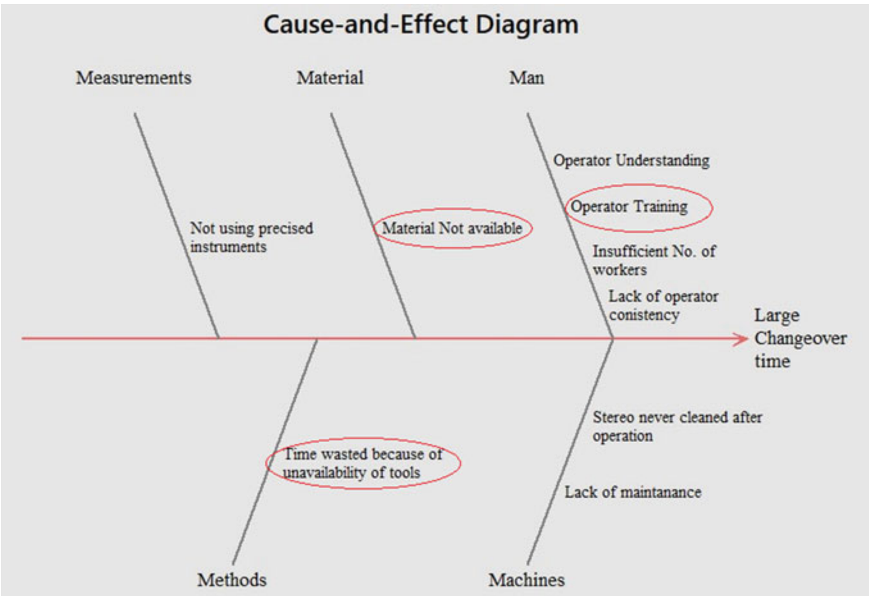


Fig. 13.2 Cause and effect diagram

Stereo Changeover time (June)	Average Changover time per day		Date	Changeover time
32	33.3		02 June 2020	33.3
37			03 June 2020	27
31			04 June 2020	34
25	27.0		05 June 2020	28.3
29			06 June 2020	25.5
27			07 June 2020	34
30	34.0		08 June 2020	29.8
34			09 June 2020	35
38			10 June 2020	36
29	28.3		11 June 2020	37
28			12 June 2020	35.5
28			13 June 2020	34.3
26	25.5		14 June 2020	28.5
25			15 June 2020	25.5
35	34.0		16 June 2020	34
33			17 June 2020	26
31	29.8		18 June 2020	32.5
28.5			19 June 2020	33.5
36	35.0		20 June 2020	34.5
37			mean	31.8
32				
35	36.0			
37				
36				
40	37.0			
35				
38	35.5			
33				
30.5	34.3			
38				
29	28.5			
28				
25	25.5			
26				
33	34.0			
35				
23	26.0			
29				
27	32.5			
38				
35	33.5			
32				
33	34.5			
36				

Fig. 13.3 Changeover times

to vary depending upon the number of daily orders. We first noted the timings for every changeover and later took the each day in order to understand and represent it in a more productive manner. We plotted a graph represents the recorded time for changeover over the given month of June. The vertical axis represents the average changeover time on a specific day while the horizontal axis showcases different days of the month. On calculations the linear changeover time for the month of June came out to be 31.8–32 min. On further analysis and study of the manufacturing process

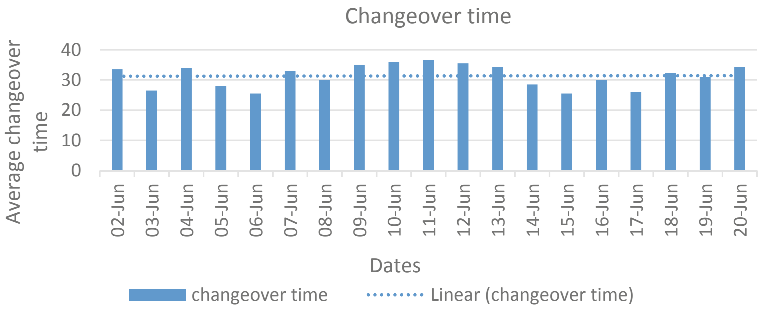


Fig. 13.4 Changeover time graph

we aimed at reducing this changeover time by 10% which will be able to make significant change in the productivity of the unit (Fig. 13.4).

13.3.3 Improvement Scope

One of the first steps in the improvement phase is the listing down of all the activities which takes place in the production of the certain product. Table 13.2 showcases all the steps which are performed in the production operation.

Once all the activities were stated, we then identified and segregated the External Activities. Moreover, we were poised to find out all the waste activities (Tables 13.3 and 13.4).

13.3.4 Implementation and Control Phase

After the identification of the all the steps and the internal, external and waste activities certain solutions were proposed according to the problems faced by the enterprise. Table 13.5 will showcase all the improvement solutions suggested and how these measures will bring change (Fig. 13.5).

The following images shows the implementation of the tag system in the industry. It can be clearly depicted that tags are now used on the cloth rolls specifying appropriate information required by the operator which will help him in identifying the rolls from the inventory.

Once the recommended solutions were proposed and started to get implemented in the unit, our next step in the project was to again calculate the changeover times after a period of 2–3 months to observe how much reduction we were able to achieve with our suggestions.

Figure 13.6 displays the changeover time readings in a graphical format. The vertical axis represents the average changeover time on specific days while the

Table 13.2 Production operation

S. No.	Steps
1.	Stock roll material was brought from the store
2.	Two people pick up the ink tray from the machine and then place it down on the floor
3.	They filled the ink back to the barrel which will not be used for the next job
4.	The operators then started cleaning the floor where the tray was kept
5.	The machine operator collected the stereo and altered it to the required dimensions
6.	On the back of the stereo double-sided tape was applied and extra tape was removed
7.	The operator observed the stereo for air bubbles and removes the bubbles with the help of a sharp pin
8.	The required stereo cylinder was searched and picked as per job specifications
9.	There was a search for Allen keys on the shop floor
10.	One of the operators unscrew the stud bolt and the already placed cylinder was removed
11.	The new required cylinder was then cleaned as it was already containing an old stereo
12.	Then the operator pasted the new stereo on the cylinder
13.	The empty cloth roll was removed from the machine
14.	After this there was a weight for the new stock material to arrive
15.	The shaft and the hub were attached to the new cloth Rolland it was put back on the machine
16.	After the preparation of the stereo on the cylinder, it was linked back to its position on the flexo machine
17.	Then one operator tights the stud bolt using Allen key while the other prepares the require ink colour
18.	The required ink tray was then cleaned with the help of thinner
19.	This tray was put back to its location on the machine and was then filled with required ink
20.	The gap between the stereo and the cloth was adjusted on the machine
21.	The machine was then started and the operator continuously checked the printed face by measuring with scale
22.	While doing this he observes any problem with the printed material and stops the machine if required
23.	The machine was again started with the appropriate adjustment

horizontal axis depicts the various days. On analysis and calculations, the average changeover time came out to be 28.91–29 min (Fig. 13.7).

The following graph depicts a comparison between the mean changeover time at the initial phase and the mean changeover time after the implementation of the desired suggestions. The difference came out to be in the region of 10% from the earlier figure of 31.90–32 min to 28.91–29 min.

Table 13.3 Internal activities

S. No.	Internal activities
1.	Two people pick up the ink tray from the machine and then place it down on the floor
2.	They filled the ink back to the barrel which will not be used for the next job
3.	The operators then started cleaning the floor where the tray was kept
4.	The machine operator collected the stereo and altered it to the required dimensions
5.	On the back of the stereo double-sided tape was applied and extra tape was removed
6.	The operator observed the stereo for air bubbles and removes the bubbles with the help of a sharp pin
7.	The required stereo cylinder was searched and picked as per job specifications
8.	There was a search for Allen keys on the shop floor
9.	One of the operators unscrew the stud bolt and the already placed cylinder was removed
10.	The new required cylinder was then cleaned as it was already containing an old stereo
11.	Then the operator pasted the new stereo on the cylinder
12.	The empty cloth roll was removed from the machine
13.	After this there was a weight for the new stock material to arrive
14.	The shaft and the hub were attached to the new cloth Rolland it was put back on the machine
15.	After the preparation of the stereo on the cylinder, it was linked back to its position on the flexo machine
16.	Then one operator tights the stud bolt using Allen key while the other prepares the require ink colour
17.	The required ink tray was then cleaned with the help of thinner
18.	This tray was put back to its location on the machine and was then filled with required ink
19.	The gap between the stereo and the cloth was adjusted on the machine

Table 13.4 External and waste activities

S. No.	External activities	Waste activities
1.	Sometimes cleaning of extra ink tray	Cleaning up of the floor where the ink tray is kept
2.	Stock roll material was brought from the store	Excess amount of tape is first applied and then it is removed which is considered as a waste activity
3.	The machine was then started and the operator continuously checked the printed face by measuring with scale	There is always a search for stereo cylinder to start a new job
4.		There is a search for Allen keys as the shop floor is always messed up
5.		A waiting for the stock material is observed

Table 13.5 Recommended solutions

Recommended solution	Implementation
1. Preparation of Stereo while the machine is running	The machine operators can prepare the stereo for the next order while the flexo printing machine is running. This will eventually save a lot of time in changeovers
2. Implementation of 5S	Implementation of 5S can help in solving a variety of problems in the industry • One of S in 5S is set in order. Set in order can be achieved by allotting proper slots for the tools to be kept • Furthermore, we proposed the idea of installing of a proper rack for the rollers to be kept in a systematic manner so that it becomes easy to identify it • Another solution we recommended was introducing of tags which will be applied on each cloth roll stating specific information about the cloth roll
3. Systematic dispatch of material from store	After careful analysis we suggested the firm to start a timely routine about at what time and what quantity of material can be dispatched from the store. This was suggested after we found that there was inadequate space available on the shop floor and thus it will lead to less claustrophobic WIP inventory
4. Proper training	Proper training should be given to the workforce to follow the system introduced
5. Weekly Maintenance of machine	A proper schedule is suggested for weekly maintenance of the machines in order to reduce the stoppage of production due to machine breakdown

Fig. 13.5 Tag system

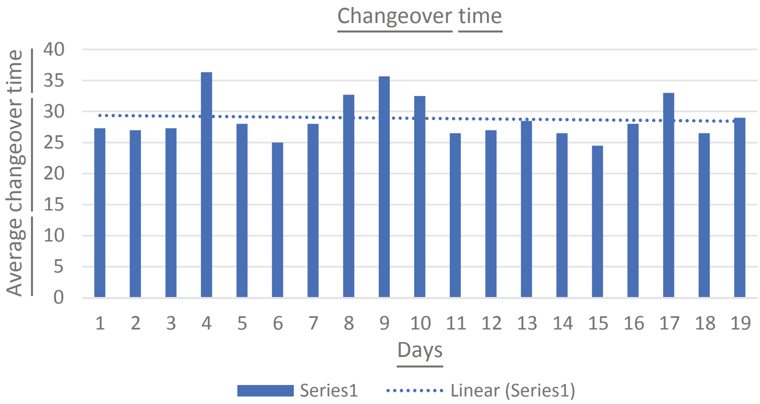
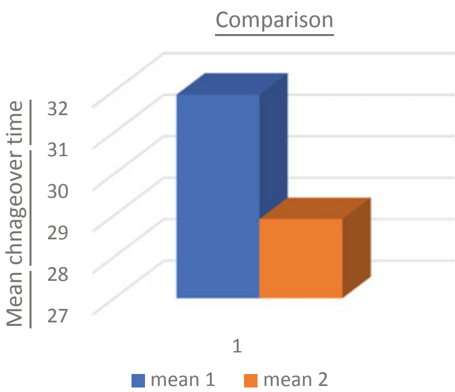


Fig. 13.6 New changeover times

Fig. 13.7 Comparison graph



13.4 Conclusion

The SMED technique of Lean Six Sigma tools was very helpful in conducting this project. Cause and effect diagram was an vital tool to identify the root causes of the problem and played significant part in completion of the project. On successful closure of the project we were able to reduce the mean changeover time by 10 %.

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