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SMED (Single Minute Exchange of Die) Methodology in Powder Coating Manufacturing Industry – Case Study in reducing Change over time

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A B S T R A C T

In today's economic world, acute agitation and harsh conflict characterize competition. This tumultuous environment has prompted businesses to re-energize themselves by following various paths such as Agile, Lean, TPM, TQM, and others in order to remain competitive in the market and achieve their goals.Nowadays, most businesses have adopted the tried-and-true strategy of Lean to outperform the competition. This situation has improved lean management tactics such as increasing the value stream, decreasing change over time, generating manufacturing flow, levelling production based on demand, and lowering capital investment, among others. The utilization of the source is mainly due to the capability of the organisation to change and manage the change. In this study, a powder coating manufacturing unit, which required set up time reduction and need to improve the productivity had been taken for project. The main objective is to reduce the change over time required for Kneader and Micropal during changing from one shade to next shade and improve the productivity. The scope includes the proposed implementation of new high pressure water cleaning, new assembly method, etc. A five-step methodology is used for set up time reduction to attain the objectives of the project. Additionally, the change-over operations were standardized and consequently the process has become faster and more intuitive for the operators

Keywords: Lean Production, SMED, Changeover time

1. Introduction

The current production environment necessitates low volume and high variation items. Only through lean manufacturing can this be accomplished. The current manufacturing approach, such as Just-in-Time manufacturing, necessitates smaller production quantities, which means longer setup time (non-productive time). In order to stay competitive, businesses should work on eliminating non-productive time. Thus, quick change over is a critical element in lean manufacturing. Quick changeover is also known as setup reduction which focuses on eliminating or reducing non value added activities during the setup. This helps companies to efficiently change the tool/mould from one part to another.

The SMED (Single Minute Exchange of Die) methodology, developed by Shingo (1985), was developed in order to reduce and simplify the setup time during change over. SMED makes it possible to respond to fluctuations in demand and results in lead time reductions, while also eliminating wastefulness during change over and diminishing lot sizes. The need for shorter changeover times has been increased from the last decade across all over industries. Now a day, market demands have shifted towards more product variants in parallel to customization and this evolution is not limited to certain types of industry; rather it is a general phenomenon. Customers require short delivery times and a high delivery reliability. The best way to overcome this problem is to produce small lot size in most economic and efficient way. It can be easily shown that there is a direct relationship between lot sizes and setup times. The shorter the changeover time, the smaller the lot size; therefore, it can be produced in an efficient way. A fundamental method to reduce set-up time, the SMED method, and all activities of setup operations can be divided into two categories: internal activities which are performed while the machine is Offline and therefore must be minimized because they decelerate the production, and external activities that are performed while the machine is running

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(Shingo, 1989). For many years, modifying the conventional SMED has received an extensive attention, and there are always arguments about the expected improvement obtained by improving activities within each implementation stage in order to focus the efforts to the implementation phase that produces the maximum improvement.

The various terms used in SMED are:

1) Change over time: Changeover time is referred to as the total time required for change from one product to the second product.

2) Set-up time: Setup time is the non-production time in which change over takes from one part to another.

3) Internal activities: The activities which are performed while the machine is offline or stopping the machine. Therefore, they must be minimized because they decelerate the production rate.

4) External activities: Operations that can be done without stopping the machine.

2. Literature Review

Single-Minute Exchange of Die (SMED) refers to the theory and techniques used for the reduction of equipment setup times. SMED has as its objective to accomplish setup times in less than ten minutes, i.e. a number of minutes expressed by a single digit. Although not all setups can be literally reduced to this time, between one and nine minutes, this is the goal of the SMED methodology (Shingo, 1985).

SMED, also known as Quick Change-over of Tools, was developed by Shingo (1985), who characterized it as a scientific approach for the reduction of setup times and which can be applied in any industrial unit and for any machine. SMED is defined as the minimum amount of time necessary to change the type of production activity taking into consideration the moment in which the last piece of a previous lot was produced in relation to the first piece produced by the subsequent lot (Shingo, 1985). Before the development of the SMED methodology, the best way to minimize the cost of idle machines during setup operations was to produce large lots, in order to obtain the lowest possible percentage of idle time per unit produced.

Benjamin claims in their article that Single Minute Exchange of Dies (SMED) is a technique used to reduce the operational downtime losses of set-up and changeover of the production process. This is accomplished by monitoring and identifying the various portions of the process and separating the internal (parts that must be performed while the machine is still operating) from the external (parts that can be performed while the machine is still running). According to Singh & Khanduja (2009), SMED has become a common strategy for reducing changeover time due to its efficiency.[1]

A changeover, or set-up, is when specific tasks must be accomplished at the end of a series while the machine is stopped before the next can be started, according to Benjamin. This could include swapping out dies or materials utilised in the process. The internal elements outlined in the SMED technique can be compared to this. The time between the completion of the last piece in a series and the approval of the first item in the following is known as changeover or set-up.[1]

After implementing the SMED methodology, it is possible to defend that simple process-based innovations, as the Separation of internal from external operations and the conversion of internal to external operations, are among the key drivers to productivity improvement.[3]

For small batch manufacturers the issues that led to the change in focus for long run producers have not been present to the same degree. SMED methodology applied to prepare an optimal standard procedure for changeover operations on defined machine. A Comparison of results and achievements before and after SMED implementation were made to measure the effectiveness of SMED to reduce cycle time. Hence, not only is it imperative to focus on reducing the amount of productive time that is lost when a machine is being set, but also to eliminate errors, with the application of poka-yoke principles to the setting equipment and procedures.[4]

Additional processes used in conjunction with the 5S method have improved the SMED method. The following improvements have been made as a result of using this method: The average tool exchange time period is lowered, and machine flexibility is increased as a result of the reduced tool exchanges in a controlled time period, increasing the number of components that may be produced.[5]

Because a programme has a beginning and an end, SMED is a process rather than a programme. As a result, regular maintenance and upgrades through SMED must be implemented.[6]

It is important to note the methodology developed by Shingo SMED as well as the derived approach proposed don't have a strict, application and it is fundamental to adapt them to the reality of the companies to be successful implemented and that is essential to mixed up functional and structural changes into implementation entails. As we have shown most of the times is not necessary to make big investments to achieve reduced changeover times if we examine well the existing resources and reorganized them to be more effective.[7]

SMED philosophy was adopted to investigate the setup operations. It primarily consisted of analyzing the external and internal setup activities in terms of their need (i.e., preparation,replacement or adjustment), time taken and the way these could be reduced, simplified or eliminated.[8]

3. Proposed SMED Methodology

Step 1: Identifying Pilot Area

In this stage, the ideal equipment was decided for SMED implementation based on duration, variation, opportunities and constraint.

Step 2: Identify elements

In this stage, the entire change over process was break down into number of elements and the time required for performing each element was recorded.

Step 3:Separate internal and external elements.

In this step we have separated the internal operations and external operations. Operations that are not required can be eliminated directly.

Step 4: Convert internal elements to external elements

The techniques like advance preparation, performing alignment and other adjustments in advance to the changeover, modularize equipment, modify equipment, etc. can be used.

Step 5: Streamlining all aspects of change over operation

This step also includes the basic improvement of internal and external setup in machine and developing different methods of complete the tasks in easier, faster and safely ways. The techniques such as use of quick release mechanism or other type of functional clamp; eliminating adjustments; eliminating motions; eliminating waiting; creating parallel operations; mechanization; etc. can be used.

4. Implementation

The production schedule for the last three months has been analyzed. The analysis showed that Kneader Change-over were the bottle neck in the company. Change-over process is 5 thoroughly evaluated on the Kneader. It is found that there are several non-value added activities happening during the Change-over process. The company is more into agile manufacturing and it needs continuous shade changes. The less time in shade change-over will improve the productivity of the company. Tools used for change-over time reduction are SMED, 5S, SOP, Poka-Yoke etc.

4.1. Time Study

Table 1 shows the average time taken by different elements of Kneader Change-over Process. Some operations were performed in parallel with other operations as there are two operators per Kneader. Hence time spent on parallel operations is not included in total actual time required. One operation of log-sheet filling was performed external to changeover. Therefore, time required for external operation is not considered in total change-over time. The average kneader changeover time sums up to 48 minutes.

Table 1 – Time study of Kneader changeover

Activity	Time(m)	Present
Crusher Cleaning	13	I
Machine Area Cleaning	13	I
Container Cleaning	7	I & P
Belt Cleaning	7	I
Roller Cleaning	4	I
Die Cleaning	4	I & P
Barrel Cleaning	3	I
Movement	3	I
Feed Hopper Cleaning	3	I
Machine Body Cleaning	2	I
Assembly	2	I & P
Start & Stop operations	2	I & P
Filling log-sheet	0	E
Total time	**63**	
Actual time required	**48**	

4.2. Bottleneck Identification

The collected detailed times are analyzed for finding out the bottleneck process during change over which is shown in the Fig. 1 below:

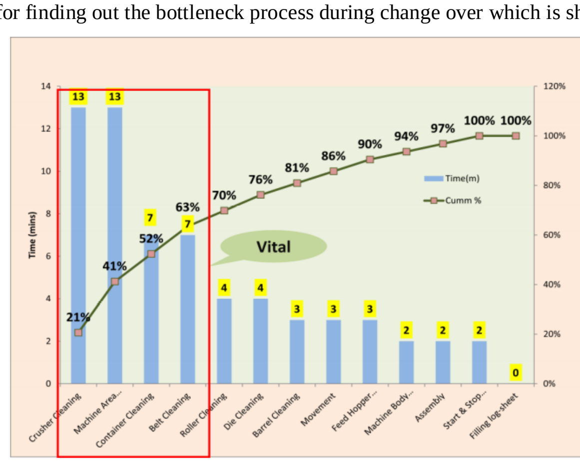

Fig. 1 - Pareto Analysis of Kneader Changeover

To reduce the overall changeover time these vital elements are further analysed and breakdown into minor element. The feasibility study is done and improvement ideas are suggested.

4.3. Crusher cleaning process improvement

To identify the root cause leading to excess time required for crusher cleaning, why-why analysis was carried out as shown in the Table 2

Table 2 – Why-why analysis of Crusher Cleaning

Why - Why Analysis	
Problem	Crusher cleaning is taking longer time
Why?	More cleaning time required to remove sticked material
Why?	Air cleaning of crusher to be followed by water cleaning and again by air cleaning
Why?	Cleaning with only pressurized air is not optimum
Why?	Flakes and some powders are formed and gets sticked to the crusher

From the Why-why analysis it was inferred that cleaning with pressurized air and later with tap water is not the optimal solution. It leads to excess time requirement to complete the cleaning process.

Therefore, as an improvement idea it was suggested to use "Pressurized Water" for cleaning process instead of pressurized air and normal water.

The following benefits were achieved by using pressurized water cleaning:

- Boost's cleaning process and eliminates first air cleaning cycle
- Better Cleaning achieved
- It can be used for cleaning of other parts as well
- Less water was required compared to previous process

Table 3 – Crusher Cleaning Process Improvement

Activity	**Time(m)**	**Current**	**After**	**Time(m)**
Air Cleaning of Crusher	7	I	Eliminate	0
Water Cleaning of Crusher	3	I	I	4
Second Air Cleaning of Crusher	3	I	I	3
Total	**13**			**7**
			Time Saved = 6 mins	

4.4. Machine area cleaning process improvement

The Table 4 shows the breakdown of Machine area cleaning process and their respective time spent. It was noted that all the operations were carried out as internal and there is scope for improvement.

Table 4 – Machine area cleaning process improvement

Activity	**Time(m)**	**Current**	**After**	**Time(m)**
Cleaning Surrounding Area with Air	4	I	I	2
Collection of flakes and other dirt with wiper and broom	2	I	E ; Before	0
Water Cleaning of Surrounding Area	3	I	E ; After	2
Wiping the surrounding area	4	I	E ; After	0
Total	**13**			**4**
			Time Saved = 9 min	

4.5. Container cleaning process improvement

It was observed that the container cleaning process was carried out as an internal one. There was the requirement that at before the start of next batch, one container in clean and ready to use condition, should be available. Therefore, the process can be moved to external in such a way that one container should be cleaned before the change-over process and remaining containers can be cleaned after the change-over process.

Table 5 – Container cleaning process improvement

Activity	Time	Current	After	Time
Container Cleaning	7	I	E	0
			Time Saved = 7 min	

4.6. Belt cleaning process improvement

The Table 6 shows the breakdown of belt cleaning process and their respective time spent. It was noted that all the operations were carried out as internal and there is scope for improvement.

Table 6 – Blet cleaning process improvement

Activity	Time(m)	Current	After	Time(m)
Air Cleaning of belt	2	I	Eliminate	0
Water Cleaning of Belt	3	I	I	3
Second air cleaning of belt	2	I	I	2
Total	**7**			**5**
			Time Saved = 2 min	

5. Results

The final results obtained from implementing above techniques are as shown in the Table 7 below:

Table 7 – Kneader SMED results

	Before SMED		**After SMED**		
Activity	**Time(m)**	**Present**		**Action**	**Time(m)**
Crusher Cleaning	13	I	I	Simplified	7
Machine Area Cleaning	13	I	I	Simplified	4
Container Cleaning	7	I & P	E	-	0
Belt Cleaning	7	I	I	Simplified	5
Roller Cleaning	4	I	I	-	4
Die Cleaning	4	I & P	I & P	-	4
Barrel Cleaning	3	I	I	-	3
Movement	3	I	I	-	2
Feed Hopper Cleaning	3	I	I	-	3
Machine Body Cleaning	2	I	I	-	2
Assembly	2	I & P	I & P	-	2
Starting operations	2	I & P	I &P	-	2
Filling log-sheet	0	E	E	-	0
Total time	**63**				**38**
Actual time required	**48**				**30**
			Total time saved = 18 min		

As a result of implementing SMED the Kneader change-over has been reduced from 48 minutes to 30 minutes in overall. 38% of change-over time reduction is achieved as shown in the Fig. 2

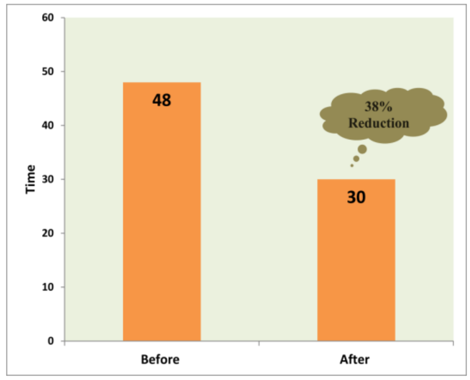

Fig. 2 Kneader results after SMED

The annual profit gains after successful implementation of SMED are shown in the Table 8 below:

Table 8 – Profit Gains

		Unit
Average initial changeover time	**48**	Min
Average final changeover time	**30**	Min
Gains per changeover	**18**	Min
Average number of daily setups	**12**	-
Production time gains per day	**216**	Min
Working days in a year	**307**	Days
Production time gains per year	**66312**	Min
Production time gains per year	**1105.2**	Hour
Average Kneader throughput	**386**	kg/hr
Expected production output per year	**426.61**	MT
Average gains per MT	**18,750**	□
Total gains annually	**79,98,885**	□

Therefore, after successful implementation of SMED the annual profit gains of up to 80 lakh rupees was achieved.

6. Conclusion

Implementing Lean principles in any process will bring huge results to organizations. This study has proved that eliminating non-value adding activities in any process can bring huge results. The payback achieved in this study indicates that if the lean concepts are organized in all departments, they would generate very significant organisational benefits.

By implementation of Single Minute Exchange of Dies (SMED), the following improvements were achieved:

- The change-over time for Kneader gets reduced successfully from 48 minutes to 30 minutes. 38% of change-over time reduction was achieved.
- Annual profit gains up to 80 lakh rupees can be achieved.
- Operator fatigue was reduced to some extent.
- Improved responsiveness to customer demand.

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