Reduction in Engine Change-Over Time using SMED Methodology

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Abstract— In today's world, customer demands comprise of a wide range of quality products delivered in a short span of time and also at a reasonable price. To meet these demands, manufacturers are constantly trying to reduce the cycle time of individual products as well as the changeover time between two different products. A lot of effort and money needs to be put in for reducing the cycle time of the products which is achieved through advanced costly technologies and rigorous quality measures. On the other hand, reducing the changeover time is an effective way in meeting the JIT philosophy without degrading the quality of the products. The SMED or 'Single Minute Exchange of Dies' methodology developed by Shigeo Shingo is an effective way in reducing the changeover time and has been verified through its application in a multinational engine manufacturing industry. In the following case study, proper implementation of the SMED methodology has been made and significant setup time reduction with minimum investment has been achieved. Further, the new methods have been standardized and sustained which has increased productivity ensuring safety and quality of the products.

Key words: SMED, Changeover time, Cycle time, Internal and External Activity

I. INTRODUCTION

Globalization has created a market which incorporates customers who demand a wide range of products to be delivered in the stipulated time. This has increased the need for companies to increase their production flexibility by reducing the batch size of the products. This in-turn has led to an increase in the number of changeovers taking place. Thus, to survive in the manufacturing business, companies desperately need to increase their changeover capability for being able to produce small quantities of a large diversity of products.

In the manufacturing process, the amount of time taken to change a piece of equipment from producing the last good piece of a production lot to the first good piece of the next production lot is the actual definition of Changeover. [1] The following figure gives an idea about the changeover activity:

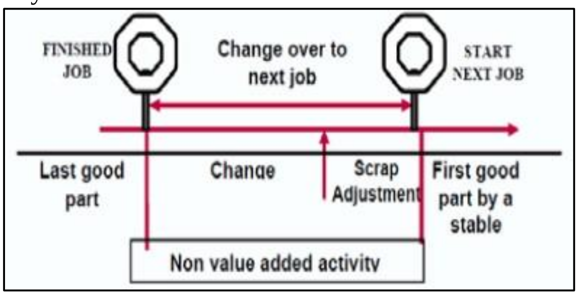


Fig. 1: Representation of Change over time [2]

The time spent during changeover costs the company money as there are no finished items being produced. [1] The backbone of this reduction in changeover time is the application of SMED methodology. SMED or 'Single Minute Exchange of Dies' is a philosophy where the target is to reduce all the steps to less than 10 min. By the systematic application of SMED methodology one can easily reduce the setup time taken between two products. The entire procedure of this technique requires lesser time and is also very cheap as compared to other methods which reduce the cycle time of individual products.

The benefits of reducing the setup time are:

- Improved lead time
- Reduced inventory
- Single Piece flow (Lower batch sizes)
- Higher efficiencies
- Increased capacity
- Increased safety
- Improved OTD and Flexibility

II. LITERATURE REVIEW / SMED

In 1950, Shigeo Shingo developed the first stage of SMED which involved splitting a setup operation into internal and external setup. [4] With reference to Taiichi Ohno's Toyota Production System (TPS), Shigeo Shingo originated SMED system at Toyota in 1970. [5] SMED mainly aims at reducing the changeover time or setup time reduction. But in today's competitive market, increased production capacity without purchasing new equipment is the need of the hour. Reducing the Batch sizes according to customer's demands as well as improving the flexibility and OTD are the other objectives satisfied by SMED Methodology. Following figure shows Economic Order Quantity and effect of SMED on reducing ordering cost due to change-over time reduction.

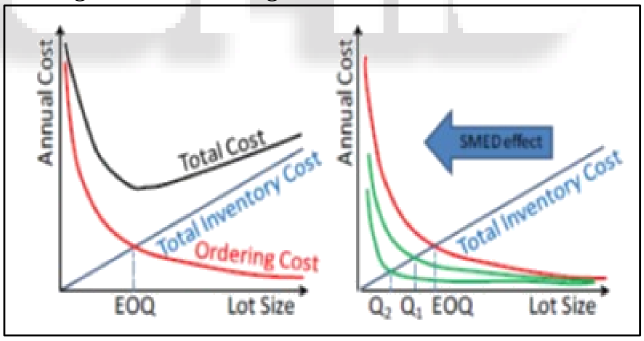


Fig. 2: Economic Order Quantity and SMED effect on reducing [1]

Following flowchart explains the stages of SMED Methodology:

A. *Stage 1: Separate setup operations into Internal, External or to be eliminated:*

During the first stage, all activities have to be classified based on whether they can be executed while the machine is working or not. [1] These activities can be categorized using video recordings and routing diagrams. Shingo suggests interviewing shop floor staff for collecting improvement ideas. [1]

B. *Stage 2: Convert Internal Elements into External Elements:*

According to Shingo, this stage involves two significant activities to be performed by the improvement team: the detailed analysis of internal operations to detect wrong assumptions, and the research of different ways to convert these activities into external work. [1] Tools standardization and the use of intermediary jigs are some techniques that support this stage. [1]

C. Stage 3: Streamline and reduce internal and external work.

At this stage, all the effort is placed on optimizing all internal tasks. [1]Some technical principles can be applied in order to reduce duration of internal activities.[1] Shingo mentioned some possible options to achieve this such as implementing parallel operations, using functional clamps, increasing mechanization of different machine components, reducing adjustments to minimum and designing effective tools to help on internal tasks. [1]

The purpose of this modification is to concentrate all resources on reducing internal times prior to streamlining external work. [1] Reducing external work does not affect the changeover time, as all activities are performed before and after the line has stopped. [1] However, added value is gained when reducing internal time. [1] Many companies focus on reducing duration of external activities with no results in changeover times. [1]

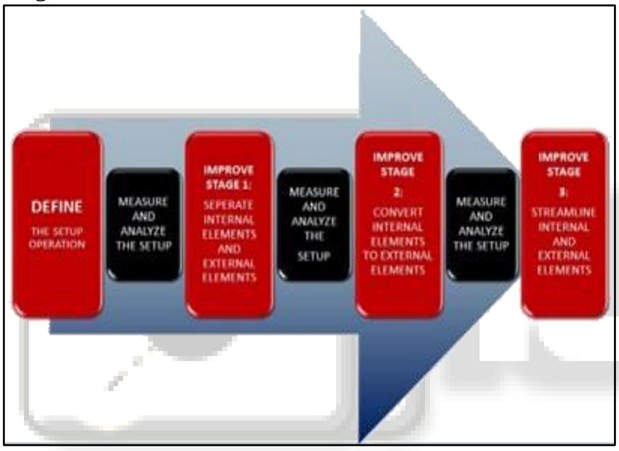


Fig. 3: Representation of SMED Methodology

III. INDUSTRIAL APPLICATION

This project was carried out in a multinational heavy duty engine manufacturing company for a period of six months. The assembly line for KV50 (type 1) and QSK60 (type 2) engines in the company comprises of a total of 23 stations. Engines successively pass over an automated conveyor through the entire assembly line. The QSK60 engine is assembled in special production lot of 10-15 engines per month according the requirement of the consumer. As the demand for QSK60 is comparatively lower than the demand for KV, it is not feasible for the company to set-up an assembly line exclusively for QSK60. Hence, the QSK60 engines are assembled on the same assembly line up to Station no. 6 and then shifted to a different unit for further assembly. When QSK60 is to be assembled, the set-up needs to be changed for Stations 1 to 6. The set-up change operations require manpower to be engaged for an extra shift (second shift) and the operating costs are high in terms of electrical consumption. This project aimed at reducing the Setup time for KV 50 to QSK 60 changeover in same assembly line from current 9 hours to 5 hours.

After a preliminary analysis of the changeover activity, problems that affected the efficacy of process were identified. Currently the changeover time is 9 hours because of unplanned activities, insufficient tool inventory, improper manpower allocation, unorganized work instructions, lack of tooling fixtures, improper maintenance, lack of co-ordination between sub stations and main stations, lack of co-ordination between assembly and machine shop/suppliers and other related problems. 80% of the changeover consists of internal activities which causes unnecessary delays. Also breakdowns are common due to lack of co-ordination. Therefore it was decided to adopt SMED methodology along with other Lean tools (5S, Poka Yoke, Visual Management and Kanban) in order to solve these problems.

The steps followed in tackling the above stated problem are described below chronologically.

A. Method Study of the Changeover Activities:

1) Work Measurement:

With the help of videos and actual observation the time-stamp for every activity related to the change-over was established. [3] All this data was compiled together to form a comprehensive analysis of time duration for the entire change-over process. [3]

2) Identification of Scope for Reduction in Time:

From the time analysis tabulated earlier, the set-up change operations which involved heavy wastage of time due to material shortage, improper management, lack of fixtures, etc. were identified and separated from the activities having no scope for reduction in time.

3) Layout of Assembly Line with Time Wastages:

A layout of the assembly line comprising of the initial six stations was plotted. The activities involving wastage of time for each station were identified and plotted on the prepared layout.

B. Separation of Internal and External Activities

The SMED methodology commands the segregation of all set-up change activities as an internal activity or an external activity. For the change-over from KV to QSK60: An internal activity is one in which the engine needs to be stopped on a particular station while the process is being performed. This results in unnecessary stoppages on the assembly line. Valuable production time is lost due to such stoppages. Hence, priority needs to be given to identify those internal activities which can be converted to external set-up. This will prevent any kind of unplanned stoppages. An external activity can be performed simultaneously while the engine moves progressively on the assembly line. An activity thus performed externally will not lead to unplanned stoppages and save production time. Accordingly, the above identified wastages were segregated into internal or external activities.

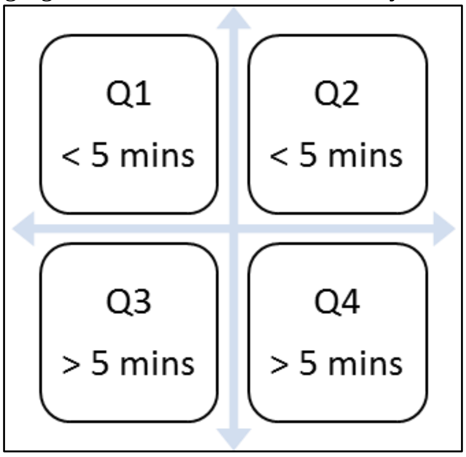
C. Conversion of Internal to External Activities:

There lies great scope for reduction in time if substantial amount of internal activities are converted to external activities. Conversion of internal to external activities is an important step in reducing the stoppages on the assembly line as well as in efficient utilization of space and time. The following step was adopted for the conversion of internal to external activities and implementing these changes:

1) Criteria for Implementation of Changes:

The complete assembly process consisted of a lot of changes and implementation of all these changes was not an easy task.

For implementation of the segregated changes, a criterion was devised which was based on the impact of the changes and the level of difficulty of implementation. Classification was done based on the cost effectiveness, operator movement, manpower cost, availability of tools, effectiveness of the implementation and the impact on the total change-over time. This criteria can be utilized anywhere, where time reduction in the process is a main objective. Classification based on the time constraints and the level of difficulty of implementation has certainly proved to be helpful and effective.
Following figure shows the criteria effectively:



Easy Difficult

IMPLEMENTATION

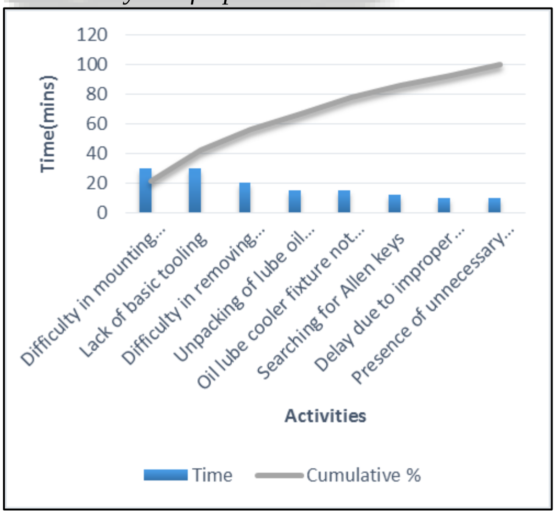
Q1: Activities having greater impact in terms of time (>5min) but easy to implement their changes

Q2: Activities having greater impact in terms of time (>5min) and difficult to implement their changes

Q3: Activities having lesser impact in terms of time (<5min) but easy to implement their changes

Q4: Activities having lesser impact in terms of time (<5min) and difficult to implement their changes.

2) Pareto Analysis Of Operations:



D. Shortening Of Internal Set-Up And External Set-Up:

At this step 'specific principles' are applied to shorten the setup times. Implementing parallel operations, using functional clamps, eliminating adjustment and mechanization techniques are used to further setup time reduction. Apart from conversion of internal activities to external activities, shortening of internal set-up and external set-up in terms of time was the major objective. Reduction in time in internal set-up activities led to cumulative reduction in time of the entire changeover process directly whereas for external set-up activities it reduced the changeover time indirectly. To achieve the objective of shortening of internal set-up and external set-up activities, two methods were broadly considered:

- Using Quality Principles like 5S, Poka Yoke and other related principles.
- Actual Design of fixtures and trolleys.

Implementation of quality principles in the already established manufacturing set-up is a more cost effective way than actual designing and manufacturing of fixtures. Design and subsequent manufacturing of fixtures and trolleys is a more time and money consuming process, but in some cases it was felt to be inevitable.

E. Project Innovations:

1) Preparation Of Socket Bins Using 5s Quality Tools:

Fig. 4: Station Specific Tool Bins

CUMULATIVE REDUCTION IN WASTAGE OF TIME FOR ENTIRE ASSEMBLY LINE = 42 MINS

2) Design Of Trolley For Systematic Placement And Mounting Of Oil Lube Cooler:

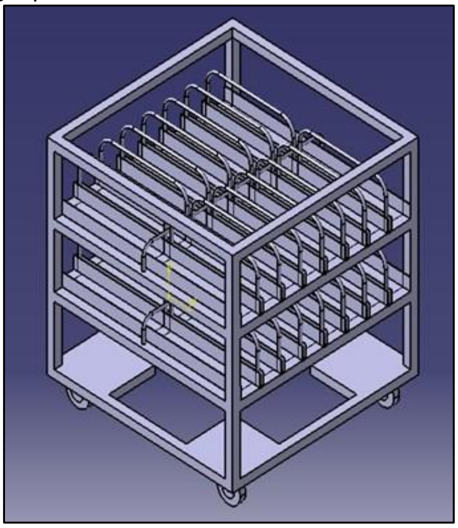


Fig. 5: CAD Model of Trolley for Oil Lube Cooler

Fig. 6: Actual Working Model of the Trolley

CUMULATIVE REDUCTION IN WASTAGE OF TIME FOR ENTIRE ASSEMBLY LINE = 30 MINS

3) Design Of Scissor Lift For Mounting Of Plates On Tod:

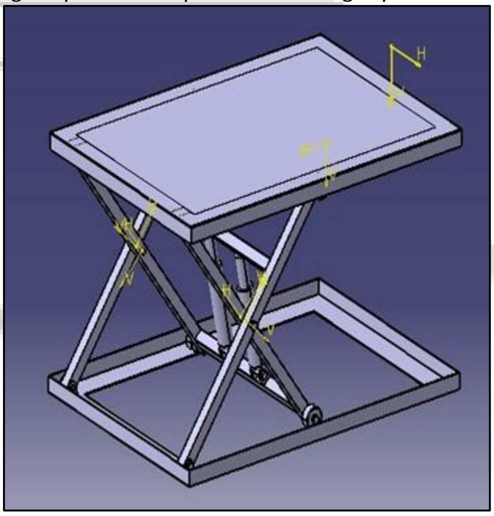


Fig. 7: CAD Model of Actuated Scissor Lift

CUMULATIVE REDUCTION IN WASTAGE OF TIME FOR ENTIRE ASSEMBLY LINE = 70 MINS

F. Results:

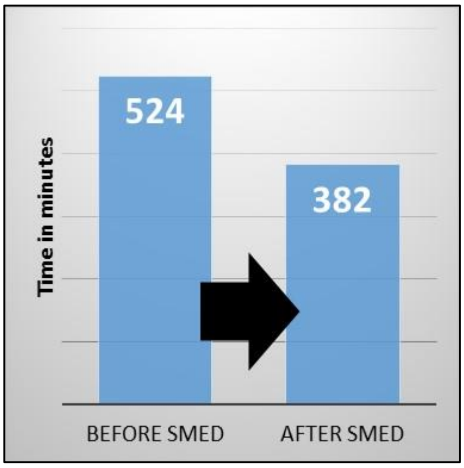


Fig. 8: Comparison Between Before Implementation and after Implementation of SMED

IV. CONCLUSION

In this study, the SMED methodology was successfully applied to reduce the changeover time in a large scale multinational industry. A standard procedure was prepared with few more recommendations in order to sustain the reduced changeover time. During the course of this project, ergonomics and safety issues were considered at all times since these are necessary to ensure good emotional content of the operators. For further improvement in the facility, Kaizen principles along with 5S must be applied and alternative ways for shortening the internal setup can be searched. Due to the reduced changeover time, the benefits to the company have been enormous. Thus SMED methodology can be applied effectively to reduce the changeover time in any type of industry.

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