

APPLYING SMED/QCO TOOL TO IMPROVE THE PRODUCTIVITY AT SCREWING STATION OF HFR ASSEMBLY – A STUDY AT ROBERT BOSCH (I) LIMITED

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Abstract- Nowadays the industrial product market is increasingly demanding more customized and quality products, forcing the manufacturers to cut down the price, in order to survive in the highly competitive product market. Working on this, Robert Bosch INdia (RBIN) Limited, Bangalore Plant (BanP) designs and produces Diesel systems which make vehicles more cleaner and economical. Bosch has to manufacture products as per the demands of every customer, economically, to maintain being the world's leading manufacturer of diesel injection systems. Fuel Injection Equipment in diesel engine is the "Heart of the Engine" and plays a major role in its performance, emissions and reliability. Hot Forged Rail (HFR) finds its application in common rail fuel injection system, which stores the fuel at high pressure (1600bar). And at the same time, the pressure oscillation, which is generated due to the high pressure pump delivery and the injection of fuel are damped by the rail volume. Its design varies according to customer requirement and engine design. Therefore, BanP has to produce different types of rails to compete the diesel market in India. In order to be customer centric and productive, BOSCH follows Bosch Production Systems (BPS), the elements of BPS in Lean manufacturing are Value Stream Mapping (VSM), Value Stream Design (VSD) and Value Stream Planning (VSP). The Single Minute Exchange of Die (SMED) is one important lean manufacturing tool to reduce waste and improve production flexibility, allowing lot size reduction and manufacturing flow improvements. Quick Change over (QCO) is a set of activities (preparation, changing and adjustment) which are being carried out in between the production of two varieties to reduce changeover time and to reach the optimum production running. The proposed SMED approach was tested for screwing machines changeovers and the implementation had enabled reduction in setup time, through company's internal resources without the need for significant investment. The objective of the present study is to implement the SMED/QCO tool approach in RBIN, BanP, HFR production line at screwing station to reduce the changeover time by 90% and improve availability by >42%, thereby eliminating the possibility of investing on new production line to meet customer demand.

Keywords: Bosch Production Systems (BPS), Value Stream mapping (VSM), Value Stream Design (VSD), Value Stream Planning (VSP), Quick Change Over (QCO), Single Minute Exchange of Die (SMED), Hot Forged Rail (HFR).

I. INTRODUCTION

While the market is increasingly demanding more customized products, manufacturers are under constant pressure to produce variety at low costs. Non-fulfillment of orders more frequently results in losing business to the competition. Combining these factors with the high cost of inventory and the need to increase productivity, and it becomes obvious that mastering quick changeover is essential to an organization's survival. As an organization begins according to customer demand (takt time) while utilizing "one piece flow." For this to happen, machines need to be set up more often, highlighting the need to reduce setup time. Reducing setup time results in increased production, better quality parts and a more flexible workplace without much investment.

Single Minute Exchange of Dies

Single-Minute Exchange of Die (SMED) is one of the many lean production methods for reducing waste in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next

product. The phrase "single minute" does not mean that all changeovers and startups should take only one minute, but that they should take less than 10 minutes (in other words, "single-digit minute").

Single-minute exchange of dies (SMED), like other lean tools, requires a committed effort from within the organization. One of the major pitfalls organizations fall into is the desire to rush into a changeover program with very little or no upfront planning. With limited time and resources, the program is doomed for failure. The other common mistake is failure to document and standardize the process.

Quick Change over (QCO)

Quick changeover incorporates proven, simple process orientated systems and methods to reduce tools, plant or equipment changeover times to facilitate increased capacity, smaller batch sizes, more agility to changing demands, lower inventory and reduced lead times. Most of the companies face this business paradigm, where they have ever

increasing requests for smaller and more frequent deliveries, changing demands requested at short notice and orders for specials or some form of uniqueness and customization of the products and services they provide and at low price. The solution is in batch size reduction, quick response and flexibility, through mastering quick changeover and standardization.

The keys to quick changeover are as follows:

1. Rethinking the idea that machines can be idle, but workers cannot be idle.
2. The ideal setup change is no setup at all or within seconds.
3. Ensuring that all tools are always ready and in perfect condition.
4. Blowing a whistle and have a team of workers respond to each changeover.
5. Establishing goals to reduce changeover times, record all changeover times and display them near the machine.
6. Distinguishing between internal and external setup activities and try to convert internal to external setup.

Basic Terms used in QCO:

The time from the last part of the old lot to the first okay part of the new lot is known as '**Loss of change over time**'. The '**Internal change over time**' is the change over time with the plant stopped.

The loss of output due to stoppage and running (incl. Release of production) in an operating system through change over processes is known as '**Gap in Change Over**'. Adding all internal and external change over processes gives the '**duration of change over**'.

The '**External change over time**' is the change over time when the machine is running.

The '**Change over frequency**' is the number of change over processes per unit of time.

The advantages of QCO are:

- **Reduce defect rates**
 - Quick Changeover reduces adjustments as part of setup and promotes quality on the first piece.
- **Reduce inventory costs**
 - Elimination of, or reduction in numbers of batches, and their sizes, allows for recovery of operating cash and manufacturing space.
- **Increase production flexibility**
 - Increase output and improve timeliness of response to customer orders.
- **Improve on-time delivery**
 - Quick Changeover supports the ability to meet customer demands.

The advantages for the employees include:

- **Easier:**

- Easier and more transparent change over processes causes less problems (and with that less stress and hectic)

- Uniform work load of all the employees

- **Quicker:**

- Quicker change over time gives more time for other work

- **Safer:**

- Less physical strain during change over

- Planning safety during the Production process

II. NEED FOR SMED

The customer demands in 2012 increased by ~87% (50,000 pieces of rails in 2011 and 4,00,000 pieces in 2012). Following the BPS principles, a VSM was prepared in January which depicted the current picture of the assembly line. And consequently, a VSD was also prepared predicting the future state. The gap between the two conditions was studied and a system CIP workshop was conducted.

III. IDENTIFICATION OF THE PROBLEM

Looking at the Takt Time Chart for the second half of 2012, the Screwing station was identified as the bottle-neck station and thus a detailed study was done. The losses were identified looking at the hourly monitoring sheet (HMS), Fig 1, which is filled up by the operators. Hourly Monitoring is done every day by the associates in the line to generate Overall Equipment Effectiveness (OEE) for each cell. Depending on 1, Cycle Time (as depicted in Fig 1) of bottle neck station in each cell, 2 (number of pieces to be produced per day) is calculated. The associates enter 3 (actual pieces produced per hour) and from there OEE of each cell is calculated.

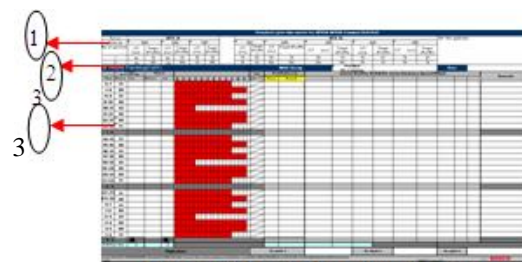


Fig. 1 Hourly Monitoring Sheet

The OEE was calculated from the HMS for CELL 2 and it looked like the following:

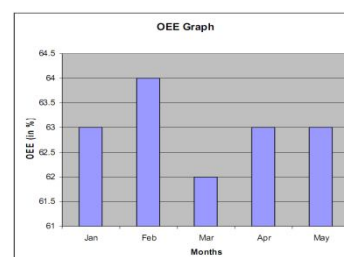


Fig 2. OEE Graph for Cell 2

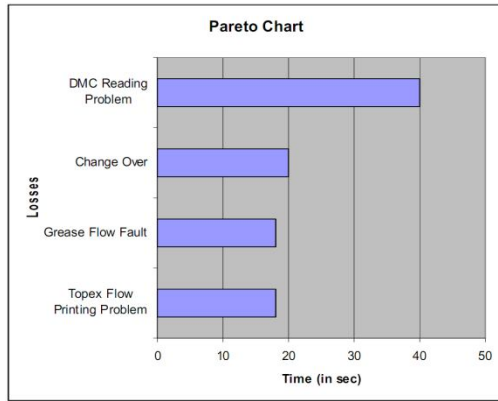


Fig 3. Losses in Cell 2

The HMS was studied carefully and the losses in Cell 2 were identified. The prominent losses are shown in Fig.3. The problem in Cell 2 was analyzed and a Quick Change over Project was opted in Screwing Station.

Is Condition:

The Present change over matrix at Screwing Station seemed like the following:
Here, 002, 004, 007, etc are the various part numbers for rail bodies for each customer and the different types of pressure sensors (RDS), Direction Control Valves (DRV) and Screw Plugs are screwed to the rail body in this Screwing Station as a part of the assembly process.

The steps involved in the change over from the various part numbers are:

	Pressure	Direction	Screw Plug
002	0281.006.047	0281.006.200	
004	0281.006.047	0281.006.144	
007	0281.006.047	0281.006.206	
261	0281.006.937		F00R.L00.412
025	0281.006.937		F00R.L00.412
006	0281.006.937		F00R.L00.412
194	0281.006.158	0281.002.507	
224	0281.006.158	0281.002.507	
193	0281.006.158		F00R.L00.412

Screwing Station									
	002	004	007	261	025	006	194	224	193
002	-	20	20	15	15	15	20	20	20
004	20	-	20	15	15	15	20	20	20
007	20	20	-	15	15	15	20	20	20
261	15	15	15	-	8	15	20	20	20
025	15	15	15	8	-	15	20	20	20
006	15	15	15	15	15	-	20	20	20
194	20	20	20	20	20	20	-	15	20
224	20	20	20	20	20	20	15	-	20
019	20	20	20	20	20	20	20	20	-

Internal Activities as per the Programmable Logic Controller(PLC) program:

- i) Start type Change.
- ii) Load new data.
- iii) Open doors.
- iv) Unscrew Screws.
- v) Close doors.
- vi) Set change over cylinder to work position.
- vii) Open doors.
- viii) MECHANICAL CHANGEOVER- take out the fixture by unscrewing screws and disconnecting the cameras.
- ix) Put the new fixture and screw it, connect the camera.
- x) Close doors.
- xi) Control and basic function ON.
- xii) Check O-ring and low pressure Testing.
- xiii) Take over new type data
- xiv) Close change over cycles.

External Activities:

- i) Bring the new fixture.
- ii) Put back the old fixture.
- iii) Bring change over tools and return it back.

IV. IMPLEMENTATION OF THE PROJECT

A study was done on the program of the screwing station and the various rail body part numbers.

	00	00	00	26	02	00	19	22	19
Fixture	✓	✓	✓	○	○	-	△	△	△
Software(PLC)	✓	✓	✓	○	○	-	△	△	△
Station	✓	✓	✓	○	○	-	△	△	△
Label	x	x	x	x	x	x	X	x	x
Customer	x	x	x	x	x	x	X	x	x

✓	is similar
○	is similar
△	is similar

Table 1.5 Comparison of Parts

Thus we saw that, 004, 002 and 007 and 261 and 025 and 194, 224 and 193 have similar properties (see Table 1.4) regarding the fixture(since they had the same size and shape), Software(since the DRV, RDS/Screw Plug are the same) and the station parameters (screwing speed, torque, etc). Hence a change was done in the Programmable Logic Control(PLC) program and a few steps were skipped(from step iii to x) when changing over from the similar types. Thus, reduction was done as per the Eliminate Combine Reduce Simplify (ECRS) method and the change over time reduced from 20mins to 2 mins.

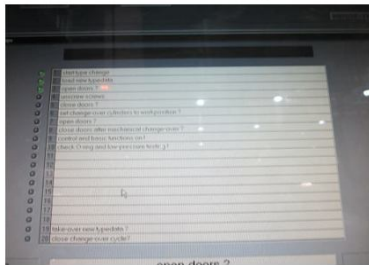
Step iii



Step x



Condition after the change



Condition after the change

Conditions after implementation of the project:

The Change Over Matrix in the screwing Station changed to the following:

V. CONCLUSIONS:

We see that the change over time reduced from 20mins to 2mins, i.e by 90% and hence the availability of the machine time is increased by 42.3 %. Along with this the Every Part Every Interval (EPEI) became 1.

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