CHAPTER 5

CASE STUDY - II

This section deals with the details about the case organization, product selection, CSM and FSM development.

5.1 ABOUT THE COMPANY

The case company is an automotive component manufacturing company supplying components to a leading automotive organization. The company is dedicated towards the manufacture of the components of the piston. The company has about 20 years of expertise in manufacturing this component and also with a manufacturing track record of 100% quality performance rating. 100% quality performance means the organization is currently following six sigma quality level. Due to the increased competition, the organization is in the position to improve productivity. An expert team was formed to implement the lean oriented VSM production.

Product Selection

The company is specialized to manufacture part family components of cylindrical geometry. It is involved in manufacturing piston components of various sizes. This component is a vital part in Telescopic shock absorber for two wheelers. This piston is a sintered component supplied as a raw material to company from the parent organization. The component is machined from
the raw material into finished product by carrying out various operations. The raw material used for this component is a powder metallurgy part. It requires complex processes to convert into a finished product. For this case study, one model of piston component (Part number: 7040538) is considered as shown in Figure 5.1.

5.2 NEED FOR CASE STUDY

The reason for selecting the component is increase in customers’ demand for the particular component. So the organization started investigating opportunity to increase the production rate without much investment. This necessitates a study to improve the productivity.

Figure 5.1 Product Details
one machine to other machine manually at shop floor. During oil dipping in nips, each nips contains about 3000 parts. The nips are transferred from the complex scheduling system. During the process, work pieces are stocked. Finally, work pieces are dipped in oil bath and dried. The company follows control on all various levels of process. Of work piece to maintain quality. Inspection is done at each of the work piece using rotary grinding machine. Grinding is done at tumbling, grinding and chamfering on the work piece. Face grinding is done at turret lathe. The process sequence starts with machining process. Every work material has been procured from supplier at an average Physical System of the company.
process, about 6000 work pieces are stocked in a perforated tray. This tray is
dipped in oil bath along with parts for about 2 minutes and dried at room
temperature for about 60 minutes. So, the time taken for oil drying for one
component is calculated as 1.66 seconds. The dried parts are inspected
visually for any flaw lines and dents at face side. The accepted parts were
packed in a plastic tray containing cups to accommodate parts. The packed
parts were subjected to shipment to the customers.

**Packing details**

One plastic tray contains 56 cups to accommodate 56 numbers of
parts. One carton box has 10 trays. One wax paper was placed over for each
two trays. One separator (thick card board) was placed for each five trays.
One big carton has four boxes. Every day, about 30,000 parts are shipped to
customer. Using this, we can identify the areas which require improvement in
the production system. The company forecasts that every month, customer
releases job order to manufacture piston components about nine lakh numbers
and this demand can vary significantly from month-to-month. Usually,
customer releases the orders to manufacture components belonging to same
part family. So there was no need to change the process sequence. For the
company, customers and suppliers are the same, parent organization. The
company receives raw materials every week from the supplier to meet the
Eliminating or converting NVA into VA

Example: Picking of tool

In case of centralized tool rack, activities for retrieving the tool include reaching the centralized tool rack, picking the tool and reaching back to the machine. In this reaching, the centralized tool rack and reaching back to the machine is considered as Non Value Added (NVA) activity and picking the tool is necessary but Necessary Non value Added (NNVA) activity whereas NNVA activity can be considered as a VA activity for the simplification of analysis. Picking of tool activity is associated with two NVA and one VA activity.

If centralized tool rack is replaced by point of use cabin, which is located near the machine those two NVA can be eliminated.

Up Time calculations

\[ Uptime = \frac{Available\ operating\ time}{Available\ production\ time} \]

Company is functioning only one shift in a day.

The effective working hours in a shift (Excluding lunch break and intervals) – 8 Hours

(i) All six lathe centers are machining the work pieces. The operations such as turning, grooving and chamfering are carried out on the work pieces.

Production rate at each machine – 800 number/Hour
Tool change is done after machining every 2000 numbers in each machine.

Time taken for tool change in a shift per machine – 45 minutes

\[
U_{\text{ptime}} = \frac{(8 \times 60 \times 6) - (45 \times 60 \times 6)}{(8 \times 60 \times 60 \times 6)}
\]

\[
= \frac{156600}{172800} = 0.906 \times 100 = 90.6\%
\]

Cycle time calculation

(i) Machining.

Production rate = 800 numbers /hour /machine

Production is carried over by 6 machines and 6 operators.

Cycle time = \((60\times60\times1) / (800\times6\times1)\)

\[
= 0.75 \text{ seconds}
\]

The uptime calculations and cycle time calculations for the remaining processes are detailed as follow:

Uptime calculation

(ii) Face grinding.

Production rate is 1500 Numbers / hour / operator

Number of operators – 3

Production in a shift – 1500\(\times\)8\(\times\)3

-36000 Numbers / shift.
Uptime = \[ (8 \times 60 \times 60 \times 3) - (0) \] / \( 8 \times 60 \times 60 \times 3 \)

\[ = 86400 / 86400 = 100\% \]

(iii) Inspection.

Number of pieces inspected – 1000 numbers / hr / Inspector

Number of inspectors – 4

Number of pieces inspected in the shift – 1000x8x4

Uptime = \[ (8 \times 60 \times 60 \times 4) - (0) \] / \( 8 \times 60 \times 60 \times 4 \)

\[ = 115200 / 115200 = 1 \times 100 \]

\[ = 100\% \]

(iv) Sorting out the work pieces by visually identifying defective pieces and isolating.

Number of pieces sorting out in the shift by three inspectors = 1300x8x3 = 31200 numbers

Uptime = \[ (8 \times 60 \times 60 \times 3) - (0) \] / \( 8 \times 60 \times 60 \times 3 \)

\[ = 86400 / 86400 = 1 \times 100 \]

\[ = 100\% \]

(v) Random inspection.

Choose the work pieces randomly (10%) from the lot (2000 Numbers) and check all dimensions and surface by quality control supervisor.

Time taken for inspecting 10% of a lot – 30 minutes

For 16 lots = 16x0.5 = 8 hours
Uptime = \[(8\times60\times60\times1) / (8\times60\times60\times1)\] = 100%

(vi) Oil dipping and Drying:

Number of pieces stored in a performed tray – 500 Numbers

Time taken to dip a tray in oil bath – 2 minutes

For 31200 Numbers, Number of trays = \(31200 / 500 = 63\) trays.

Time taken for dipping 63 trays in oil bath one after other – 63x2

=126 minutes

=2 hours x 6 minutes

Drying time required is 12 hours for each work piece.

Work pieces in the trays are allowed to dry in atmosphere and untouched for 12 hours

Uptime = \((12 – 0) / 12\)

= 100%

(vii) Visual Inspection and packing:

The finished work pieces are checked for any dent marks, flows and turns at face side. The accepted parts are kept for packing.

Three Inspectors doing the visual inspection, inspecting each finished work piece.

Time taken for inspecting all 63 trays – work pieces - 3Hour

After visual inspection, the same persons doing the packing
Time taken for packing all finished parts of 63 trays – 5 hours

Uptime = \( \frac{(8 \times 60 \times 60 \times 3)}{(8 \times 60 \times 60 \times 3)} \)

= 100%.

**Cycle time calculation:**

(ii) Face Grinding.

Production rate – 1500 Numbers / hour / operator

Number of operators doing this job – 3

Cycle time = \( \frac{(60 \times 60 \times 1)}{(1500 \times 3)} \)

= 0.8 seconds

(iii) Inspection.

Inspection is carried over by one inspector in one hour = 1000 numbers

Number of inspectors – 4

Cycle time = \( \frac{(60 \times 60 \times 1)}{(1000 \times 4)} \)

= 0.9 seconds

(iv) Sorting out is done by three persons at the rate 1300 Numbers / hour / person.

Cycle time = \( \frac{(60 \times 60 \times 1)}{(1300 \times 3)} \)

= 0.92 seconds

(v) Random Inspection.

Time taken to inspect 10% of work pieces of one lot (2000 numbers) – 30 minutes
(ie) Time taken to inspect 200 Numbers by one supervisor – 30 minutes

Cycle time = \((30 \times 60) / (200)\)

= 9 seconds

(vi) Oil Dipping and Drying.

Two persons combined and doing the works of oil dipping for 31200 Numbers – 2 hours 6 minutes

= 7560 seconds

Drying the all 31200 pieces at a time – 12 hours = 43200 seconds

Total time = 7560 + 43200 = 50760 seconds

Cycle time = \(50760 / 31200\) = 1.626 seconds

(vii) Visual inspection and packing.

Time taken for Visual inspection for all 31200 Numbers – 3 hours

Packing for all 31200 Numbers – 5 hours

Total time taken = 3+5 =8 hours

Cycle time = \((8 \times 60 \times 60) / (31200)\) = 0.92 seconds

5.4 INTEGRATION OF VSM AND FUZZY QFD

Once relationships between PMs and IWs were assessed using Linguistic variables and then transferred into fuzzy numbers and the relative importance \(RI_j\) of the \(j\)-th Proposed Methodology can be computed as a fuzzy
cumulative value using Equation (5.1) (Bottani, 2009; Vinodh & Chintha 2011b).

\[ RL_j = \sum_{i=1}^{n} W_i \otimes R_{ij}, \quad j = 1, \ldots, m \]  

(5.1)

where \( W_i \) is the weighted importance of the \( i^{th} \) Identified Waste and \( R_{ij} \) the fuzzy number expressing the relationship between the \( j^{th} \) Proposed Methodology and the \( i^{th} \) Identified Waste.

\[ \text{Score}_j = RL_j \oplus \sum_{j' \neq j} T_{jj'} \otimes RL_{j'}, \quad j = 1, \ldots, m \]  

(5.2)

\( T_{jj'} \) of the correlation matrix is assessed using the linguistic variables, has an incremental change of the degree of attainment of the \( j \)-th attribute when the attainment of the \( j' \)-th one is unitary increased. So, the final score \( j \) of the \( j \)-th proposed methodology can be computed using Equation (5.2) (Bottani, 2009; Vinodh & Chintha 2011b).

The resulting score \( j \) is also a fuzzy number. In order to rank the proposed methodologies, the crisp values are used. The crisp value of a fuzzy triangular number \( a(l, m, u) \), is computed using Equation (5.3) (Bottani 2009; Vinodh & Chintha 2011b).

\[ \text{Crisp Value} = \frac{l + 2m + u}{4} \]  

(5.3)

Based on the crisp values, the proposed methodology with the highest crisp value is given more importance. The matrix is shown in Figure 5.3. After ranking the proposals, the identified best improvement proposals are 5S, QCO, SM, AM, VM, VW and WC. As shown in Figure 3.
The weights for the identified wastes were obtained from the experts. Then relational ship matrix and correlation matrix was constructed after discussing with the cross functional team.

![Figure 5.3 Fuzzy QFD Matrix](image)

**Model calculation:**

Using the Equation (5.1), Index will be calculated as shown in Figure 5.3.

Sample calculation for 5S proposal is shown below.

\[(0.7, 1, 1) \times (0.7, 1, 1) + (0.3, 0.5, 0.7) \times (0.7, 1, 1) + (0.5, 0.7, 1) \times (0.7, 1, 1) = (1.05, 2.2, 2.7)\]

Using the Equation (5.2), Score will be calculated shown in Figure 5.3.
Sample calculation for QCO proposal is shown below.

\[(2.12, 4.4, 5.4) + (0, 0.3, 0.5) \times (1.89, 3.9, 4.7) = (2.12, 5.57, 7.75)\]

### 5.5 DEVELOPMENT OF FUTURE STATE MAP

The identified proposals are implemented in future state map and are shown in Figure 5.4.

- 5S concept has been implemented in all the cells. This will reduce the non value added time associated with the activities like searching for tool, etc.

- Quick change over practices has been used in the cell to reduce the time required for changing the work and tool.

- Super market concept has been introduced in between each station to store work in process.

- Autonomous maintenance will approach to stop accelerated deterioration of plant and equipment.

- Virtual work cell has been formed to significantly increase the material flow, which reduces the distance travelled by materials and inventory.

- Automatic loading system for feeding the work pieces to each machine can eliminate the present method of manual loading and also the human fatigue.
Improvements in each cell

With reference to Figure 5.4, the improvements in each cell are discussed as follows: At cell number 1, lathe and Face Grinding are placed together. To achieve Quick change over, Automatic loading system has been introduced in the lathe to feed work piece and automatic tool changing system will be introduced to reduce tool changing time to certain extent. Cutting tools can be sharpened earlier during idle time and also stocked well in advance in tool magazine. Both automatic loading system and automatic tool changing system may reduce manual work and increase the productivity. The cycle time will be reduced so the number of machines may get reduced to four and four operators can look after these machines. Face grinding is done manually using rotary grinder. By giving proper training to operators, face grinding can be done with same three operators.

Total number of operators required to work in this cell is = 4+3=7.
At cell number 2: Inspection and Oil Dipping will be carried out. For inspection, the introduction of Co-ordinate Measuring Machine system simplify the checking of vital measurements on each work piece and eliminate manual work. Inspection can be done at faster rate. Two operators are enough to handle this inspection work. Oil dipping is to be done manually. The work pieces are stocked in perforated trays and dipped in oil bath for 2 minutes, and then work pieces are needed to be kept in atmosphere with trays for minimum 12 hours. Two operators are enough to perform this task.

Number of operators required to work in this cell =2+2=4.

At cell number 3: Visual Inspection and Packing will be done.

These will be done manually to keep the packed goods ready for shipment.

Number of operators required to work in this cell =3.

Sorting out and random inspection are eliminated in FSM.

Total number of operators = 7+4+3=14.