CHAPTER 4

CASE STUDY - I

The details of the case study are presented in the following subsections:

4.1 ABOUT THE COMPANY

The case study has been carried out in a Pump Manufacturing Organization, Mayur Industry, Coimbatore, Tamil Nadu, India. It is one of the premier and pioneer pump manufacturing industries. The organization manufactures pumps for agriculture and domestic needs. The products manufactured by the company include submersible pumps, centrifugal pumps, etc. such as bore well pump, jet pump, domestic / mini mono block, open well submersible mono block, industrial motors, bore well compressor pumps, power loom motors, shallow well pumps.

4.2 NEED FOR CASE STUDY

In the company, there existed a need for the managers of the case organization to identify a method for scientific prioritization of wastes and the identification of techniques to eliminate wastes in VSM. In this context, the researcher discussed with the managers of the case organization to conduct the study.
4.3 DEVELOPMENT OF CURRENT STATE MAP

Steps in VSM

1. Understand the current states and prepare the current state map.

The customer information/demand need to be documented; a quick walkthrough to be completed to identify main processes; the basic production processes to be mapped; the data collection to be defined; the data need to be collected and mapped; supplier information need to be documented; information flow to be established; the material location where it is being pushed to be identified; the production lead time to be quantified versus processing time.

2. Data collection

The following terminology need to be understood:

- Cycle time is the elapsed time between one part coming off the process and the next part coming in.
- Change over time is the time to switch from producing one product type to another.
- Available work time is the amount of work time available per shift in each process.
- Uptime is the amount of time machine is running.
- Value added time is the time spent in transforming the product for which the customer will be paying.
- Lead time is the time taken for one part to travel through the entire value stream from start to finish.
supplier capabilities and recognizing supplier capabilities and constraints, calculating current inventory/WIP, computing takt time, ensuring continuous flow, balancing the line and making future state drawing.

6. Future state map need to be created after incorporating improvement proposals. This will be followed by quantification of Lean performance measures improvement. The production time calculations are presented as follows:

**Production time calculation:**

For the component Pump Casing which is one of vital part in the pump, current state map is a snapshot of the existing processes based on which the improvement areas need to be identified. The case study is carried out for the component Pump Casing which is one of vital part in the pump.

Actual available production time = (510- 50) = 460min

One 30-min lunch break = 30min

Two 10-min breaks = 20min

Available production time: 8.5 hr x 60min = 510min

Actual available production time = (510- 50) = 460min

= 460 x 60 = 27600 sec
The total of 27600 seconds is the actual available production time to produce the products what the customer demands.

**Takt time:**

Takt time is the rate at which a company must produce a product to satisfy customer demand.

**Takt time calculation for pump casing:**

\[
\text{Takt time} = \frac{\text{Available production time} \div \text{Total daily quantity required}}{75} = \frac{460}{75} = 6.13 \text{ min / piece}
\]

**Pitch:**

\[
\text{Pitch} = \text{Takt time} \times \text{Pack-out quantity} = 6.13 \times 5 = 30.666 \text{ min} = 1840 \text{ sec.}
\]

Table 4.1 shows the attribute collection checklist for pump casing.

**Table 4.1 Attribute collection checklist**

<table>
<thead>
<tr>
<th>Attribute Collection Checklist for Pump Casing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total time per shift = 8.5 hours or 510 min</td>
</tr>
</tbody>
</table>
Before mapping the current state, the main production processes are decided for the product pump casing as follows:

Facing > ID Turning > Flange facing > Drilling > Deburring > shipping. Figure 4.1 shows the pump casing.

![Figure 4.1 Pump casing](image)

To review the attribute checklist, it has been decided to collect data on the following process attributes:

- Quantity of parts shipped per month and per day
- Available production time
- Cycle time
- Changeover time
- Uptime
- No of operators
**Process Attributes**

**Availability:**

Total available production time is 8.5 hours (510 minutes) per shift. There is a 30-minute unpaid lunch break and two 10-minute breaks—a total of 50 regularly scheduled minutes of planned downtime. Therefore, the available production time is 460 minutes (27,600 seconds) per shift.

**Shipping:**

Location, staging area

Frequency / method = daily / UPS

Finished-goods inventory = 300 units

**Deburring:**

Cycle time = 30 sec

Availability = 27,600 sec

Uptime = 100%

Operator = 0 (drilling operator does the deburring whenever necessary)

WIP = 300 units between drilling and deburring

Time between deburring and shipping: 4 days
Drilling:

- **Cycle time** = 120 sec
- **Change over rime** = 80 sec
- **Availability** = 27,600 sec
- **Uptime** = 99.7%
- **Operator** = 1
- **WIP** = 300 units between flange facing and drilling

Time between drilling and deburring: 4 days

Flange facing:

- **Cycle time** = 150 sec
- **Availability** = 27,600 sec
- **Uptime** = 99.6%
- **Operator** = 0 (facing operator also does flange facing)
- **WIP** = 700 units between turning and Flange facing

Time between flange facing and drilling: 9.33 days, say 9 days

ID Turning:

- **Cycle time** = 300 sec
- **Change over** = 150 sec
Availability = 27600 sec

Uptime = 99.4%

Operator = 1

WIP = 750 units between facing and ID turning.

Time between turning and flange facing: 10 days

Facing:

Cycle time = 300 sec
Changeover time = 150 sec
Availability = 27600 sec
Uptime = 99.4%
Operator = 1

WIP = 550 prior to facing

Time between facing and turning: 7 days

**Total value stream WIP inventory**

To calculate total stream WIP, by totaling the amount of WIP inventory on hand between each operation.

- Raw material prior to facing - 550 casings
- Between facing and turning - 750 casings
- Between turning and flange facing - 700 casings
Between flange facing and drilling - 300 casings
Between drilling and deburring - 300 casings
Between deburring and shipping - 300 casings
Total inventory - 2900 casings

Also the number of days of WIP on-hand between each operation is to be calculated. Daily WIP is determined by dividing the actual quantity of units by the daily total quantity of units required by the customer. The daily customer requirements (demand) is obtained by dividing the number of units required per month (1500) by the number of shipping days per month (20).

Total number of units required per day:

1500 units required per month / 20 shipping days per month

= 75units per day

WIP in terms of days on hand:

Raw material prior to facing
550 units (75 units per day = 7 days on hand)

Between facing and turning
750 units (75 units per day = 10 days on hand)

Between turning and flange facing
700 units (75 units per day = 9.33 days, say 9 days on hand)

Between flange facing and drilling
300 units (75 units per day = 4 days on hand)

Between drilling and deburring
300 units (75 units per day = 4 days on hand)

Between deburring and shipping

300 units (75 units per day = 4 days on hand)

Total inventory (in days) =

7+10+9+4+4+4 = 38 days on hand (i.e.) Total Lead Time is 38 days.

**Total product cycle time:**

The total product cycle time is also considered as total value adding time, the cycle time for each operation is listed as below:

- Facing: 300 sec
- Turning: 300 sec
- Flange facing: 150 sec
- Drilling: 120 sec
- Deburring: 30 sec

By adding the cycle times for each operation, the total product cycle time becomes,

300 sec + 300 sec + 150 sec + 120 sec + 30 sec = 900 sec

Table 4.2 shows the data collected for pump casing.
Table 4.2 Data collection for pump casing

<table>
<thead>
<tr>
<th>Customer requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Average demand, 1500 units per month that is 75 units per day.</td>
</tr>
<tr>
<td>• Shipping month: 20 days</td>
</tr>
<tr>
<td>• Units per container: 5</td>
</tr>
<tr>
<td>• Container per day: 15</td>
</tr>
</tbody>
</table>

Supplier information:
The organization receives a weekly shipment of 550 units from its supplier.

Table 4.3 shows the current state data for various operations. Figure 4.2 shows the developed current state map.

Table 4.3 Current State Data

<table>
<thead>
<tr>
<th></th>
<th>Facing</th>
<th>ID turning</th>
<th>Flange facing</th>
<th>Drilling</th>
<th>Deburring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle time</td>
<td>300 sec</td>
<td>300 sec</td>
<td>150 sec</td>
<td>120 sec</td>
<td>30 sec</td>
</tr>
<tr>
<td>Changeover</td>
<td>150 sec</td>
<td>150 sec</td>
<td>100 sec</td>
<td>80 sec</td>
<td>0 sec</td>
</tr>
<tr>
<td>Operators</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Uptime</td>
<td>99.4%</td>
<td>99.4%</td>
<td>99.6%</td>
<td>99.7%</td>
<td>100%</td>
</tr>
<tr>
<td>Availability</td>
<td>27600 sec</td>
<td>27600 sec</td>
<td>27600 sec</td>
<td>27600 sec</td>
<td>27600 sec</td>
</tr>
</tbody>
</table>
The identified wastes in our study include overproduction, over processing, waiting, inventory, defects, transportation and motion. The identified techniques include 5S, Quick Change Over (QCO), Autonomous Maintenance (AM), Single Piece Flow (SPF), Kanban and Kaizen. Fuzzy QFD has been used for prioritizing wastes and improvement proposals. Figure 4.3 shows the identified wastes, improvement proposals and their relationship. Figure 4.4 shows the developed Fuzzy QFD.

**4.4 FUZZY QFD**
<table>
<thead>
<tr>
<th>Waste of over production</th>
<th>H</th>
<th>S</th>
<th>W</th>
<th>M</th>
<th>M</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste of over processing</td>
<td>S</td>
<td>S</td>
<td>W</td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>Waste of waiting</td>
<td>VH</td>
<td>S</td>
<td>SP</td>
<td>W</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Waste of inventory</td>
<td>VH</td>
<td>S</td>
<td>SP</td>
<td>M</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>Waste of defects</td>
<td>VH</td>
<td>S</td>
<td>W</td>
<td>W</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Waste of transport</td>
<td>VH</td>
<td>S</td>
<td>M</td>
<td>W</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>Waste of motion</td>
<td>H</td>
<td>W</td>
<td>S</td>
<td>S</td>
<td>M</td>
<td>W</td>
</tr>
</tbody>
</table>

Figure 4.3 Identified wastes and Improvement proposals and their relationship

<table>
<thead>
<tr>
<th>Weights</th>
<th>Kanban</th>
<th>SPF</th>
<th>AM</th>
<th>QCD</th>
<th>Kaizen</th>
<th>5S</th>
</tr>
</thead>
<tbody>
<tr>
<td>waste of over production</td>
<td>H</td>
<td>S</td>
<td>W</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>waste of over processing</td>
<td>H</td>
<td>S</td>
<td>W</td>
<td>W</td>
<td>W</td>
<td>S</td>
</tr>
<tr>
<td>waste of waiting</td>
<td>VH</td>
<td>S</td>
<td>SP</td>
<td>W</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>waste of inventory</td>
<td>VH</td>
<td>S</td>
<td>SP</td>
<td>M</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>waste of defects</td>
<td>VH</td>
<td>S</td>
<td>W</td>
<td>M</td>
<td>W</td>
<td>M</td>
</tr>
<tr>
<td>waste of motion</td>
<td>H</td>
<td>W</td>
<td>S</td>
<td>S</td>
<td>M</td>
<td>W</td>
</tr>
</tbody>
</table>

Figure 4.4 Developed Fuzzy QFD
The highly prioritized wastes include Inventory and waiting. The prioritized techniques include ‘Kanban’ and ‘SPF’.

4.5 DEVELOPMENT OF FUTURE STATE MAP

The identified techniques for waste elimination will be incorporated in the future state map. The future state map enables the identification of improvement proposals for eliminating wastes thereby streamlining the processes.

OPERATOR BALANCE CHART FOR CURRENT STATE:

Total cycle time= 900 sec, takt time= 368 sec & 3 operators

Figure 4.5 shows the cycle time for various operations.

![Cycle Time Chart](image)

**Figure 4.5** Cycle time, Operator balance chart for the current state
After reviewing the current state, discussion is made with operators and the production supervisor to set the total cycle time of 720 sec as a target for future state which is derived from total cycle time of 900 sec. of current state. To achieving this cycle time should require only 2 operators.

Number of operators = 720 / 368

= 1.95 (i.e.) 02 operators.

The new target can be achieved by making the following changes:

- Improve the programming and tooling maintenance.
- Distribute the work of five operations between two operators.
- Reducing the changeover times in machining operations.
- Re arrange the processes according to operators’ allocation.

Decides that the value stream should operate with two operators. Although the personnel requirement is calculated as two operators at a total cycle time of 720 seconds.

The operator balance chart for the future state is shown in Figure 4.6.

Total cycle time = 720 sec
Takt time = 368 sec
Operators = 2
Plan for work cells

The use of work cells promotes one piece flow, because in work cells equipment and personnel are arranged in process sequence. The cell includes all the operations necessary to complete a product. For future state mapping, the sequence of operations is reviewed according to redesign and validates the work cell arrangement.

Also, achieving a balanced line depends on applying the principles of cell design. The plan is to keep machining (facing and flange facing) as a stand-alone operation in one cell and combine I.D turning, drilling and deburring into another cell. The icons representing the work cells are added to the future state demand map.

Two future state cells:

I Cell - Facing & Flange facing

II Cell - I.D Turning, Drilling & Deburring
New attributes for each cell:

I Cell

- Facing & Flange facing.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle time</td>
<td>352 sec</td>
</tr>
<tr>
<td>Changeover</td>
<td>150 sec</td>
</tr>
<tr>
<td>Availability</td>
<td>27600 sec</td>
</tr>
<tr>
<td>Uptime</td>
<td>99.4%</td>
</tr>
<tr>
<td>Operator</td>
<td>1</td>
</tr>
</tbody>
</table>

II Cell

- ID Turning, drilling & Deburring

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cycle time</td>
<td>368 sec</td>
</tr>
<tr>
<td>Changeover</td>
<td>less than 2min.</td>
</tr>
<tr>
<td>Availability</td>
<td>27600 sec</td>
</tr>
<tr>
<td>Uptime</td>
<td>99.5%</td>
</tr>
<tr>
<td>Takt time</td>
<td>368 sec</td>
</tr>
<tr>
<td>Operator</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4.7 depicts the future state map with all improvement proposals incorporated.
Figure 4.7 Future State Map