APPLICATION OF KANBAN SYSTEM FOR IMPLEMENTING LEAN MANUFACTURING
(A CASE STUDY)

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ABSTRACT
This paper deals with implementation of lean manufacturing in Engine valve machining cell in a leading auto components manufacturing industry in the South India. The main objective of this paper is to provide a background on lean manufacturing, present an overview of manufacturing wastes and introduce the tools and techniques that are used to transform a company into a high performing lean enterprise. Value stream mapping is a main tool used to identify the opportunities for various lean techniques. The focus of the lean manufacturing approach is on cost reduction by eliminating Non- Value added activities. Applications have spanned many sectors including automotive, electronics and consumer products manufacturing. In this paper, Value Stream Mapping (VSM) is used to map the current operating state for production line. This map is used to identify sources of waste and to identify lean tools for reducing the waste. To eliminate the wastes found from the current state map Kanban system is suggested for pre machining section and single piece flow concept is suggested for machining section. Then a future state map has been developed for the system with lean tools applied to it

KEYWORDS: Lean manufacturing, Value Stream Mapping and Kanban System

1. INTRODUCTION
Many manufacturers are now critically evaluating their processes to determine their effectiveness in bringing maximum value to customers. Factory management techniques of yesterday are being replaced by more efficient methods that greatly minimize delays, reduce costs, and improve quality. Lean manufacturing is a whole-systems approach that creates a culture in which everyone in the organization continuously improves processes and production. It is a system focused on and driven by customers, both internal and external.

The aim of Lean Manufacturing is the elimination of waste in every area of production including customer relations, product design, supplier networks, and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and
Economical manner possible. Essentially, a "waste" is anything that the customer is not willing to pay for. Typically, the types of waste considered in a lean manufacturing system are Overproduction, Waiting, Inventory or Work in Process (WIP), Processing waste, Transportation, Motion and Making defective products.

2. METHODOLOGY
The following steps are involved in the implementation of lean manufacturing.

• Choosing a product or product family and Study of manufacturing methods and sequence of operations.
• Study of layout and Construction of Current State Value Stream Map.
• Identification of Wastes and Looking out for the methods to eliminate these wastes.
• Construction of Future State Value Stream Map and Implementation of the proposed concept.
• Analysis of economical benefits associated with proposed concept.

3. CHOOSING A PRODUCT OR PRODUCT FAMILY
It would be highly creditable to implement the concept of lean manufacturing in an organization which has smaller more flexible machines that are typically organized into work cells devoted to production of a family of products. In accordance a leading valve manufacturing unit in South India who are interested in implementing the lean manufacturing concept.

4. STUDY OF MANUFACTURING METHODS AND SEQUENCE OF OPERATIONS
The following sections show the processes and sequence that have been currently done in the company to bring the final product (Engine Valve) from the raw material which is stored in the raw material store.

5. CURRENT STATE FOR PASSENGER CAR ENGINE VALVE MANUFACTURING LINE
Data collection for the material flow started at the shipping department, and worked backward all the way to the upset and forging process, gathering snapshot data such as inventory levels before each process, process cycle times (C/T), number of workers, and changeover (C/O) times, materials handling system etc., for the current state mapping. The Value Stream Mapping for the passenger car engine valve manufacturing line has been drawn. By analyzing the Value Stream Mapping, the following activities are found as the wastes.
The operations, head diameter turning and grooving & chamfering have been done by two consecutive machines. Two consecutive grinding operations have been done by two consecutive grinding machines. Two valve seat grinding machines have been used to meet the customer demand. This is due to the incorrect selection of grinding wheels. The grinding of valve seat is necessary, but before that the valve seat turning is not necessary as it have currently being done. Therefore it is the waste process. The same end finishing operation has been done at two different stations. The semi finished products in batches are moved manually between stations. This leads to excessive transportation waiting of products. Loading
and unloading activities are done at each station and therefore it needs one operator at every station and it also leads to operator fatigue. Most of the machines have its own inspection stations even though the inspection does not add value to the products. Moreover the machining process is stopped when the inspection is done. The operators are idle, in most of the stations, while the machine process the product. This above wastes indicates the improvement opportunities from current line. By going through these wastes, the methods to eliminate or reduce these wastes are to be found. Then the Future State Map to be drawn considering with the improved methods. Then the two maps are to be analyzed to compare the economical benefits Future state over current state.

### Table 1: Current State for Passenger Car Engine Valve Manufacturing Line

<table>
<thead>
<tr>
<th>Process</th>
<th>Cycle Time in sec</th>
<th>Value Added Time in sec</th>
<th>Change Over Time in sec</th>
<th>NO. WIP</th>
<th>Loading Method</th>
<th>Unloading NO. of m/c per operator</th>
<th>Method of Transferring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough grinding Head</td>
<td>13</td>
<td>11</td>
<td>600</td>
<td>1</td>
<td>Manual</td>
<td>Auto</td>
<td>1</td>
</tr>
<tr>
<td>Diaturning</td>
<td>18</td>
<td>15</td>
<td>300</td>
<td>1</td>
<td>Auto</td>
<td>Auto</td>
<td>1</td>
</tr>
<tr>
<td>Grooving and chamfering</td>
<td>10</td>
<td>8</td>
<td>300</td>
<td>1</td>
<td>500</td>
<td>Auto</td>
<td>1</td>
</tr>
<tr>
<td>Finish tappet end I</td>
<td>5</td>
<td>3</td>
<td>300</td>
<td>1</td>
<td>1500</td>
<td>Auto</td>
<td>1</td>
</tr>
<tr>
<td>Finish grinding Flame</td>
<td>14</td>
<td>12</td>
<td>900</td>
<td>1</td>
<td>Manual</td>
<td>Auto</td>
<td>1</td>
</tr>
<tr>
<td>Hardening</td>
<td>15</td>
<td>13</td>
<td>0</td>
<td>1</td>
<td>1000</td>
<td>Manual</td>
<td>1</td>
</tr>
</tbody>
</table>
6. ELIMINATION OF WASTES BY PROCESS IMPROVEMENTS

6.1 Kanban System for Pre Machining Section

6.2 Introduction to Kanban System
The word Kanban has come to stand for a variety of items ranging from shelves, bins, electronic messages and order slips to the entire reorder point system. It is a small piece of a large puzzle. Kanban system guides everyone in an industry from machine operator to trolley driver to know what the next process to be carried out.

6.3 Kanban Technique
The technique that makes the JIT principles practical is called KANBAN. KANBAN is a Japanese word meaning signboard or billboard. (Kan = visual, Ban = card). Kanban is a signal to replace what has been used. If the authorization is present, one can act. If it is not one can’t. KANBAN is therefore a way of controlling inventory. In earlier days Kanban is the special manufacturing system proposed by Toyota.

6.4 Functions of Kanban system
- It provides pick up or transport information.
- It provides production information.
- It prevents over production and excessive transport.
- It serves as a work order attached to goods.
- It reveals existing problems and maintains inventory control.

6.5 Criteria to select Kanban items
- Self certified items, that are past 6 months there is no quality issue.
- For stable process.
- For tools life monitoring system
- Once in 3 months raw material inspection report must be submitted.
- Once in 3 months layout inspection report must be submitted.
- Any process change must be approved by customer.
- Special process must be approved by customer.

6.6 Kanban flow diagram
6.7 Types of Kanban

The kanban system is based on use of cards called ‘Kanbans’. The card is put in a rectangular vinyl slack. The following three kinds of cards are normally used:

- Move kanban
- Production kanban
- Supplier kanban

To make kanban system work, manufacturing processes are designated as preceding process and subsequent process. The withdrawal kanban details the quantity that the subsequent process should withdraw, while the production ordering kanban shows the quantity preceding process should produce. By drawing the Value Stream Map as a tool, a number of wastes were listed out in the current manufacturing line out of which unnecessary inventory is very important as it affects more, the cost of production. We can call this production as a ‘Push Production’ as the machine stations in the manufacturing line produces the valves based on the capacity of the machine station not based on the demand. And also a WIP of 3 days of demand are maintained along the manufacturing line. Kanban system is an information system to harmoniously control the production quantities in every process. We have suggested that this Kanban system can be implemented to reduce the inventory in the pre-machining section (Raw material, Upsetting & forging and Heat treatment).

The Kanban system is based on the use of cards called “Kanbans”. The card is put in a rectangular vinyl slack. The following are the two kinds of cards normally used.
To make the Kanban system work, the manufacturing processes are designated as preceding process (PP) and subsequent process (SP). The Withdrawal Kanban (WK) details the quantity that the subsequent process should withdraw, while the Production Ordering Kanban (POK) shows the quantity which the preceding process should produce. These cards circulate within the factory (Pre-machining section).

6.8 Kanban Job Flow
6.9 Number of Kanban Cards

Number of cards = \( \frac{ADD \times \text{Lead Time Conveyance} \times (1 + \text{safety coefficient})}{\text{Container capacity}} \)

Where, the bottleneck (2 hour round trip) process or station is Heat Treatment in our case because the optimum number of parts that can be in a batch to do the heat treatment process is 500.
Number of cards (RM) = \(\frac{2000 \times \left(\frac{0.25}{6}\right) \left[1 + \left(\frac{0.25}{6}\right)\right]}{500}\) = 0.12 = 1 (round off)

Number of WKs = 1, Number of POKs = 1

Number of cards (FORCE) = \(\frac{2000 \times \left(\frac{0.5}{6}\right) \left[1 + \left(\frac{0.5}{6}\right)\right]}{500}\) = 0.26 = 1 (round off)

Number of WKs = 1, Number of POKs = 1

Number of cards (HT) = \(\frac{2000 \times \left(\frac{2}{6}\right) \left[1 + \left(\frac{2}{6}\right)\right]}{500}\) = 1.25 = 2 (round off)

Total Number of WKs = 2, Number of POKs = 2

Therefore Total cards in the pre-machining section = 8 Kanban cards.

A trial had taken for the Kanban movement with time for a part of a shift starting at 6:00
am and ending at 2:00 pm (8 hour shift). The following table shows Kanban movement with time.

Table 2: Kanban Movements with Time

<table>
<thead>
<tr>
<th>Time</th>
<th>Raw material</th>
<th>Forging</th>
<th>Heat treatment</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
<td>WK</td>
<td>P</td>
<td>FGS</td>
</tr>
<tr>
<td>6:00</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:01</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:05</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:10</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:15</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:20</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:25</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6:35</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:40</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>


6.3 Waste Elimination and Layout upgradation in Machining Section

In the machining shop there are three stages for grinding the stem. The purpose is to reduce the diameter from 5.95 to 5.469. The amount of material removal in each stage is 0.375, 0.092, and 0.014mm. Since the finish grinding is required the operation is mandatory but we can eliminate the intermediate grinding operation by purchasing the bar of the size which comes after the first stage grinding operation. The diameter will be equal to (5.95-0.375). Hence the inventory gets reduced. The second waste which we can eliminate is by using a single cutting tool. Turning of head diameter, valve seat, chamfering at head and tappet grooving, facing and chamfering are done at two stations even though they are consecutive operations. Since these operations involve lathe, this can be combined and done in a single station. The third waste which we can
eliminate is by eliminating the finish tappet end operation. Since this operation is to check the overall length of the valve to correct size this can be performed at the end before the final inspection.
Table 3: comparison between current and future state

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Current state</th>
<th>After implementation of future state</th>
</tr>
</thead>
<tbody>
<tr>
<td>O/P per shift</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>No. of operators in machining</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Productivity per operator</td>
<td>222</td>
<td>400</td>
</tr>
<tr>
<td>Transportation of material b/w</td>
<td>Manual</td>
<td>Automatic</td>
</tr>
<tr>
<td>Machining section layout</td>
<td>Straight layout</td>
<td>‘U’ layout</td>
</tr>
<tr>
<td>Loading and unloading</td>
<td>Manual</td>
<td>Automatic</td>
</tr>
<tr>
<td>Inventory at pre machining</td>
<td>12000</td>
<td>4000 (1 day demand)</td>
</tr>
<tr>
<td>section</td>
<td>(3 days of demand)</td>
<td></td>
</tr>
<tr>
<td>Inventory at machining section</td>
<td>12000</td>
<td>Single piece flow</td>
</tr>
<tr>
<td></td>
<td>(3 days of demand)</td>
<td></td>
</tr>
</tbody>
</table>

This operation can be performed by the grinding operation without changing any alternate machinery or setup. Hence the required length can be obtained. The fourth item which we can eliminate or reduce is the inspection as it will not add any value to the product. Since one engine valve is being inspected for about four minutes involving three members this can be modified by adopting a simple but effective method. We can adopt the multi gauging system based on machine vision system. This system takes just about 10 seconds to inspect the valve. Hence this effectively reduces time and manpower. In the second stage of operation seat turning is one of the operations. Instead of doing this operation if forging operation is performed to an extend that the seat parameter is brought to a level of what it will be after the seat turning operation then seat turning operation can be eliminated. Hence we can directly perform the seat grinding operation thus reducing the time needed for the particular seat turning operation.

7. CONCLUSION

Thus, the value stream maps for the current
state and future state for both pre machining and machining sections have been drawn. The future state map is drawn after the elimination and or reducing of wastes which were found from the current state map. The necessary kaizens were implemented in the process to reduce the wastes. The future state map was developed for the system with lean tools applied to it, which will improve productivity to a greater extent. The elimination and or reducing of wastes is by making the process improvements in the current manufacturing line by adopting some lean tools like JIT, set up time reduction, WIP reduction etc.

9. REFERENCES

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