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Application of Value Stream Mapping for Lead Time Reduction and Inventory Control

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Abstract: Mapping a process for simply visualizing a flow is a well known concept in organizational area. Value Stream Mapping (VSM), a lean tool, is a preferred way to implement Lean Manufacturing through series of steps. It identifies the stream of value through a system and is focused on material and information flow (Rother and Shook, 1998). The purpose of this paper is to utilize VSM to reduce lead time and control inventory for a manufacturing unit. A case study is considered with current state and future state maps.

Keywords: Inventory control, Lead time reduction, Lean Manufacturing, Value Stream Mapping, VSM, Waste

I. Introduction

Lean manufacturing, a philosophy derived from the Toyota Production System (TPS), is based on waste elimination which tries for customer satisfaction through continuous improvement (Womack et al. 1990, 1996). To survive in competitive market, manufacturers have realized that the traditional mass production should be advanced towards the new ideas of lean manufacturing (Abdulmalek et al., 2007).

Value stream mapping enables to see entire organization process on paper, in both its current state and desired future state. It represents information and material flow from raw material to finish goods and helps to identify the waste and areas for improvement. The visual representation facilitates lean approach by identifying the value-added and non-value added steps. It also contains the data like process time, set-up time or change over time, WIP inventory and number of workers/shifts.

II. Literature Review

Taiichi Ohno (1988), Shingo (1989), Womack et al. (1990), Womack and Jones (1994, 1996, 1998, 2000, 2005 and 2009), Hines and Rich (1997), Rother and Shook (1999) have effectively studied TPS and lean.

Womack, Jones and Roos (1990) in 'Machine that changed the world' termed 'Lean' concept as a system working on minimum resources to manufacture increased throughput with more variety of finished goods.

Womack and Jones (1996) in 'Lean thinking' recommended five steps to add value to a process; which are specify value, identify value stream, create flow, use pull and move towards perfection.

Hines and Rich (1997) proposed seven VSM tools; which are process activity mapping, supply chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis, and physical structure mapping. Authors also described value stream analysis tool (VALSAT), specifying which tool to be used in particular circumstances. Authors reported deficiencies arising while extending waste removal to the complete supply chain.

Rother and Shook (1999) in 'Learning to see' workbook explained how to create a map for value stream of a product. Authors stated four initial VSM steps; product family selection, current state drawing, future state drawing and implementation. Despite of the success of the method, current state map in 'Learning to see' lacked mapping of entire supply chain.

Womack and Jones (2002) in Seeing the whole article incorporated Learning to see by Rother, Shook and VSM tools by Hines, Rich together as 'Extended Value Stream Mapping' to address enterprise level VSM and overall supply chain.

Vikram and Sudhir (2014) proposed implementation plan for application of VSM with simulation for manufacturing industry. Simulation approach was suggested to control the inventory and reduce lead time by proposing modifications for the existing manufacturing condition.

III. VSM Methodology

Rother and Shook (1999) in 'Learning to See' workbook has suggested following steps for VSM:

1. Select Product family and Decide value stream level
2. Map Current State
3. Map Future State
4. Implement work plan

IV. Case Study

This case study is carried out in a compressor and motor manufacturing industry located at Satara, India. Following steps were followed for VSM implementation at Manufacturing Unit.

A. Selecting Product family and deciding value stream level

Initial step for VSM implementation is defining product family for VSM. A product family is a group of products that share the same or similar processes or machines. The Step also decides the scope of analysis for the case study with the help of VSM Level.

Product family having maximum annual production was selected from five product families, due to the potential of savings it could generate. VSM was started at single facility level for the manufacturing industry under study.

B. Current State Mapping

a) Data collection (Gemba)

Initial map was drawn during Gemba (shop floor visit) capturing how things were done. Drawing was accomplished while walking along the actual process. It provided basics for identifying wastes and its root causes. Data was gathered from the company's ERP systems and records maintained at shop floor. Relevant Data for the selected product family included monthly and annual demand, Suppliers, clients, Numbers of working days, Number of shifts per day, Total working hours per shift.

b) Time Study

During time study, cycle times for production line operations were observed. Cycle times were recorded with 5 iterations for each operation using a stop watch with a data sheet as shown in Table I.

Table I: - Average Cycle Times at Production Line B1

Operations	Time (sec)					Average (sec)
Bush Press Operation	14	16	15	14	15	15
Boring	83	87	84	85	87	85
Slotting	62	59	61	63	58	60
Drilling	63	61	61	62	63	62
Dibburing	50	48	51	49	52	50
Honing	32	29	31	30	30	30

c) Process Activity Mapping

Process Activity Mapping (PAM) was used to identify the total lead time and identification of waste (Hines, Rich 1997). Figure 01 shows the process level map for the production line B1 at the Manufacturing Unit.

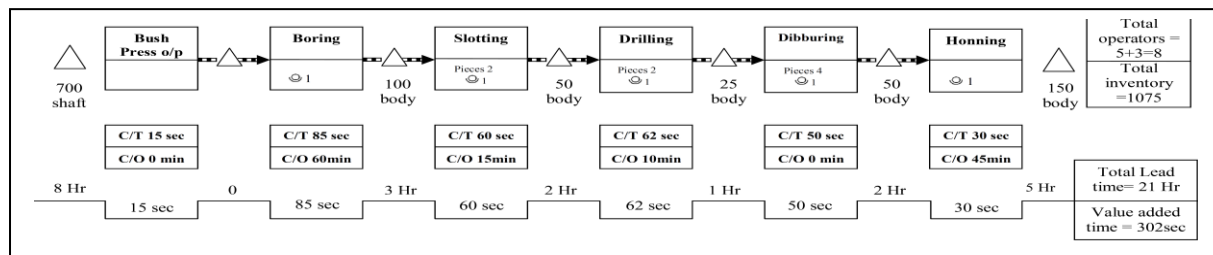


Figure 01: Process Level Map for Production Line B1

The production line B1 contained six steps starting with bush press operation, boring, slotting, drilling, deburring and ends with honing. The minimum cycle time was 15 seconds for bush press machine and the maximum was 85 seconds boring machine. The time data used in the map indicates the average cycle times for each operation. Based on time studies, the total cycle time for B2 line was 302 seconds, which is 5.03 minutes. As seen in the figure 01, the operation time was greater at second step of boring (87 sec), compared to other operations. This step took the longest time in the whole production line and slows down the total process. So bottle neck was found at start of the line B2 at boring with 87 sec. A bottle neck in an operation is a step that takes significantly longer time than the rest of the operations, thus slowing down the whole production line. The bottleneck at this step slows down the line and causes a buildup of materials. Suggested improvements are given in further section of this report.

d) Information Flow

Centralized ERP system was used for communication from different channels of industry. PPC department escalated production schedule to all internal departments and operation stations of the industry.

e) Current State Map (Single facility level current state map is shown in Figure 02)

C. Future State Mapping

Major amount waste was identified from the current state map. With the application lean tools, various gap areas in current state were bridged in order to prepare future state map. Lean tools such as TAKT Time Calculation, Continuous Flow, First In First Out and Transportation elimination were used for waste reduction.

a) TAKT Time Calculation

TAKT time is the available working time (in second per shift) divided by the customer demand (in units per shift). Available working time per shift is 430minute. Customer demand per shift is 400 units. $TAKT\ time = (430 \times 60\ seconds) / (400\ unit) = 64.5\ seconds/unit$. On the future-state map, takt time is shown in separate box above the process boxes. As only cycle time for boring machine was exceeding takt time, it was considered for a major maintenance schedule with machine redesigning/repair program. Approximate reduction of cycle time after repair program was expected about 72sec with 30min change over time.

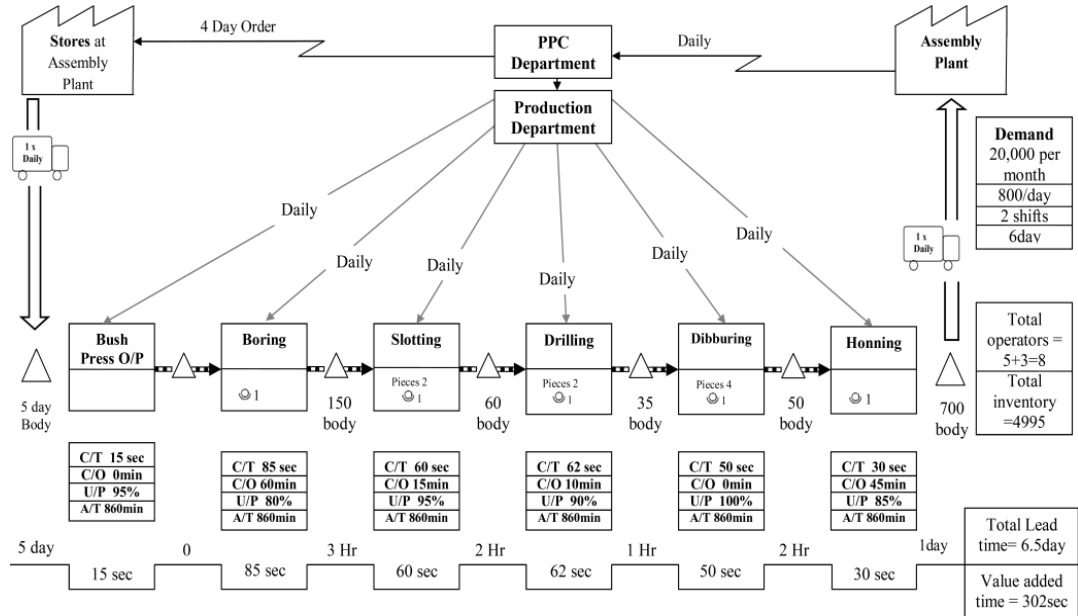


Figure 02: Current State for Manufacturing Unit

b) Continuous Flow

Continuous Flow was proposed with the chute between work stations at production lines. Before implementing VSM, the senior engineers of the manufacturing unit were thinking to include continuous flow in the unit. It was a good opportunity to implement the concept. A plan was to set up a line of production machines with conveyor (chute) connecting each of them. Also bush press operation and boring proposed to be carried out simultaneously, both current-state process boxes combined into one box on the future state map.

c) First In First Out (FIFO)

FIFO was utilized to maintain controlled inventory. It is a lane which can hold fixed/decided number of inventory. Whenever the lane is full, the earlier operator stops producing parts preventing the overproduction of products/parts. So lane between two decoupled processes maintains a flow between them. FIFO symbol is shown between two process boxes with maximum inventory it can hold.

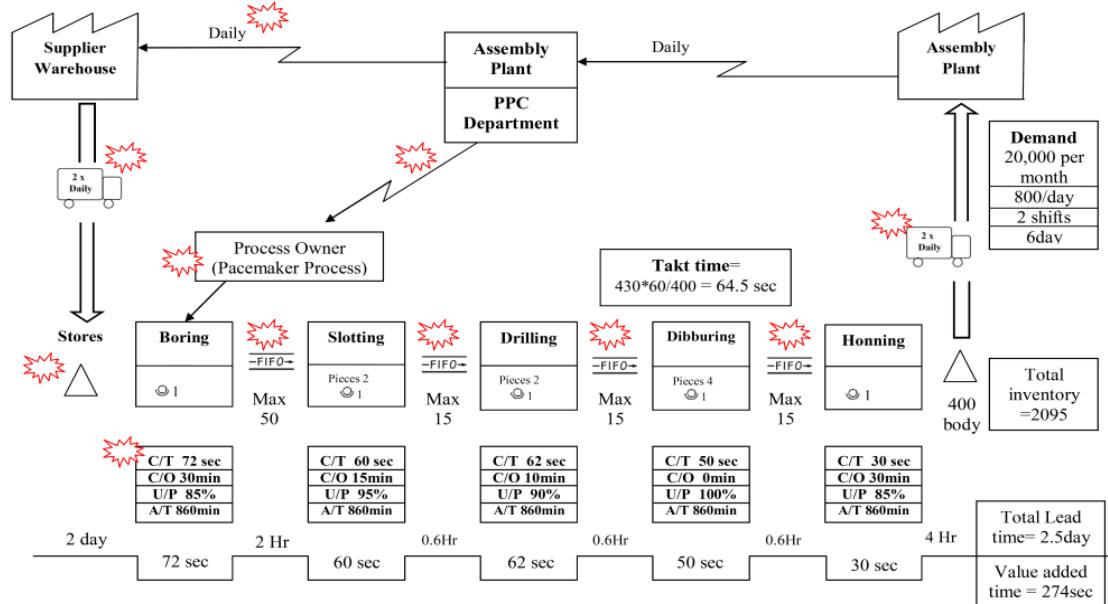


Figure 03: Future State for Manufacturing Unit

d) Pacemaker Process

For pull system, production is scheduled from only one point in value stream, which is called as pacemaker process. Production control at this process decides pace for remaining value stream. On the future-state map, pacemaker process is shown which is controlled by the assembly customer's orders.

e) Transportation elimination

Unnecessary transportation from Stores at Assembly plant to manufacturing unit was eliminated by providing storage facility at manufacturing unit itself. Also unnecessary information flow is avoided with deciding a process owner for value stream.

f) Future State Map (Single facility level future state map is shown in Figure 03)

g) Improvements

Table II shows 'before and after' conditions for manufacturing unit. It can be seen that large amount of waste could be removed through these actions.

Table II: - Lead Time Reduction for Manufacturing Unit

	Order lead time	Bush Press Operation	Boring	Slotting	Drilling	Deburring	Honning	Production Lead time
Before	5 days	15 sec	85 sec	3 hr	2 hr	1 hr	2 hr	6.5 days
After	2 days	Merged with boring	72 sec	0.6 hr	0.6 hr	0.6 hr	30 min	2.5 days
Reduction	3 days	0 sec	13 sec	2.4 hr	1.4 hr	0.4 hr	15min	4 days

D. Implementations

Implementation of VSM has been going on for last quarter year and will continue to do so, as VSM is a continuous process. During this period following results have been attained.

- By eliminating unnecessary transport and inspection process between stores at assembly plant to manufacturing unit, it was possible to reduce the order lead time from 5 days to 2 days.
- Continuous flow was installed between all operation stations of production line resulting in 66% reduced WIP inventory.
- Boring machine can be considered for major repair operation during next quarter of planning with alternative solution of continual of production.

V. Conclusions

By controlling WIP inventory fewer than 66% and reducing production lead time by 3 days 4.2 hr in time span of quarter year, we can say VSM is effective way to control the inventory and reduce lead time by implementing modifications in the existing manufacturing conditions. VSM deals with overall, integrated optimization of enterprise processes at every level. VSM can be utilized in following manner.

- VSM is utilized to identify and then eliminate sources of waste applying variety of lean tools.
- Main purpose is to establish continuous flow of material/product through entire supply chain process.
- Goals for VSM are shortest lead time, zero inventories with lowest cost and highest quality of product.

Addressing enterprise level VSM with 'Extended Value Stream Mapping' is future scope for the study.

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