

Lead Time Reduction on Connecting Rod Machining Line by using Value Stream Mapping

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ABSTRACT: Nowadays in a competitive and economic market, Companies want less lead time, low cost, higher customer demand and satisfaction. As such, a company concentrate more on reducing lead time. To sustain in market firms have to find out different ways to reduce production time and eliminate different types of waste, improve operational performance and product quality. Value stream mapping is one of the lean manufacturing tools that map information flow, material flow, activities and process elements as they are the part of supply chain. The value stream mapping helps to identify value added and non-value added stages. This study is carried out on using value stream mapping technique. So as to find waste and eliminate those areas which are generating different type of waste in precision component machining firms. The objective of this study is to use value stream mapping for reducing lead time and at same time control inventory leading to increase in productivity against demand. Current state map is created to understand how different process are done and to identify different areas where improvement potentials lie. Future state map is created to show the implementation action plan with takt time.

KEYWORDS: Lead time, lead time reduction, value stream mapping, current state map, future state map, inventory control, Takt time, Non-value added time, non-value added time

I. INTRODUCTION

Companies continuously strive to increase the productivity and output of their operations. Lean was originally created and defined as the Toyota waste disposal process along with supporting a system to reduce or eliminate waste and value-free activities from various processes. Both non-added value and value added activities are obtained from value stream map creation. This helps to identify waste generating area in production line so as to reduce production lead time. Value Stream Mapping is representation and streamlines work forms utilizing the strategies of Lean tool. Value stream mapping (VSM) helps to recognize, exhibit and help to reduce waste in processes. From this study we are concentrating on region creating different type of waste and eliminating them by utilizing lean tool. To improve their productivity Industries alter more capital and resources. Optimization of time, capital and work environment helps to reduce production lead time.

II. LITERATURE REVIEW

The research study was carried out in VST Tillers and Tractors precision component machining firm. The objective of this study is to reduce lead time and at the same time control inventory leading to increase in productivity. For this, to know supply chain losses or non value-added activities is necessary this data is obtained by creating value stream mapping. Vikram M. Patil, S. G. Bhatwadekar [1] By controlling WIP inventory by less than 66% and reducing production lead time by 3 days 4.2 hours in a quarter of the year, we can say that VSM is the effective way to control inventory and reduce lead times by making modifications in existing production conditions. Jafri Mohd Rohania, Seyed Mojjib Zahraee [2] after using lean tools, such as kanban, kaizen, 5s etc. value-added time decreased from 68 minutes to 37 minutes and Production Lead Time (PLT) decreased from 8.5 days to 6 days. Manjunath M. [3] According to this paper, after creating current state and the future state value stream map for a manufacturing firm this helps in 38.2 percent reduction in Lead time, reducing process times by 2.65 percent and a 48.3 percent inventory reduction. The cycle time can be reduced from 93 minutes to 67 minutes with the help of the transfer of the nonlinear workstation to

the conveyor workstation. Anupam Sihag, Vinod Kumar [4] In this study by changing layout, the inventory time was reduced from 3 to 1 day, with an improvement of 33.33%. Process lead time was reduced by 52.94% and processing time by 80.69%. Gokulraju R, Vigneshwar K [5] suggested to reduce Lead times and decreasing the throughput time of high pressure gate valve production line by using the value stream map. By implementing line balance, 5S and ergonomics, it is possible to achieve the maximum performance potential of the Manufacturing system. R.M. Belokar [6] reported a case study on VSM application in an automotive industry where they achieved nearly 67% improvement in cycle time by improving value-added activities.

III. METHODOLOGY

Value Stream Mapping (VSM) is one of the lean tools that help users see and understand the flow of material and information as products make their way through the value stream. VSM has the major steps as suggested by Rother and Shook is shown in Figure 1. The objective of the research is to reduce production lead time and control WIP so as to increase the production rate in the VST Tillers and Tractors industry, Mysore in order to meet customer demand. Full-capacity batch processing and bottlenecks in the production process contribute significantly to long production lead time. The results of the research would have a direct impact on the product production lead time and on WIP, helping to reduce costs and meet customer demand.

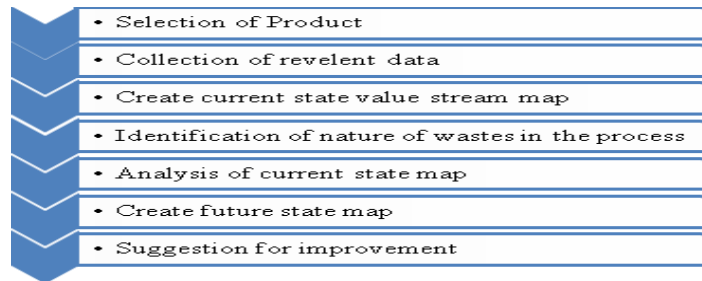


Fig.1 Implementation steps in value stream mapping

To create value stream map following strategies are applied:

1. Obtaining related data from the company.
2. Conducted time studies by collecting cycle time and number of operators for each machine.
3. Data collected through gemba walk (shop floor observation) for each process and machine.
4. To draw current and future state VSMs E-draw Max version 7.9.4 software is used.

The current information was collected directly from the company through discussions with managers, owners and production supervisors. An example of such information is raw material supply, general process flow, customer demand etc. Time studies were conducted to obtain accurate information about the cycle time, number of operators involve in each processing phase. Time studies have given the observed value of time for individual processes. Information about the cycle time and the number of operators involved in each processing phase, the amount of inventory and work in progress between the processes were determined. A current map has been drawn showing the flow of material and information. The takt time was calculated and compared with the average cycle time. The different areas that needed improvement were identified. Subsequently, a future status map was developed followed by some suggestions. Lean tools and techniques have been suggested to improvise the flow of material and information.

CASE STUDY

VST Tillers and Tractors precision component machining company selected as a case study in this paper. Since an analysis has been performed, we have found that in house production components have bottlenecks. In addition, the parts must be transferred from one machine to another to complete the operations. This situation causes a decrease in labor productivity and increases the cost of handling materials. Therefore, this causes low quality, lower labor productivity, delays of orders, more waiting times, more material movement, more work in progress (WIP). For these problems, it is necessary to identify the key areas, which produce waste, and to determine the bottleneck operating machine in the supply chain. The following information is related to the production line: 3 work shifts per day; Net available time per shift = 25200 seconds, Net available time for three shifts = 75600 seconds, working time per shift = 480 minutes, lunch break = 30 minutes, other allowances = 30 minutes, working days in a month = 26 days



1. Current state mapping

This case study is carried out in a VST tillers and tractors precision component machining industry located at Mysore, India. Following steps were followed for VSM implementation at Production Unit.

A. Data collection (Gemba)

The initial map was drawn during Gemba (workshop visit) capturing how things were made. The drawing of value stream map was done by walking through the real process. It Provided basics for identifying waste and its root causes. The data were obtained from the company's systems and from the records kept in the workshop. Relevant data for the selected product family include total working hours per shift, suppliers, customers, monthly and annual demand, number of working days, number of shifts per day.

B. Time Study

During the time study, cycle times for operations on the production line were observed. Cycle times were recorded with 4 iterations for each operation using a stopwatch with a data sheet as shown in Table 1.

Table 1. Average cycle time at production line

Operation	Time (sec)				Average
	Trial 1	Trial 2	Trial 3	Trial 4	
Slitting	194	192	196	194	194
Milling and Boring	813	815	813	814	814
Manual Assembly And Deburring	240	242	240	241	240
Vibro Benz (Machine Deburring)	66	67	65	66	66
Bush Pressing	14	14	16	13	14
Honing	138	137	135	135	136
Inspection	181	180	180	181	180
Number Punching	100	98	97	105	100
Packaging	182	180	179	180	180

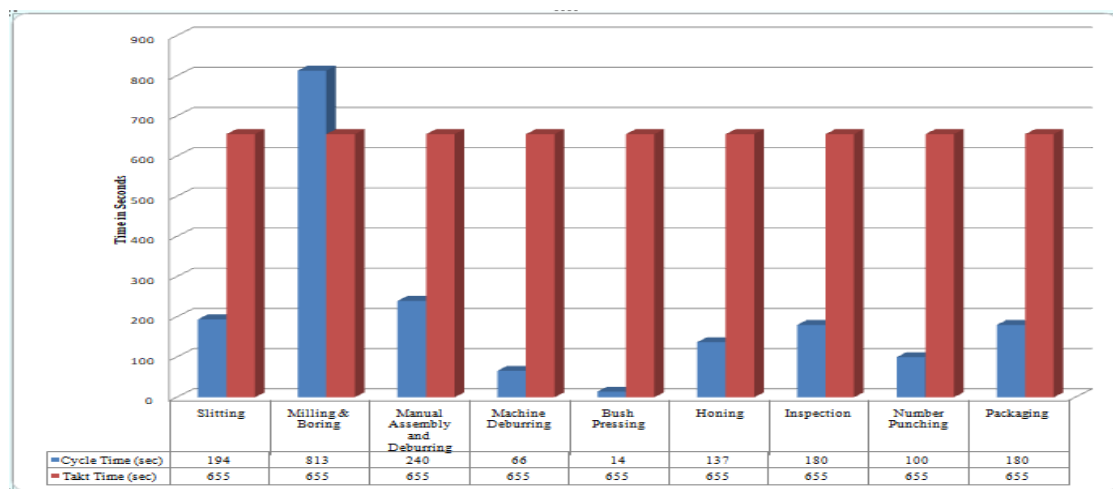


Fig.2 Graphical Representation of Comparison Between Takt Time and Station Cycle Time

C. Process Activity Mapping

Process Activity Mapping (time line) was used to identify waste and total lead time. Figure 3 shows the time line for the production line at the Production Unit.

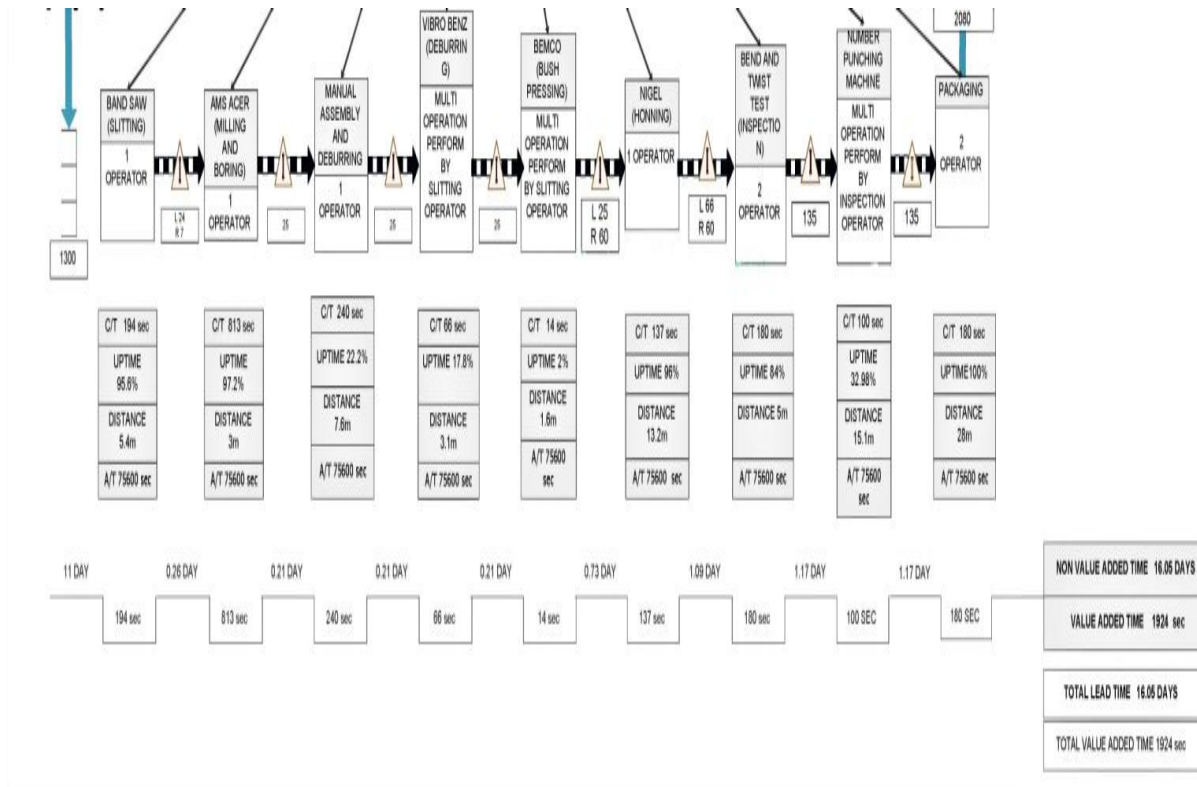


Fig.3 Show the time line map for production line

The VWH connecting rod machining line contained nine steps starting with slitting operation, milling and boring, manual assembly and deburring, Machine deburring, bush pressing, honing, inspection and end with packaging. The minimum cycle time was 14 seconds for bush press machine and the maximum was 813 seconds for AMS Acer machine (milling and boring operation). The time data used in the map indicates the average cycle times for each operation. Based on time studies, the total cycle time for VWH connecting rod machining line was 1924 seconds, which is 32 minutes. As seen in the figure 2, the operation time was greater at second step of milling and boring operation (813 sec), compared to other operations and takt time. This step took the longest time on the entire production line and slowed down the whole process. So bottle neck was found at start of the production line at boring and milling operation with 813 seconds this is obtained from line balancing graph as cycle time of milling and boring operation is higher then takt time which is 655 seconds as shown in fig 2. 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 in this step slows down the line and causes an accumulation of materials. Suggested improvements are given in further section of this report.

D. Information Flow

Production department escalated production schedule to all internal departments and operation stations of the industry.

E. Current state value stream map is shown in figure 4.

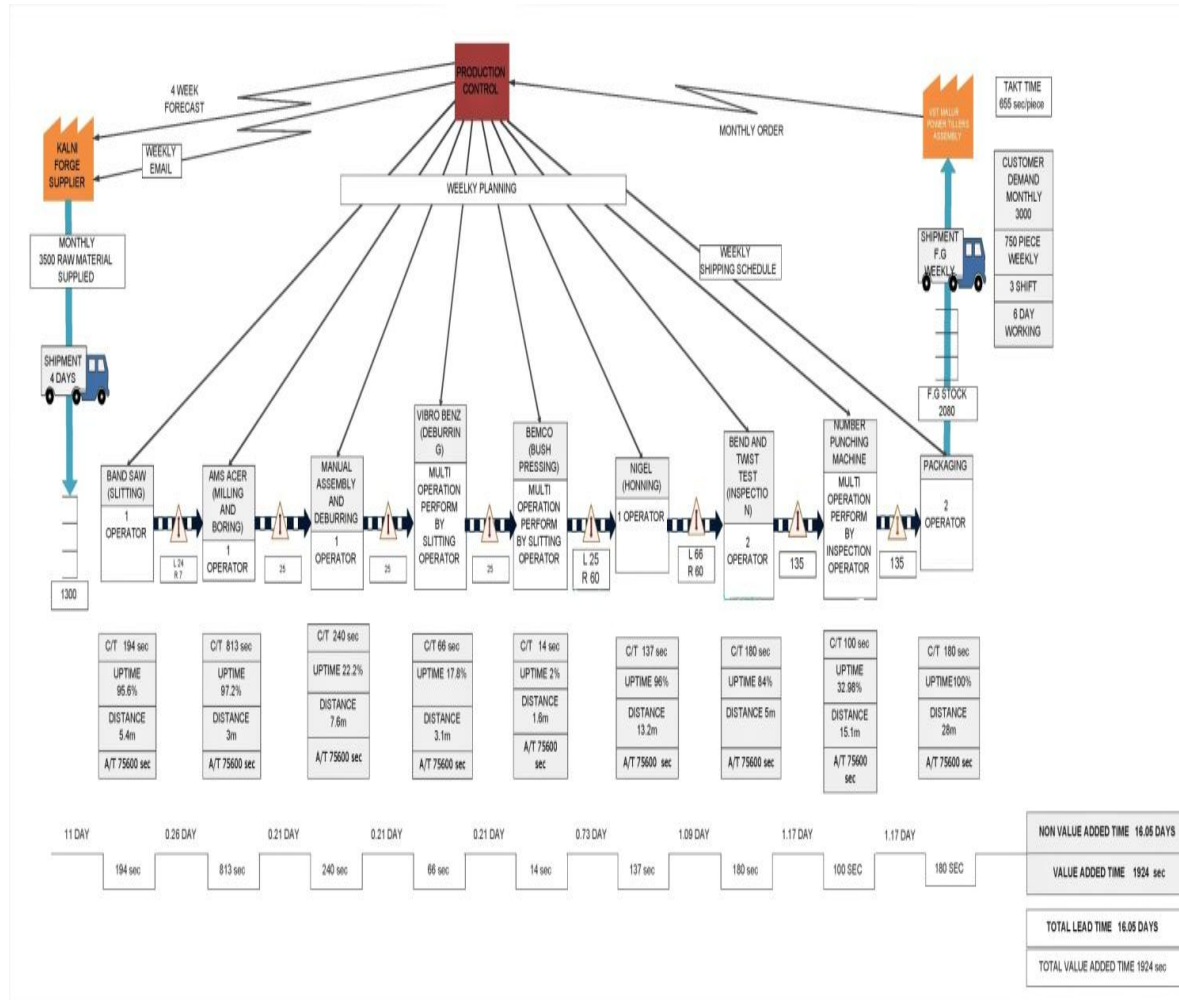


Fig.4 Shows Current State Value Stream Map for VWH Connecting Rod Machining Line

Lean implementation through kaizen and development of Future state map

2. Future State Mapping

The major amount of waste was identified by the current state map. Using lean tools, several gap areas in the current state have been bridged together to create a future state map. Manpower reduction, Takt time calculation, first in first out, delay in material transfer and reduction of material movement are some of the lean tools were used to reduce wastes. Kaizen shows important lead role in improving the productivity and quality of the products. VSM brainstorming analysis revealed the following major non value added activities (NVA) identified as poor processing, operator movement and skill, material movement at larger distances between the machines and delay in material transfer for which proposed plant layout change are suggested as shown in figures 5 and proposed lean solutions are suggested as follows in table 2.

A. Takt Time Calculation

Takt time = $\frac{\text{Net time available for production per month}}{\text{Customer monthly demand}}$

3 shift

1 shift = 8 hour= 480 min

Lunch Break = 30 min Tea Break= 30min

Net time available for production per month = 1965600 sec

Customer monthly demand= 3000

Takt time = 655.2 sec(10.92 min)

Company has to produce 1unit for every 655.22sec (10.92 min) during 3 shifts to meet customer demand

On the future-state map, takt time is shown in separate box. As only cycle time for AMS Acer machine was exceeding takt time, it was considered for a major maintenance schedule with machine redesigning/repair program and tool changing is done at faster rate. Approximate reduction of cycle time after repair program was expected about 752 sec.

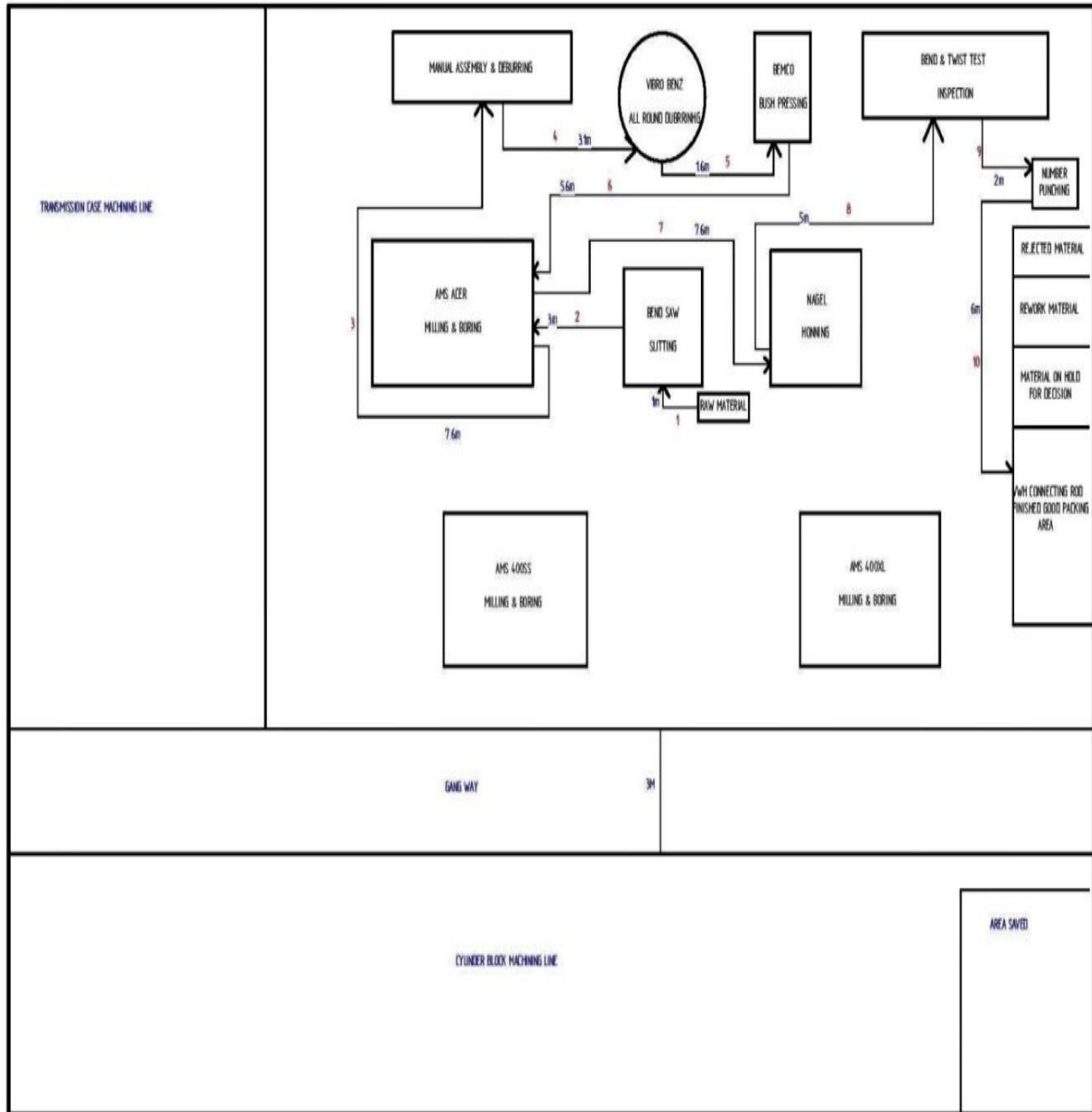


Fig.5 Shows Proposed Layout for VWH Connecting Rod Machining Line



Table 2. Proposed Solution

Station	NVA Activities	Task Involved	Proposed solution	Expected outcome (Time Saving)	Expected outcome (Distance saving)	Manpower Saving
Packing station	Movement	Inspection area to packing area long distance movement	Packing station is shifted to connecting rod machining line	30 SEC	21 m	0
Number punching machine	Movement	Inspection to number punching station long distance movement	Number punching machine is shifted near to inspection area	86 SEC	15.1 m	0
Packing Station	Number of operator is more	Perform by two operator	Packing is to be done by inspection operator (1)	0	0	2
Honing machine	Tool changing for small and big end boring	More time taken to change the tool by operator	Under guidance of tool department team tool changing is to be done	Before take 1140 sec after improvement take 480 sec save 660 sec	0	0
AMS Acer machine	Worn out tool changing	More time taken to change the tool by operator	Under guidance of tool department	Before take 840 sec after improvement take 256 sec save 584 sec	0	0
Raw material bin	Movement	Slitting machine to raw material bin long distance movement	Raw material bin shifted near to slitting machine	10 sec	5.4 m	0

B. First in first out (FIFO):

FIFO was used to keep a controlled inventory. It is a lane that can contain a fixed or decided inventory number. When the lane is full, the previous operator stops producing parts to avoid overproduction of products. The lane between two decoupled processes therefore maintains a flow between them. The FIFO symbol is displayed between two process boxes with the maximum inventory it can contain is shown in fig 6 (Kaizen burst2)

C. Pacemaker Process

For the pull system, production is planned from a single point in value stream, called the pacemaker process. The production control department in this process decides the pace of the flow of remaining value stream. On the future status map, the pacemaker process is applied to AMS Acer machine shown in fig 6 (kaizen burst 8).

D. Manpower and movement reduction

Number punching machine is relocated near inspection area to reduce walk distance. Current state condition it is 15.1m it is reduced to 2m after relocation shown in kaizen burst 3. Also helps to reduce cycle time from 100sec to 14sec shown in fig 6(kaizen burst 6). Packaging area is relocated near inspection area to reduce walk distance. Current state condition it is 28m it can be reduced to 6m after relocation save total packaging area and reduce walk distance shown in (kaizen burst 4). Also helps to reduce cycle time from 180sec to 150sec shown in fig 6(kaizen burst 7).

Before, packaging was done by two operators whereas after relocation it is done by one inspection operator this will eliminate two operators shown in fig 6(kaizen burst 5). After relocating raw material bin near to Slitting machine this help to reduce walk distance from 5.4m to 1m also reduces cycle time from 194 to 184sec shown in fig 6(kaizen burst 9).

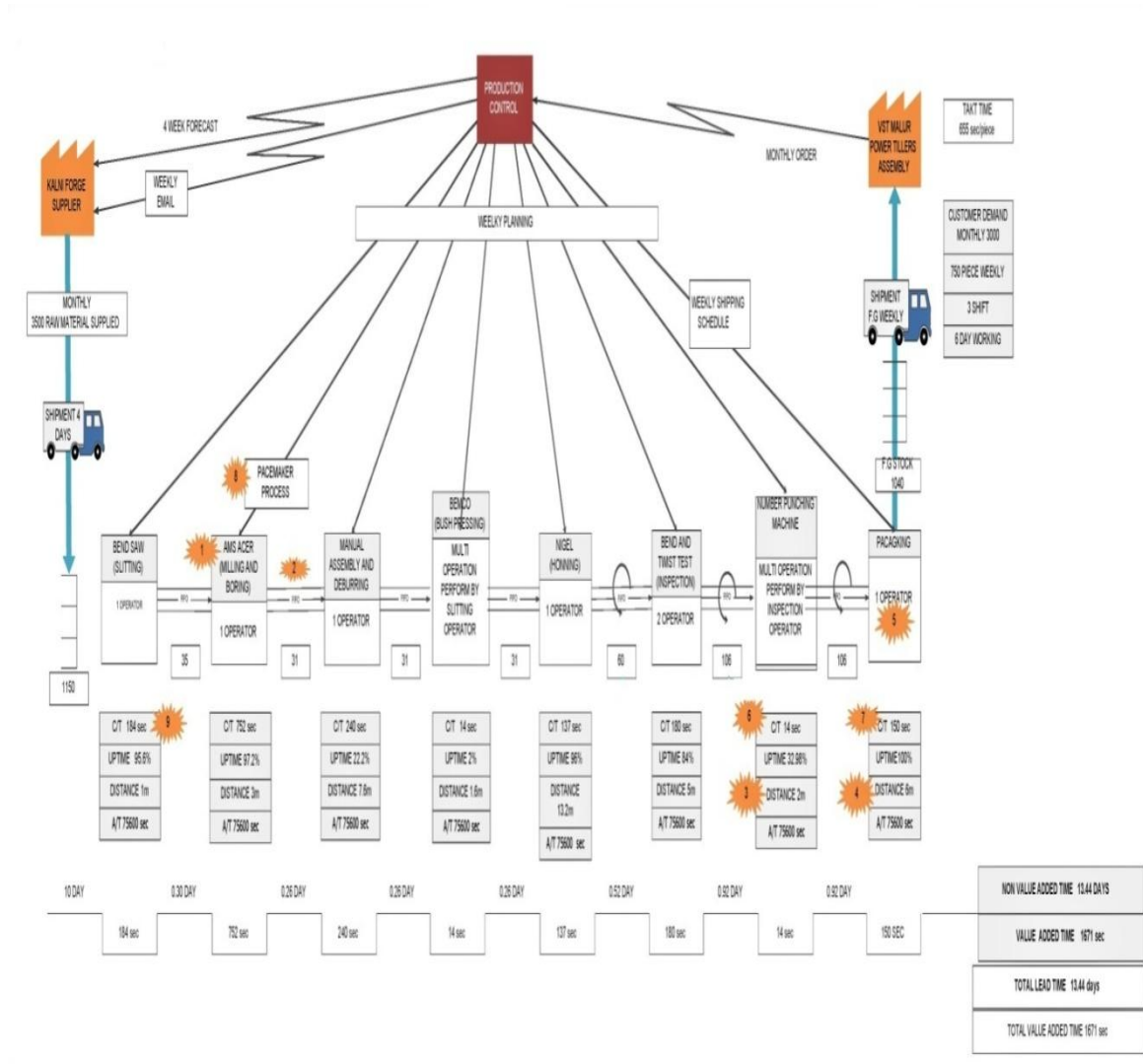


Fig.6 Shows Future State Value Stream Map for VWH Connecting Rod Machining Line

IV. RESULTS & SUGGESTIONS

Comparative study show the significant reduction occurs in WIP and Production Lead Time. Value stream mapping technique was used to draw maps and after applying some tools and giving some suggestions for the product following results are obtained shown below in table 3 and 4.



Table 3 Reduction in work in process of different processes

Processes	WIP in Current State Map	WIP in Future State Map	% Reduction
Bush Pressing	85	31	64%
Honing	126	60	52%
Inspection	135	106	22%
Number Punching	135	106	22%

Table 4 Reduction in Production Lead Time

Time	Current state map	Future State Map	Reduction
Production Lead Time	16.05 days	13.44 days	2.61days
Total Processing Time	1924 sec	1671 sec	13%

Value stream mapping analysis at VWH Connecting Rod Machining Line gives the areas which have different types of wastes and require a lot of improvement. So following suggestions are advised to production line regarding the shop floor activities improvement.

- As only cycle time for AMS Acer machine was exceeding takt time, it was considered for a major maintenance schedule with machine redesigning/repair program and tool changing is done at faster rate. Approximate reduction of cycle time after repair program was expected about 752sec.
- FIFO was used to keep a controlled inventory. It is a lane that can contain a fixed or decided inventory number. When the lane is full, the previous operator stops producing parts to avoid overproduction of products.
- Number punching machine is relocated near inspection area to reduce walk distance. Current state condition it is 15.1m it is reduced to 2m after relocation. Also helps to reduce cycle time from 100sec to 14sec shown in figure 9.
- Packaging area is relocated near inspection area to reduce walk distance. Current state condition it is 28m it can be reduced to 6m after relocation save total packaging area and reduce walk distance. Also helps to reduce cycle time from 180sec to 150sec shown in figure 9.
- Before packaging is done by two operators whereas after relocation it is done by one inspection operator this will eliminate two operators. After relocating raw material bin near to Slitting machine this help to reduce walk distance from 5.4m to 1m also reduces cycle time from 194 to 184sec shown in figure 9.
- After applying FIFO & pacemaker process to AMS Acer machine now material can be physically pulled between each process help to reduce inventory between each process.
- Total elimination of Vibro Benz machine after analysis help to reduce waiting components and total lead time.
- After lean implementation manpower reduces from 8 operators to 6 operators and total product distance travel is reduces from 82m to 43.8m as shown in figure 7 and 8

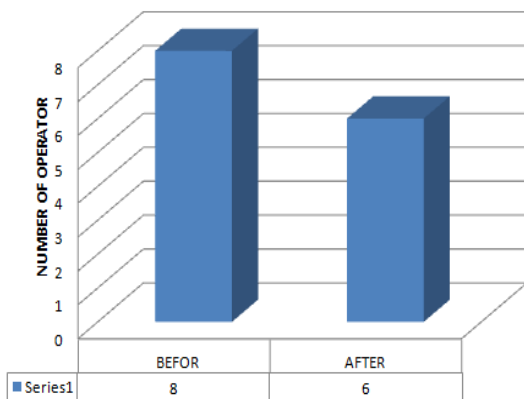


Fig.7 Graphical Representation of Manpower

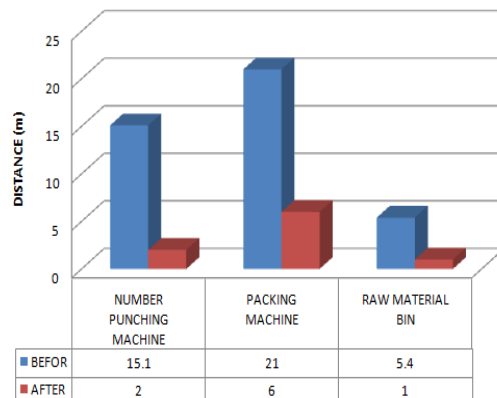


Fig.8 Graphical Representation of Distance

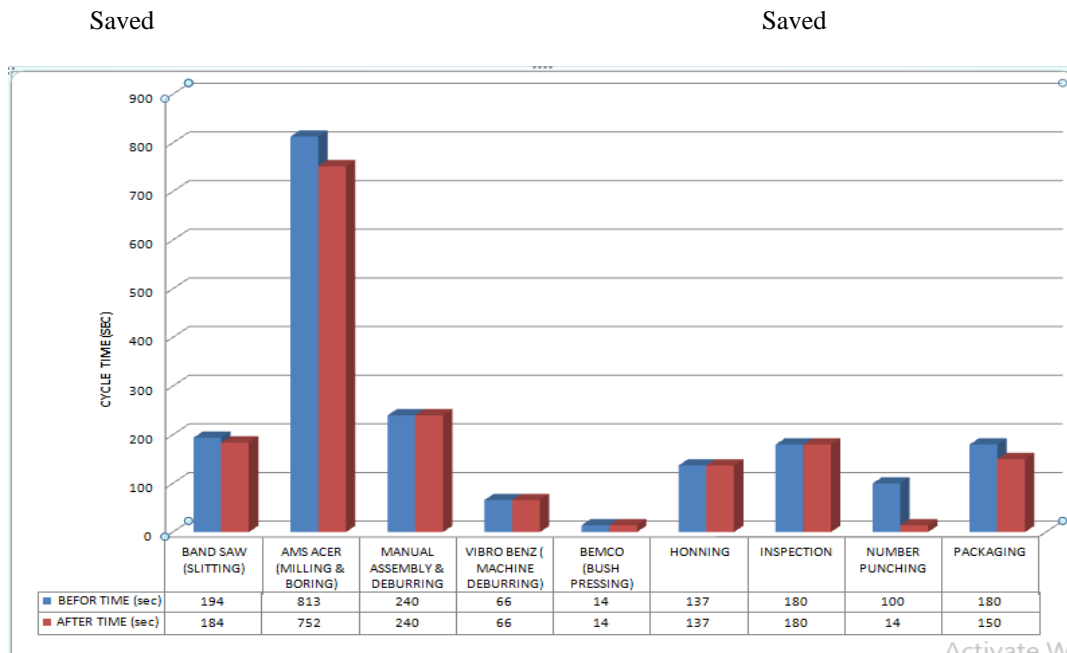


Fig.9 Graphical Representation of Cycle Time Reduction

V. CONCLUSION

By controlling the WIP inventory between each process and reducing production lead times by 2.61 days, we can say that VSM is an effective way to control inventory and reduce production lead times by implementing modifications to existing production conditions. This research study describes how value stream mapping can be used to graphically visualize the flow of material and the flow of information from the customer's order to the finished product. With this approach (VSM) it is possible to reduce waste in the company. The measure of the success of value stream mapping in this research was to address the way in which identified waste can be reduced through value stream mapping. The results indicate that the VST Tillers and Tractors industry should incorporate kaizen, pull system and first in first out (FIFO) wherever possible based on customer satisfaction. It can be concluded that the VSM study has been able to highlight a number of unnecessary activities in the process of machining of VWH connecting rod components. These activities have been related to waste such as large production lead time, WIP, storage etc.

VSM can be used in the following way.

- a) VSM is used to identify and therefore eliminate waste sources using a variety of lean tools.
- b) The main purpose is to establish a continuous flow of material / product throughout the entire supply chain process.
- c) The objectives for VSM are zero inventories at the lowest cost and maximum product quality, shorter production lead time and delivery time.

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