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Lean Manufacturing Implementation Through Value Stream Mapping: A Case Study

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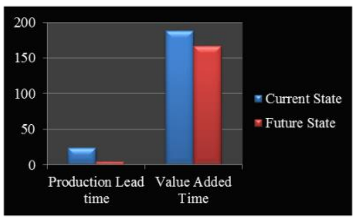
Graphical abstract



Abstract

Lean Manufacturing (LM) is a business strategy that was developed in Japan. The main contribution of lean manufacturing is the identification and elimination of waste. Companies apply LM to sustain their competitiveness over their competitors by improving the manufacturing system's productivity and quality enhancement of the product. The goal of this paper is to apply one of the most significant lean manufacturing techniques called Value Stream Mapping (VSM) to improve the production line of a company that produces several components for vehicle assembly line by decreasing the waste and non-value added activities. First, the current value stream map of production line was developed using personal interviews, observations and secondary data of the company. Subsequently, the future value stream map was proposed based on the lean manufacturing principles to improve total production lead time and value added time. Based on the final result it can be concluded that VSM is a useful and applicable approach that can help managers conceptualize the different kind of wastes and defects. Final result showed that the production lead time and value added time improved up to nearly 80 % and 12 % respectively by eliminating the wastes based on lean principles and VMS method.

Keywords: Lean manufacturing; value stream mapping; waste; assembly line

■1.0 INTRODUCTION

Several methods and approaches exist such as computer simulation, statistical analysis and lean tools for improving the efficiency by determining the best combination of resources in production lines or construction process [1-2]. In recent years, there has been a substantial growth in profit in most of the leading manufacturing companies around the world due to the use of lean manufacturing for supporting their competitiveness in the international market [3]. Some of the benefits of applying LM in companies include cost reduction, cycle time elimination, and waste decrement. In fact, the major aim of lean manufacturing is to decrease cost by reducing the non-value added performances. Lean manufacturing employs diverse tools and methods such as Just-In-Time (JIT), Total Productive Maintenance (TPM), Cellular Manufacturing and 5S, for realizing this objective [3]. Lean operating values originated from the workplace and also had different names with same meanings like Lean Manufacturing, Toyota Production System, and Lean Production. It is generally purported to have started in Japan, specifically in Toyota, although Henry Ford had utilized the components of lean in the beginning of 1920's according to proof denoted in this following quotes; "One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle" [3]. At first, the meaning of lean was introduced by the National Institute of Lean Network Standards and Technology Manufacturing Extension Partnerships [3], as an organized way for identifying and reducing operation stoppages so as to achieve nonstop smooth operation flow during the product manufacturing [3]. Usually, lean is made up of personality and individual mechanisms, which serve as building blocks in lean planning, when used in companies to improve efficiency [4]. Fundamentally, lean manufacturing is organized to remove any form of devastation or features which often leads to waste in an organisation and thus, preventing loss of resources [5]. This process eliminates non-value additional processes in the manufacturing lifecycle, improves production efficiency and motivates customers' choice. In addition, faster production workflow invariably increases return on investment (ROI) for the organisation and reduces waste, increases earnings of employees, renders higher profits to shareholders and added feature value for consumers. A brief description of the various available lean methods is explained as follows [4-6]:

- Cellular Manufacturing: systematize the whole processing for a particular product or related products into a set or cell that it includes all the needed equipment, machines, and operators.

- Just-In-Time (JIT): This is a method whereby a client's request is treated such that the request is sent out backward from the last assembly to unprocessed material, thus ''pulling'' all the needed resources as at when needed.
- Kanbans: The marking system for developing JIT production.
- Total Preventive Maintenance (TPM): Employees perform arranged tools protection to identify any irregularities. The aim is to be able to identify, modify and repair faults in operations in order to avoid crashes. Operators are included in protection and controlling activities to avoid and offer warning of breakdowns since they are nearby to the machines.
- Setup Time Decreasing: Always attempts to reduce the setup period for a machine.
- Total Quality Management (TQM): A method of nonstop development of using participative management to address the core requests of consumers based on the assumption that incompetency is not created by the people but is created by the system. Key elements are used for participation and preparation, problem solving team, arithmetical methods, long-term aims, and detection.
- 5S: Concentrates on efficient workplace organization and standardized work events.

This paper, aims at using a case-based method to examine how lean manufacturing tools if applied appropriately, facilitates the manufacturing processes in industry through improved product quality and control (inventory, financial and operational). Value stream mapping is used to identify sources of waste, and lean tools for waste reduction and for mapping the future state of development.

■2.0 LITERATURE REVIEW

The predominant use of Value Stream Mapping (VSM) rose due to successes achieved in Toyota of Japan during the 1980s' as an offspring of the earlier work progress performed by Taiichi Ohno of Toyota between 1960 to 1970 [7]. In addition, VSMs, firstly named "material and information flow maps" was mentioned on one-page shapes representing the process used to create a product [8-9]. Firstly, they were extended in Toyota Motor Corporation by Operations Management Consulting Division in the early 1980s in Toyota City of Japan [9]. Also, VSMs recognizes methods used for capturing objects and data to run with any suspension, progress efficiency of product and competitiveness [8]. It also promotes people development method instead of inaccessible progression developments. Moreover, VSM is a lean progression way of mapping used for comprehending the performance progress applied to create manufactured goods (Green Suppliers Network) [7]. The "Value Stream" is one of the conception of VSM that had been developed by Rother and Shook in 2009 and it is "all the performance (both value-added and non-value added) presently needed to bring an invention to the mainstream, which is vital for any invention; firstly the invention flow from unprocessed materials into the arms of the consumer and secondly the plan flow from perception to launch" [7]. Furthermore, researchers describe VSM as a visual mapping method used for the flow of information and objects to visualize the position of time sequence for every stage of the supply chain from human resource to data flow [8].

VSM is a collection of approaches used to visually demonstrate the material and data flows during the manufacturing process in order to identify and process value-additions so as to reduce the non-value addition performances [10-11]. Therefore, it is the planning of the material and data flows that requires their actions to be organized in firms, providers, and distributors for allocating items to consumers [12]. According of Garcia, VSM is the basic conception of lean manufacturing, which is like an action that adds no value to the product, and as such, is considered a waste that needs to be eliminated or reduced [13]. On the other hand, according to Chakravorty, VSM has been utilized as a foundation in the area of lean performance for promoting successful operations [14]. VSM employs the use of mapping methods to plan both material flows and data flows such that the data flows indicates and controls the material flows, industrial engineers make use of different method known as the customary process mapping methods. This improved visual demonstration makes it easy to identify the value-adding phases into a value flow and also helps reduce the non-value-adding wastes it causes [12]. According to Ohno, VSMs assist organizations identify a waste activity during business processes or see performances that causes production cost to increase but does not cause increase in value [15, 16] . On the other hand, VSM has the ability of exposing waste in business processes or manufacturing by recognizing and eliminating non-value-adding actions that cause time and money wastage in every stage of production [17]. In this paper, VSM is applied to improve the production line of a company that produces several components for vehicle assembly line based on decreasing the waste and non-value added activities.

■3.0 MATERIAL AND METHOD

3.1 Value Stream Mapping

Value stream is a complete group of some performance containing value added and non-value added actions. Values stream is regarded as the flow of products that is initiated by the raw material and ending by consumer [18]. The main goal of VSM is the reorganization of all types of waste in the value stream to try for reducing these wastes [18]. The definition of value stream mapping is a collection of techniques to demonstrate visually the data flow and materials flow during the production process. Therefore, the aim of value stream mapping can be recognized as value-added actions and non-value-added actions. In addition, value stream maps should be a representation of the actually events instead of the supposed event, therefore it causes chances for development and recognition. Also, it is regularly used in process sequence time development projects because it shows accurately the steps of a process activates to complete timing of stages performance. Moreover, it used in procedure analysis and development with recognizing and reducing time spent base on non-value added performance. In fact, lean manufacturing is a catchphrase. Mostly it means like advantages, cost diminution and lead-time decrease. Although, it will require some numbers to be encouraged if companies are in beginning of implementing lean manufacturing and if companies are in beginning of benefiting from lean manufacturing. It requires calculated advantages of lean manufacturing when its values are realized effectively [18]. As such, the objectives of this research are listed as follows:

- Comprehend the present state of the assembly line manufacturing.
- Recognize the key part of waste, problem and chances amongst the process.
- Implement of prospect state vision of all process.
- Enhance the productivity.
- Expand an action plan to get the higher production and lead time elimination

3.2 Case Study

A company that produces several components for vehicle assembly line was selected as the case of study. The process of production line includes the cutting a metal, welding and subsequent assembly. Finally the components are staged and shipped to the vehicle assembly factory on a daily basis. This company produces 18400 pieces per month that comprised of two types of products that are left hand drive (LH) 12,000 pieces and right hand drive (RH) 6,400 pieces. There is once a day shipment to the assembly factory by truck. The work time of this company is 20 days in a month as well as two shifts in a day and eight hours working time in each shift, in addition it includes 10 minutes breaks during each shift.

4.0 RESULT AND DISCUSSION

4.1 VSM: Current State Map

Whole information about the present state map was gathered based on the method suggested by Rother and Shook[18]. In the issue of the material flow data collection began in the distribution section, and also worked rearward for the stamping development, collecting image data like catalogue levels earlier than beginning every process, cycle times (CTs) process, quantity of employees, and convert (CO) times. Figure 2 demonstrated the present position map which was drawn. In this figure the map's small boxes describe the progression and the number of the boxes is the amount of workers in every processes. In addition, every process has a data box under that includes the CT process, the numeral of shifts, machine reliability (MR), and the CO time. It must focus on this collected data whereas walking the shop ground and discussion to the foreman and workers at every workplace. All of the processing and installing times are according to the middling of past data. The timeline in the underside of the present situation map is shown in Figure 2 that there are two elements. The first element is about the waiting time of production in days which is gained by adding the number of lead-time from every inventory triangle earlier than every process. Therefore, the time of each inventory triangle is computed by separating the inventory numbers into the everyday customer needs. The totality lead time is approximately 23.6 days. The second component of the timeline is the value-added or processing time which is approximately 188 second. This period is computed by summing the processing time for every process in the value flow. The CT for every process is the average CT that was found out by using real data in the firm.

4.2 VSM: Takt Time

Takt Time plays a leading role in manufacturing systems. Many factories run this without knowing what it is such as what those industrial units lose or how things are going minute by minute as a fine-grained sense [18]. Truthfully, if they have another way to immediately see disruptions, act to clear them, followed by solving the underlying problem then they are as "lean" as anyone. So here is the second heresy: What you need is some way to determine the minimum resource necessary to get the job done (JIT), and a way to continuously compare what is actually happening vs. what should be happening, and then a process to immediately act on any difference (JIDOKA) [18]. This is what makes "lean" happen. Takt Time is just a tool for doing this. It is an expression of consumer requirements that normalized and levelled over the prefer time to produce. Takt time helps to make easy the ability of calculation in a difficult flow. In addition, the necessary speeds of machines and other capital tools are determined. By using this, the minimum batch sizes are estimated when there are changeovers involved. So, to calculate the takt time, the following formula is used [18]:

$$\text{Takt time} = \frac{Available\ minutes\ for\ production}{Required\ unites\ of\ production}$$

In this company, there are two 8 hour transfers on 5 day occupation in a week. In addition, there is a 0.5 hour unpaid lunch break in the middle of the work day.

$$\text{Takt time} = \frac{(8*60*60*2\ shift)-(2400\ Second\ breaks)}{920\ Daily\ required\ units\ of\ production} = \frac{52200}{920} = 60\ \text{Second}$$

Step I- Create a Cycle Time / Takt Time Graph: Based on the data that were collected during the drawing current value stream mapping, the cycle time/ takt time graph was drawn in Figure 1. This graph shows the comparison between the overall takt time and cycle time for each process. This step plays an important role to make a decision about how and what to improve in future steps.

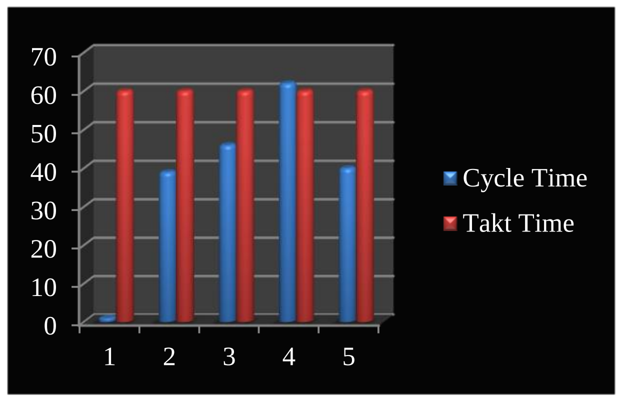


Figure 1 Cycle time vs. Takt time

Step II- Make to order model: In the next step the distribution model of goods should be determined. In this case one product is produced as well as the customer demand is constant. Therefore, one make to order model should be designed. The wastage during changeover of one process to another has been reduced, so the PLT for process get reduced.

Step III- Calculate Optimal Crew Size and Implement One Piece Flow: Another important step is determining the number of crew. In order to calculate the optimum crew size this formula is applied: (Total Cycle Time/ Takt time).In our case the number of crew size is equal to: 188 sec/ 60 sec. This resulted in an optimal crew size of 3.13 operators. Since we cannot have 0.13 persons they rounded up to 3.

Step IV- Pull Process: In the final step, one system is considered to have a signal when to produce and when not to produce. In this case supermarkets were built as kanban system.
Figure 2 shows the current value stream map for the selected company based on the data that has been gathered and calculated.

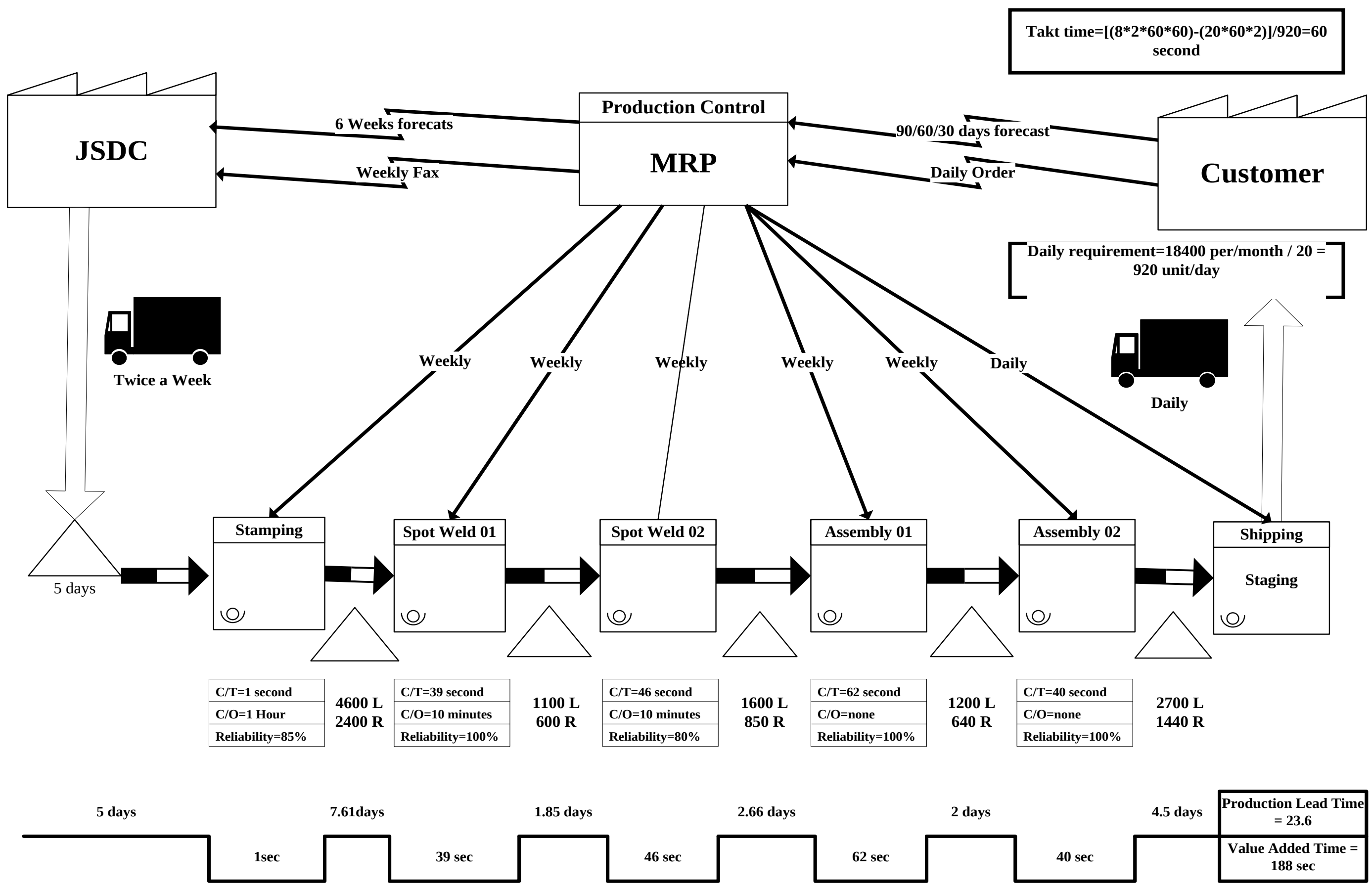


Figure 2 Current value stream map

4.3 VSM: Future State Map

The process for explaining of the future state map starts though developing the present state map, where marked areas for development starts for showing up. While looking at the schedule among the complete value stream for creating the perfect future state map it should be try to definition lean manufacturing equipment to drive down both. It was followed an efficient procedure where it was tried to respond a series of prepared questions and so this allows to come up with an perfect future state map that will facilitate in reducing or at least eliminate variety kinds of waste in the present manufacturing structure. In this case following equipment was designed to implement the future value flow map.

Balance the Line: Firstly, for realizing there is a “line” – a value stream that requires it to flow. Queuing effects will tend to build in waits between each task, and pile up work at bottlenecks in an uncontrolled process with variations of any sort. Waiting can also be triggered directly by effects external to the process, such as lack of resources, information, or authority to proceed. If resources typically personnel are not available to start a task, it waits. If externally-provided information is not available, tasks either wait, or proceed with “bad” information only to rework later. Finally, if external approval (e.g., from a review) is required to proceed, and it is not forthcoming, the task will wait. To minimize this waiting, all of the following are necessary:

Eliminate Bottlenecks: Bottlenecks are identified as tasks to take more time for doing and/or to have fewer assets that accessible to them than the take a break of the process. Regarding the current VSM, it is obvious that the assembly 01 station has the most cycle time with 62 second times that makes WIP before the station. In order to eliminate the bottleneck in this station, assets and effort must be allocated since at least on average every station takes the same amount of time.

Minimize and Buffer Variation: Variation is a fundamental possessions of product development processes that should be reduced by availability. This means in higher level as taking high-variability performances such as technology progress off the essential path, and having fall-back policies to buffer beside technical breakdowns. On the Other hand, in lower levels it means to have the necessary training for allocation simple processes for standardization, and for the supporting from avoiding postpones related to tools or software crashes. In addition, variations cause alters in workload in both actively managed by switching assets to job that are in unpredicted problems and buffered against by having a reserve of available assets.

Eliminate Unnecessary or Inefficient Reviews and Approvals: Reviews is used for reducing the risk. They are at best necessary non-value-added quality assurance tasks if all they are doing is catching mistakes. In all status, they should be arranged in so that highest value is created at lowest cost to the process. The costs take two major forms: waiting for approvals that are ultimately given, and rework loops when reviews find problems or value-added opportunities. The former is pure waste of waiting, and should be eliminated; the latter may be value added, but must be managed.

Sometimes it happens to illustrate a technique for streamlining review while preserving or increasing value. Three tasks are followed by reviews in which the task is quality checked and any problems with the task, previous tasks, integration between tasks, or changes in external factors can result in rework. A combined review is carried out to look at issues of integration and changes in external factors. A separate value-based judgment is then made as to the degree of rework that is appropriate to address the concerns brought up in the review. If iteration or rework is required, the first task is to create a plan for the rework, rather than just "sending it back". Moreover, the drawing check has been replaced with a design check, where a group including stress and manufacturing engineers review the design. The hope is to catch design problems early, and avoid large and costly rework loops. Figure 3 shows the future state of value stream map based on the improvements.

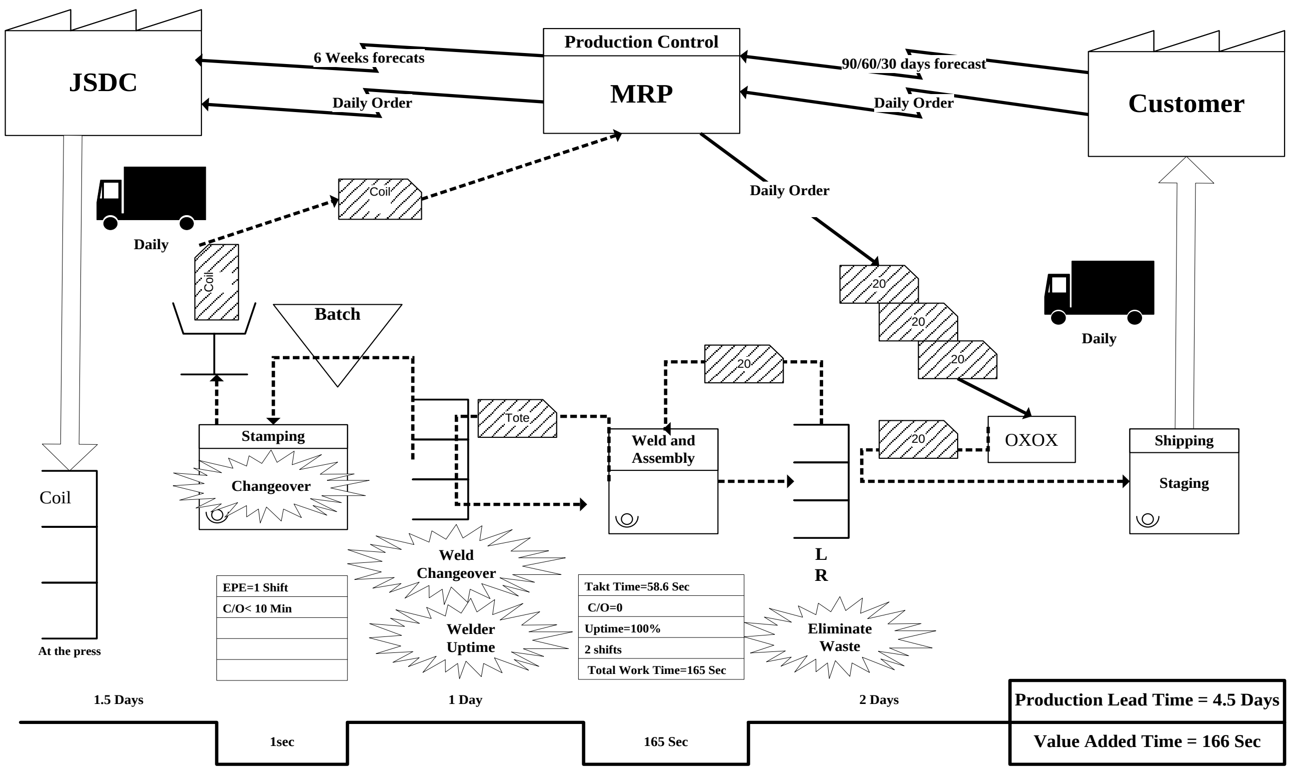


Figure 3 Future value stream map

4.4 Discussion

This research work has been intended to Value Stream Mapping (VSM), which is becoming an essential tool for realizing lean manufacturing in actual production settings. Essential concepts have been discussed, as have common symbols and nomenclature, methodologies and curriculum infusion techniques. Figure 3 shows the future value stream map after implementing the some lean principles. The results are shown in the form of current and future process mapping and improvement is shown in the reduction in valued added time and production lead time. In the Future State Map for assembly and welding process, two processes are gathered to reduce non value added time during processes. Supermarkets are placed between processes to reduce inventory wastages during process and to turn process from build to stock to make to order. Make to order process lead to assembly of parts when order placed by customers. It provides reduction in inventories. The information and communication flow between processing lines improved by scheduling pacemaker in the process as well process turned from push to pull by Kanban system. On this research we have made some sizeable improvements. Production Lead-time (PLT) has gone from 23.6 days to 3.5 days, and the value added time decrease from 188 second to 166 second (Figure 4).

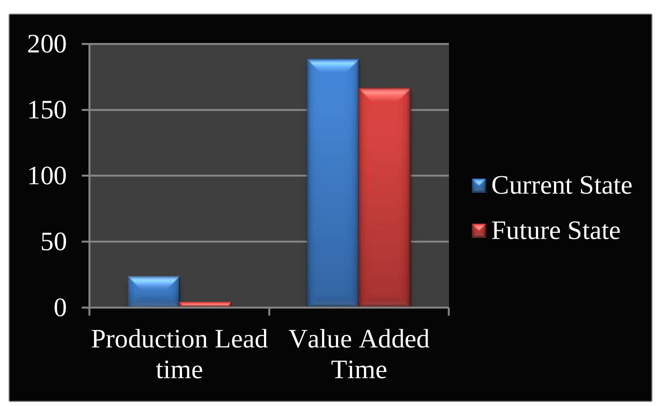


Figure 4 Current state vs. future state

5.0 CONCLUSIONS

The Goal of this paper was to develop a value stream map for production line of a company that produces several components for vehicle assembly line. The main purpose was to determine and reduce waste for any process which does not add value to the final product in the production line. Furthermore, this paper focused on decreasing production lead time and value added time. It was shown from the current state map of production line that lead time and value added time for the product is 23.5 days and 188 second respectively. Moreover, since of difference between processing time and lead time, it can be concluded that there are lots of non-value added activities such as waiting for product, moving raw material from one to another section, setting up times. In addition, the process changes from the push to pull. Finally, after implementing the lean thinking and by applying lean tools and methods the process lead time and value added time reduces to 4.5 days and 166 second respectively. It means that the production lead time and valued added time in this case of study will be improved up to near 80 % and 12 % respectively by eliminating the wastes based on lean principles and VMS method. More investigation can be done by conducting more in-depth research of VSM integrated with computer simulation to verify the proposed VSM method.

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