

APPLICATION OF VALUE STREAM MAPPING IN THE AUTOMOTIVE INDUSTRY: A CASE STUDY

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ABSTRACT – Today, the automotive industry is becoming one of the essential industries in a country due to high demand from customers. This increasing demand also causes the companies in the manufacturing industry to be exposed to increasing challenges with respect to cost-effectiveness, lead time, and quality of production systems. This situation also increases the waste that occurs in the production line which is basically due to poor plant processes where excessive movement and the high processing time occur. From the previous research that the current method to detect waste is not effective where most methods do not fulfill the same framework, conditions, objectives, level, or degree of completion of detecting waste in the production line. In this paper, effort is made to detect non value added in automotive industry using VSM. VSM entails the mapping the industry current process and evaluating it for waste and bottleneck by calculating value-added and non-value-added time. The data was collected from incoming warehouse until the outgoing warehouse. The data is also taken during the observed component as it passes through the machining, painting, assembly, final assembly and final inspection processes. Based on the analysis of bottlenecks, solutions are suggested, and a future state map is created. The lead time of the process is improved by 67% where the waste is reduce to 74% based on created map.

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INTRODUCTION

Today, companies in the manufacturing industry are exposed to increasing challenges with respect to cost-effectiveness, lead time, and quality of the production system. The automotive manufacturing industry also impacts this increasing challenge and has great concern over improving its productivity for maximum efficiencies to remain competitive. The automotive industry is the activities that manufacture motor vehicles such as motorcycles, light trucks, and vans. There are many processes involved in manufacturing vehicles such as stamping and welding processes. The automotive industry is becoming one of the essential industries in a country because of the high demand from customers. The increase of the number of products also will increase the rate of problems where an automotive company without a clear timeline between customer order and the product delivery is running production which lastly the product cannot deliver on time and needs to be placed in inventory. The increase in inventory levels also increases cost since the more significant the stock, the more labor is required to maintain inventory accuracy (Arunagiri, 2014). A lot of waiting time between the workstations due to poor plant processes can affect the smoothness of the process.

Lean manufacturing (LM) has been applied by various leading manufacturing organizations all around the world to eliminate waste from the business processes (Fercoq, Lamouri, and Carbone, 2016). Value stream mapping (VSM) is an effective tool for the practice of lean manufacturing (Rahani, 2012). Value stream mapping is a lean tool to view the entire production process while allowing the company to make a change to optimize the efficiency of production. Value stream mapping is also the process of visually mapping the flow of information and material as they prepare a future state map for better method and performance. In addition, it is used as a communication tool in the lean community since it uses standard terminology and improvement methods. This method will identify waste by recognizing and removing the steps which do not add value to the process of producing the products. This method gives more understanding of the flow of processes in production since it is one of the lean manufacturing tools and techniques. The process flow of production is visualized using the current state map by using the actual data process of the products which helps in identifying and simplifying the waste that occurs in the current process. The improvement process flow of production after the non-value-added activity is visualized in a future state map.

In the automotive manufacturing industries, a lot of processes and vendors are involved in manufacturing a finished product. This makes several types of activities exist in the system and each activity produces their own wastes. The accumulated waste from the production line can give an effect on the entire production process. The existence of these wastes in the production line can increase the operational expenditure and can lead to profit losses. Therefore, the manufacturer needs to reduce the wastes in their production line while these resources spent on these wastes can be used for the other activities. One of the solutions is to apply the Value stream mapping in their company. This paper aims to introduce the practice that had been applied in one of the automotive manufacturer in Malaysia.

LITERATURE REVIEW

The automotive industry is known as a sector that produces complicated components and is an industry that requires a considerable amount of physical capital in the form of plants and equipment with a large workforce. The automobile is widely regarded as the most successful manufactured product of the 20th century, and it will continue to be critical to the operation of numerous industries, sectors, societies, and economies worldwide (Geneva, 2021). As shown in Figure 1 where versions supply chains consist of designing, developing, manufacturing, marketing, selling, repairing, service automobile, and automobile component. Malaysia Investment Development Authority (MIDA) in 2020 stated that Malaysia has a high rank among Asian countries for car ownership ratio in the region which contribute to a company such as Honda, Toyota, Mercedes-Benz, and BMW have set up their operation due to high demand where it proves that Malaysia is not left behind in automotive production where Proton become national car after gaining independence. 4.8% of the total production of all manufacturing industries in Malaysia is a production by car manufacturers (Anazawa, 2021).

The automotive industry is undergoing a transformation when Toyota's production method begins in Japan after World War II. Toyota implement this method after Japan's industry had low productivity and lack of resources than Ford US. Ford is well known that introducing mass-production techniques for manufacturing cars (Logu, 2021).

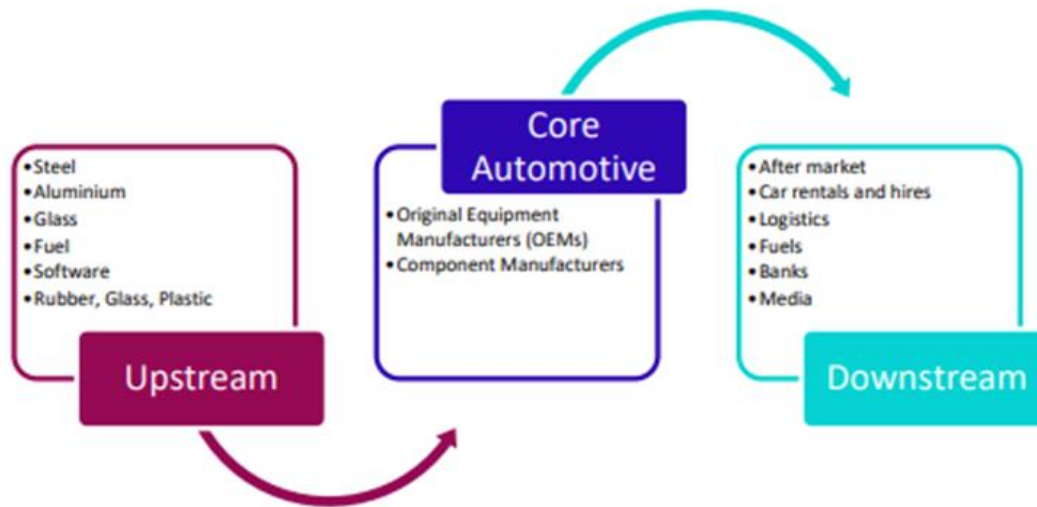


Figure 1: Simple version of the automotive supply chain (Geneva, 2021)

Waste means a valueless item that is damaged and cannot be used. It also can be defined as unwanted, excess, unproductive, unused, junk, and refuse (D.J.B, 2010). Manufacturing acts as one of the largest industries where 38% of waste is from a developing country such as Malaysia where according to the Malaysia Investment Development Authority (MIDA) in 2005 about 19000 tons per day of waste is produced. The manufacturing industry cannot avoid in produce waste from day to day since almost everything in our daily life is from natural resources before proceeding to manufacture industry. These demands also cause nature not able to renew and replenish itself in order to provide a clean environment but one key to reducing waste generation is to provide an opportunity for people to learn about and contribute to current waste initiatives (Ishola, 2019). In lean manufacturing, overprocessing, overproduction, high inventory, waiting time, unnecessary motion, defects, and unnecessary transportation are considered waste (Wahab, 2013). In lean thinking, every activity that does not add value must be reduced or eliminated if possible. The main purpose of lean methodology is by reconstructing existing manufacturing methods and processes by reducing waste in order to achieve cost reduction, increase quality, increase profit, and maximize customer value (Nallusamy, 2020). James Womack, the founder of the Lean Enterprise Institute (LEI) in 1997, stated in the LEI (2007) report that the most significant benefit of Lean Manufacturing is that it enables resources by requiring less human effort, space, capital, and time, effectively turning waste into available capacity. There are different lean manufacturing tools which are quantity circle, Kaizen, 5S, cause and effect diagram, FMEA, Poka-yoke, SMED, Kanban, Just in time, DMAIC, Time and motion study, and VSM (Palange, 2021).

Value stream mapping is a suitable tool for engineers or managers to add value to a process or workflow by analyzing activities in the production flow. Value stream mapping is a pencil and paper tool that is created using a predefined set of standardized icons while value stream is a collection of all actions in processing product from raw material and ending with a customer that contributes to value-added and non-value added thus identifying all type of waste in cycle chain and plan to eliminate these non-value-added. It is also known as a method that used symbols, metrics, and arrows to show and improve the flow of the process whereas figure 2 shows a common symbol used in the mapping value stream.

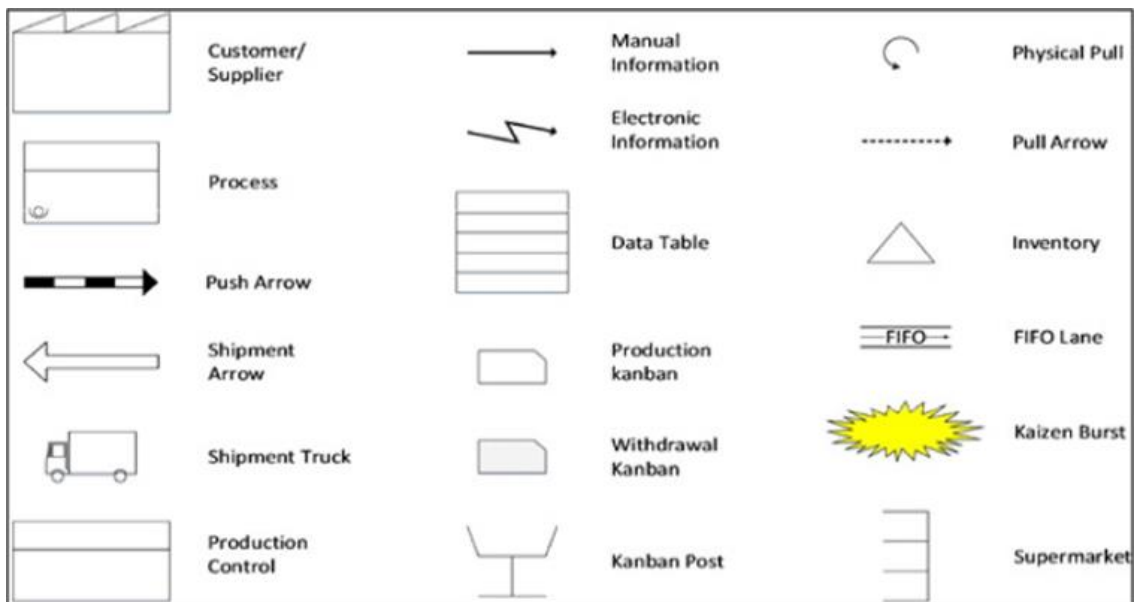


Figure 2: Symbol used in value stream mapping

Value stream mapping also has been widely used in manufacturing industry since it is considered as a reusable tool for organization which allow the operation to become simpler and more regular (Belokar, 2012). Cycle time in a machining process decreases after applying value stream mapping where the benefit of the lean system which is a response to customer demand becomes quick, waste in inventory and machine can be eliminated and single-piece flow for crankshaft manufacturing system is constructed (Venkataraman, 2014). Value stream mapping is also applied in service businesses such as call centers, health care, and higher education. Dittmer (2021) states a study of value stream mapping in the breast cancer center in Germany. The purpose of the research is to design the discharge process of the patients. The problem such as lack of professional staff and complex structure is been detected after all the process is visually in value stream mapping.

A lot of studies applying value stream mapping showed a good result and get maximum effectiveness from production. Yuvamitra (2022) applies value stream mapping in rope manufacturing where the overall time required to receive an order from customers decreases while the processing time and waiting time also decrease where about 88% total waiting time of the process is reduced after using the new setup in production. Zahraee (2021) applies value stream mapping in the construction industry which focuses on the concrete pouring process (CPP) which production lead time has to reduce by 35% after adding two trucks for the whole process where the takt time reduce from 138s to 93s. He has also done an analysis in the Heater industry where after implementing the value stream mapping the production lead time reduces from 17.5 days to 11 days and the value-added time reduce from 3412 seconds to 2415 seconds. The takt time also becomes 192 seconds from 250 seconds. Azizi (2015) applied value stream mapping in a small-medium enterprise where in the current state map the cycle time exceeds the takt time. After implementing value stream mapping, the cycle time reduce and WIP inventory becomes 0 from the actual 144. This shows that the implementation of value stream mapping gives a high impact on improvement.

METHODOLOGY

The company for this case study is a manufacturer and assembler of various types of motorcycles and scooters below 250 cc for both local market and oversea market. They produce approximately 130,000 units per year. The company is also developing and manufacturing their own 115 cc engine. The process started as the raw material from the material supplier, followed by five processes, namely machining, painting, engine assembly, final assembly and inspection. Finally the finished product will be stored at the outgoing warehouse. The study was conducted in four phases as shown in Figure 3. The phases are:

Phase 1: Observation and Data Collection

Phase 2: Construction of Current State Map

Phase 3: Analysis current state mapping

Phase 4: Development of Future State Map

Phase 4: Comparing Current State and Future State Map.

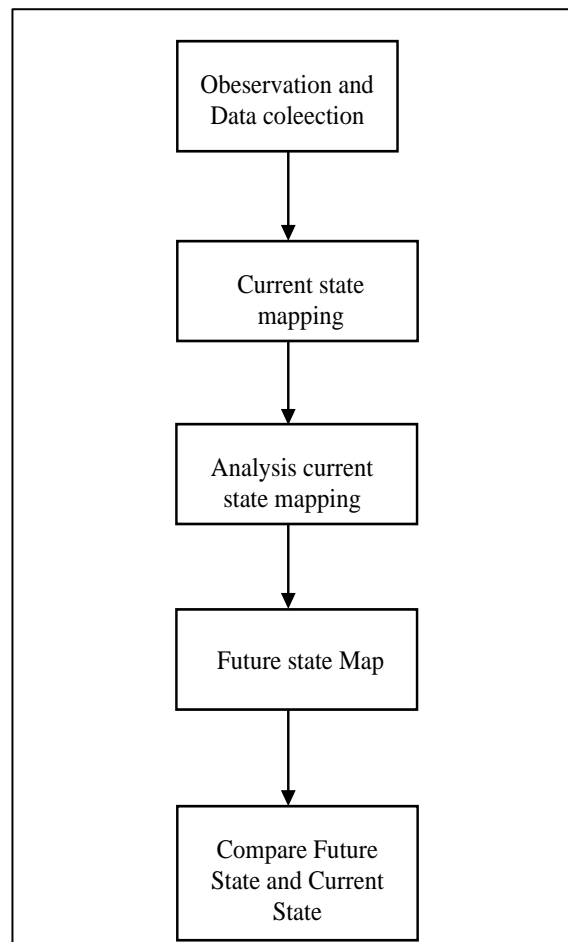


Figure 3: Value stream mapping methodology

Phase 1: Observation and data collection

The observation and data collection is done when visiting the production line in one of the automotive company in order to get more understanding of the process. The data consist of every process from raw material to finish well. The data consist of inventory, cycle time, and waiting time recorded using a stopwatch and video recorder. After that, a product family matrix is constructed in order to define the product family for VSM.

The observations were supported by reviewing the current procedures such as Standard Operating Procedure and the existing Process Flow Chart. Interviews with the persons in charge of the production line and the operators were also essential to gain the information about the operations of the production line. The data collection phase starts by selecting which component from the motorcycle engine to be traced from the incoming until to the outgoing of production line.

The time consumed for each type of activities was recorded from the incoming until to the outgoing of the production line. The activities that involved in the production line consist of inventory, waiting and transportation were taken into account during the data collection phase. The time consumed by each component was recorded for each station along the way in the production line. All the time recorded was averaged for use in constructing the Current State Map in the next phase and the time recorded were verified by person in charge of production line.

Phase 2: Current state mapping

After all the data is collected, the current state map is plotted from the customer to the supplier which is considered material flow. The material flow consists of a process box, transportation, and an icon. Lastly, the timeline of production is constructed at the bottom of the mapping. The plotting of all data is based on the collected data. The Current State Map is shown in Figure 4.

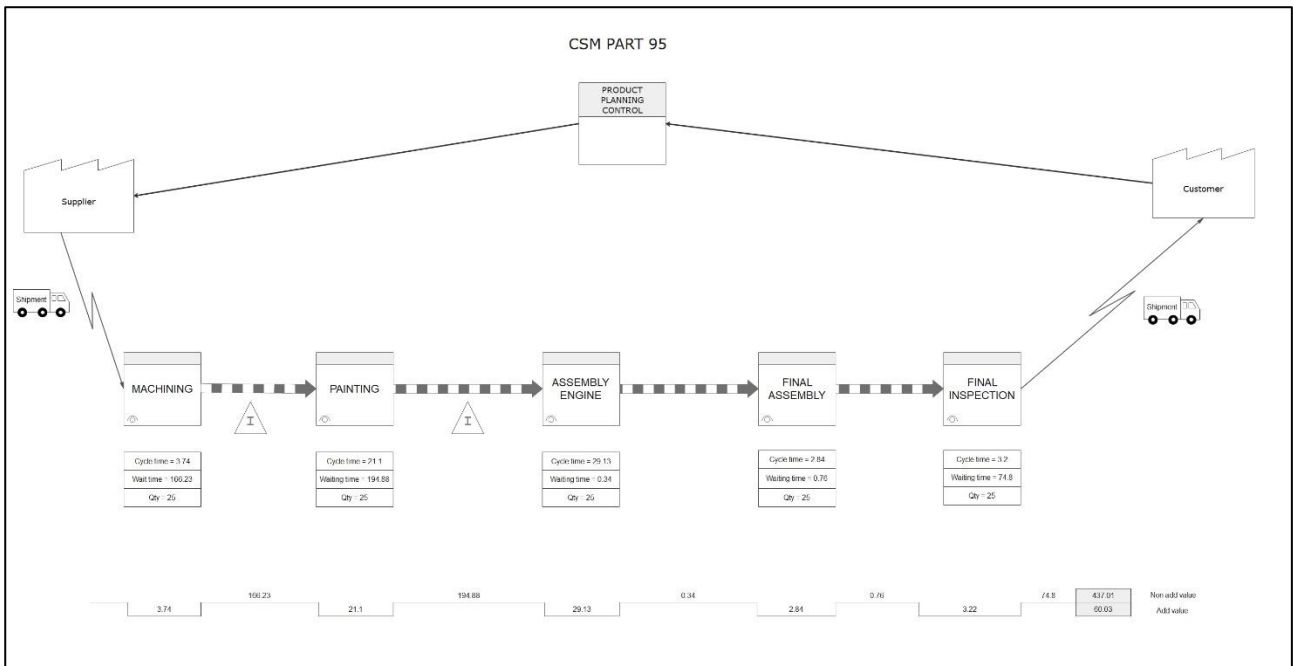


Figure 4: Current State Map

Phase 3: Analysis of Current State Map

The calculation of the takt time is conducted since the mapping should always start with customer expectations using the equation below :

$$\text{Takt time} = \frac{\text{Total available time to produce part}}{\text{Customer demand}}, \text{Takt time} = \frac{480}{47} = 10.2 \text{ hours}$$

Takt time plays a leading role in the manufacturing system where it shows the cycle time of the process to meet the customer’s expectations. But, the current state map shows that the assembly engine station is the bottleneck in the process. The comparison of the cycle time of each station is shown in the figure below where the assembly engine has a high cycle time followed by the painting stations. Figure 5 shows the cycle time for each station.

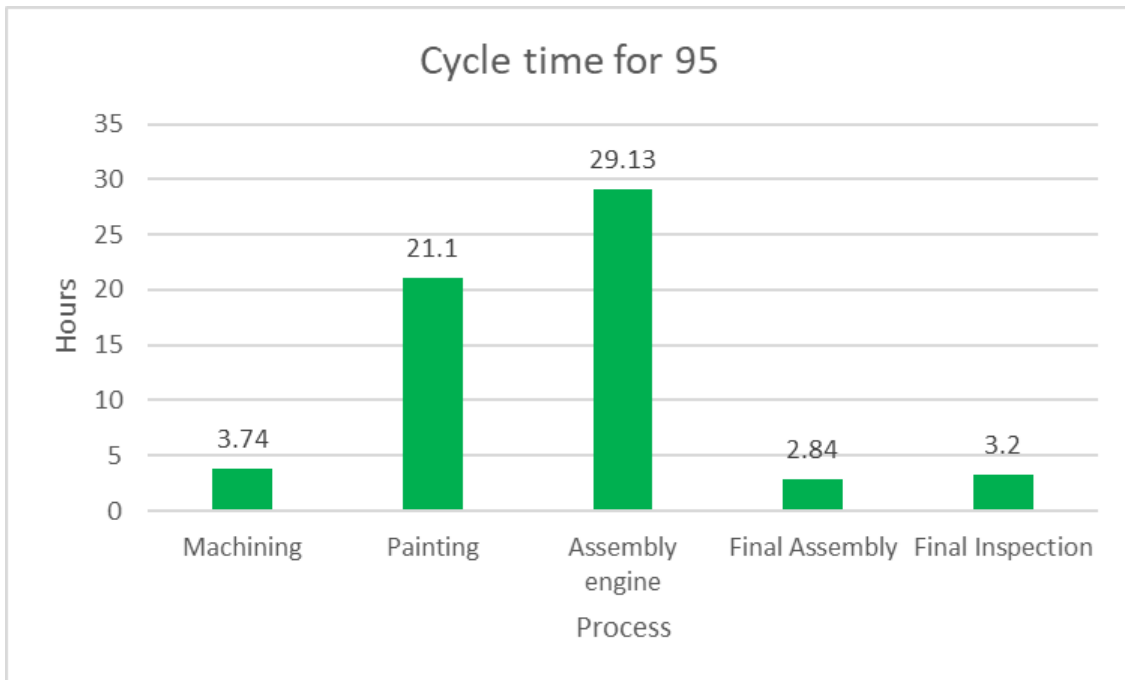


Figure 5: Cycle time of each station

Takt time is used in order to define the number of machines. The calculation machine in stations is calculated as shown in table 1.

Table 1: The number of the machine in each workstation

Operation No.	Operation Name	Cycle time	Machine required	Target= 25 part
1	Machining	3.74	1	Production time = 480 hours
2	Painting	21.1	2	Takt time= 10.2
3	Assembly engine	29.13	3	
4	Final Assembly	2.84	1	
5	Final inspection	3.2	1	

Then the average cycle time for the painting and assembly engine is calculated using the equation below :

$$\begin{aligned} \text{Average C/T for Assembly engine} &= \frac{\text{Cycle time}}{\text{Batch Size}} \\ &= \frac{29.13}{25} \\ &= 1.17 \text{ hours/parts} \end{aligned}$$

$$\begin{aligned} \text{Average C/T for Painting process} &= \frac{\text{Cycle time}}{\text{Batch Size}} \\ &= \frac{21.1}{25} \\ &= 0.84 \text{ hours/parts} \end{aligned}$$

Since the average cycle time is below the takt time it shows that it is not the problem in terms of capacity. However, the cycle time of these two stations is half of the product which can cause unbalance. Then, combining the workstation is suggested in order to make the flow of production more balance and also reduce the waiting time between the workstation. Table 2 shows the result after the combination of workstations.

Table 2: Improvement after combination workstation

	Cycle time (hours)	Reduce (hours)
Station A (Machining, Painting process)	21.1	192.3 waiting time
Station B (Assembly engine, final assembly, inspection)	29.13	1.1 waiting time

Although there is a lot of improvement but the waiting time between station A and B is still high and required improvement. The waiting time occur because all the 25 parts are brought at once from station A to station B. A pull system is suggestion to reduce the waiting time occur. It set to 5 part to move from the station.

Phase 4: Develop Future State Map

Based from analyzed result in phase 3, the future state is mapped. The result is shown in Figure 6.

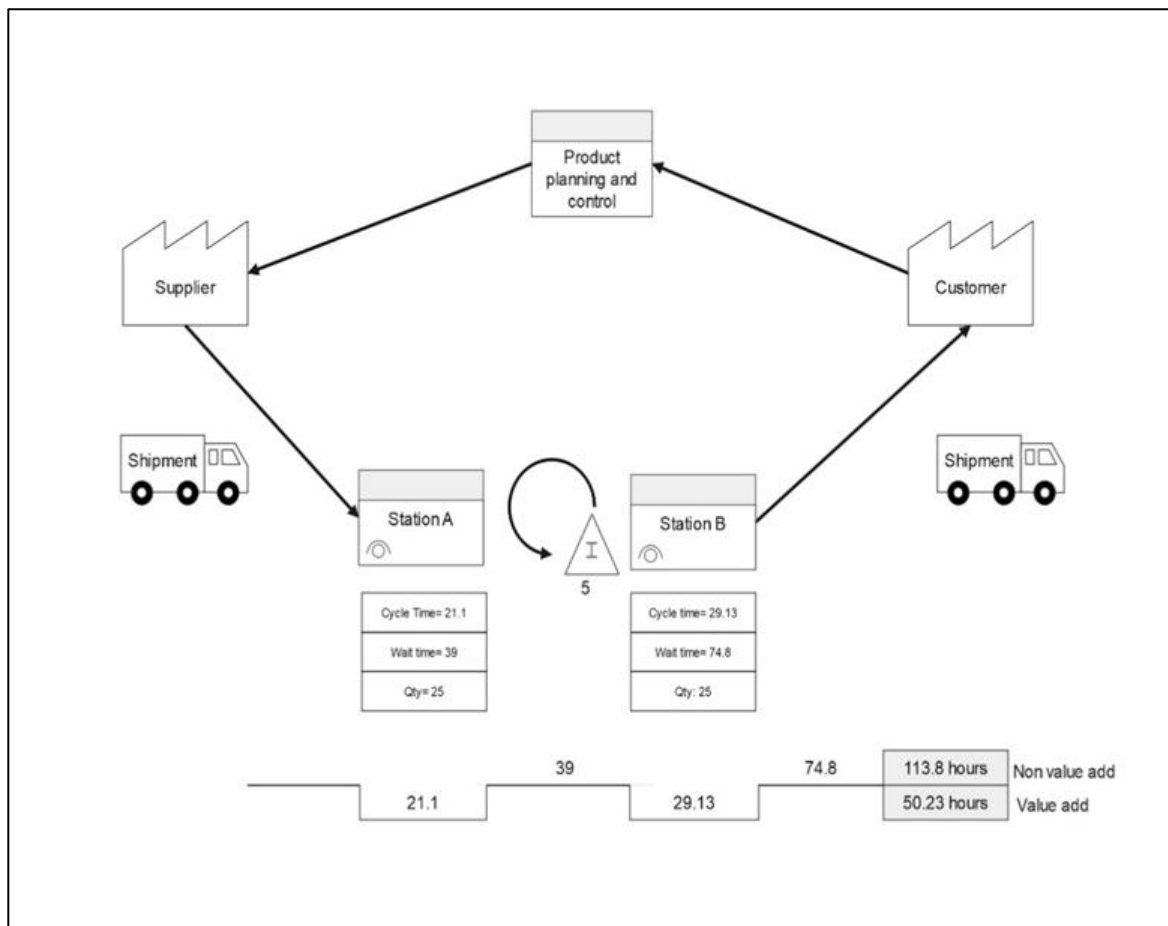


Figure 6: The Future State Map

Phase 5 : Compare Future State And Current State

After the future state is mapping, the result shows that nonvalue add activity reduces to 113.8 hours. In order to define whether there is an improvement or not, a comparison of the current state map and future state map is done as shown in table 3.

Table 3: Comparison of Future state and current state

Variable	Before	After	Improvement
Lead time	497	164.03	67%
Non-add value	437	113.8	74%

RESULT AND DISCUSSION

From table 3, we can observed that there were 67% and 74% improvement in ladd time and non-add value, respectively. The accumulation of waste in the production line is the factor that affects the efficiency of the production and causes the company needs to bear a lot of costs. Without eliminating this waste, it can make the company get a problem such as being unable to meet the customer demand. This situation can cause the company will lose their customer and become less competitive in the current market. According to the study finding, it is shown that there is a waste occur after the current state map is constructed which is basically an unbalanced production line and high waiting time. This situation can cause an unbalance workload of the workstation. A balancing production is produced after the workstation is combined from five workstations into two workstations. Waiting time is high between the work station is solved by applied pull system to make a continuous flow of the production. The analysis of the current state map is an important thing in order to make an effective reduction or eliminate the waste.

CONCLUSION

It can conclude that the current state map gives a visualization of flow production in order to define the bottleneck in the process. The correct analyses of the current state map really make the waste occur can be reduced or eliminated for mapping the future state map. With the help of a future state map, it really helps as a reference for the production line to operate a more effective with less value-added activity for the upcoming. As shown in the result that value stream mapping

is an effective tool for planning of reduction of waste in the production line. The result and study also have shown a result that meets its aims. Value stream mapping tools really help with the current trend of the company has challenges on cost and efficiency of production. Hence, there are a lot of concepts for improvement that can be used which is according to the situation that occurs in the production. This show that this value stream mapping tool is very flexible to be performed.

It is highly recommended that can apply in a real situation with the actual data for future progress. The capability of visualization in production flow really makes it more effective for a company in the automotive industry to analyze its performance by eliminating and reducing waste.

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