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Process Time improvements through the application of Value Stream Mapping support Lean System

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ABSTRACT

Lean manufacturing is necessary for company nowadays to be competitive. In order to achieve lean manufacturing the company need to eliminate all the waste that occurs in their operation. There are many ways to achieve lean manufacturing system which is by improving cycle time in company production. Hence there are many tools can be used to apply lean system, one of the famous lean method to improve cycle time is value stream mapping (VSM). The main objective of this paper is to improve process cycle time by applying Value Stream Mapping. This research applied Value Stream Mapping at manufacturing Company XYZ focusing in production process. Based on the data collected, current state map been developed and the analysis on the current state map were done to identify the waste. The main waste in Company XYZ is ineffective time management. New improvement was suggested by proposing future state of VSM. Based on the future state of the VSM, the final results show that the total lead time decreased from 352.6 seconds to 199.5 seconds, and NVA time from 119.7 seconds to 17.6 seconds, respectively. The findings of this study show that VSM is an efficient and effective approach to identify waste and make improvements.

Key words : Lean manufacturing, Value stream mapping, Value added, Non-value added

1.INTRODUCTION

Lean manufacturing is crucial for every industry to ensure maximum profitability and productivity. In addition, it also minimizes losses arising from waste that occur in the company's production process. Lean is defined as the removal of systematic waste by all members who related to operation from all areas of value stream [1].

As mentioned by [2], value stream comprises all actions of either value added (VA) and value-added (NVA) that are needed to bring a product or group of products from raw material till send to customer hand. The Value Stream is an action whether or not it adds value to produce a product or service in the workflow from the beginning of the process till send to the customer [3]. As cited by [4], the main concept of lean manufacturing is a pulling production where the flow on the factory floor is driven by demand from downstream to the upstream production. There are some changes that are required in lean manufacturing, which can cause problems if not been handled correctly. As described by [5], value stream mapping (VSM) as one of the tools for improvement in lean manufacturing (LM) to help visualize the entire production process, which represents the flow of material and information. According to [6], VSM has successfully been used as a lean tool in manufacturing processes.

VSM help companies in the process of identifying activities and processes that do not added value and also a method for the continuous improvement. The main goal of VSM is to determine the activities that have no value and then make an improvement. Processes that do not added value been identified as waste. Every company has a set of goal to be achieved. Somehow, there are waste in production that occur in most of the manufacturing company and prevent company from achieving the goals. Overproduction, time waiting, transport, inappropriate processing, unnecessary motion,

reword or defect and access inventory [3].These waste will result in increasing the production time, cost and also reduced the product quality.

In another word, this will cause the company to faces losses. Based on the observation at the company production line, the main waste that occurs was time waiting. Waste of time occurs because of the ineffective time managed by the organization.

According to [7], reducing cycle time should be the most important element for any continuous improvement project. According to [8] said that cycle time is a critical factor for customer satisfaction because it represents the responsiveness to the market. With the improvement in cycle time, the company can continue to be competitive in the market. Based on this problem, lean manufacturing is a method that eliminated waste and non-value added process in the production is the suitable method to be implemented.

VSM is a tool that is excellent as the starting part of improvement process towards creating lean enterprises [9]. Based on the situation, there are three research objectives of this research which are: i) To create the current state of VSM of the manufacturing process, ii) To determine the value added and non-value added time using lean manufacturing concept and iii) To develop a future state of VSM to improve operation value of the manufacturing process.

VSM is a suitable method to identify waste of time in the manufacturing process. Hence, this research applied VSM to identify the non-value added time that contributes to the waste in company process cycle. Most companies can benefit from the introduction of Lean System as an organizational tool for process improvement.

2.LITERATURE REVIEW

This part contain the literature review of the study. Literature review is an important element in a research. The literature review consist some of the information from previous research done by another researcher which are related on the definition, method of the research, all the data that related to the research. Generally this part discussed on the result and method can be used from the pass research.

2.1 Value Stream Mapping

Value Stream Mapping (VSM) is an advanced form of process mapping. During a value stream mapping session, all value added (VA) and non-value added (NVA) activities required to bring a product or service to the customer are identified [2]. Thus, a Value Stream Map is a tool to see and understand the flow of information or material as the product or service moves through the entire value stream. Value stream mapping (VSM) has successfully been used as a lean tool in manufacturing processes [6].

2.1.1 Current State Map

The Current State Map (CSM) charts present the flow of information and material as a product goes through the manufacturing process. This is vital both to understand the need for changed and to understand where opportunities lie [9]. According to [10] a current state should be 80% accurate. The current state will allow everyone to share the same point of view, to work with the same data. This map does not solve any problem but it will present all the information needed for making right and correct decision [10]. The viewer should be able to look at the map and within a short interval of time understand the value stream.

2.1.2 Future State Map

The Future State Map (FSM) is a chart that suggests how to create a lean flow. It proposes closing the gap between the CSM and the envisaged. According to [11] the future state map must be a visual representation of how the value stream should work to be more efficient.

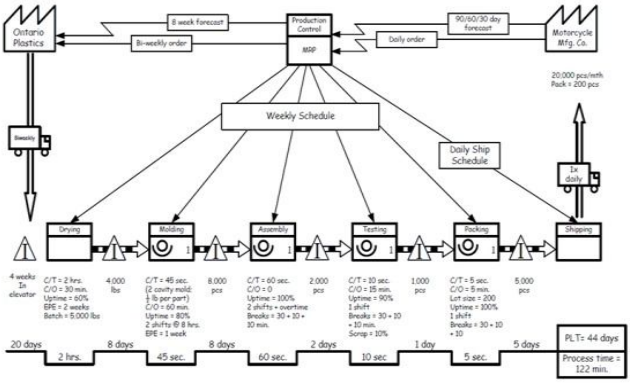

Figure 2.1: Example of VSM

2.2 Process Cycle Time

Cycle time was known as the time in which the starting of operations until the completion of an operation [7]. Waste can be very costly thus, its early elimination is necessary to decrease the overall cost [6]. By improving cycle time a company can increase their productivity. In most of production cycle, there are waste occurs. Those waste will increase cycle time of an operation. To improve cycle time the company can eliminated tasks that has no value. However there are some activities that has no value but it required in production process. For example transfer process from a workstation to next workstation. This activities is required but add no value. For these types of activities the manager can reduce time per task by put the workstation closer.

2.2.1 TAKT Time

TAKT Time is the maximum amount of time a product needs to be manufactured to meet customer demand. The term is derived from the German word "TAKT" which means

"pulse." Defined by customer demand, it creates a pulse in all business processes to ensure continuous flow and capacity utilization [12]. Perfect Stream Value is an operation in which each operation has a cycle time equal to the TAKT Time. Meanwhile, if the cycle time is exceed than the TAKT time, customer demand is cannot be fulfil [12]. TAKT time ensures that all capabilities in the business are planned and applied to meets the customer's demand. TAKT will help deliver the right product at the right time in the right quantity to the customer [13].

2.2.2 Lead Time

The amount of time it takes to produce an item, including order preparation time, turnaround time, setup time, run time, transfer time, check-in time, and time placed. Lead Time is the estimated amount of time that has passed from time of the raw material is received to the time the finished product is delivered to the customer [10].

2.3 Value Added Activities

The value-added activity is what must be done to meet customer needs. Without this activity, the customer will not get the desired output. It also addresses the forms, features or functions that customers want.

2.4 Non-Value Added Activities

Non-Value Added activity is a waste. They do not contribute to the needs of customers. Non-value-added activities are those that used resources but do not generate value. Activities that are not required to produce the product or improve the process can eventually be eliminated by changing the company's processes or procedures.

2.5 Lean Manufacturing System

Lean manufacturing system is a management practices that can be used by a company to improve their manufacturing operations. Lean manufacturing also can be define as manufacturing without waste [14]. Lean manufacturing was really important for a company to stay competitive. In order to achieve that, company need to offer better product and service through implementation of lean manufacturing.

2.6 Type of Waste

There are seven type of waste that occurs in most company. These waste also known as non-value added activities and cause the loss in company production. If these waste can be reduce or eliminate the company can increase their profit and productivity. Those waste as explain by [2] are: -

i. Overproduction
ii. Product defect
iii. Time waiting
iv. Transportation
v. Inappropriate processing
vi. Inventory
vii. Unnecessary motion
viii. Underutilize talent

3. METHODOLOGY

Research methodology is the process used to gather information and data for research. This methodology may include interviews, surveys and other research techniques, and may include present and historical information. There are a few technique that has been identified to ensure the research objectives can be achieved. In this chapter researcher explain in detail on how the research been conducted.

3.1 Research Design

The aim of this research is to identify waste in company production. The data from this research collected by using observation and interview. For this research, the observation was done at the production line of Company XYZ, while the interview was done with the administration manager. This research is a qualitative research.

3.2 Research Process

This research used several observation process that need to be completed for data collection. All the process of the research are based on figure 3.1.

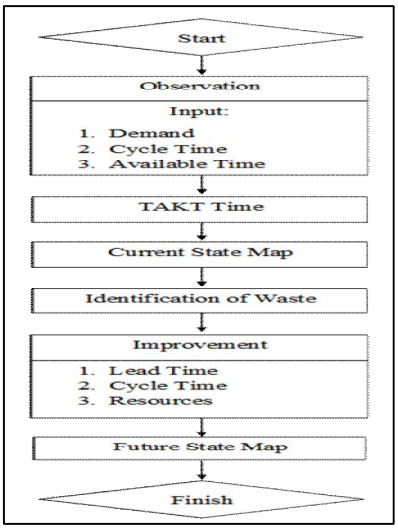

Figure 3.1: Research flow chart

This study was carried out by using observation at the company production process and the interview with the company administration manager. The observation was conducted to record time needed for each processes in the production line. The data from observation and interview were recorded for analysis purpose.

4.RESULTS AND ANALYSIS

This part consists of the analysis of the data provided from the research area. The data represent the current state map of the workplace. This part also discussed for the

implementation of value stream mapping in the company production area. From the current state map, the wastes which are the non-value added element are identified. Figure 4.1 shows Current state of VSM. There are 17 processes are required to produce the product as of Table 4.1.

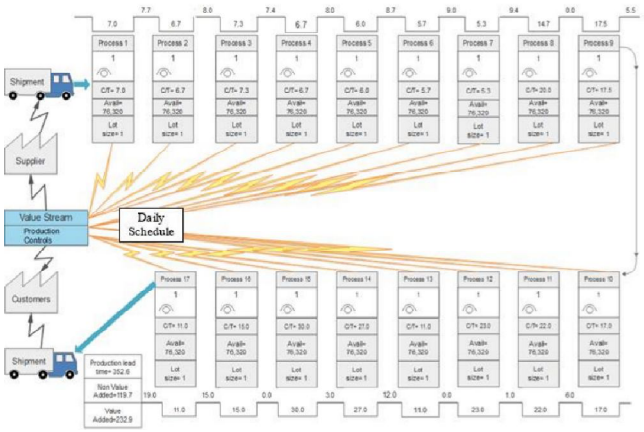

Figure 4.1: Current State VSM

From Table 4.1, the total lead time for manufacturing process is 352.6 seconds (5.88 minutes). The result shows that the times for value added time, 232.9 seconds (3.88 minutes) is lower than the non-value added time, which is 119.7 seconds (1.99 minutes). Thus, it can be concluded that the flow has more non-value added times.

Table 4.1: Summary of VA and NVA times

Total Operation Time (sec)				
#	Process	VA Time (sc)	NVA Time (sc)	Lead Time (sc)
1	Manual Insert 1	7.0	7.7	14.7
2	Manual Insert 2	6.7	8.0	14.7
3	Manual Insert 3	7.3	7.4	14.7
4	Manual Insert 4	6.7	8.0	14.7
5	Manual Insert 5	6.0	8.7	14.7
6	Manual Insert 6	5.7	9.0	14.7
7	Manual Insert 7	5.3	9.4	14.7
8	Solder	14.7	0.0	14.7
9	PWB App Check/ ICT	17.5	5.5	23.0
10	PWB Check Auto	17.0	6.0	23.0
11	DC Cod Solder	22.0	1.0	23.0
12	CCD Checking	23.0	0.0	23.0
13	Apply Grease & Bond	11.0	12.0	23.0
14	Case Assembly / Welding & Aging	27.0	3.0	30.0
15	Electrical Check	30.0	0.0	30.0
16	Double Check	15.0	15.0	30.0
17	Packing	11.0	19.0	30.0
	Total	**232.9**	**119.7**	**352.6**

Accordingly, the result for non-value added ratio (NVA ratio) is 32.1 percent lower than value added. This table shows that 66.05 percent of overall lead time is used for creating value into product while 33.95 percent of lead time is waste to production operation.

Waiting time can be clearly seen in the production process which is using the conveyor belt that needing all the process in the conveyor line to be completed before the belt can be move. The time waiting for all the process in the conveyor line to be completed is consider as non-value added time.

4.1 TAKT Time

A perfect Value Stream is the one where each operation has a cycle time equal to the TAKT Time. Therefore, for this process, TAKT time calculated as figure 4.2:

Customer demand per day: 5000 units

Working time: 2 shift per day (24 hours)

Break time: 1.4 hours per shift

Available time: 10.6 hour per shift

$$\text{TAKT time} = \frac{\text{Net Operating Time}}{\text{Customer demand}} = \frac{24 \text{ hours} - 2.8 \text{ hours} \times 60 \text{ min}}{5000 \text{ units}}$$

$$= 0.2544 \text{ min} \times 60$$

$$= 15.3 \text{ second}$$

Figure 4.2: TAKT time calculation

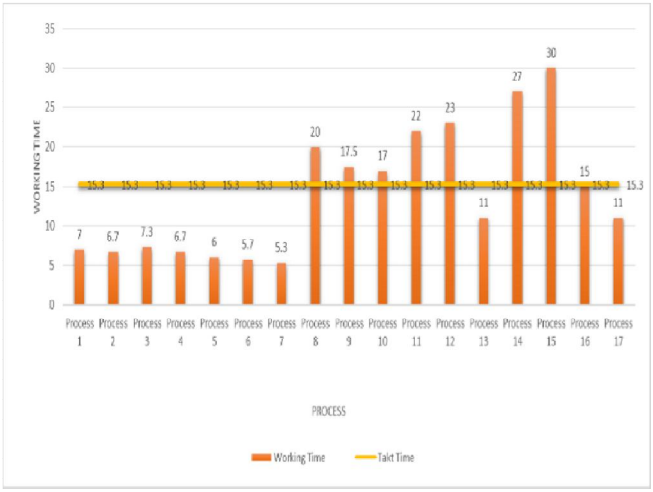

Figure 4.3: TAKT time graph for current process

From Figure 4.3 can be clearly see the process that exceed the customer demand or TAKT time are process 8, process 9, process 10, process 11, process 12, process 14, process 15. The purpose of TAKT time is, to serve as a management tool to see whether production is inlign or not.

4.2 Problem Identification

Identifying waste is the main step to be started for improving flow of production to find root cause of the problem occurred. So in this research, the improvement process will use the lean manufacturing tool which is VSM because the

tools are the significant tools for improvement is this study. In table 4.2 show the problem identification was done by researcher during the collection of data in the company.

Table 4.2: Problem Identification

No.	Waste	My observation
1	Time waiting	All the worker work at conveyor belt, they need to wait all the worker in the same line to complete their task first before they can proceed to the next task.
2	Underutilize talent	Some worker has special creativity and talent but they are told to de only one task

4.3 Current State Value Stream Mapping

4.3.1 Kaizen Burst

Kaizen burst is done in order to suggest the improvement for future state of value stream mapping. For the current state map of value stream mapping, there were two Kaizen burst that have been identified. The main focuses was to reduce cycle time and the non-value added time of the operation. Based on the TAKT time that been given by the company, there were several processes that exceeded the TAKT time while there were also several processes that the cycle time too short compare to the TAKT time.

All these condition has led to high amount of non-value added time in the process cycle time. The differences between TAKT time and the actual working time was considered as waste. This company was using conveyor belt in the production process, so it was very important for each processes to have approximately same process cycle time. Then, the waiting time of each employee at the workstation will be shorter. From the company current state map, there were a big difference in longest working time and the shortest working time in each conveyor belt that causing large amount of non-value added time. Below is the suggestion for reducing cycle time.

4.3.2 Combining and Eliminate process

There were several process that was simple and below the TAKT time can be combined in order to reduce non value added time. Those process were process material insert 1 until material insert 7 which required around 7 second for each process while the TAKT time were 15.3. There were a lot of non-value added time, if those process doesn't combined. The operator at these workstations can be transferred to those processes that exceeded too much from the TAKT time, so the working time of processes that exceed the TAKT time can be reduced.

Table 4.3: combining and eliminating summary

Total Operation Time (sec)							
Current State Value Stream Mapping				Future State Value Stream Mapping			
Operation	Process	Operator	Times	Times	Operator	Process	Operation
1	Manual Insert 1	1	7.0	13.7	1	Manual Insert 1	1
2	Manual Insert 2	1	6.7				
3	Manual Insert 3	1	7.3	14.0	1	Manual Insert 2	2
4	Manual Insert 4	1	6.7				
5	Manual Insert 5	1	6.0	17.0	1	Manual Insert 3	3
6	Manual Insert 6	1	5.7				
7	Manual Insert 7	1	5.3				
8	Solder	1	14.7	14.7	1	Solder	4
9	PWB App Check/ ICT	1	17.5	17.5	1	PWB App Check/ ICT	5
10	PWB Check Auto	1	17.0	17.0	1	PWB Check Auto	6
11	DC Cod Solder	1	22.0	11.0	2	DC Cod Solder	7
12	CCD Checking	1	23.0	11.5	2	CCD Checking	8
13	Apply Grease & Bond	1	11.0	11.0	1	Apply Grease & Bond	9
14	Case Assembly / Welding & Aging	1	27.0	13.5	2	Case Assembly / Welding & Aging	10
15	Electrical Check	1	30.0	15.0	2	Electrical Check	11
16	Double Check	1	15.0	15.0	1	Double Check	12
17	Packing	1	11.0	11.0	1	Packing	13
Total		17	232.9	181.9	17	Total	

5. FUTURE STATE OF VSM

5.1 Future State Value Stream Mapping

Future state value stream mapping is a tool to show the improvement plan in order to get smoother process. Figure 5.1 demonstrate the future state map of value stream mapping for the studied product. Kaizen burst was done in order to suggest improvements to reduce non-value added time in manufacturing process. A future state of value stream mapping should have all possible flaws and errors reduce or eliminated.

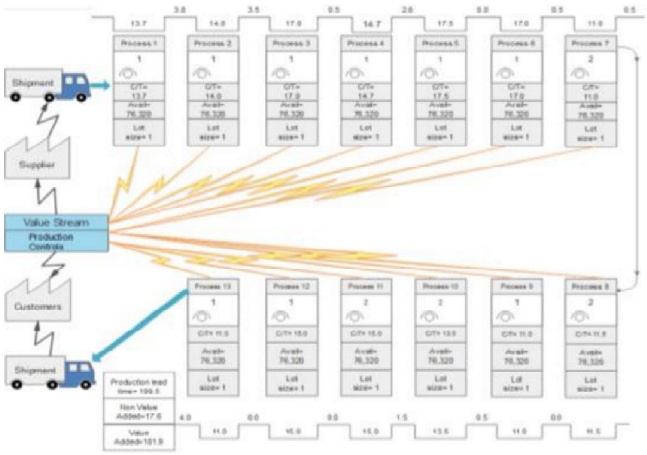

Figure 5.1: Future state value stream mapping

From Table 5.1, the total lead time for manufacturing process is reduce to 199.5 seconds (3.33 minutes). The result shows that the value added time also reduced to 181.9

seconds (3.03 minutes) while the non-value added time are 17.6 seconds (0.29 minutes).

Thus, it can be concluded that the flow has more value added processing time. The decrease in non-value added time reduce the waste in the production.

Table 5.1: Summary of VA and NVA times

Total Operation Time (sec)				
Operation	Process	VA Time (sc)	NVA Time (sc)	Lead Time (sc)
1	Manual Insert 1	13.7	3.8	17.5
2	Manual Insert 2	14.0	3.5	17.5
3	Manual Insert 3	17.0	0.5	17.5
4	Solder	14.7	2.8	17.5
5	PWB App Check/ ICT	17.5	0.0	17.5
6	PWB Check Auto	17.0	0.5	17.5
7	DC Cod Solder	11.0	0.5	11.5
8	CCD Checking	11.5	0.0	11.5
9	Apply Grease & Bond	11.0	0.5	11.5
10	Case Assembly / Welding & Aging	13.5	1.5	15.0
11	Electrical Check	15.0	0.0	15.0
12	Double Check	15.0	0.0	15.0
13	Packing	11.0	4.0	15.0
	Total	181.9	17.6	199.5

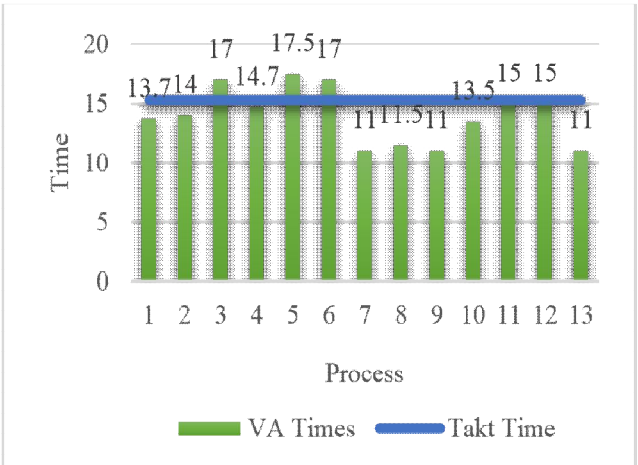

Figure 5.2: TAKT time graph for future process

Figure 5.2 show the changes of process after the application of Kaizen burst. The processes that over the TAKT time had reduce to three which are process 3, process 5 and process 6. There are several processes that finish faster have been combined in order to stabilize the process time to the TAKT time while the process with requiring too much time have been added an operator in order to achieved TAKT time of the process.

5.3 Improvement proposal for problem identification

The table 5.2 shown the problem identification that being done by the researcher during the collection of data in the company. There are some suggestions for each problem identified. The suggestions are as below:

Table 5.2: The improvement suggestion

No.	Waste	My observation	Suggestion
1	Time waiting	All the worker work at conveyor belt, they need to wait all the worker in the same line to complete their task first before they can proceed to the next task.	Production process use the conveyor belt. So, the process time for each processes must be approximately same. The process which have short cycle time can be combined to capture conveyor speed. While combining processes, excess operator are transferred to process that have longer cycle time. By doing this, the production lead time can be reduced and the production TAKT time can be achieved.
2	Underutilize talent	Some worker has special creativity and talent but they are told to de only one task	Give the employees chance of job rotation

5.4 Comparison of cycle time between current state and future state

From the outcome of the previous data on problem identification, its shows future state of VSM is improved based on kaizen bursts identified. Table 5.3 shows the comparison of current and future state of VSM.

Table 5.3: Comparison between current and future value stream mapping

Total Operation Time (sec)							
Current State Value Stream Mapping				Future State Value Stream Mapping			
Operation	Process	Operator	Times	Times	Operator	Process	Operation
1	Manual Insert 1	1	7.0	13.7	1	Manual Insert 1	1
2	Manual Insert 2	1	6.7				
3	Manual Insert 3	1	7.3	14.0	1	Manual Insert 2	2
4	Manual Insert 4	1	6.7				
5	Manual Insert 5	1	6.0	17.0	1	Manual Insert 3	3
6	Manual Insert 6	1	5.7				
7	Manual Insert 7	1	5.3				
8	Solder	1	14.7	14.7	1	Solder	4
9	PWB App Check/ ICT	1	17.5	17.5	1	PWB App Check/ ICT	5
10	PWB Check Auto	1	17.0	17.0	1	PWB Check Auto	6
11	DC Cod Solder	1	22.0	11.0	2	DC Cod Solder	7
12	CCD Checking	1	23.0	11.5	2	CCD Checking	8
13	Apply Grease & Bond	1	11.0	11.0	1	Apply Grease & Bond	9
14	Case Assembly / Welding & Aging	1	27.0	13.5	2	Case Assembly / Welding & Aging	10
15	Electrical Check	1	30.0	15.0	2	Electrical Check	11
16	Double Check	1	15.0	15.0	1	Double Check	12
17	Packing	1	11.0	11.0	1	Packing	13
Total		17	232.9	181.9	17	Total	

From Table 5.3, comparison between current state and future state of value stream mapping is shown. Before Kaizen Burst is implemented, the total process is 17. However after implementing the kaizen burst the process had been reduce to 13, the non-value added time has been reduce by combining process have shorter cycle time and the operator transferred to process that have exceeding to much from TAKT time. By doing this the amount of process cycle time will be approximate to the TAKT time provided by the company.

5.5 Analysis the result of Current State and Future State

After the implementation of the kaizen burst and propose improvement, the result obtained for the future state is analyzed. The comparison of the lead time, number of operation, value added times, and non-value added times between current state and future state is done. The result is shown in the Table 5.3 below.

Table 5.4: The percentage of comparison of lead time, no. of operation, VA times, and NVA times between current state and future state

Aims	Current State	Future State	Changes (%)
Lead time (sec)	352.6	199.5	Reduced 43.42%
No. of operation	17	13	Reduced 23.53%
VA Times (sec)	232.9	181.9	Reduced 21.90%
NVA Times (sec)	119.7	17.6	Reduced 85.30%

As the result, the lead time for the operation in future had reduced 43.42% compare to the current state. Number of operation also had reduced to 13 processes from17 processes at the current state which represented by 23.53% of reduction. By change that been made the value added time had reduced 21.90% from current state. It goes the same with the non-value added time which have been reduce 83.63 % from the current state. This shows that the non-value added time in production process have been reduced.

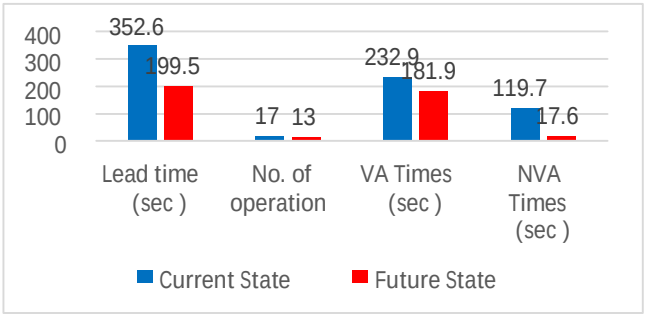

Figure 5.3: Comparison of lead time, no. of operation, VA times, and NVA times between current and future state

6. CONCLUSION

The aim of this research paper is to identify several cause of waste that may occurs in the company production line. This research was done in attempted to eliminate or at least reduce the waste that occurs in the production process by using the Value Stream Mapping to model the current state of VSM. This research use the value stream mapping tools in identifying the generated waste in the manufacturing company and identify ways of reducing this waste while at the same time decrease the process cycle time in production line.

This research focused on each process cycle time for the whole production process. This research was carried out by using observation at the company production process and the interview with the company manager. The observation was conducted to record time needed for each activity to be completed. Each process were observe with the need of research to gain the correct data. The tools used was value stream mapping. From the future state of value stream mapping can be concluded that the non-value added time also have been reduced. Reducing non-value added time will improve cycle time. Improving cycle time also consider as reducing and eliminating waste that occurs in company production. This research has completed all research objectives been mentioned earlier.

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