IMPROVING THE EFFICIENCY OF THE PRODUCTION PROCESS IN THE SURFACE MOUNT TECHNOLOGY (SMT) INDUSTRY WITH A LEAN MANUFACTURING APPROACH

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ABSTRACT

The Manufacturing industry needs commitment for continuous improvements in various aspects of technology and business processes currently in-use. This allow companies to streamline processes and costs incurred in production operations, so that productivity continues to increase and they are no waste elements occurs. This study aims to analyse the non-value added/wasted Sufrace Mount Technology (SMT) production process and based on results formulate recommendations to mimimize these negative factors to increase Surface Mount Technology (SMT) production efficiency. Additionally this study allows to conduct sensitivity analysis and introduce cost benefit factors in optimised production process. Method uses in this researches is VSM, VALSAT, WAM, RCA, and FMEA. Based on the results of Current State VSM, the PCE value is 9.18%, which means that the production process is not efficient. Using VALSAT method with PAM tools allow us to calcute following values: VA is 84.5, NVA is 420 and NNVA is 60. Utilizing WAM we can identify that waste in aspects like waiting, transportation and motion have the highest engagment in current non-optimized process. This is also exposed to RCA, root cause of current inefficencies in SMT production process are caused by capacity of the chip mounting and not properly utilisation of IC mounting machines. It is proven that the highest RPN on FMEA is motivated by engine capacity that is not used efficently. Authors suggest to create a new line in the SMT process by using same number of Chip and IC mounting machines with addition of several new machines to support current process.

Keyword: Efficiency; Surface Mount Technology (SMT); Lean Manufacturing; Value Stream Mapping (VSM); Non Value Added/Wasted;

1. INTRODUCTION

Along with the development of industry 4.0, the manufacturing industry is facing increasingly fierce industrial competition. This is motivated by the many more innovative businesses that appear every day, both locally, nationally, and internationally. Business people are required to be aggressive and creative in order to be able to adjust to changes in the business environment that are so fast. The manufacturing industry is also facing rising workers' wages, expensive materials, and other overhead costs that are increasingly soaring (Sayyida, 2011)

The manufacturing industry needs to be committed to making continuous improvements in various aspects so that the company can streamline the process and streamline the costs that come out in the production process, so that productivity continues to increase and there is no waste in it. An alternative solution that can be done to build this commitment is to improve the production system, namely by streamlining or eliminating one of the processes that are

considered unnecessary or can be combined with other processes (Gasperz, 2007). If this is done, then the company's goal of being able to produce quality products at affordable prices and timely delivery will be achieved properly. Of course, these efforts can increase consumer confidence, supply chain efficiency and increase competitiveness.

According to Taylor and Brunt (2001) activities in an industrial flow are categorized into three, namely adding value (value added), needed but not adding value or waste (necessary but non-value added), and not adding value (non-value added) or waste (waste). According to Charron, et al. (2015) one of the problems that often occurs in companies is that there is still a lot of wasted in the production process which is an activity that takes up time, resources and space, but does not add value to products or services from a customer perspective (non-value added) (Setyabudi, 2017).

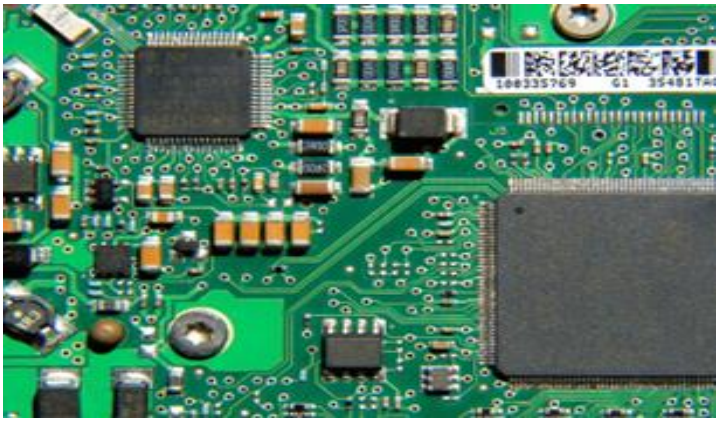
Theuse of resources in processes that do not have added value (non-value added) is one example of inefficiency that occurs in the production process (Ismed, 2014). Companies that are able to reduce and eliminate non-value added activities will maximize value added activities, so that manufacturing cycle effectiveness (MCE) will be optimal (Wijayanto, 2016). Wasted is any kind of loss resulting from an activity that generates directly or indirectly generates costs, but does not add to the benefits / value of a product from the client's point of view (Siti et al., 2014). According to (Al-Moghany, 2006) wasted is any kind of loss on the material, time and monetary results of an activity but does not add value or process to the product. Farmoso et al (2002) defines wasted as the loss or loss of various resources, namely material, time (relating to labor and equipment) and capital, resulting from activities that require direct or indirect costs but do not add value to the final product for the construction service user.

To analyze and minimize wasted, an integrated system approach is needed to identify and reduce the occurrence of wasted in the system so that the company can save raw material resources, time and energy so that there is an increase in efficiency. One of the approaches used to eliminate wasted is lean manufacturing. Lean manufacturing aims to optimize the production process commonly used by many manufacturing companies. According to (Gasperz, 2007) lean manufacturing is a continuous effort to eliminate wasted that occurs in an industrial company and increase the value added of products (goods and / or services) in order to provide value to customers (customer value).

Taiichi Ohno, who is the head of Toyota, identified seven types of waste, namely *overproduction, waiting time, transportation, over process, unnecessary inventory, unnecessary motion* and *defects*. Taichi said that waste occurs everywhere and it can be found that waste occurs anywhere and more waste can be found unnoticed in every activity (Womack and Jones, 1996). *The tool* that is commonly used to be able to identify types of waste is *Value Steam Maping* (VSM). *Value steam mapping* is a picture of overall production activities aimed at providing added value, identifying waste in the process, by shortening *lead time processes* and also costs (Kundgol et al., 2021). *Value stream mapping* allows finding problems and finding solutions to improve company performance (Antonelli & Stadnicka, 2018). So, simply put, this VSM is needed to provide an overview of the current production process. After getting an overview of the production process as a whole, we will be able to see wasted activities. That way we will know which processes need to be improved. If these *wasted* activities are able to *be*

improved, then the *lead time* of the production process will be shorter, even in some cases the use of *manpower* is also reduced, which in turn will reduce production costs. In order for the increase in productivity to be seen, it requires a comparison of VSM before and after optimization.

Printed Circuit Boards (PCB) are tools that contain conductor material that can be formed into circuits to connect electronic components so that they become a circuit. The PCB sighting can be seen in figure 1.1.



Picture. 1.1 PCB Apparition Examples

The concept of lean manufacturing is adopted from the Toyota production system (TPS) concept. TPS is a system with the basic idea of "wasted elimination" that is applied in all aspects of production. The realization of this idea was first carried out by Sakici Toyoda, through his automatic weaving machine which was created in 1924. According to Kiichiro Toyoda (1930) wasted can be manifested in the form of inventory piles in some cases. Other cases include process steps that are actually unnecessary, or defective products. All these wasted elements are interconnected and create other wasted-wasted, which will certainly have a very negative impact on management and corporations (Shift Indonesia, 2013).(Shift Indonesia, 2013)(Shift Indonesia, 2013)(Shift Indonesia, 2013). Printed Circuit Boards (PCBs) are tools that contain conductor material that can be formed into circuits to connect electronic components so that they become a circuit.

To be able to connect electronic components so that it becomes a series, a technology is needed, one of which is Surface Mount Technology (SMT). This method is carried out by a robotic machine that is automatically able to carry out the installation of electronic components regularly, neatly, and meticulously. With SMT technology, electronic equipment or gadgets (such as cellphones, compact cameras, computers) can now be designed with a smaller size, this is because SMT machines have the ability to pair very small components up to 0.4 mm X 0.2mm (CHIP SMD resistor 0402).

Some of the studies related to *lean manufacturing* that are referenced in this study are the following. Research from Rahmad Hidayat (2014) with the title, "Application of *Lean Manufacturing* With VSM and FMEA Methods to Reduce *Wasted* in Plywood Products (Case Study of Dept. Production of PT Kutai Timber Indonesia). To

reduce the *wasted* that occurs, a *lean manufacturing* approach with the *Value stream mapping* (VSM) method is used to map production flows and information flows to a product at the total production level, as well as *Failure Mode and Effects Analysis* (FMEA) analysis to determine the causes of process failures that occur on the production line. Wasted identification begins with the delineation of the current state map, then wasted analysis is carried out into category 7 *wasted*. After that, a root cause analysis of wasted emergence is carried out using a fishbone diagram, and FMEA analysts to find out the highest RPN value which will then be a priority for providing appropriate improvement proposals and according to problems and conditions. The improvement recommendations given are related to the highest RPN value in the *identified wasted* is to provide a more precise and ergonomic material handling tool design, carry out maintenance activities, and increase the number of dryer machines.

Research conducted by Raden Muhammad Fadly (2018) entitled, "Proposed *Wasted* Reduction Using *Lean Manufacture* Method in the PT. Beautiful Tips Pulp & Paper". The purpose of the study is to identify activities with Process Activity Mapping to determine value added and *non-value added* and eliminate waste so that the most efficient process time is obtained, it is expected that product quality will increase. These problems can be solved with *Lean Manufacture* using the *Value stream mapping* method approach. This method can provide *lean* metric calculation values and sigma rate calculations. The actual results showed that the leadtime was 289 minutes, the value added time was 78.88 minutes, *the non-value added* time was 210 minutes. Efforts that can be made by companies to reduce *the wasted* that is happening are to apply the 5S method during production activities and implement SOPs that have been provided by the company. Using the proposal from the *Value stream mapping* approach, the leadtime was obtained was 218.61 minutes, the value added time was 78.61 minutes, *the non-value added* time was 178.73 minutes. The reduction of waiting time is carried out by preparing alternatives by analyzing 5 why *tools* and *wasted* analysis with PAM. Through the estimation of improvement results, the percentage of value added activity was obtained at 36%, before the estimated results for *value added* activities the percentage was only 27%. There has been an increase in *value added* activity by 9%, and has reached the lean concept whose percentage is 30% of the total lead time.

Research conducted by Nur Muflihah (2017) with the research title, "Implementation of *Lean Manufacture* With VSM Method to Reduce *Wasted* in Ship Production Process (Case Study of PT. Pal Kaprang Division). The purpose of the study is to evaluate the production process through a lean manufacturing concept approach, to evaluate and identify *wasted* products carried out value stream *mapping*, namely mapping through a detailed value stream based on the concept *of lean manufacturing*. Wasted identification begins with the delineation of the current state map, then wasted analysis is carried out into category 7 *wasted*. After that, a root cause analysis of wasted onset is carried out using root cause analysis. The study showed that 53% is a value adding activity, 35% is a necessary but non-value adding activity , and 12% is *a non-value* adding activity. Paretto's Law used to find out that 23.8% of the *wasted* that was the most critical cause was defects with a contribution of 80%.

The differences between the previous study and this study are as follows: The

subject of the previous study was the production process of plywood, paper, vessels, and shoe cleaners. While the subject of this study is the production process of Printed Circuit Board (PCB) with Surface Mount Technology (SMT) technology. The purpose of the previous study was the efficiency of the production process by providing suggestions for improvements in the production process only, but in this study in addition to providing improvements in the production process, it also provided the results of sensitivity and cost-benefit analysis if these improvements were implemented. In the previous study, it did not conduct a sensitivity and cost-benefit analysis.

The objective of the research is analyse the non-value added/wasted Sufrace Mount Technology (SMT) production process and based on results formulate recommendations to mimimize these negative factors to increase Surface Mount Technology (SMT) production efficiency. Additionally this study allows to conduct sensitivity analysis and introduce cost benefit factors in optimised production process.

2. LITELATUR REVIEW

Optimization

Andri Rizki Pratama (2013: 6) defines optimization as an individual effort to increase activities to be able to minimize losses or maximize profits in order to achieve goals properly within a certain deadline. According to S. Rao, John Wiley and Sons (2009) optimization is a process to achieve a state that gives the maximum or minimum value of a function. Based on some of the definitions above, it can be concluded that optimization is an attempt to achieve an optimum value by maximizing a function or minimizing the loss of that function.

Production Process

Ahyari (2002) says the production process is a way, method or technique of adding to the usefulness of goods and services by using existing production factors. Subagyo (2000: 8) mentions the production process or operating process is the process of changing inputs into outputs. Seeing from the several definitions above, it can be concluded that the production process is an activity to produce goods or services using production factors so that they have benefits for consumers.

According to Subagyo (2000:8-9), the production process is divided into 3 types that are extreme in nature, namely:

1. Continuous production process

   The continuous production process is a production process that never changes the kinds of goods that are worked on.
2. Intermittent production process

   It is said that the production process is intermittent because changes in the production process are interrupted at any time if there is a change in the type of goods that are worked on.
3. Intermediated production process

   In reality, the two kinds of production processes above are not fully applicable. It is usually a mixture of the two. This is because the types of goods worked on are different, but the kinds are not too many and the number of goods of each kind is a bit large.

Surface Mount Technology (SMT)

According to James J. Licari and Dale W. Swanson (2011), Surface Mount Technology (SMT) is basically a component assembly technology associated with printed circuit boards in which components are mounted and connected on the surface of the board using a batch solder re-flow process. SMT differs from other Printed Circuit Board / Printed Wiring Board (PCB / PWB) methods

in that component wires are inserted into plated holes and wave-soldered from below to fill the holes and connect the components.

Lean Manufacturing

Gaspersz (2011) explains that lean focuses on identifying and eliminating non-value adding activities in production design (for the manufacturing sector) or operations (for the service sector) and supply chain management, which are directly related to customers. . Lean means a continuous effort with activities or solutions to eliminate wasted, reduce non-value added (NVA) operations and to increase added value (Wee, 2009). So, we can conclude that lean is a continuous effort to eliminate (wasted) and increase the added value (value added) of products (goods/services) in order to provide value to customers (customer value). Taiichi Ohno at the Toyota Motor Company developed a lean strategy in the 1950s (Ohno, 1991). Lean was then able to change the competition and has led to the maturity of the growth phase in the organizations it has implemented.

Meanwhile, according to Tischler (2006) there are three objectives in the application *of lean manufacturing*:

1. Better process, which is to provide more value to customers and do it more efficiently (less cost, less waste, and with the least action)
2. Better working conditions, which include a clearer work flow, a greater division of work values and goals, a greater ability to carry out work (be more proud and enjoy the work), a greater ability to keep improving and improving everything (fewer restrictions so that the opportunity to develop is greater), the feeling that workers are part of the service (not just doing routine work), and a feeling of integrity (workers do what they say).
3. Meet the needs and goals of the organization, which can include profit, growth, value, and influence.

Wasted

One way to increase productivity and efficiency is to eliminate waste. Waste in Japanese is Muda, which is everything whether material, machinery, equipment and tools, human resources, information capital, processes, managerial which do not provide added value (non-value added) to products or work results (Womack & Jones, 1996). Toyota has identified seven main types of non-value added activities in business or manufacturing processes. These seven wastes can be used in product development, order taking, and office procedures, not just in the production line. The following are several types of wasteful activities, namely over production, waiting, excessive transportation, inappropriate processing, unnecessary inventory, motion, and defects.

Value Stream Mapping (VSM)

Liker and Meier (2007) say that Value stream mapping is a methodology from lean to make a big picture of reducing waste. Value stream mapping also aims to improve each process so that the process flow can flow.

Some of the advantages if the process can flow according to Liker (2006) are:

1. Inherent quality. It is easier to create quality in the process of one-piece flow. Each operator is a quality inspector and fixes any problems at that station before handing it over to the next station. But if it escapes and continues to proceed to the next station, the damage will be detected more quickly and the problem can be immediately diagnosed and corrected.
2. Creates true flexibility. When dedicated equipment to one type of product, it will

have less flexibility in scheduling it for other purposes. But if the lead time to create a product is very short, we have more flexibility to respond and make what the customer wants.

3. Creating higher productivity. In *one piece flow* , there are fewer activities that do not add value, such as moving materials so that productivity will also increase.
4. Free up the workspace. Empty space between appliances is a waste, but part of this room is wasteful due to the increasingly accumulated supplies. In one cell, all the equipment is close to each other and only a small amount of space is left for supplies. Maximizing the use of space, it can accommodate more capacity.
5. Improving work safety. *One piece flow* will indirectly improve work safety, because the material is driven in a smaller batch size in the factory. A smaller batch means not using forklifts which is the main cause of accidents.
6. Increased morale. In *one piece flow* people do work that adds value and can immediately see the results of the work, thus giving them a sense of success and job satisfaction.
1. Reduce inventory costs. Freeing up capital so that it can be invested elsewhere, the point is not to make investments in the form of supplies that are just quietly waiting on the production floor.

3. RESEARCH METHODS

This research was carried out in the SMT industry. Meanwhile, the research implementation will be carried out in 6 months from May to November 2022.

In conducting this research, two types of data sources were used that were distinguished based on how to get them, namely:

1. Primary data is data obtained from direct observations to the production department. Primary data is obtained from interviews, documentation in the form of photos, recorders, and *stopwatches*. The data needed includes all activities carried out from the beginning to the end of the production process or goods ready for consumption by consumers.
2. Secondary Data That is data obtained by researchers indirectly from sources related to research. Secondary data is generally in the form of historical production data, attribute data, and other supporting data both through System Application and Processing (SAP) and those that are not entered into the SAP system as a complement to research.

Meanwhile, the data collection methods used in this study are:

1. Observation

   Is a data collection technique where researchers make direct observations on the object of study. The activities reviewed are the production process.
2. Interview

   It is a data collection technique by asking questions to the operator by means of direct question and answer. Interviews were conducted with operators working on the production line regarding the causes of problems and finding the variables needed for data processing.
3. Literature review

   The literature study method is carried out by collecting information through the company's System Application and Processing (SAP), internet, books, and journals that support this research.

In this research there are several stages that must be passed properly. There are three stages that will be discussed in the discussion below. The stages of the research are: initial identification stage, data collection and processing stage, data analysis and interpretation stage, improvement alternative

preparation stage, and conclusion and suggestion stage. In general, the stages of the research can be seen from Figure 3..

Initial Identification Stage is regarding the initial stages carried out in research in the form of problem identification, literature studies, field studies, problem formulation, and determination of research objective. Then after that to data analysis and interpretation stage to analyze and interpret the results of data processing obtained in the previous stage and method need to use in the researched. Below is method that useses in research:

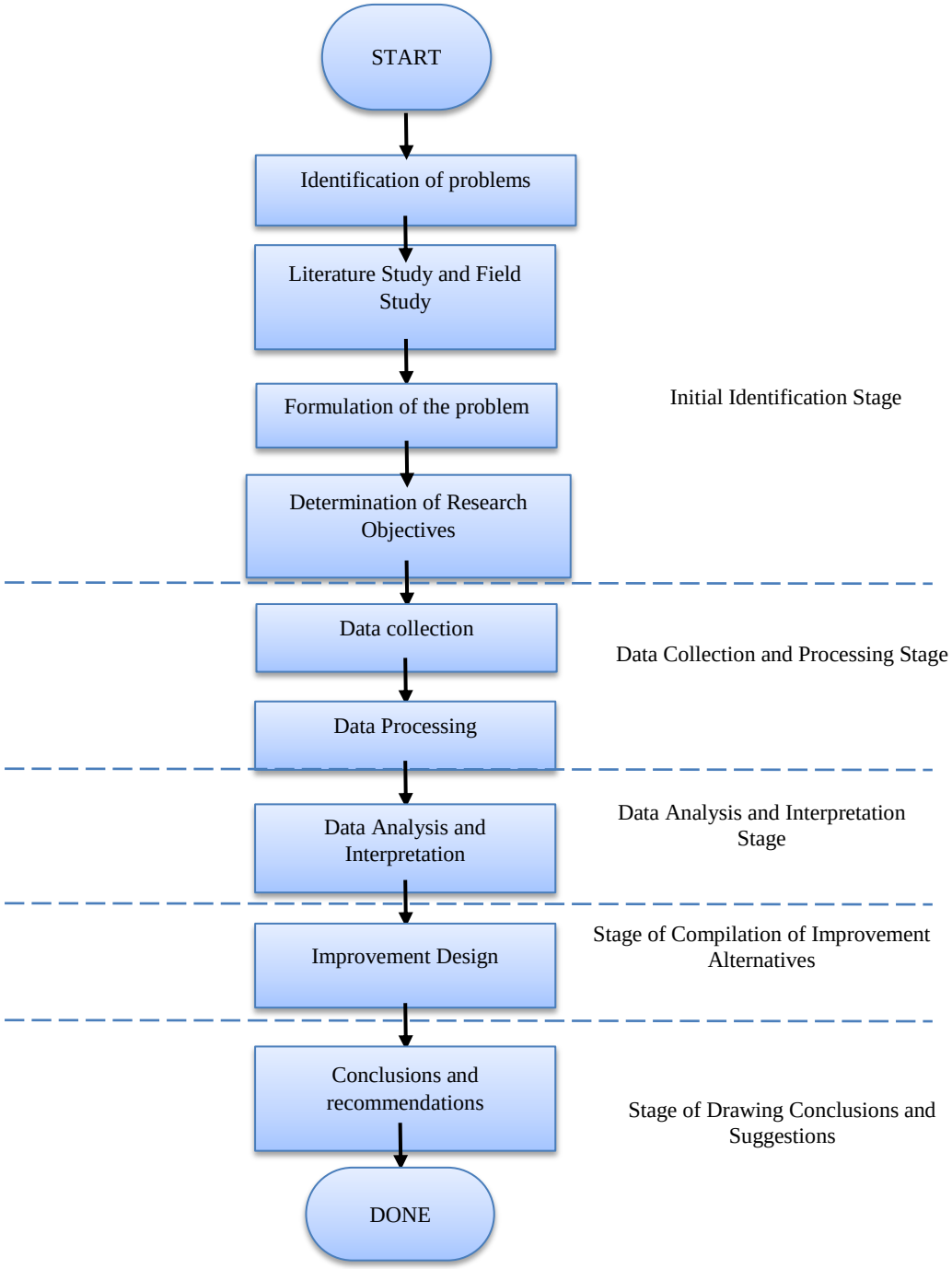


Figure 3.1 Research Stages

Value Stream Mapping (VSM)

Value stream mapping is used to determine the types of wasted motion, waiting time, and transportation that appear in the company's business processes. The symbols used to create a value stream mapping are as figure. 2

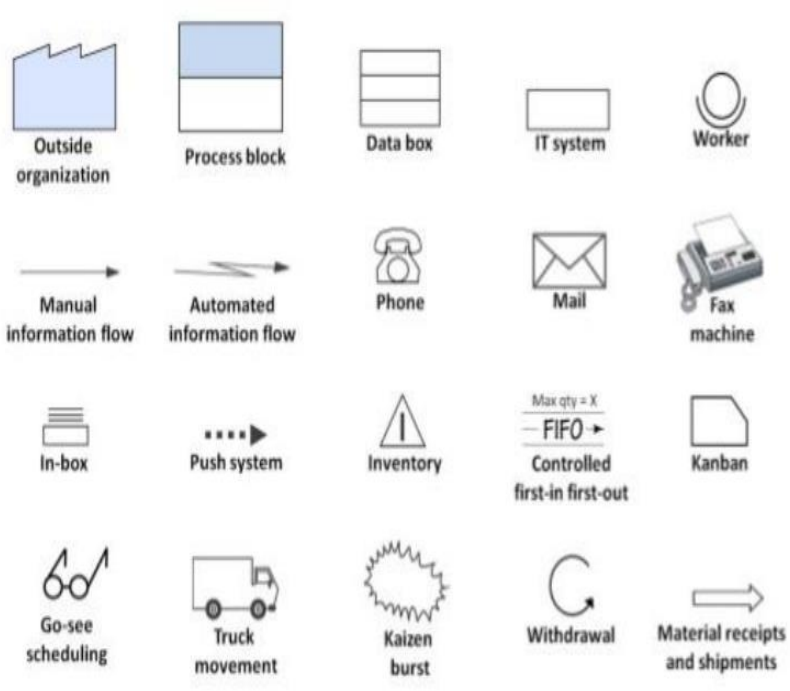


Figure 2. Symbols in Value Stream Mapping
Resources: Hines and Rich, 2002

Value stream mapping Analysis Tool (VALSAT)

While the tools used to analyze Value Stream Mapping are VALSAT which is an approach that is used by weighting waste, then from this weighting a tool is selected using a matrix as figure 2.

Table 1. Value Stream Analysis Tools

Waste / Structure	***Mapping Tools***						
	Process Activity Mapping	***Supply Chain Response Matrix***	***Production Variety Funnel***	***Quality Filter Mapping***	***Demand Amplification Mapping***	***Decision Point Analysis***	***Physical Structure***
Overproduction	L	M		L	M	M	
Time Waiting	H	H	L		M	M	
Transport	H						L
Inappropiate Processing	H		M	L		L	
Unnecesary Inventory	M	H	M		H	M	L
Unnecesary Motion	H	L					
Product Defects	L			H			

Waste / Structure	*Mapping Tools*						
	Process Activity Mapping	***Supply Chain Response Matrix***	***Production Variety Funnel***	***Quality Filter Mapping***	***Demand Amplification Mapping***	***Decision Point Analysis***	***Physical Structure***
Overall Structure	L	L	M	L	H	M	H
Origins of Tool	*Industrial Engineering*	*Logistics*	*Operation Management*	*New Tool*	*System Dynamics*	*Efficient Consumer Response/ Logistics*	*New Tool*
Notes: *H = High correlation and usefullness* *M = Medium correlation and usefullness* *L = Low correlation and usefullness*							

(Resources: Hines and Rich, 2002)

Waste Assessment Model (WAM)

This analysis was conducted to determine the relationship between wasted in the SMT production process. In addition, an analysis of critical waste will be carried out in the SMT production process.

Root Cause Analysis (RCA)

RCA analysis is a method for solving problems, trying to identify the causal factors of a problem or unexpected event. The main objective of this method is to identify factors expressed in terms of nature, magnitude, location and time as a result of certain habits, actions and conditions that must be changed to avoid unnecessary errors. In this study the tools used to analyze the root cause are fishbone diagrams

Failure Modes and Effects Analysis (FMEA)

FMEA is an analytical method based on the root causes of problems that have been identified in Route Cause Analysis (RCA). The root of the problem is then analyzed for the impact and magnitude of severity, occurrence and detection that occurs to produce a Risk Priority Number (RPN). Based on the value of the RPN, the authors can provide recommendations for improvement so that it can be optimally applied to the company.

In this researc used quantitative methods. This method explains that quantitative research requires a researcher to explain how a variable affects other variables (Creswell, 2012: 13). In conducting this research, two types of data sources were used which were differentiated based on how to obtain them, namely primary data and secondary data. Primary data is data obtained from direct observation to the production department. Primary data obtained from interviews, documentation in the form of photos, recorders, and stopwatches. The data needed includes all activities carried out from the beginning to the end of the production process or goods ready for consumption by consumers. Meanwhile, secondary data is data obtained by researchers indirectly from sources related to research. Secondary data is generally in the form of historical production data, attribute data, and other supporting data either through the Application and Processing System (SAP) or not entered into the SAP system as a research complement. The data collection methods used in this study were direct observation of the SMT production process, interviews with experts in the SMT production process, and literature review by collecting information through the company's System Application and Processing (SAP), the internet, books, and journals that support this research.

4. RESULT AND DISCUSSION

Advantages of smt chip processing are high assembly density, small size, and light weight of electronic products, the volume and weight of chip components are only about 1/10 of the traditional plug-in components. Generally speaking, after using SMT, the volume of electronic products is reduced by 40% ~ 60%, Weight reduction by 60% ~ 80%. High reliability and strong anti-vibration ability. The degree of defection of solder joints is low. Good high frequency characteristics. Reduces electromagnetic interference and radio frequencies. It is easy to implement automation and increase production efficiency. Reduce costs by up to 30% to 50%. Save materials, energy, equipment, labor, time, etc. Due to the complex process of smt chip processing, many smt chip processing plants have emerged, specializing in the processing of smt. di Shenzhen chips, thanks to the rapid development of the electronics industry, smt chip processing performance This is an industrial boom (Neoden, 2020).Service improvement is carried out by using a Lean Manufacturing approach to identify waste by using an analysis tool called Value Stream Mapping (VSM). Value Stream Mapping (VSM) is a tool or an ideal tool as the first step in carrying out the change process to get lean manufacturing conditions or lean enterprises (Goriwondo, 2011) Value stream is defined as a special activity in a supply chain that is needed for the design, determination and determination of a particular product or value. Current State VSM shown in Figure 3.

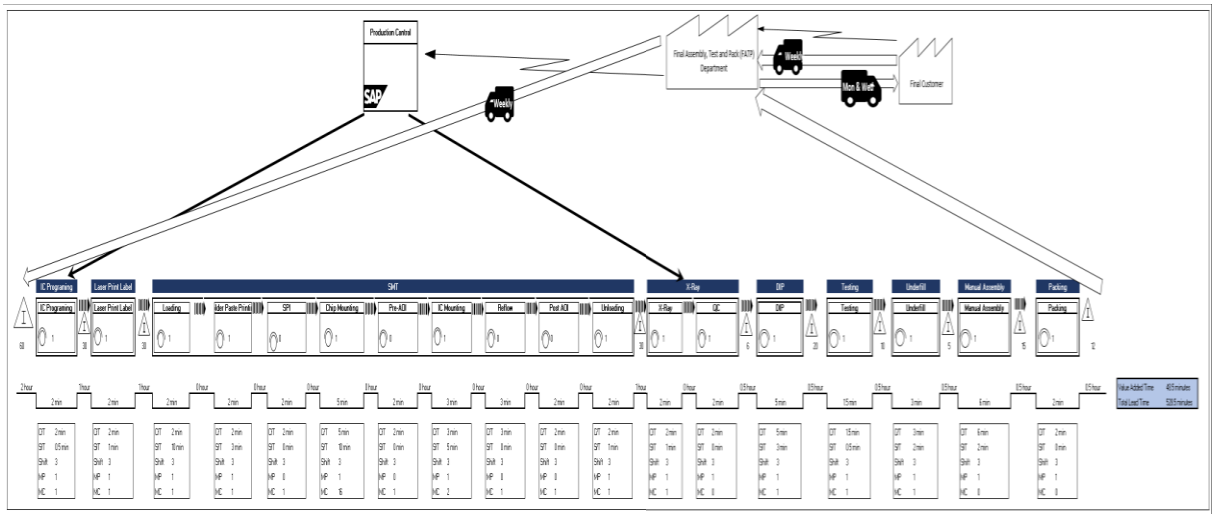


Figure 3. Current State VSM

Based on this mapping, it can be seen that based on the current state of VSM in Figure 4.33, the value added time of SMT is 48.5 minutes and the total lead time is 528.5 minutes or 8.8 hours for 1 batch Work Order (WO), with the calculation of Process Cycle Efficiency (PCE) as follows :

$$PCE = \frac{\text{Value Added Time}}{\text{Total Lead Time}}$$

$$PCE = \frac{48.5 \text{ minutes}}{528.5 \text{ minutes}} = 9{,}18\ \%$$

Based on the calculation above, the PCE in the current SMT production process is 9.18% or less than 25%. So, it can be concluded that the current SMT production process is not efficient. So that efforts are needed to increase efficiency in the SMT production process. In the next section, the sources of waste in SMT will be analyzed and efforts to eliminate them.

Once the SMT production process is known, seven wastes (seven wastes) are measured, such as overproduction, defects, unnecessary inventory, unnecessary motion, inappropriate processing, transportation, and waiting that may occur in the SMT production process using percentage weights using the Value Stream Mapping Analysis method. Tools (VALSAT). The results of weighting the waste are as Table 1 dan result for VALSAT as Table 2.

Table 1 Result of Weighting The Waste

No	*Wasted*	*P1*	*P2*	*P3*	*P4*	*Total Score*	*Weight*
1	*Over Production*	*1*	*2*	*1*	*1*	*5*	*6,95%*
2	*Waiting*	*4*	*4*	*4*	*3*	*15*	*20,83%*
3	*Excessive Transportation*	*3*	*3*	*4*	*3*	*13*	*18,06%*
4	*Innapproriate processing*	*2*	*1*	*2*	*2*	*7*	*9,72%*
5	*Unnecessary inventory*	*3*	*3*	*3*	*3*	*12*	*16,67%*
6	*Unnecessary Motion*	*3*	*3*	*4*	*4*	*14*	*19,44%*
7	*Defect*	*2*	*2*	*1*	*1*	*6*	*8,33%*
Total						*72*	*100,00%*

Table 2. VALSAT Result

Waste / Structure	**Bobot**	**Mapping Tools**						
		Process Activity Mapping	**Supply Chain Response Matrix**	**Production Variety Funnel**	**Quality Filter Mapping**	**Demand Amplification Mapping**	**Decision Point Analysis**	**Physical Structure**
Overproduction	6,94%	0,07	0,21		0,07	0,21	0,21	
Time Waiting	20,83 %	1,87	1,87	0,21		0,62	0,62	
Transport	18,06 %	1,63						0,18
Inappropiate Processing	9,72%	0,87		0,29	0,10		0,10	
Unnecesary Inventory	16,67 %	0,50	1,50	0,50		1,50	0,50	0,17
Unnecesary Motion	19,44 %	1,75	0,19					
Product Defects	8,33%	0,08			0,75			
Total	100,00 %	6,78	3,78	1,00	0,92	2,33	1,43	0,35
Ranking		1	2	5	6	3	4	7
Notes: H = High correlation and usefullness M = Medium correlation and usefullness L = Low correlation and usefulness								

From Table 2 it can be seen that the tools that have the highest weight are PAM (Process Activity Mapping). This map can identify waste in your value stream and optimize processes to make them more efficient and effective through simplification, combination, or elimination. Result for PAM summary as per Table 3.

Table 3 PAM Summary

Activity	Time	Unit
VA	48.5	Minutes
NVA	420	Minutes
NNVA	60	Minutes
Total lead time	528.5	Minutes

In the table, the VA value in the SMT production process is 68.5 minutes, then the NVA value in the SMT production process is 500 minutes with a total distance of 2889 meters, and the NNVA value in the SMT production process is 315 minutes. So the total lead time is 528.5 minutes or 8.8 hours. So the VA in the SMT production process is only 12.96% of the total lead time.

To be able to identify the most critical waste to be handled, a method is needed that is able to identify waste and simplify waste problems so that waste can be avoided by using the WAM method. Based on the waste matrix value as Table 4. Based on the wasted relationship matrix above, wasted activities for waiting, excessive transportation, and motion have the highest scores. So that these three activities are the most critical wasted that must be corrected immediately.

Table 4 Wate Matrix Value

X/Y	O	W	T	P	I	M	D	Total Score	Persentage
O	10	2	4	2	4	4	2	28	12%
W	4	10	8	4	6	8	2	42	18%
T	2	8	10	4	4	8	4	40	17%
P	4	6	4	10	4	4	4	36	15%
I	2	2	4	2	10	2	2	24	10%
M	2	8	8	4	4	10	2	38	16%
D	4	2	4	4	4	4	10	32	13%
Total Score	28	38	42	30	36	40	26	240	100%
Persentage	12%	16%	18%	13%	15%	17%	11%	100%	

After identifying critical waste in the previous section, a root cause analysis will be developed to find the root cause of the problem by using Wasted with Root Cause Analysis (RCA) with Fishbone tools.

1. Motion

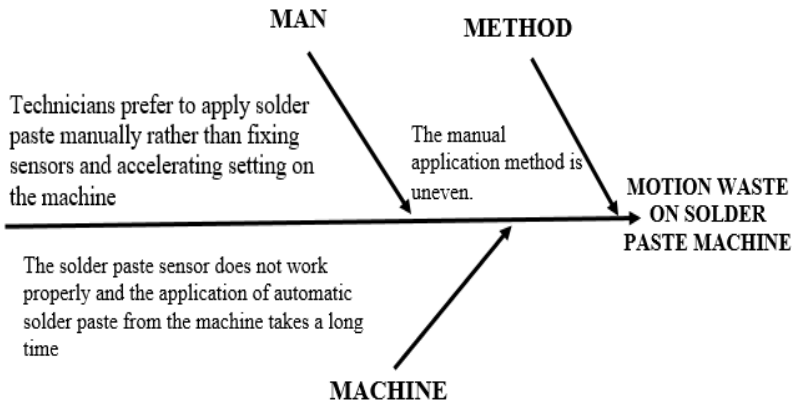


Figure 5 Motion Waste on Solder Paster machine Root Cause

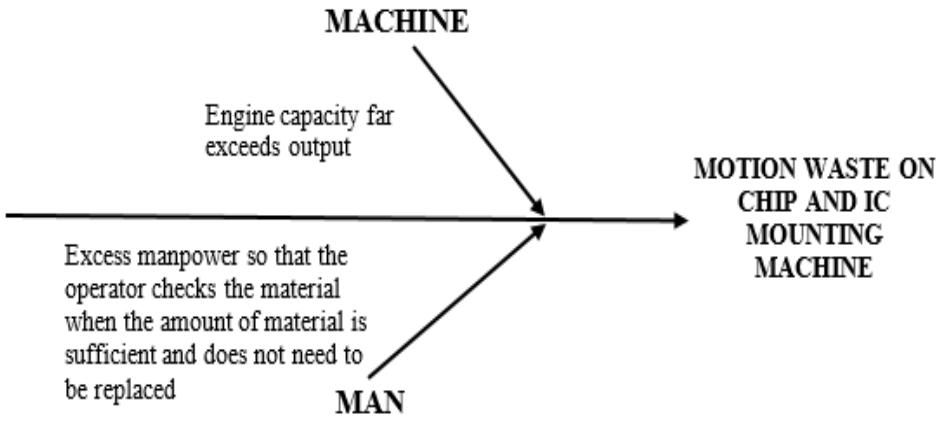


Figure 6 Motion Waste on Chip and IC Mounting Machine Root Cause

In the Figure 5 and 6, it can be seen that one of the root causes of motion waste is because the sensor of the solder paste printing machine does not work properly, this makes technicians have to apply solder paste manually. When in fact the application of solder paste can be set automatically. Besides that, motion waste is also due to the machine capacity which is far more than the output issued by production.

2. Waiting

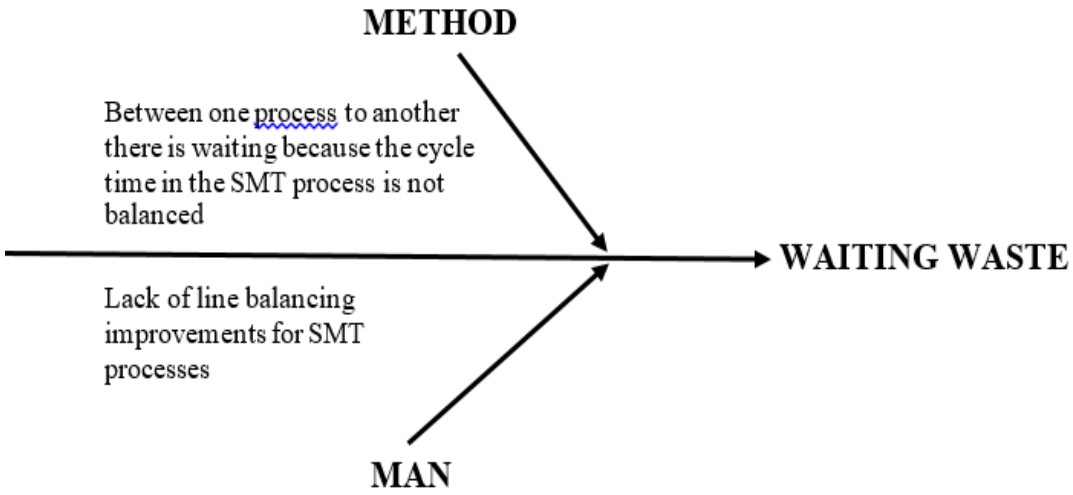


Figure 7 Waiting Waste Root Cause

From the Figure 7 above it can be seen that waiting waste occurs because between one process to another there is waiting because the cycle time in the SMT process is not balanced which is caused by a lack of improved line balancing for the SMT process.

3. Transportation

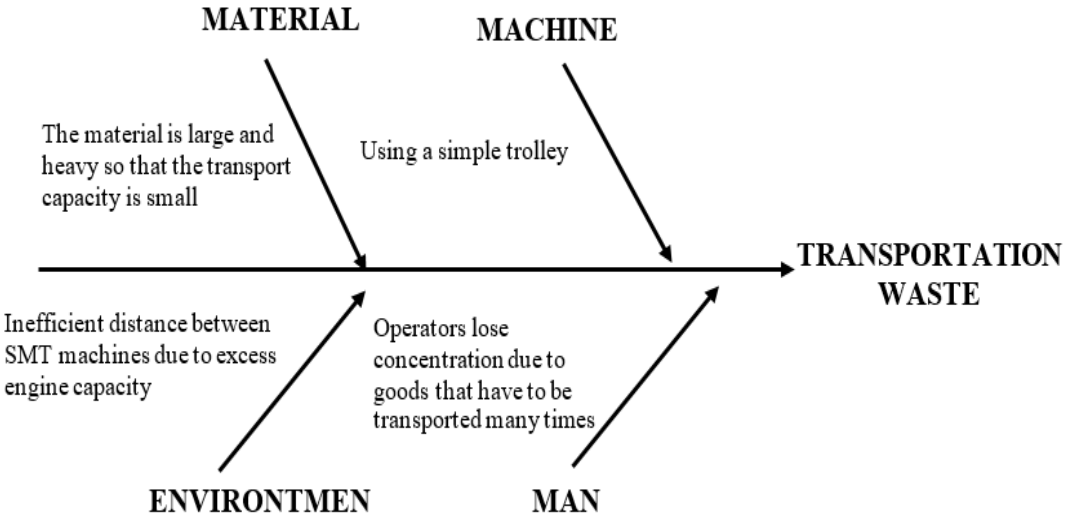


Figure 8 Transportation Waste Root Cause

In the Figure 8, it can be seen that the root case for the occurrence of transportation waste is due to the long distance between departments, which is caused by the inefficient distance between SMT machines due to excess machine capacity. This also causes the operator to easily lose concentration because they need to haul the material many times.

To identify potential errors in a process with the aim of eliminating or minimizing the risk of production losses (Yumaida, 2011), FMEA is needed. Pareto Chart Of FMEA shown in Figure 9. Base on that figure, failure cause of machine capacity far exceeds the number of orders due to the lack of number of points in one PCB (Symbol "A), machine capacity far exceeds the number of orders due to the lack of number of orders in one type of PCB model (symbol B"), and the advantages of manpower on the production line have the highest RPN (symbol "D". While RPN for the sensor on the solder paste printing machine does not work properly(symbol "C"), Waiting time for materials is long (symbol "E") and the distance between departments is far (symbol "F") still lower.

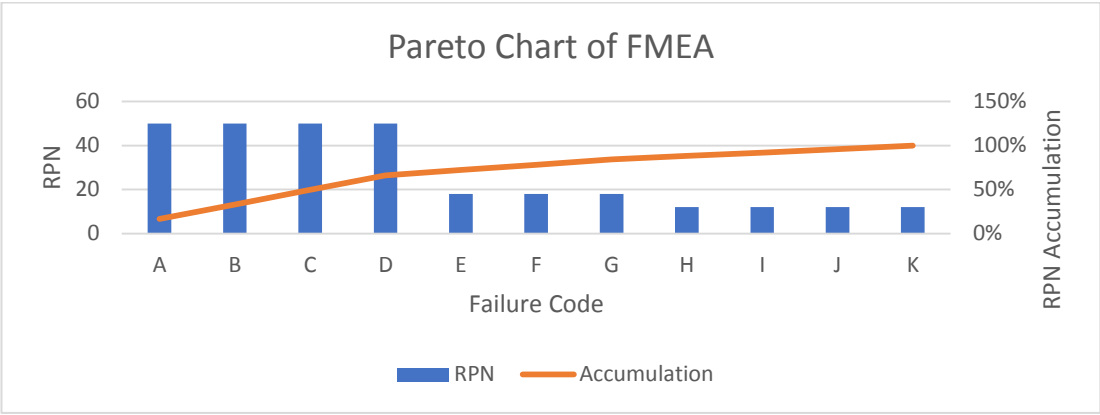


Figure 9 Pareto Chart FMEA

Based on the analysis used, the root cause of the wastage is due to the SMT engine capacity which is not properly utilized. Therefore the author recommends creating a new line for the SMT production process. The following is a Future State Value Stream Mapping based on recommendations as Figure 10.

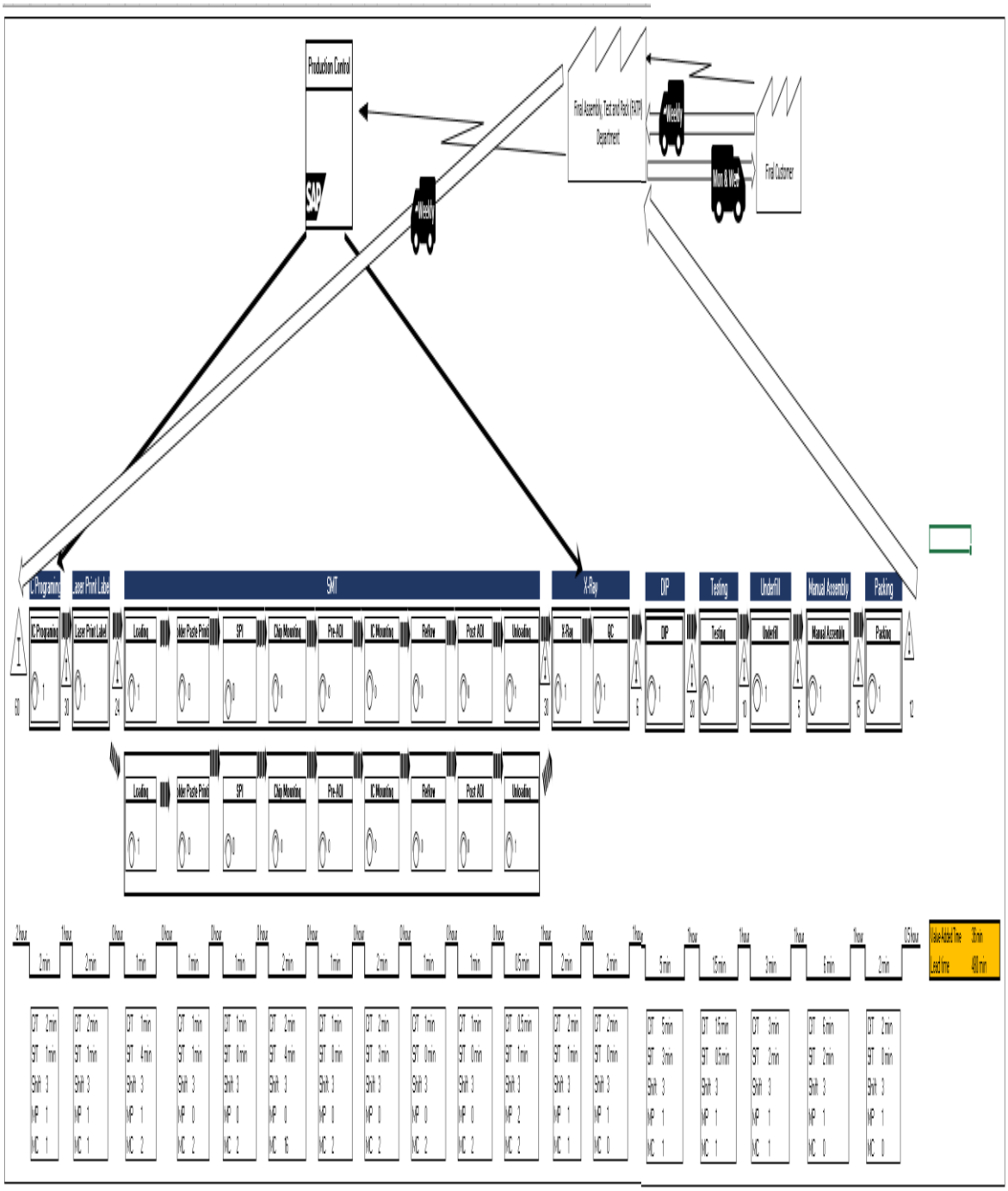


Figure 10. Future State VSM

The addition of the SMT line does not increase the machine capacity because the bottleneck in the SMT process is in the chip mounting and IC mounting machines. While on the new line, chip mounting and IC mounting machines are not added, but are only divided into 2 parts. Initially, for 1 SMT line, 16 chip mounting machines and 2 chip mounting are needed, then after improvements are made, Line A has 8 chip mounting machines, and line B has 1 machine IC mounting. Likewise, line B has 8 chip mounting machines, and line B has 1 IC mounting machine. However, because it has been split into 2 lanes, the value added time has decreased. As a result, the hourly output also decreased from 30 panels to 60 panels. This also gives an illustration that the machine that was originally utilized 34% turned into 68%.

5. CONCLUSIONS

Non-value added / wasted processes that can be minimized in the Surface Mount Technology (SMT) production process are waste in waiting, excessive transportation, and unnecessary motion in the SMT process. The way to minimize non-value added / wasted processes in the SMT process is by adding SMT lines, using the same chip mounting machine and IC but with additional supporting machines. Based on this recommendation, the engine capacity, which was originally only at 34% utilization, changed to 68%.In order to be able to minimize non-value added / waste processes in the SMT production process, the authors recommend adding the SMT line by using existing IC and chip machines, but adding several supporting machines.

Advice that can be given to companies is:

1. Companies must be able to create a systematic and well-documented recording system to facilitate the design of repairs in the future
2. The repair process must be carried out continuously, so it takes a commitment from everyone to participate in the repair process. In addition, management supervision is needed to ensure that improvements that have been designed properly, implemented properly

Meanwhile, suggestions that can be given to the implementation of further research are:

1. Further research can be carried out with a more complete range of data, the more complex the problem analyzed and the more accurate the data obtained.
2. Lean assessment of the company should be carried out in terms of improving the improvement criteria based on the recommendations given in the study.

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