PRODUCTIVITY IMPROVEMENT USING VSM AT TT ELECTRONIS SDN BHD

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Dedicated to My Beloved Abah and Mak

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ABSTRACT

This project presents the application of the VSM as improvements at TT electronics Sdn Bhd. A process is the transformation of raw materials into product that custom needed. An operation is the from receiving raw material, tinning, winding, forming, header assembly, epoxy application, oven curing, cooling, cutting, pitch 1-VMI,boundary VMI, VMI, VMI mantis, testing and packaging. The objectives of this project are to study existing process of product HA00-10502LF, to eliminate waste and non-value added in the process and to improve productivity by using Value Stream Mapping. The methodology was creates by draw the current state of the VSM and generate the future state of VSM to developed the improvement action plan, the future value stream map was plotted and the improvement was highlighted at selected area that needs to improve. The simulation model of the future stream map was build using Witness software. The tool of VSM used in this project successfully achieved.

ABSTRAK

Projek ini mengajukan aplikasi *VSM* sebagai penambah baik produktiviti di TT Electronics Sdn Bhd. Dalam proses ini ialah transformasi bahan-bahan mentah kepada produk yang dikehendaki. Proses ini terdiri daripada menerima bahan mentah, *tinning*, penggulungan, membentuk, pemasangan header, aplikasi epoksi, pangawetan , penyejukan, pemotongan, *Pitch 1-VMI*, *Boundary*, *Final VMI*, *Mantis*, pengujian dan pembungkusan. Objektif kajian ini ialah untuk mengkaji proses sedia ada iaitu produk HA00-10502LF, untuk mengurangkan kitaran masa pemprosesan dan juga mengurangkan proses yang tidak member nilai bagi meningkatkan produktiviti dengan menggunakan aplikasi *value stream mapping* ini. Kajian ini bermula dengan malakarkan nilai *di current value stream* mapping untuk diberikan di *future state map* untuk membuat penambahbaikan di tempat yang dikenal pasti mempunyai masalah. Dengan menggunakan aplikasi simulasi *di future stream map* ini, aplikasi *VSM* didalam kajian ini berjaya dicapai.

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CHAPTER 1

INTRODUCTION

This Chapter will cover the background of project, problem statement, objective, and project scopes.

1.1 BACKGROUND OF PROJECT

In the modern world at this time, the manufacturing industry is one of the key sectors in the economy increased. All products are manufactured has been keen to give and receive extensive and satisfying demand from customers. Dealing with the ever-constant competition not only can provide good results and satisfying, but it can improve the quality of excellence in management and can play the important role sector economy at the industrial.

The project was corporate with TT Electronics Sdn Bhd. This company is located in the Jalan Tanjung Api, Kuantan, Pahang Darul Makmur. The company produces automotive electronic components such as Encoders, Hybrid Microcircuits, Magnetic Components, Panel Potentiometers and others. The product is sold for the customer in area Malaysia.

There are four department at TT Electronics which are Production Magnetic Line which focus on standard and customize design of transformers and indicators product, Production M44 Potentiometers which produce variable resistor 44 trimming potentiometers, Production CNC area that have several CNC machine which capable to wind/form flat/rectangular wire, Production Moiled Inductor that produces high performance inductor into iron powder press and Production Agilent which consist of production cell that produces transformers.

The discussion and interview has been made with the production manager and supervisor at the TT Electronics where some observation in company was identified. The production line of make a product HA00-10502LF is at Production Magnetic Line is the one target to improve where the production that produced not meets customer demand.

1.2 PROBLEM STATEMENT

In the semiconductor industries such as TT electronics Sdn Bhd, the lack of using lean tools exists because of lack of confidence use lean tools in these companies. The main problem that often occurs on the assembly line is a non-value added and high processing time. This will lead to bottlenecks in certain processes and cause unconsistent process flow.

The problem of low productivity will also occur when the cycle time exceeds the takt time, this will create problems for the company not being able to meet customer demand due the inconsistent of production. Besides that, poor workstation and manpower and delay on the production of this line often occur in production.

1.3 OBJECTIVE

The objective of this study is:

i. To study existing process in product HA00-10502LF
ii. To reduce cycle time and non-value added in the process
iii. To improve productivity using Value Stream Mapping

1.4 PROJECT SCOPES

This study will analyze an industry specific problem in this company to increase the productivity and solve the alternative solution.

i. This study is conducted at TT Electronics Sdn Bhd which located at Kuantan, Pahang.
ii. The process flow of production will be identification using method Value Stream Mapping by draw a current state map, it can be calculated cycle time and non-value added time.
iii. This study evaluates and implement by lean tool at future state map and propose improvement using simulation.

CHAPTER 2

LITERATURE REVIEW

This chapter presents the literature review of the definition productivity and value stream mapping, waste and simulation modeling. All the lean can use in this method such 5S in industries, Kanban, and Kaizen hat mentioned in this chapter.

2.1 PRODUCTIVITY

Productivity can be defined as multiple sources of (input) in an organization, industry or country and it can also be identified by the value or quantity of output that can be generated by the input unit. Input is a source of resources expended to produce the output and the output is an outcome that produced by an organization or factory. But, the productivity is not just a function of input or output, productivity is a one strategy decision that makes to improve and increase the ratio of produced to make goods or services in relation to resources used. In a world of 'more with less', productivity improvement is a creative and strategic process that involves the work of the all the senior leaders and it also makes a difference between success and failure

Productivity is one method that gives good impact on the economy and is one of the most important. In addition, productivity is also providing important competition of the manufacturing sector and influence the processes of economic production.(Gupta and Kulkarni 2015)

2.2 VALUE STREAM MAPPING

Value stream mapping is a tool that gives a visual to displays of the values of such information, material and process. Besides that, it also has a reputation for exposing the waste in the all sectors of manufacturing, production and business. it also eliminates non-value adding steps / value stream mapping in the one of leans tools to eliminate all the waste and can give improved the operational productivity and procedures. Current state map in the value stream mapping is too prepared, analyzed and suggested to how to improve the all the operational process. After that, drawn the future state map after present the study and come to know about improvement intact time by applying the proposed the changes if got the incorporated for the future state map (Silva 2012).

Value Stream mapping is also known as “Material and information flow mapping” in Toyota. It is developed as a outcome of the work done by Taiichi Ohno at Toyota in the 1960’s -70‘s. (Kothari and Verma 2015) VSM is used in the operation of electronic production. That study to identify problems in the processes involved in the identified product. The main objective is to reduce waste and production leads time, and then gives a current value stream map created. A future state value stream map created which has served a goal for future lean activities. Reduction in WIP has been done by converting the system to push pull systems and also through the process of improving the process by the incorporation of the concept of kanban, kaizen and supermarket concepts. This implementing lean manufacturing system can increase the competitiveness of a company in the global arena. a company in the global arena. The research results indicate that an overall reduction of 16.22 % was achieved in the processing time, 37.56 % in the lead time and 30% reduction in inventory. For increase in value added ratio was 33.65 %. Due to practical limitations and it was not possible in these tools to gauge the total effect strategies of improvements to present the study.

2.3 5S

5S is a method of approach to organize, order, clean, standardize and continuously, which was created to increase the working space (R. S. Agrahari and Dangle 2015). It results from the Japanese word that starts with the events that began with the letter S. In Japanese the word is Seiri, Seiton, Seiso, Seiketsu and Shitsuke. he translated means Sort, Set in order, Shine, Standardize and Sustain.Sort is helpful to remove all items that are not needed and only thing remaining is required only where needed, while Seth is a method of specifying the location and quantity of goods or requirements necessary to produce efficient operation.Standardize is the implementation of visual display and control where needed, Sustain also help to maintain good organization through training and total employee involvement.

The improvements 5S before and after can give the implementation by pictures in the paper. It also can build a stronger work ethic in the line management and workers that would be expected to continue the good practice (Agrahari, Dangle et al. 2015)

2.4 KANBAN

Kanban (kahn-bahn) is from the Japanese word that translated it literally means “visible record” or “visible part”. Kanban system is one of the tools under lean of manufacturing system, it can achieve the minimum inventory at a time. The kanban system can also provide many advantages in managing a business and operation. By using the Kanban method, it can provide many benefits and provide strategic operational decision for use in production. It also helps companies to increase productivity and at the same time it can also reduce waste in output outcome. In Japan, companies there were thoroughly implement Kanban system and successful to do this system because by originated in their country. However, in countries such as Malaysia, not all companies in the country using this system, especially SMEs in manufacturing sector. It is because they are having problems to making the system effective. Thus, for understanding the Kanban system is so important in lean manufacturing (Rahman 2013)

2.5 KAIZEN

A Japanese term meaning “change for the better”. It also got from word Kaizen (Ky ‘zen) is a Japanese term that means continuous improvement taken from words 'Kai', which means continuous and 'zen' which means improvement.

Kaizen is a standard rate which has been set and it will be improved for a better rate. Kaizen also provide standard surveillance a good job and provide good training to maintain their ability to meet all standards ongoing basis.

Base on (Gauri, Gajbhiye et al. 2015) the paper carried on by him, Kaizen and techniques is used to increase productivity in the industry. In their main product is, they produce Cotton Ginning machines and its parts. The concept of kaizen is used to examine any problems that they face in the industry and find the right solution for his company is a high-performance. They added economy by providing solutions in the industry of eliminating non-value added activities, travel time, interruptions and keeping the standardization in industry. The concept is that do always look at every process

i. To every problem in the industry
ii. Always looking for design ideas and action to overcome the problems encountered.
iii. Implementing
iv. Analyze every aspects of conclusion
v. Improve each solution and determine the final result to quantity as well as quality

Based on the study from (kumar and Pandey 2013) before and after the modification and the improvement in the data collected, the cost of rejections level of the products has been identified. Then they calculate the standard cost basis. After that, they calculate the conclusion to find out the graph and table.

2.6 WASTE

Waste can be defined as the activity that add cost but do not add value to the product. Waste definition according to (Magee 2007) is a kind of activity in a process that consume more resources and lead in the decrease of productivity efficiency, quality and increase lead time as well. Previously, lean manufacturing only classified under seven categories of waste only and moving through the years. The seven categories of waste as defined by (Liker 2004) are as follows:

1. Overproduction – Product to be produced is more than it is require that lead to other waste at inventory, transportation and manpower.
2. Waiting – Production are stop because of worker need to wait for raw material, machine or information before can proceed with the next process and this lead to unproductive. The waiting can occur in various ways for example, due to unmatched worker/machine performance, machine breakdowns, lack of work knowledge, stock outs and capacity bottleneck.
3. Transportation – Unnecessary motion by carrying work in process (WIP) that delays the movement of material or product.
4. Over processing – Using unneeded process to produce parts. This over processing may happen because of improper tools, product designs that lead to over processing. This kind of waste to time consumes and machines which do not add any value to the final product.
5. Excess Inventory – It is referring to unnecessary raw material and includes WIP that cause waste in obsolescence, damaged goods, transportation, storage costs and delay. Also, the extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.
6. Unnecessary Movement – It indicates any unnecessary motion that the workers or material movement that have to perform during their work. For example movement during searching for tools that brings no value to the product or process.

7. Defects – It is occurring when a product failed to meet the specification of products that may lead towards customer dissatisfaction.

2.7 SIMULATION MODELING

According to (Lian and Van Landeghem 2002), simulation is an activity based on mimics or imitating the actual system using entities such as computers. It works by focusing on the process flow, logic and dynamic. Simulation can be considered as a representative of the real world where in reality simulation created to find a design solution that leads to the best solution can be created. By using this simulation model, the experiment with “what if” situation can be held to test, understand and evaluate the best operating strategy using the computer software.

There is a lot of simulation software in the market that relate to the study propose. The name of a few well known software common among the analyst are Arena, Automod, Extend, Flexsim, MicroSaint, ProModel, Quest, SIMUL8 and Witness (Mohamad 2012).

All the simulation software has attained qualification for its purposes which translate to equal accuracy and effectiveness. The software only differs in term of its features and content and some differs to the fixture available. From amongst the regularly preferred simulation software, this study has chosen Witness as the model simulator. The reason behind the selection is because it is included and taught in the academic syllabus which will in turn ensure the validity of the produced result.

2.8 PREVIOUS RESEARCH ON PRODUCTIVITY IMPROVEMENT

Past literature review has showed that most of practitioners and researchers had highlighted. (Sihag, Kumar et al. 2014) have created current map for industry automobile, the company has produced product automotive. The company has produce the process trimming, drawing, restricting, welding and pinching. Cycle time, work in progress (WIP) has required designing a future state map. After the analysis has created, the future state map shows the improvement in the process inventory. The inventory process has reduced from 33.33%, and the process lead time has reduced by 52.94% also the processing time has reduced by 80.69%.

Based on (Rahani and al-Ashraf 2012), lean production has been suitable for the process industry sector like automotive manufacturing plant. Value stream Mapping (VSM) is an appropriate step or lean tools to identify all the waste and opportunities to improve the productivity. Value Stream Mapping (VSM) also involves many steps process and analyzed to help source hidden waste n waste.

In previous research conducted by (Renu Yadav 2012), it describes the methods used value stream mapping technique in the manufacturing factory by a railway helical spring's manufacturing company. The aim of this implementation technique is to identify the problems that exist within the factory waste and increase productivity and improve performance. Various problems areas was prepared and identified to be placed in the current state map. After that, the future state map is prepared to give the proposed improvement to take the action plan. Data were collected and achievements of value stream mapping has been reported by the reduction in cycle time, reduction of lead time and also the inventory level in that area. The conclusion is that the company can reduce the manufacturing of lead time from 36.86 days to 34.06 days.

Lean tools that describe by the (Rumbidzayi Muvunzi July 2013), tools used are the value stream mapping. The purpose of using this method in the manufacture of this is to identify waste and reducing waste. This company produces the kind of concrete roof tiles (MCR). Data collection method and samples are taken and designed into Current State Map. Future state map improvements have been proposed to suggest the optimum space and also a more effective workforce in the process carried out by using the Microsoft Visio Software. At that time, the excesses are identified and corrected, including the form of transport, in the molding process, process waiting time and also consumption of raw material. After identified, the conclusion has been made and increased the productivity from 20,220 tiles per month to 28,350 tiles per month. Besides that, waste reduction also be identified and reduced from 245 defective tiles per day to 10 defects. On average, the company can savings amount of $ 4419.9 per month.

Value Stream Mapping tools research from (Joshi and Naik 2012) show that, the small industries company for the researcher is produce a product sheet metal dies, the problem has been identified using lean tools is at Tool Room. The cycle time in that process is high and it is taking 14400 minutes. Identify the problem by draw the current state map to calculate the work in progress (WIP). After analyze from the data future state map, the production of cycle time reduce 9600 minutes from 14400 minutes and improvement 30% the cycle time.

Based on previous research from (Kabir, Boby et al. 2013), there are many advantages of using strategic Six Sigma principles in the organization. The objectives of previous reasearh are to study and evaluate processes of the case organization, to find out current sigma level and finally to improve existing sigma level through productivity improvement. According to the objectives, current sigma level has been calculated and given suggestions for improvement. This has been done by using six-sigma DMAIC cycle. Especially in improve phase of DMAIC cycle, different improvement tools are used like 5s, supermarket and line balancing. By using these it has been possible to improve productivity by reducing defect rate. The DMAIC problem solving approach has helped to reach measurable results and conclusions. The tool work has been carried out in a fan manufacturing company to show how to improve its productivity and quality by using Six-sigma. All the charts and diagrams used here are drawn carefully to show the real scenario of the case organization. By implementing Six-sigma a perfect synchronization among cost, quality, production time and control time will be observed.

Based on previous research from (Kulkarni, Kshire et al. 2014), the research is to improve the productivity using lean deployment and work study method. The objective of this paper is to present an overview on a new combined methodology for the efficient improvement in productivity with the help of various Work Study Methods associated with Lean Manufacturing Principles & Tools. Lean manufacturing tools are one of the most influential & most effective methodologies for eliminating wastes (MUDA), controlling quality, and improving overall performance of any machine, system or process in any industry with the complete assurance of large annual profit margins. This research proposes genuine solutions & concepts for implementing Work Study Methods and deploying associated lean manufacturing tools in any enterprise or industry, covering the technical, engineering, and manufacturing aspects as well as the business etiquette affairs. Lean Manufacturing together with Work Study Methods, being the most sophisticated & vast area of studies has a huge scope for implementation & deployment of their very own concepts.

Based on previous research from (Sadri, Taheri et al. 2011) to improving productivity through Mistake-proofing of Construction Processes. The method that used is Poka-yoke. The concept of Poka-yoke can be applied to virtually every type of project by exploring ways to present how an activity is supposed to be done, make it impossible to do it incorrectly, or make it obvious (known) when it has been done incorrectly. Poka-yoke devices are categorized by three attributes: smartness, simplicity and inexpensiveness. Mistake-proofing also releases workers from tedious and repetitive activities while giving them an opportunity to maximize their roles in building quality, in the process, by decreasing product deficiencies and the related cost of rework's research was conducted in an actual building project in which a trolley hoist was used to haul bricks between the ground level and various floors. The research demonstrated that with a small investment, a simple poka-yoke technique can bring about a drastic change in productivity. Noticeable improvement in the trolley hoist process due to the application of lean-based approach not only did save a remarkable amount of project time and cost in a period of a few days, but also reduced the time spent on non value-adding activities which are considered “waste” in lean thinking. While this case study only took into account a relatively small portion of a larger building construction project, it is conceivable that the methods and techniques discussed in this paper have high potential of mistake-proofing in construction processes through the use of (even small and simple) poka-yoke devices. Therefore, it can ultimately lead to significant improvements in overall project productivity in a long term.

Based on previous research from (Bin Che Ani and Bin Shafei 2013), the technique that use to improve the productivity in manufacturing CNC machine process through implementing SMED technique and eliminating waste in the case study company. SMED technique is a systematic approach that enables to reduce dramatically the “set-up time” or “changeover time. The objective of this paper is to improve the productivity by using SMED technique and waste elimination and achieving 95% of the productivity in CNC process.

Based on the study, the result shows lower productivity due to high changeover time during changing model which affected the productivity for the CNC process in the case study company. This method contributed to an excessive inventory because they produced more than they needed to satisfy customer’s needs. the research were started with the process familiarization. The case study company was supplied the child parts for the automotive, medical and oil and gas sectors. The SMED technique was applied to solve the problem of the high changeover time or conversion time. Analysis of the problem has been conducted and the root cause was identified. Tools that were used in collecting data are stop watch, cam recorder and camera. Working instruction or check sheet was applied to eliminate this error. Based on the result, the implementation of the working instruction or check sheet was improved 100% of the errors. The steps in SMED were used to make the improvement to ensure that the productivity can be increased and the time has taken for the machine changeover can be reduced.

In this previous research from (Mahto and Kumar 2008), the method that used to improve productivity using root cause analysis at automotive component manufacturing plants situated in Jamshedpur, India. A root-cause identification methodology has been adopted to eliminate the dimensional defects in cutting operation in CNC oxy flame cutting machine and a rejection. A detailed experimental study has illustrated the effectiveness of the proposed methodology. In this research, the identification of the problem has been simplified taking into consideration a particular stage of manufacturing. It has been observed that RCA can also be implemented in each and every individual set up of manufacturing to improve product quality and productivity. Root Cause Analysis (RCA) is a useful tool for trouble shooting breakdowns and efficiently coming to a solution. Finding and Defining the Actual Cause of the problem was encountered in the initial processing of the material. Root Cause Analysis tools were used with Management Oversight and Risk Tree (MORT) methodology. After implementation of proper maintenance schedule and giving training to the operators and maintenance persons, data were collected to estimate the improvement in quality in terms of rejection. After implementation of root cause analysis and elimination of defects, it has been observed that the quality trend has improved a lot. It has been observed that after application of Root Cause Analysis, the product quality and productivity of the plant has improved

2.9 COMPANY BACKGROUND

The selected company for this study is TT Electronics. This company located at Kuantan, Pahang. TT Electronics was established in 1987 and originated from the amalgamation of a number of private and public company in 1980’s. Product that produces is electronic component through to specialized magnetic materials, power supplies and generators.

The figure 2.1 shows the components of product in the production line magnetic that produce. This inductor calls HA00-10502LF. Type of product is an assembly at production line that have 15 process and 23 operator. Base on interview with supervisor of this production line Mr Azizul, this industry working day is 5 day per week. This production line has only 1 shift and working hour 8.83 hour/shift and 30 minutes breaks for lunch. Demand for this production line is 2800 pieces per day, that’s means 56000 pieces per month.

Figure 2.1: Inductor Product HA00-10502LF

2.9.1 Overall Process At Selected Station.

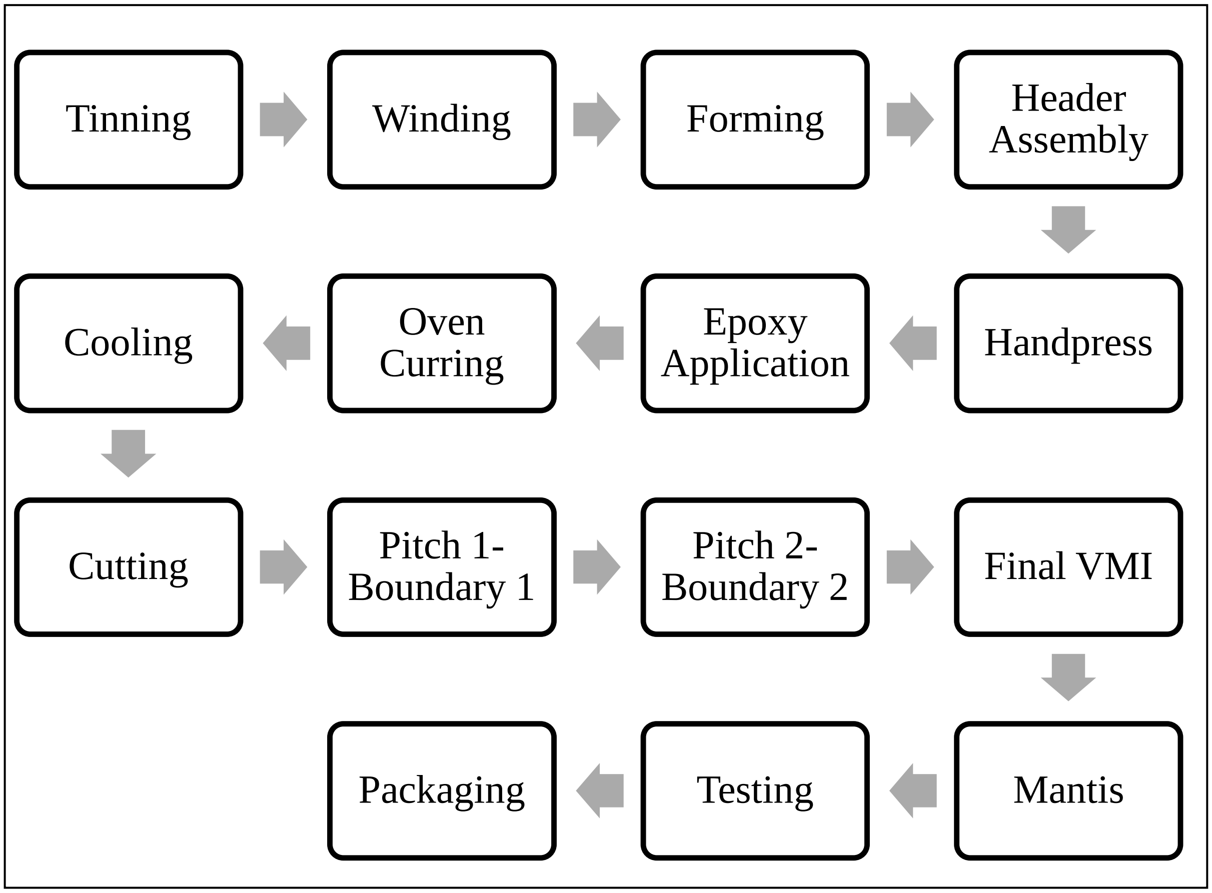

Figure 2.2: Process flow production of HA00-10502LF

I. Tinning

The process is to coating both end of the wire lead-out using a flux. The coating must be coat until a level of stripping and based on the standard operation procedure, the 4 pieces of wire must be dipping into the flux in one cycle. The finish part will used 2 pieces of coated wire.

II. Winding

In this station, a main part for this model call as core is winded with a two pieces of coated wire using a winding machine. An operator just need to install a core on a clamp, and put a wire at a right side, and then push the switch to start the machine.

After winding the right side finish, the core is rotate to start winding the other side. The machine will wind the core with 5 turn for each side.

III. Forming

Forming process is done by using jig. A model part is place on the forming jig and all the wire will be pulling on the slot. Then, the grip part will be cut using pliers and cutters.

IV. Header Assembly

On this stage, the product part will be assembling with header. An operator must make sure the position part number of winding and forming finish is on the front part during a process of assembly.

V. Hand Press

A hand press machine is used in this process and the process is to align the toroid and to ensure the header is fixed with the core of the model part.

VI. Epoxy Application

Epoxy is put on all the lead-out in between core and header at the back side. An operator must follow the sequence standard operation procedure to ensure all the lead-out has been put with the epoxy.

VII. Oven Curing

In this process, a product that has been put with the epoxy is place in the curing jig and it will place on the oven.

VIII. Cooling

After a product is put out from the oven, it will undergo cooling process to cool the product before go to next process.

IX. Cutting

After cooling process, the model part will undergo cutting process to cut the lead-out using a machine call as chopper. Each cycle will cut two pieces of model.

X. Pitch 1,Boundary 1

This is one of the visual mechanical inspection where an operator check the boundary 1 using U jig (side) and pitch 1 using base jig.

XI. Pitch 2,Boundary 2

This process same with pitch 1 boundary 1, but this station using square hollow jig to check the whole dimension of the model (front/rear).

XII. Final VMI

This inspection are doing for inspect overall part at the model using a machine that call naked eye and a gauge is require to check lead-out pitch and length, winding gap and boundary.

XIII. Mantis

Mantis inspection is used to inspect the model using an apparatus microscope. This station will detect a defect such as ‘wire defect’.

XIV. Testing

This is the final test of this model where it used for determine whether the model is functional or not.

XV. Packaging

The last station is packaging where 200 pieces of products will be pack inside one box and it will be placed on the pallet.

CHAPTER 3

METHODOLOGY

This chapter explain the methodology used in this project from starting until end of the project. This chapter will cover the flow chart with different phase and step by step the how to conduct the project**.**

3.1 FLOW CHART

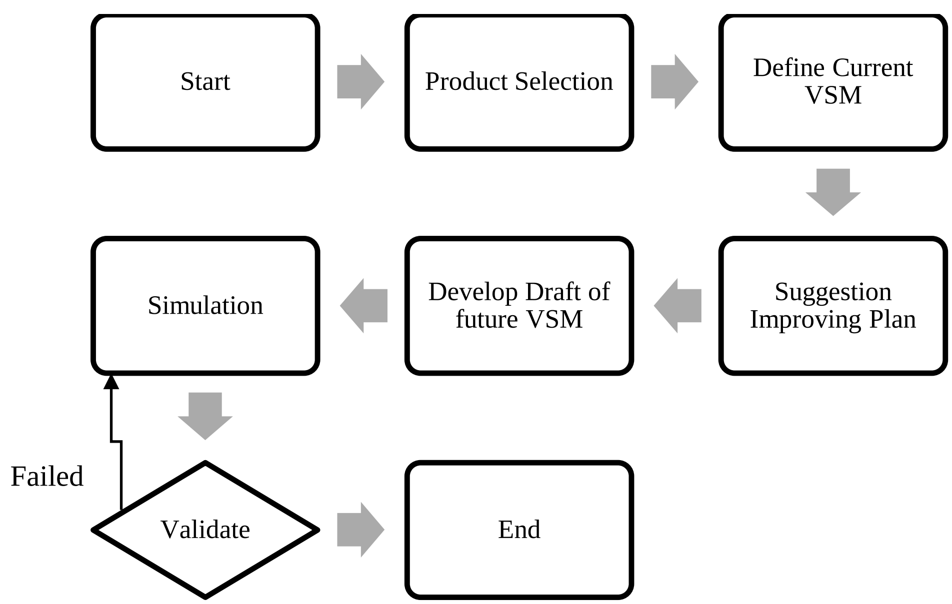

Figure 3.1: Project Flow Chart

3.2 PRODUCT SELECTION

Firstly define the first process that need to decide what exactly wish to map, in company TT electronics Sdn Bhd has produced a electronic part by the order from customer. The process is carried out by identify from the customer order and go to make products from raw material and do all the process step and final process. All the cycle time at production line has been taken

3.3 DEFINE CURRENT STATE MAP

In order to map the current state, need to observed and collected information regarding the flow of information, material, process and work in progress or inventory in the selected area. The information is important because it will enable to mapping the current value stream mapping. Thus it can provide better understanding and can be used in identifying and eliminate waste in the production process and directly map the future state value stream mapping and make the simulation to create a better vision on ideal value flow.

3.3.1 Current value state map

Before draw a current state map collect a require data to draw current state map. Data cycle time is collected by using a stopwatch. Cycle Time is a actual time required for a worker to complete one cycle of job and process lead times is a period of time between the initiation of any process production and the completion of the process.

3.3.2 Calculation of takt time

Then calculate TAKT Time. TAKT time is an average of time between production units necessary to meet the customer demand.

Takt Time= (Available Time)/(Number of Unit)

3.4 SUGGESTION IMPROVING PLAN

The suggestion improving plan is to give a better idea on how to solve the problem and to overcome with a total solution.

3.5 DEVELOP DRAFT OF FUTURE STATE MAP

Formulate an implementation plan based on the future state map with start the implement, review the progress and remap the process.

3.6 SIMULATION MODEL USING SOFTWARE

In this section, the result from proposed that implement in draft suggestion for FVSM is transferred in the simulation model. The simulation model consists of the changes made from CVSM. This simulation model is purposely built to become a visualization that helps to show the after implement of lean towards the production line. This can give management a better comparison and understanding regarding change that has been made. By doing this simulation, it can help to encourage the management to consider in implementing the proposed solution in the production line.

3.7 VARIFICATION AND VALIDATION

Verification step is done by verify the simulation model whether it is reflected accurately towards the real operation model. It can be done by comparing the conceptual model for the production representation done in the simulation software. A few questions can be asked to ensure it for example is, are the input parameters and logical structure of the model is represented correctly.

In validation stage, it consists of calibration of the model which is the comparing process of the model to the actual system behavior. Is will act as guideline in improving the simulation model.

CHAPTER 4

RESULT AND DISCUSSION

This chapter will discuss on the result and discussion for the project which explain the approach of product selection and justification, product process flow, data collection, current value state map, and the analysis of the current state map. Then the data that is collected will be briefly discussed for suggesting a proper improvement in simulation.

4.1 PRODUCT SELECTION

Base on collecting the relevant data and interview with supervisor of production line, there have been a discussion on deciding which product will be taken as the case study. The criteria that a product has to bear in order to have substantial replication on the production flow are as follows:

1. Large demand.

2. Constituted the majority process.

3. Has the biggest impact of the company.

Based on the data collection and interview supervisor of the production line, it shows that the line of production HA00-10502LF is taken as the product choice since it has a large demand, are undergoing a similar process between the product choices and lastly it has the biggest impact towards the company.

4.1.1 Production Flow Process

The material flow of production begins in the area of receiving as raw material and travels through the process in the plan. The process flowchart of assembly production line is as illustrated in figure 4.1 below:

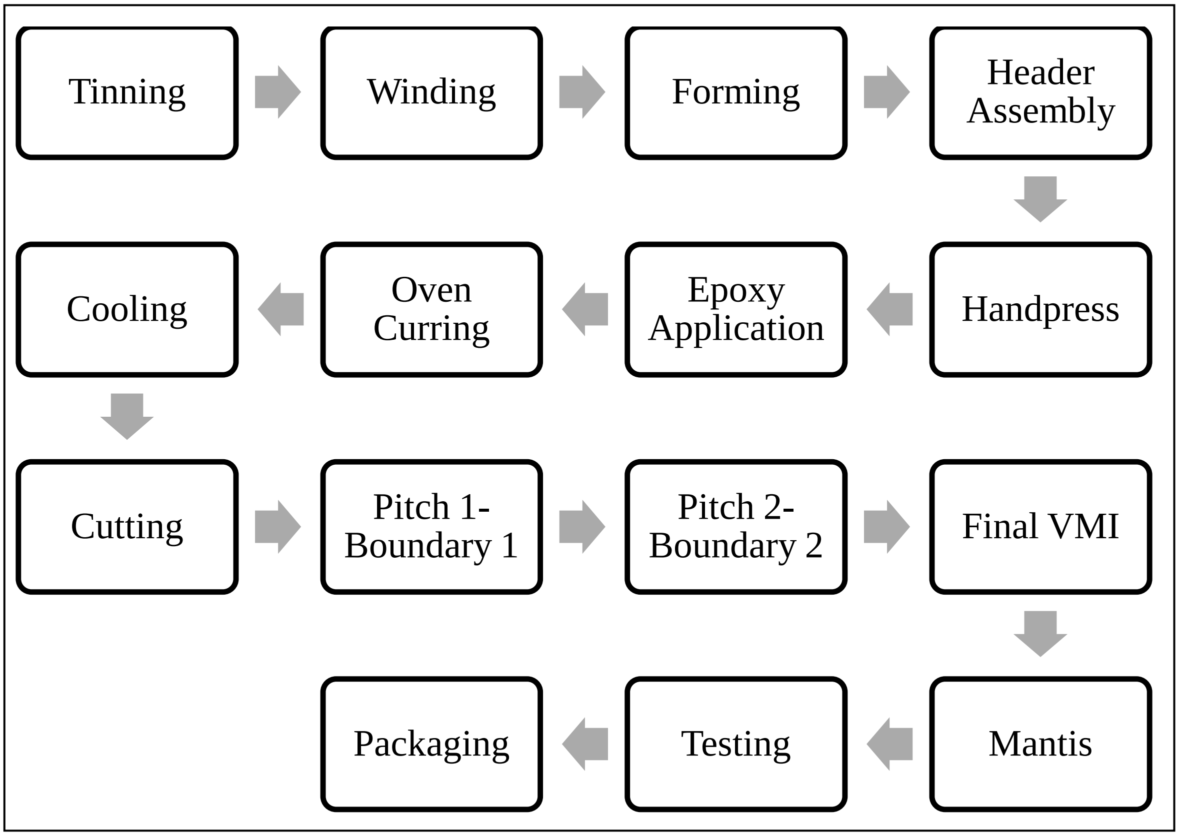

Figure 4.1: Process Flow of HA00-10502LF.

I. **Tinning**

The process is to coating both end of the wire lead-out using a flux. The coating must be coat until a level of stripping and based on the standard operation procedure, the 4 pieces of wire must be dipping into the flux in one cycle. The finish part will used 2 pieces of coated wire.

II. **Winding**

In this station, a main part for this model call as core is winded with a two pieces of coated wire using a winding machine. An operator just need to install a core on a clamp, and put a wire at a right side, and then push the switch to start the machine. After winding the right side finish, the core is rotate to start winding the other side. The machine will wind the core with 5 turn for each side.

III. **Forming**

Forming process is done by using jig. A model part is place on the forming jig and all the wire will be pulling on the slot. Then, the grip part will be cut using pliers and cutters.

IV. **Header Assembly**

On this stage, the product part will be assembling with header. An operator must make sure the position part number of winding and forming finish is on the front part during a process of assembly.

V. **Hand Press**

A hand press machine is used in this process and the process is to align the toroid and to ensure the header is fixed with the core of the model part.

VI. **Epoxy Application**

Epoxy is put on all the lead-out in between core and header at the back side. An operator must follow the sequence standard operation procedure to ensure all the lead-out has been put with the epoxy.

VII. **Oven Curing**

In this process, a product that has been put with the epoxy is place in the curing jig and it will place on the oven.

VIII. Cooling

After a product is put out from the oven, it will undergo cooling process to cool the product before go to next process.

IX. Cutting

After cooling process, the model part will undergo cutting process to cut the lead-out using a machine call as chopper. Each cycle will cut two pieces of model.

X. Pitch 1,Boundary 1

This is one of the visual mechanical inspection where an operator check the boundary 1 using U jig (side) and pitch 1 using base jig.

XI. Pitch 2,Boundary 2

This process same with pitch 1 boundary 1, but this station using square hollow jig to check the whole dimension of the model (front/rear).

XII. Final VMI

This inspection are doing for inspect overall part at the model using a machine that call naked eye and a gauge is require to check lead-out pitch and length, winding gap and boundary.

XIII. Mantis

Mantis inspection is used to inspect the model using an apparatus microscope. This station will detect a defect such as ‘wire defect’.

XIV. Testing

This is the final test of this model where it used for determine whether the model is functional or not.

XV. Packaging

The last station is packaging where 200 pieces of products will be pack inside one box and it will be placed on the pallet.

4.1.2 Data Collection

The data parameters needed for constructing current value stream mapping are as follows:

1. Operator at the station

2. Cycle time

From the above listed data parameters, only cycle time, operator in each station will be manually documented using stopwatch. The data collected in each process were recorded in the Table 4.1. The data taken is 3 times.

Table 4.1: Cycle time of product HA00-10502LF

No	Process	No of Operator	1 cycle/S	2 cycle/S	3 cycle/S	Average Cycle Time/S
1	Tinning	1	3.13	3.52	2.95	3.2
2	Winding	3	10.77	13.66	9.89	11.44
3	Forming	3	4.61	6.19	9.27	6.69
4	Header Assembly	3	14.42	12.36	16.05	14.27
5	Hand press	1	4.25	12.47	10.48	9.06
6	Epoxy Application	3	7.50	9.72	11.25	9.49
7	Oven Curing	1	5.23	7.02	6.83	6.36
8	Cooling	1	4.51	5.64	4.93	5.02
9	Cutting	1	2.71	7.51	6.48	5.56

10	Pitch 1-Boundary 1	1	4.54	3.78	5.41	4.57
11	Pitch 2-Boundary 2	1	5.19	6.25	4.64	5.36
12	Final VMI	1	11.41	9.42	13.47	11.43
13	Mantis	1	14.42	17.48	13.78	15.22
14	Testing	1	10.85	14.44	11.29	12.19
15	Packaging	1	3.81	2.18	5.25	3.74
	Total Labor	23				123.59s

4.2 DEFINE CURRENT STATE MAP

After collect the data of cycle time, map the current state to observed base on collected information regarding the flow of information, material, process and work in progress or inventory in the selected area. The information is important because it will enable to mapping the current value stream mapping.

Thus it can provide better understanding and can be used in identifying and eliminate waste in the production process and directly map the future state value stream mapping and make the simulation to create a better vision on ideal value flow.

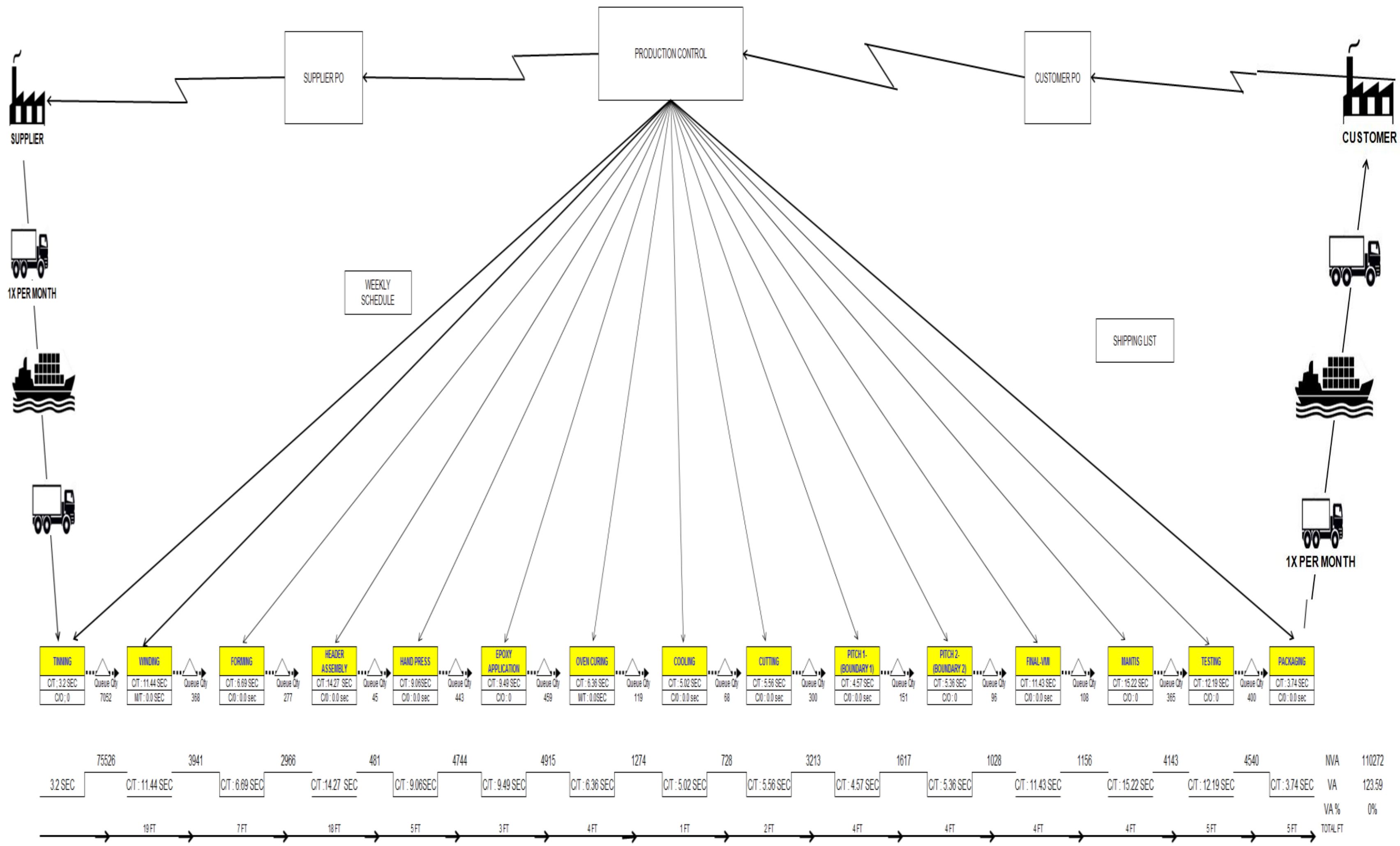

Figure 4.2: Current State map

4.2.1 Analysis of Current Value Stream Map

The CVSM as shown in Figure 4.2 is being analyzed and its results show it took on 123.59 seconds for the processing time to produce one product HA00-10502LF at this production line. Where the value added time 0.149 percent of the total non value added time.

The reason why the time non value added too high needs to be analyzed in order to find in the data identification of waste. The improvement opportunity needs to be looking in this context specifically and not only in the cycle time. This is because opportunity of 99.89 percent in lead time is bigger compared towards the improvement opportunity in cycle time.

But before the main reason on why does the production took a lot of time in inventory were done, the cycle time also needs to be analyzed to ensure that it is based on demand or in simple word based on the takt time for production. This is to ensure the cycle time for process also can be improved although it is not high opportunity.

4.2.2 Calculation of Takt Time

Calculate the takt time is purposely a step before making future state VSM. It can become a number of units produced towards comparing with customer demand. This can give the idea where it can improve.

Demand = 56000 pieces/month

Working Hour / sec $= 8.83 \times 60 \times 60$

$= 31788$ sec

Lunch Hour / sec $= 30 \times 60$

$= 1800$ sec

Total working hour / day = 29988 sec

Working day / month = 20 Day

Total available time / month = 599760s

TAKT Time = 56000/599760

= 10.71 sec

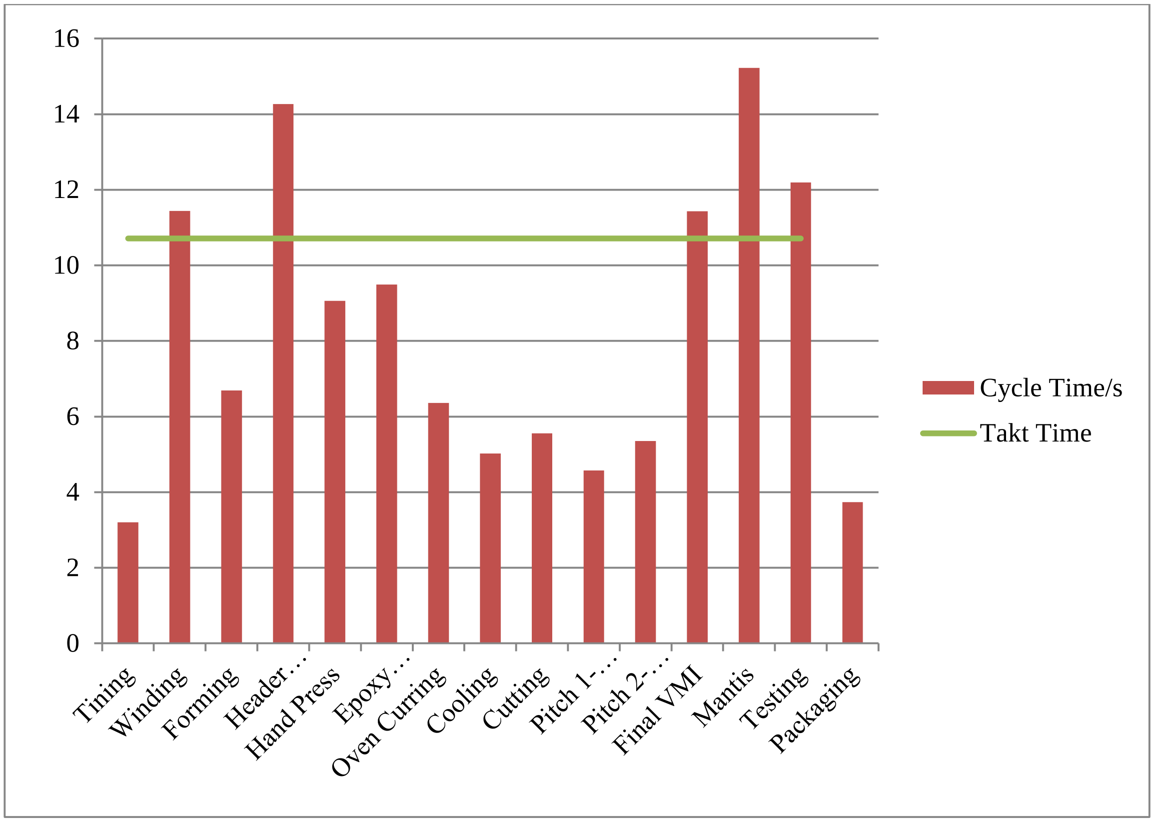

Figure 4.3: Graph Cycle time vs Takt time

Based on the Figure 4.3, the comparison of cycle time towards takt time shows that have processes exceeded with takt time. It means the production out of control with demand rate of customer. The calculation of this takt time shows that the line need for improvement is winding, header assembly, final VMI, mantis and testing. This processes need to be focus because have a bottleneck problem. The bottleneck processes needs to give attention with to find the problem occurs and give suggestion to make a change for better in improve the production. This is important to ensure the modifiers or improvement made for the current process is long lasting in production.

4.2.3 Actual Output Processes

Based on data obtained by the current state map. Real data is calculated to determine the actual output produced on one day, it’s to ensure real data can be compare with the simulation for the propose of improvement. The Table 4.2 shown the total of process and product produced per day.

Table 4.2: Total process and product produced per day

No.	Process	Cycle Time/s	Working Time/Cycle time	Product Produced/Pieces
1	Tining	3.2	29988/3.2	9371
2	Winding	11.44	29988/11.44	2621
3	Forming	6.69	29988/6.69	4482
4	Header Assembly	14.27	29988/14.27	2101
5	Hand Press	9.06	29988/9.06	3309
6	Epoxy Application	9.49	29988/9.49	3159
7	Oven Curring	6.36	29988/6.36	4715
8	Cooling	5.02	29988/5.02	5973
9	Cutting	5.56	29988/5.56	5393
10	Pitch 1-Boundary 1	4.57	29988/4.57	6561
11	Pitch 2-Boundary 2	5.35	29988/5.35	5605
12	Final VMI	11.43	29988/11.43	2623
13	Mantis	15.22	29988/15.22	1970
14	Testing	12.19	29988/12.19	2460
15	Packaging	3.74	29988/3.74	8016

Total product produced/pieces = 67359 Pieces

Total workers = 23

Output = 67359/23

=2928 Pieces/Day

4.3 SUGGESTION IMPROVING PLAN

Based on current state map, it can identify waste in this process to give suggestion for improving.

Waiting

Waste of waiting happen because of the wastes from header assembly, mantis, and testing. From the current state, obviously it is seen the processes of header assembly, mantis and testing take a lot of cycle time. It can give impact of processes packaging waiting the product done.

4.3.1 Suggestions for Improving Current Value Stream Mapping

In this section will contain suggestions for improving Current Value Stream mapping (CVSM). The suggestion will help to improve the condition in the production line with overcoming the problem faced that affect the lead time. In this case, the improve suggestion will be referred to the analysis done previously.

Waiting

In order to reduce waste of waiting, process of header assembly problem because using manual assemble. Suggestion is to produce a jig and fixture to operator speed up the process and continue to next process. Base on (kumar and Pandey 2013) by modification and adapting kaizen techniques, it can be the processes more efficient and effective. In operation mantis, suggestion add another machine and at mantis. The addition of mantis machine is in light of fact that to avoid bottleneck occur at that station.

4.4 DEVELOP DRAFT OF FUTURE STATE MAP

Having visualized the CVSM, Some of the necessary changes in the value stream for the production of HA00-10502LF product were outlined in the draft of Future Value State Mapping as shown in figure 4.5. In this section the possible improvement that may implement in future value state map will be plot in Figure 4.4.

4.4.1 Draft of Future Value State Mapping

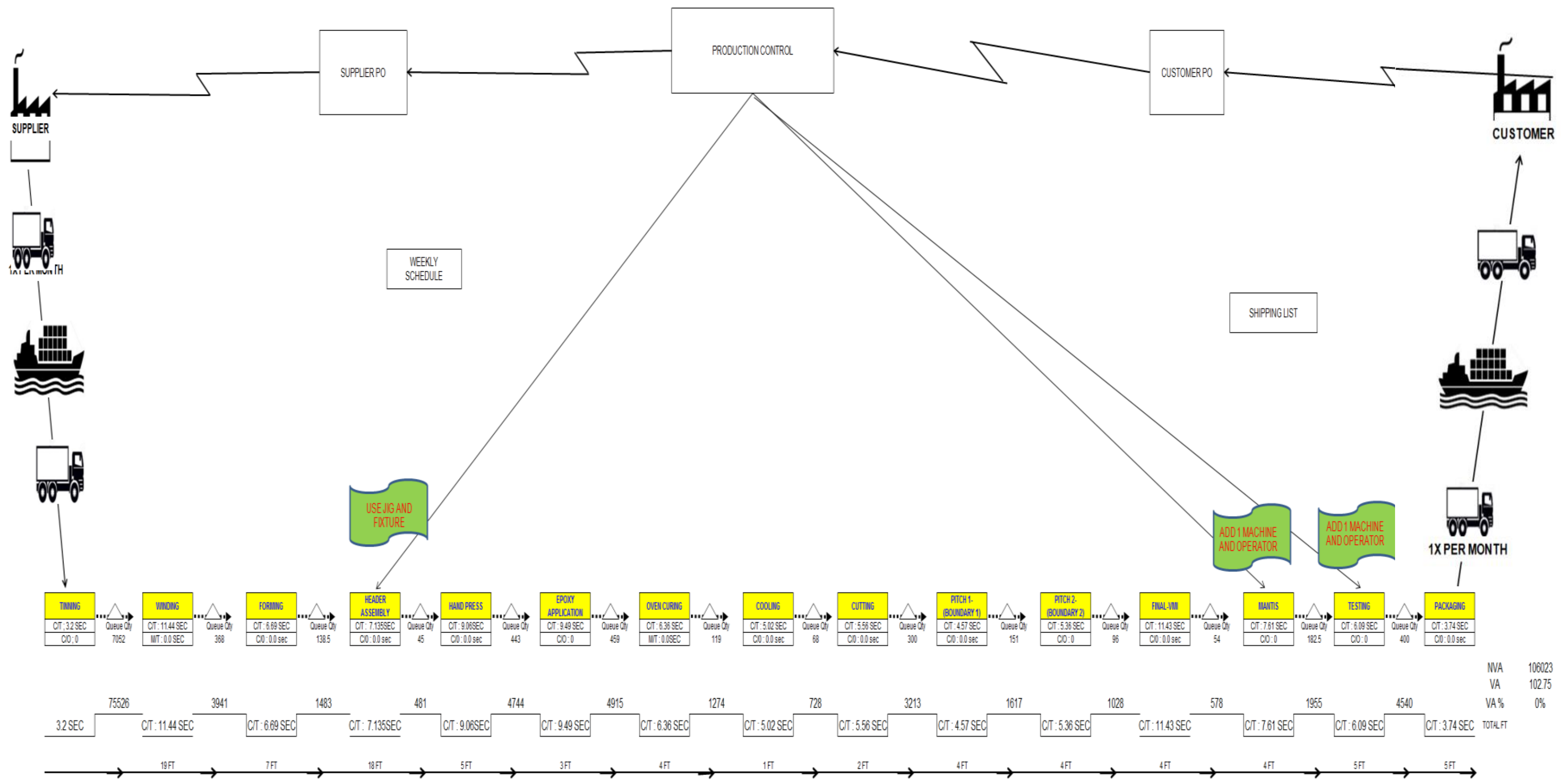

Figure 4.4: Draft of Future Value State Map

4.5 SIMULATION MODEL USING SOFTWARE

In this section, the result from proposed that implement in draft suggestion for future state map is transferred in the simulation model. The simulation model consists of the changes made from current stream map. This simulation model is purposely built to become a visualization that helps to show the after implement of lean towards the production line.

Witness software is simulation that uses in this case study. This can give management a better comparison and understanding regarding change that has been made. By doing this, it can also help to encourage the management to consider in implementing the proposed solution in the production line.

4.5.1 Current layout

To analyze the productivity of the current with calculate the maximum output in one day. In simulation the amount of time used 8.83 hour as standard working time per day.

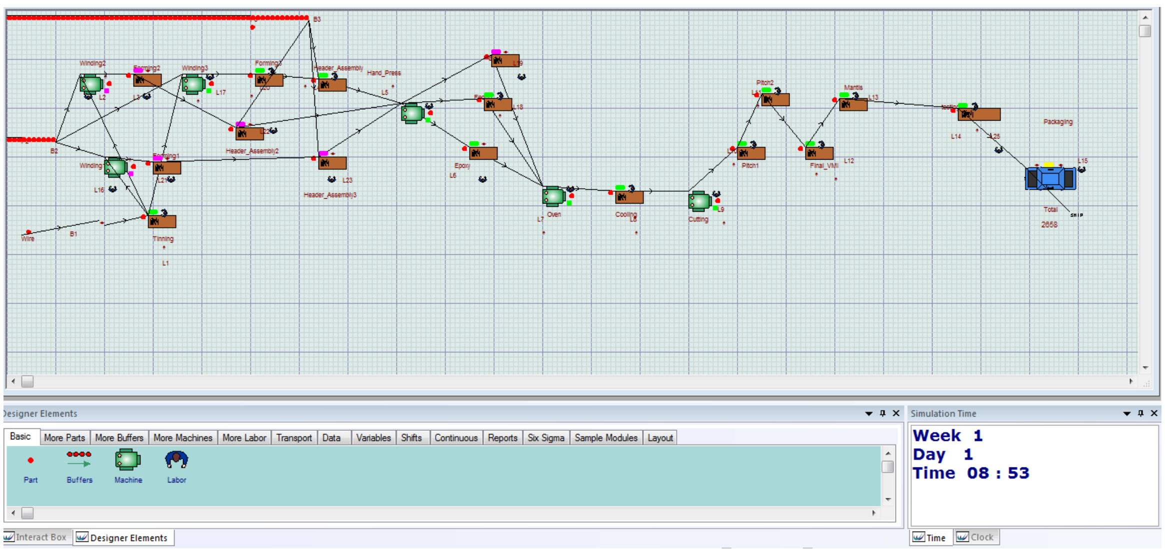

Figure 4.5: Current layout of Production Line HA00-10502LF

The process assembly the product has three stations from tinning, winding and header assembly. The layout show process starts from tinning process and go to the winding process. Winding process has three stations that have three operators doing the winding process. After the process winding, process proceed to forming process. Forming process has three stations and go to the process hand press. After process hand press, the process proceeds until at packaging. Total output for one day that shows at simulation process is 2658 pieces/day. The calculation above shows the productivity units. Average idleness base on total idleness percentage at Figure 4.6.

Unit produce $= 2658\ pieces/day$

Labor $= 23\ labor$

Lunch / minutes $= 30\ minute$

Total Working hour /day $= 8.83\ hour - 30\ minute$

$= 8.53\ hour/day$

Labor hour per day $= 23 \times 8.53$

$= 196.19\ hour/day$

Productivity $= \frac{Unit\ produce}{labor\ hour\ per\ day}$

$= \frac{2658}{196.19}$

$= 13.54\ units/\ labor\ hour\ per\ day$

WITNESS

Machine Statistics Report by On Shift Time

Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wai	% Setup	% Setup Wa	% Broken D	% Repair W	No. Of Oper
Winding2	0.01	0.07	0.00	0.00	99.92	0.00	0.00	0.00	0.00	0.00	2
Tinning	0.06	21.01	0.00	0.00	78.93	0.00	0.00	0.00	0.00	0.00	2101
Forming2	0.03	0.04	0.00	0.00	99.92	0.00	0.00	0.00	0.00	0.00	1
Header_Ass	0.09	31.18	0.00	0.00	68.73	0.00	0.00	0.00	0.00	0.00	2104
Epoxy	0.03	74.01	0.00	0.00	25.96	0.00	0.00	0.00	0.00	0.00	1051
Hand_Press	0.03	29.85	0.00	0.00	70.13	0.00	0.00	0.00	0.00	0.00	2107
Oven	0.12	41.82	0.00	0.00	58.06	0.00	0.00	0.00	0.00	0.00	2103
Cooling	0.15	32.99	0.00	0.00	66.86	0.00	0.00	0.00	0.00	0.00	2102
Cutting	0.16	36.53	0.00	0.00	63.32	0.00	0.00	0.00	0.00	0.00	2101
Pitch1	0.17	30.01	0.00	0.00	69.83	0.00	0.00	0.00	0.00	0.00	2100
Final_VMI	0.18	74.98	0.00	0.00	24.84	0.00	0.00	0.00	0.00	0.00	2097
Pitch2	0.17	35.18	0.00	0.00	64.65	0.00	0.00	0.00	0.00	0.00	2099
Mantis	0.22	99.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2096
testing	60.07	39.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2096
Packaging	75.49	24.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2095
Winding1	0.02	0.07	0.00	0.00	99.91	0.00	0.00	0.00	0.00	0.00	2
Winding3	0.05	70.72	0.00	0.00	29.23	0.00	0.00	0.00	0.00	0.00	2099
Epoxy1	0.05	73.98	0.00	0.00	25.97	0.00	0.00	0.00	0.00	0.00	1051
Epoxy2	0.07	0.21	0.00	0.00	99.72	0.00	0.00	0.00	0.00	0.00	3
Forming1	0.04	0.04	0.00	0.00	99.91	0.00	0.00	0.00	0.00	0.00	1
Forming3	0.07	90.80	0.00	0.00	9.13	0.00	0.00	0.00	0.00	0.00	2098
Header_Ass	0.07	0.04	0.00	0.00	99.88	0.00	0.00	0.00	0.00	0.00	3
Header_Ass	0.09	0.04	0.00	0.00	99.86	0.00	0.00	0.00	0.00	0.00	3

Figure 4.6: Current Layout Statistic

Based on the Figure 4.6, the machine statistic showed the machine statistics during the ongoing process. As shown on the figure, the highest percentage of busy is 99.78% on the process of Mantis. This is because at this station, the machine needs to support all the part that come from the pitch 1, pitch 2 and final VMI. Because of this station have high percentage of busy, it will causes the next station have high percentage of idle. From the calculation above show that efficiency of the machine per day.

Total labor = 23 labor

Average idleness % = 5.97%

Efficiency = 100% - 5.97%

= 94.02%

4.5.2 Proposed future layout

Based on current layout, the improvement suggestion need to be done which involved the addition of applying jig and fixture at header assembly, so the cycle can reduce and add machine and worker at mantis and testing. Figure 4.7 shows the improved layout of production line HA00-10502LF.

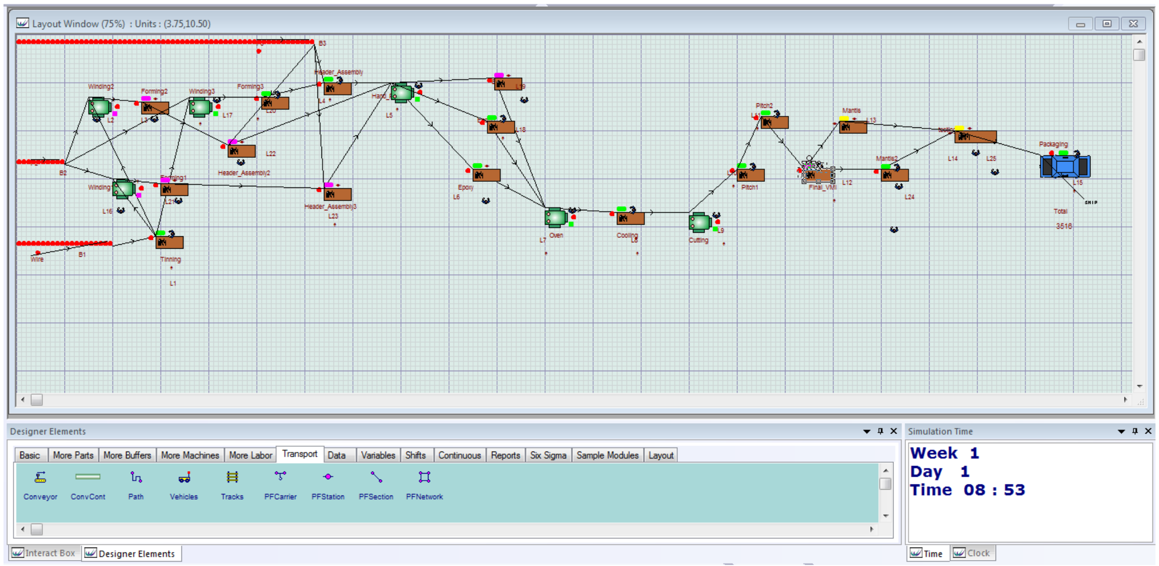

Figure 4.7: Proposed Layout of Production Line HA00-10502LF

Total output for one day after proposed new layout improvement that show at simulation process is 3516 pieces/day. The calculation above shows the productivity units.

Unit produce $= 3516\ pieces/day$

Labor $= 25\ labor$

Lunch / minutes $= 30\ minute$

Total Working hour /day $= 8.83\ hour - 30\ minute$

$= 8.53\ hour/day$

Labor hour per day $= 24 \times 8.53$

$$= 213.25\ labor\ hour/day$$

Productivity $$= \frac{Unit\ produce}{labor\ hour\ per\ day}$$

$$= \frac{3516}{213.25}$$

$$= 16.48\ units/\ labor\ hour\ per\ day$$

WITNESS

Machine Statistics Report by On Shift Time

Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wai	% Setup	% Setup Wa	% Broken D	% Repair W	No. Of Oper
Winding2	0.01	0.07	0.00	0.00	99.92	0.00	0.00	0.00	0.00	0.00	2
Tinning	0.06	14.01	0.00	0.00	85.93	0.00	0.00	0.00	0.00	0.00	1401
Forming2	0.03	0.04	0.00	0.00	99.92	0.00	0.00	0.00	0.00	0.00	1
Header_Ass	0.09	41.49	0.00	0.00	58.43	0.00	0.00	0.00	0.00	0.00	2799
Epoxy	0.03	98.44	0.00	0.00	1.53	0.00	0.00	0.00	0.00	0.00	1398
Hand_Press	0.03	39.69	0.00	0.00	60.28	0.00	0.00	0.00	0.00	0.00	2802
Oven	0.12	55.65	0.00	0.00	44.23	0.00	0.00	0.00	0.00	0.00	2798
Cooling	0.16	43.90	0.00	0.00	55.94	0.00	0.00	0.00	0.00	0.00	2797
Cutting	0.16	48.61	0.00	0.00	51.24	0.00	0.00	0.00	0.00	0.00	2796
Pitch1	0.17	39.94	0.00	0.00	59.90	0.00	0.00	0.00	0.00	0.00	2795
Final_VMI	0.18	99.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2792
Pitch2	0.17	46.83	0.00	0.00	53.00	0.00	0.00	0.00	0.00	0.00	2794
Mantis	33.56	66.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1396
testing	46.83	53.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2790
Packaging	67.37	32.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2790
Winding1	0.02	0.07	0.00	0.00	99.91	0.00	0.00	0.00	0.00	0.00	2
Winding3	0.05	47.15	0.00	0.00	52.80	0.00	0.00	0.00	0.00	0.00	1400
Epoxy1	0.05	98.40	0.00	0.00	1.55	0.00	0.00	0.00	0.00	0.00	1397
Epoxy2	0.07	0.28	0.00	0.00	99.65	0.00	0.00	0.00	0.00	0.00	4
Forming1	0.04	0.04	0.00	0.00	99.91	0.00	0.00	0.00	0.00	0.00	1
Forming3	0.07	60.53	0.00	0.00	39.40	0.00	0.00	0.00	0.00	0.00	1399
Header_Ass	0.07	0.04	0.00	0.00	99.88	0.00	0.00	0.00	0.00	0.00	3
Header_Ass	0.09	0.04	0.00	0.00	99.86	0.00	0.00	0.00	0.00	0.00	3
Mantis2	33.58	66.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1395

Figure 4.8: Proposed Layout Statistic

Based on the Figure 4.8, the machine statistic showed the machine statistics during the ongoing process. As shown on the figure, the percentage of busy mantis reduces to 66.44 percent than 99.78 percent before. From the calculation above show that efficiency of the machine per day. Average idleness base on total idleness percentage at Figure 4.9.

Total labor = 25 labor

Average idleness % = 7.32%

Efficiency = 100% - 7.32%

= 92.68%

4.6 VERIFICATION AND VALIDATION

In this project situation, to verify the simulation model is similar towards the real operation model. The model is basically built by collecting data cycle time and plotting for at current value stream mapping**.** Then the data stimulate obtain from the simulation for example the cycle time process to the real data. It is shown that there are similarities between the data obtain and also stimulate the data which can confirm the simulation model is reflected accurately in the operational model.

The comparison is being made between the actual value obtained in the current value data and the simulation result. Validation of simulation is attempting to bring a great impact in establishing a simulation model correctly. It can be achieved by confirming that simulation model was an accurate representation of the real system (Lian and Van Landeghem 2002). In this study the simulation model is being compared with actual current value stream mapping value output at table 4.2.

Table 4.3: Show the simulation result vs actual value

Metric Count	Simulation Result	Actual Value/Real	% Difference
Output	2658 pieces/day	2928 pieces/day	9.22%

Base on table 4.3, the simulation model may be differ in the assumption of data that stimulate in the model differs with a 9.22 percent of the difference. Thus it affects the validation is not fully accurate towards the real system. Based on validation, the model may seem to differ but there still a probability of declaring the model is can be accurate. It is because it just tested in the respect of variable chosen. Beside there may become more accurate if the data for replication is made based on larger samples(Mohamad 2012). The current simulation model is validated and can be run. It also can be used to propose in the improvement.

4.7 RESULT AND COMPARISON

Based on the trial run in simulation, the proposed future output value for unit per day produced is at 3516 units/day. The difference towards the real demand for one shift is at 2800 units/day. This has shown that based on the changes made in FVSM can increase the production from the current situation and will support the demand required from customer.

Based on Figure 4.9 show that the percentage of productivity level. For productivity of current layout 2658 units/day and productivity of purpose improvement is 3516 units/day. The total improvement productivity output percentage is 32.27%.

By using formula productivity percentage $= \frac{Total\ ouput\ per\ day}{Demand\ per\ day} \times 100\%$

Current productivity $= \frac{2658}{2800} \times 100\%$

=94.92%

Proposed improvement productivity $= \frac{3516}{2800} \times 100\%$

=100%

Total improvement Productivity percentage $= \frac{[3516(new) - 2658(old)\,]}{2658} \times 100\%$

$= 32.27\%$

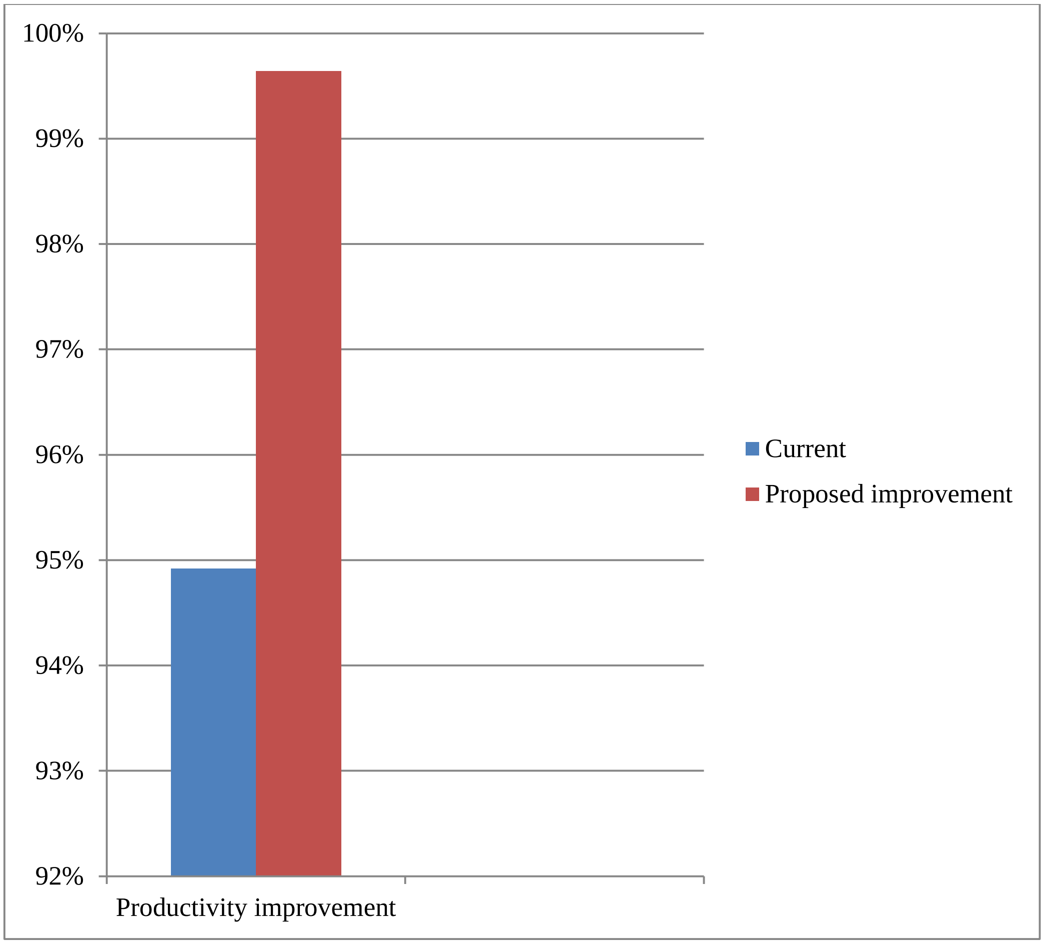

Figure 4.9: Percentage of Productivity Improvement

Based on the analysis done, it shows that by using this simulation it can be a tool that help in understanding regarding change that has been made in future stream map. The positive result in proposed improvement output can support demand expected than current to 32.27%. Last but not least, this simulation will be a good indicator to test what if scenario for any proposes solutions that related to the real production.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 OVERVIEW

In this final chapter of study, it will conclude all the results and its finding based on the objective made. It also will explain on how the result will relate to the objective of studies that has been made in early stage. Last but not least, a few recommendations for a better future study will be included in this chapter.

5.1 CONCLUSION

Based on the studies and report writing that focused, developing Value Stream Map (VSM) and perform simulation as encouragement tool. It show that value stream map is a common used for continuous improvement towards lean in manufacturing industry. Base on first objective that have been made, using value stream mapping, it help to understand the existing process of production line product HA00-10502LF.

Then, based on the VSM for current state, the waste of cycle time and non value added within process were highlighted and thus enable the opportunity to suggest for improvement. Base on the simulation that has been made, objective to reduce cycle time and non value added has been made an achieved. By identify waste and analyze the VSM and its opportunity for Kaizen and also suggest future state value stream mapping and perform a simulation.

Based on the suggestion, the future value stream map was plotted and the improvement was highlighted at selected area that needs to improve. The simulation model of the future stream map was build using Witness software. From the simulation, the data compare with the current layout was made to and validate. Then simulation model based on proposed future layout is done and compare with current layout. It shows the production of HA00-10502LF improve the productivity and can keep up with the demand. It achieved the final objective that has been made.

5.2 RECOMMENDATION

From the study that has been made, VSM already helps to pinpoint the areas for potentially improve and this may help as a guide for a better solution. There are many lean tools and suggestion for get a better result. In this study only focus a few methods to improvement.

Other than that, the use of witness simulation can be improvised by learning distance at plant layout. This will help to increase the improvement in implementing lean tools in production line.

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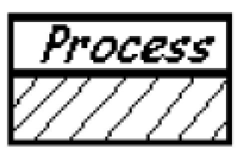
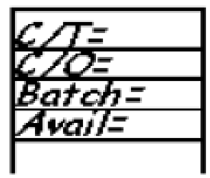
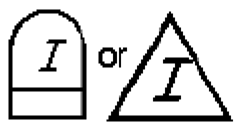
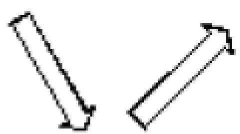
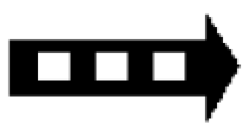
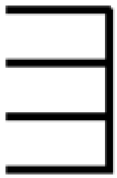
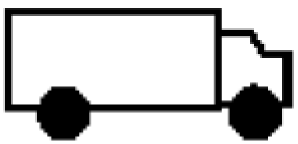
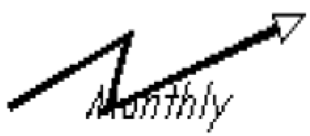
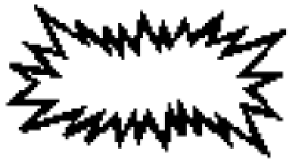
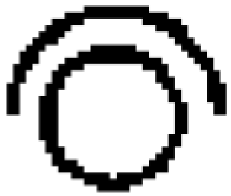
APPENDIX A1: SYMBOL OF VSM

Symbols	**VSM Process Symbols**
	Customer/Supplier Icon: represents the Supplier when in the upper left, customer when in the upper right, the usual end point for material
	Dedicated Process flow Icon: a process, operation, machine or department, through which material flows. It represents one department with a continuous, internal fixed flow.
	Shared Process Icon: a process, operation, department or workcenter that other value stream families share

	Data Box Icon: it goes under other icons that have significant information/data required for analyzing and observing the system
	Inventory Icons: show inventory between two processes
	Shipments Icon: represents movement of raw materials from suppliers to the Receiving dock/s of the factory. Or, the movement of finished goods from the Shipping dock/s of the factory to the customers
	Push Arrow Icon: represents the “pushing” of material from one process to the next process.

	Supermarket Icon: an inventory “supermarket” (kanban stockpoint)
	Material Pull Icon: supermarkets connect to downstream processes with this "Pull" icon that indicates physical removal.
	FIFO Lane Icon: First-In-First-Out inventory. Use this icon when processes are connected with a FIFO system that limits input.
	External Shipment Icon: shipments from suppliers or to customers using external transport

Symbols	**VSM Information Symbols**
	Production Control Icon: This box represents a central production scheduling or control department, person or operation.
	Manual Info Icon : A straight, thin arrow shows general flow of information from memos, reports, or conversation. Frequency and other notes may be relevant.
	Electronic Info Icon : This wiggle arrow represents electronic flow such as electronic data interchange (EDI), the Internet, Intranets, LANs (local area network), WANs (wide area network).
Symbols	**VSM General Symbols**
	Kaizen Burst Icon: used to highlight improvement needs and plan kaizen workshops at specific processes that are critical to achieving the Future State Map of the value stream.

	
	Operator Icon : represents an operator. It shows the number of operators required to process the VSM family at a particular workstation.
	Other Icon : other useful or potentially useful information.
	Timeline Icon : shows value added times (Cycle Times) and nonvalue added (wait) times. Use this to calculate Lead Time and Total Cycle Time.