Implementation of Lean Manufacturing System To Eliminate Wastes on The Production Process of Line Assembling Electronic Car Components With WRM And VSM Method

[Case Study In Production Process of Daihatsu SIGRA Type 1.5 L 3NR-Ve, DOHC Dual VVT-i]

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Abstract

The main purpose of manufacturing industry is to produce goods economically in order to gain profit and be able to deliver products on time. Ineffective and efficient production processes lead to non-current production. Lean production systems help companies to be competitive, especially in terms of reducing waste (waste) that occurs in their operations. This study aims to reduce production waste in one automotive company by using Waste Relationship Matrix (WRM), Waste Assessment Questionnaire (WAQ) and Value Stream Mapping (VSM). Activities in the automotive Industry is to design, develop, manufacture, market and sell motor vehicles in the world. The three methods are intended to identify and analyze the waste (waste) that occurred and make improvements to eliminate waste. From the research results obtained type of waste "form" is waiting and motion. While the type of waste "to" the inventory. The three types of waste is the greatest procession to occur in the process of assembly trimming on the production line of Daihatsu SIGRA 1.5 L 3NR-Ve, DOHC Dual VVT-i at PT. Astra Daihastu Motor. Then performed the improvement implementation by using WRM and VSM method obtained the results of waste efficiency that occurs in the type of waste from the motion from 17.65% to 15.75%, waiting from 15.88 to 13.12%, and lead time down from 14.202 minutes to 12.322 minutes in one assembly process trimming. Some suggestions for improvements made are the implementation of the FIFO system (First in First Out), Improving changes in movement and movement of workers, and line balancing on the assembly line trimming process lines of automobile production processes.

Keywords
Efficiency of Production System, Lean Manufacturing System, Waste Relationship Matrix (WRM), Waste Assessment Questionnaire (WAQ), Value Stream Mapping (VSM).

1. Introduction

The growth of car production in Indonesia is increasing every year. This will certainly lead to competition among car manufacturers and will lead to a lot of market strategies taken by car manufacturers by making various types and variants of the car to meet market demand. The total volume of car production in Indonesia by the end of 2016 is 1,177,356 units. This shows the volume of car production in Indonesia is very large (Gaikindo, 2016). The success of the car production process is strongly influenced by the factors of production that occur in it. Covers human components, machinery, methods, and materials. In the production process there are many processes that can be categorized in the form of waste, or waste. Conceptually, waste is all activities and events in value streams that include non value added (NVA). This classification refers to the categorization of activity within a company by Hines and Taylorv (2000) which classifies activities within the organization into three: (1) Value Added [VA]; (2) Non Value Added [NVA]; And (3) Necessary but Non Value Added [NNVA]. Activity is called the VA if it adds value to the end consumer, whereas if it does not provide added value to the end consumer then the activity is classified as NVA. Among the two groups there are the last (NNVA) groups that do not add value but are required eg material handling or inspection. According to Gaspersz (2007), the NNVA group, although not necessarily, is reduced as much as possible or eliminated whereas NVA should be prioritized for removal.

In addition, in the process of improvement to eliminate waste that occurs in the production process line is analyzed and make the matrix of spread on the activities included in the category of non added value activitie or waste with Waste Relation Matrix (WRM), Waste Assessment Questionnaire (WAQ) and Value Stream Mapping (VSM). The basic concept of WRM is by identifying and eliminating waste by analyzing the related factor whether a waste falls on other waste. In the concept of lean, waste is a something that may occur in the activity and not add value to the product, but instead add to the burden of resource consumption (Porter in Hicks et al., 2004). At least there are seven kinds of waste that is: (1) over production; (2) waiting time (delay); (3) excessive transportation; (4) inappropriate processing; (5) excessive inventory; (6) unnecessary motion; And (7) defect. Eliminating or reducing waste is considered to improve the efficiency and productivity of the process. Further, according to Rawabdeh, Assessment of Job Shop (2005). The systematic and continuous identification and elimination of waste in the overall flow of the production process will lead to increased efficiency, improved process productivity and strengthening overall corporate competitiveness. In general, manufacturing companies that make these efforts will soon experience benefits such as: decreasing inventory (raw materials, finished products and WIP) as well as improving product quality, lower overall cost, as well as increased ability to fulfill customer orders. With WRM method will be obtained the results of analysis that will be cross-checked with field facts to determine the suitability and effectiveness. It is hoped that with the implementation of this method, efforts to identify and eliminate waste will be more effective and systematic.

In this research, case study conducted at PT. Astra Daihatsu Motor is one of the largest car manufacturers in Indonesia. PT. Astra Daihatsu Motor (ADM) was established in 1973. With its share holder namely Daihatsu Motor Co., Ltd. (61.76%), PT. Astra International, Tbk. (31.87%), and Toyota Tsusho Cororation (6.37%). With its main business in the automotive field are: Stamping, Engine, Casting, and Assembly. ADM has a plant site in Sunter, North Jakarta. PT. Astra Daihatsu Motor after nearly 44 years established from the beginning of a dealer and importer of cars from Japan now ADM has its own production plant that produces products in the form of car so that is Daihatsu Sirion, Xenia, Grand Max, Terrios, Luxio, Town Ace, Lite Ace, Ayla , And the latest is the Daihatsu Sigra car. The production process includes Stamping, Casting, Assembly (body, trimming, chassis). Porduk taken as the object of research is Daihatsu SIGRA product with 3NR-VE type, 1.5 L DOHC Dual VVT-i with the reason of assembly process happened beberpa constraint that is the length of trimming process. In the process of assembly trimming the process of cabling and electrical in the car is done manually that has a long time on the whole production process. This trimming process has several assembly posts that are trimming main control, wire engine, wire floor, head lining, instrument panel, dashboard, and stop light, sent light, audio, and horn. It's trimming assembly process is the most complex process in the car production process where the control center and also the car controls are here. With the trmimming assembly process is done correctly all the electrical functions that exist on the car will be able to run properly. This process is the last process in the car production process before entering into peroses inspection in total.

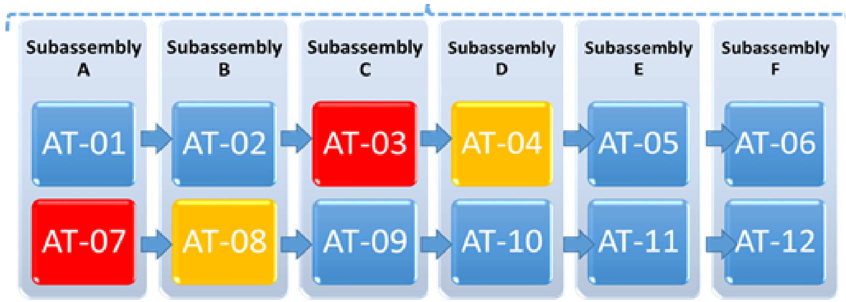

Figure 1. Waste Point in Asembly Trimming Process
(Source: R & D Division PT. Astra Daihatsu Motor)

Here are the problems detected at the beginning of observation and brainstorming with PPIC manager, Warehouse, Quality, and Production Division at PT. Astra Daihatsu Motor is the main reason why this research is done. Some of the things that happen are as follows:

- AT-03 (Assembly Trimming - Subprocess 03): Main Assembly Process Control System (Dashboard)
- AT-07 (Assembly Trimming - Subprocess 07): Electrical Sensor Assembly Process (Speed, Tachimeter, Fuel, Distance, door, safety belt)
- The assembly process on AT-03 & AT-07 exceeds the standard time set by the parrot that is 2.05 minutes per process.
- There is a bottleneck on AT-03 & AT-07 and waiting time at AT-04 & AT-08
- From the results of initial observation of waste types that occur ie waste Motion, Waiting and Inventory. With the highest incidence index value.

Based on observation and brainstorming with supervisor at PT. Astra Daihatsu Motor, found that the length of waiting time which is waste or waste in the form of waiting and motion in the assembly trimming assembly process cause the addition of lead time of car production process so that the waste need to be eliminated. Therefore the purpose of this study is to provide suggestions for improvement to eliminate waste in the form of waiting and motion that occurs in assembly line assembly line process (assembly trimming) to reduce the lead time of car production process.

2. Literature Study

2.1. Production System

The production system is an integral system that has structural and functional components. In modern production systems there is a process of value-added transformation that converts inputs into outputs that can be sold at competitive prices in the market. The process of transforming added value from input into output in modern production systems always involves structural and functional components. The production system has the following characteristics:

1. Have components or elements that are related to each other and form a unified whole. This is related to the structural components that build the production system.
2. Have an objective underlying its existence, namely to produce products (goods and / or services) quality that can be sold at competitive prices in the market.
3. Have activities in the form of process transformation of value added input into output effectively and efficiently.
4. 4. Have a mechanism that controls the operation, in the form of optimizing the allocation of resources.

2.2 Lean Concept

Lean Thinking is an evolutionary method. It aims to organize and manage an organization in improving the productivity, efficiency, and quality of the products and services it produces. (ITC, 2004) Whereas according to Vincent gaspersz (2007) basically the concept of lean is The concept of downsizing or efficiency. This concept can be applied to manufacturing companies and services, because basically the concept of efficiency will always be a target to be achieved by the company. Lean fully talks about the elimination of "muda" or waste, therefore it is important for us to know the true concept. Waste can be defined as any non-value-added work activity in the process of transforming inputs into outputs along the value stream.

2.3. Waste

The main purpose of the lean system is to reduce waste. Waste or young in Japanese is anything that is not valuable or not worth adding. Waste is something that customers do not want to pay for it. Reaffirmed by Hines and Taylor (2000) that waste means non-valueadding activities, in the customer's perspective. There are two main types of waste (waste), namely Type one waste and Type two waste (Vincent Gaspersz, 2007). Type One Waste is any activity that does not add value in the process of transforming the input into output along the value stream, but the activity at the moment is unavoidable for various reasons.

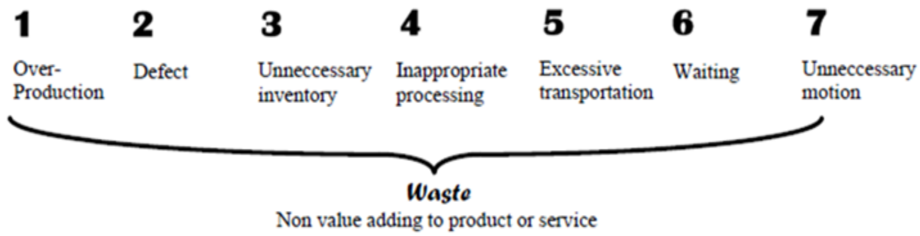

Figure 2. Seven Waste (Muda)
(Source: Rawbdeh, Assesment in Job Shop 2005)

2.4.Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is one of lean manufacturing tools originally derived from Toyota Production System (TPS) known as "material and information flow mapping" (WPI, 2007). Russell and Shook (1999) define VSM as a powerful tool that not only identifies process inefficiencies but can also guide improvements. Furthermore, Jones and Womack (2000) mentioned that VSM is a visual mapping process of information and material flow aimed at preparing better methods and performance in a proposed future state map.

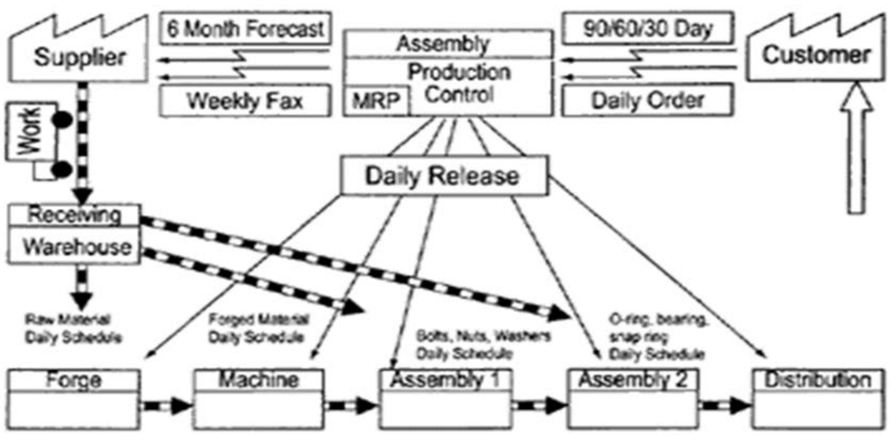

Figure 3. Value Stream Mapping (VSM)
(Source:Value Stream Mapping Theory, Richard, 2012)

2.5. Operation Process Chart (OPC)

The Operation Process Chart (OPC) is a working map that describes the working order by dividing the work into detailed operating elements. Sutalaksana (1979) argues that the operation process map describes the operations and inspection steps experienced by the material in its sequence from the beginning to being a whole product or as a semi-finished material. So it can be said that the operation process map is a map that describes work activities systematically and contains information needed for further analysis, such as time spent, materials used, and machines used. The information recorded through the operation process map has many uses. The uses include knowing the machine requirements and budgeting, estimating material requirements, helping to determine the layout of the plant, as well as for job training.

2.6. Waste Realtionship Matrix (WRM)

The analysis of the criteria of the relationship between waste is done by using WRM. WRM is a matrix consisting of rows and columns. Each line shows the influence of each waste on the other six types of waste. While each column shows the waste that is affected by other waste. The diagonal matrix represents the highest value of relationship as shown in Table 1. It indicates that each waste has a great relationship with itself (Rawbdeh, 2005). The six questions above will be asked for each relationship between the waste so that there are a total of 186 questions (31 relationships x 6 questions). Scores obtained from six questions for each relationship between waste then totaled to get the total value of each relationship. The total value is then converted into a symbol of the strength of the relationship (A, I, U, E, O, and X) by following the conversion rules specified in the standard Waste Relationship Matrix (WRM) table as the reference calculation. Where all types of waste are mutually influencing in the sense other than giving effect to the other types of waste, Rawabdeh (2005).

Table 1. Waste Relationship Matrix Table

F/T	O	I	D	M	T	P	W
O	A	A	O	O	I	X	E
I	I	A	I	I	I	X	X
D	I	I	A	I	E	X	I
M	X	O	E	A	X	I	A
T	U	O	I	U	A	X	I
P	I	U	I	I	X	A	I
W	O	A	O	X	X	X	A

(Source: Rawabdeh, Assesment in Job Shop 2005)

Table 2. Question list of WRM

No	Questions	Choices of Answer	Skor
1	Does i produce j ?	a. Always b. Sometimes c. Rarely	= 4 = 2 = 0
2	What is the type of the relationship between i and j ?	a. As i increases j increases 2 b. As i increases j reaches a constant level 1 c. Random depends on conditions.	= 2 = 1 = 0
3	The effect of j due to i:	a. Appears directly and b. Clearly Needs time appear c. Not often appears.	= 4 = 2 = 0
4	Eliminating the effect of i on j is achieved by: ….	a. Engineering Methods b. Simple and direct c. Instructional solution	= 2 = 1 = 0
5	The effect of j due to i, mainly influences: …..	a. Quality of products b. Productivity of resources c. Lead time d. Quality and productivity e. Productivity and lead time f. Quality and lead time g. Quality, productivity and lead time	= 1 = 1 = 1 = 2 = 2 = 2 = 4
6	In which degree does the effect of i on j increase manufacturing lead time ?	a. High degree b. Medium degree c. Low degree	= 4 = 2 = 0

2.7. Cycle Time, Takt Time, Standar Time

Cycle time is the average time obtained from the time data of the worker to complete his work (Chase et al., 2007). While Normal Time is the working time required by a worker to complete his work at normal working speed (Niebel, B & Freivalds, A, 2003). Calculation of cycle time and normal time is intended to calculate the shoulder time of each operator in each work process. Standard time is the time required for a worker to complete his or her work with an average level of skill which includes the time slot given by considering the situation and conditions of the work to be completed (Niebel, B & Freivalds, A, 2003). The usefulness of the Standard Time calculation is for the planning of labor requirements, for estimating the costs in determining the wages of employees, for production scheduling, and for showing the output that a worker can produce in a day.

2.8. Waste Assessment Questionnaire (WAQ)

Waste Assessment Questionnaire is created to identify and allocate waste that occurs in the production line (Rawbdeh, 2005). Waste Assessment Questionnaire consists of 68 different questions, these questions represent activities, conditions and behavior in a production floor that can specifically generate waste. Some questions are grouped in the "From" type which means that the question refers to any kind of waste that can trigger or generate different types of waste. While the other question represents the type "To" which means all kinds of waste generated by other waste. Each question on the waste assessment questionnaire consists of three answers with weights of each: 1, 0.5 and 0. The questions are categorized into 4 groups: man, machine, material and method. Each question is grouped into several types with the same degree based on the answers to develop a waste assessment questionnaire model. The final value of the waste depends on the combination of answers.
The steps to analyze WAQ according to Rawabdeh (2005) are as follows:

a. Calculate the number of waste questions type from and to from any waste (waste).
b. Incorporate the initial weighting of WAQ questionnaire questions based on WRM.
c. Divide each weights of waste by the number of questions (Ni) to eliminate the effect of variations on the number of questions.

3. Research Methodology

The type of data required in this study consists of two types namely, primary and secondary. Primary data is data that dikloeh through direct observation, interviews and questionnaires. While for secondary data obtained through internal company both historical data and records or standards that have been established company.
The research consists of four main stages:

A. The initial phase of the study, including:

- Determining the topic of research to be undertaken
- Define research objectives
- Define problem limits
- Conduct literature studies on theoretical basis used as a reference such as Lean Manufacturing System, Waste Relationship Matrix (WRM), Waste Assessment Questionnaire (WAQ), and Value Stream Mapping (VSM)

B. Stages of data collection and processing, carried out by:

- Identify, collect, and determine the required data
- Create a Current Value Stream Map design
- Identify waste or waste using the Waste Realtionship Matrix (WRM) method by asking 186 questions with composition (31 waste relationship and 6 questions)
- Designing matrix tables and relationship diagrams among wastes based on WRM analysis
- Conduct a final score calculation of the WRM matrix results, then crosschecked with the actual conditions of the production process.
- Design a diagram of the direction of the emergence of linkages or ridges between the detected wastes.
- Create a VSM design with the composition of current VSM with target VSM expected.
- Creation of standard tables Waste Matri Value (WMV) as the basis for calculation

C. Phase Data analysis consisting of:

- Analyzing the Current Value Stream Map of the existing production system
- Analyze waste (waste) that occurs findings with the method of Waste Relationship Matrix (WRM)
- Analyze the relationship between waste that occurs from the WRM matrix table
- Analyzing the results of the final score calculation of the relationship between the wastes in the data matrix

- Analyze the comparison of current and proposed Value Strea Map

D. The final stage, which contains the conclusions of the whole process for production that is analyzed for the related company. At this stage, will be concluded the results of research and give advice and input to the company to do improvement and improvement.

4. Result and Discussion

4.1. Assembly Plant

The process of making a vehicle requires a long series of processes starting from a design and image design to become a reliable and quality car. In general, the process of making a car can be divided into three main processes, namely pre-production, core production process, and post-processing.

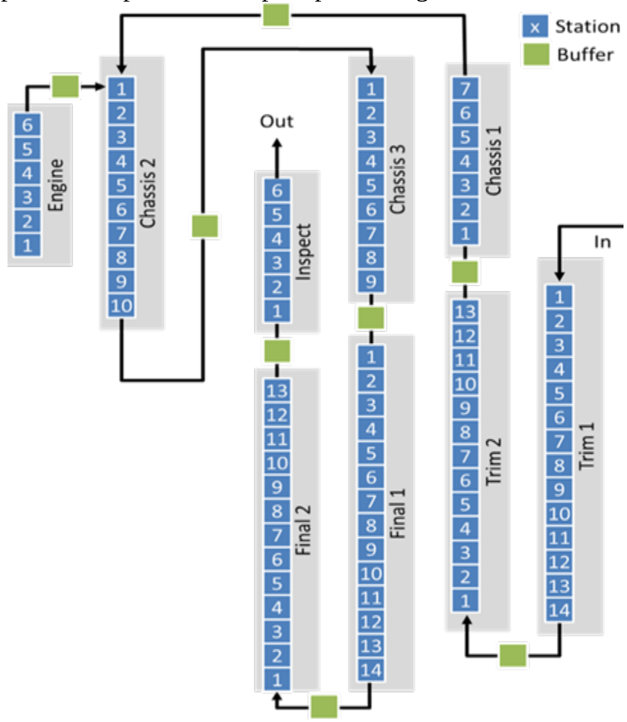

Figure 4. ***Product Layout Assemby Trimming***
(Source: Production Division PT. Astra Daihatsu Motor)

4.2. Assembly Trimming

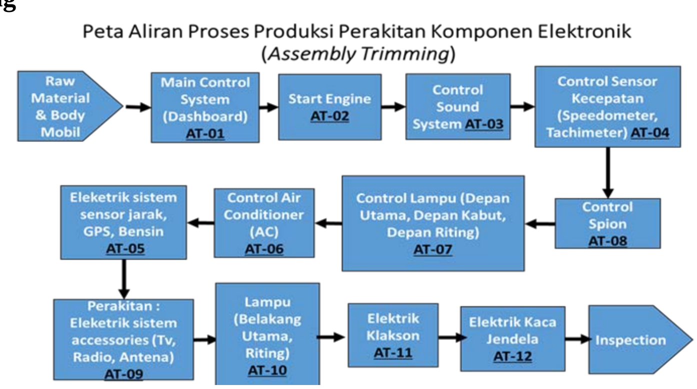

Figure 5. Proses *Sub-Assembly Trimming*
(Source: *R&D Division* PT. Astra Daihatsu Motor)

In the process of assembling these electronic components, there are 12 work stations with the number of workers 3 to 4 people. Where each worker has their own jobdesk to assemble electronic components.
Assembly Trimming (AT) consists of:

AT 01 = Main Control System (Dashboard)
AT 02 = Start Engine (Stering)
AT 03 = Control Sound System
AT 04 = Speed Sensor Control
AT 05 = Electrical System (Proximity sensor, GPS, Fuel)
AT 06 = Control Air Conditioner (AC)
AT 07 = Control Lamp (Main light, Fog, Riting)
AT 08 = Control Spion
AT 09 = Electrical System Accessories (Radio, Antenna, etc)
AT 10 = Rear Backlight, and Main
AT 11 = Horn
AT 12 = Electric Window Glass

4.3 Operation Process Chart

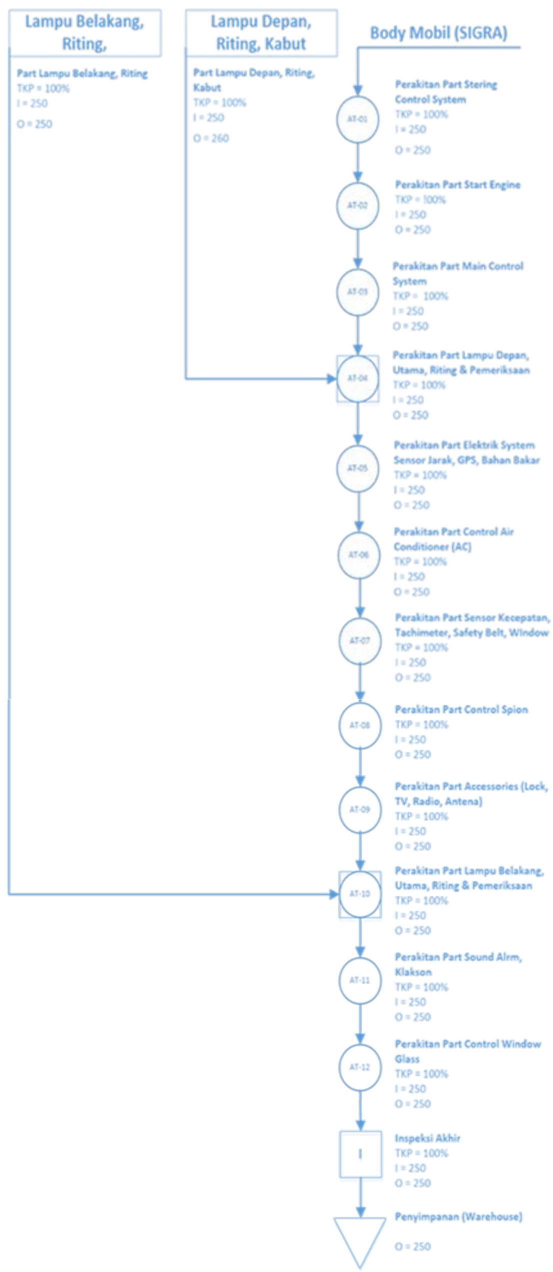

Figure 6. ***Operation Process Chart (OPC)*** **Observation**

This operation process shows the flow of assembly trimming process in automobile production process. There are 12 sub-assembly processes: AT-01 AT-02 AT-05 AT-06 AT-07 AT-08 AT- 10, AT-11, AT-12. With the standard assembly time determined by the company is 2.05 minutes.

4.4 Current Value Stream Mapping (VSM)

Current Value Stream Mapping (VSM) is designed based on the current conditions before the repair on the assembly line assembly process of electronic parts (assembly trimming) Daihatsu Sigra car production process, at PT. Astra Daihatsu Motor. At current VSM there are 12 sub-processes consisting of AT-01, AT-02, AT-03, AT-04, AT-05, AT-06, AT-07, AT-08, AT-09, AT- 10, AT-11, AT-12. A total of 12 sub-processes are the object of research that I do by using WRM and VSM methods. From this mapping it is known that the system applied by PT. ADM can still be improvised to achieve an effective and efficient production process.

4.5 Time Study

Uniformity Test and Data Sufficiency Test
ULC (Upper Limits Control = x + (kc)
LLC (Lower Limits Control = x – (kc)
Where :

K = Level of Certainty in the research (1-α=95%)

$$\sigma = \sqrt{\frac{\sum(x-\bar{x})^2}{N-1}}$$

Table 3. Uniformity Test

Workstation	$\bar{x}$	σ	BKA	BKB
AT-01	1.672	1.211	3.781	0.430
AT-02	1.231	1.243	3.462	0.453
AT-03	0.461	1.103	3.893	0.432
AT-04	1.212	1.345	3.824	0.543
AT-05	1.011	1.342	3.88	0.321
AT-06	0.432	1.358	3.936	0.334
AT-07	0.521	1.394	3.992	0.342
AT-08	1.211	1.431	4.048	0.320
AT-09	1.111	1.467	4.104	0.299
AT-10	1.341	1.504	4.16	0.277
AT-11	1.223	1.540	4.216	0.255
AT-12	0.512	1.576	4.272	0.233

Table 4. Data Sufficiency Test

Work Station	N'	N	Enough
AT-01	13	35	Enough
AT-02	15	35	Enough
At-03	25	35	Enough
AT-04	28	35	Enough
AT-05	29	35	Enough
AT-06	29	35	Enough
AT-07	29	35	Enough
AT-08	24	35	Enough
AT-09	15	35	Enough
AT-10	12	35	Enough
AT-11	28	35	Enough
AT-12	25	35	Enough

Formula to Data Sufficiency Test

$$N' = \frac{\frac{k}{s}\sqrt{N\sum x^2 - (\sum x^2)}}{\sum x}; \text{ N>}N'$$

The data is enough if N’ is smaller than total amount of experiment data (N=35)

N '= Number of observations that should be done.
K = Belief level in observation (k = 2, 1-α = 95%).
S = Degree of Accuracy in research (5%)
N = Number of Observations already done
Xi = Observation Data
* Performed calculations on data from each Workstation from AT-01 to AT-12.0

4.5 Waste Relationship Matrix Calculation

Table 5. Calculation of WRM

F/T	O	I	D	M	T	P	W	Score	%
O	10	10	4	10	8	0	8	48	14.12%
I	4	10	6	8	10	0	0	38	11.18%
D	8	10	10	6	8	0	8	50	14.71%
M	10	6	8	10	10	6	10	60	17.65%
T	4	8	4	8	10	0	10	42	12.35%
P	6	10	6	6	8	10	8	48	14.12%
W	4	8	6	10	2	10	10	54	15.88%
Score	46	62	44	58	56	26	44	340	100%
%	13.53%	18.24%	12.94%	17.06%	16.47%	7.65%	14.67%	100%	

- Based on the above table shows the value of from Motion and from Waiting has the largest percentage of 17.65% and 15.88% which means that waste Motion and Waiting if it happens then have a large enough effect to cause other waste.
- Also note the value to inventory has the largest percentage of 18.24% of this indicates that waste inventory is the waste that most affected other wastes.

Waste Relation Matrix (WRM) calculation system aims to determine the weight of the relationship between each waste that occurs in the assembly trimming process of the car.

4.6 Proposed Improvement

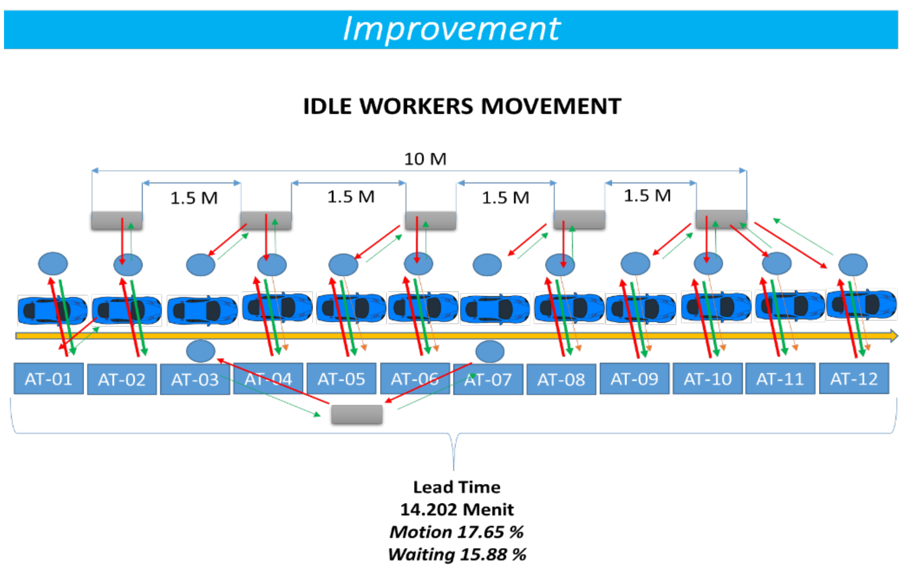

Figure 7. Idle Workers Movement

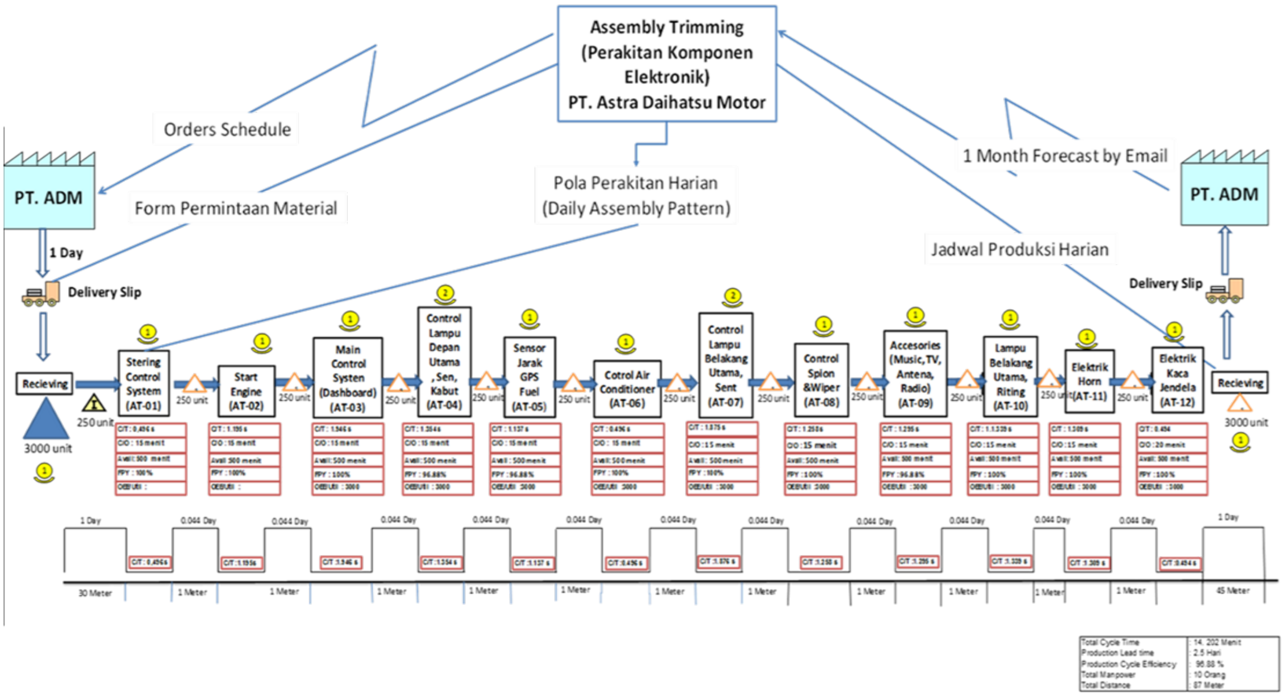

Figure 8. Current Value Stream Mapping (VSM)

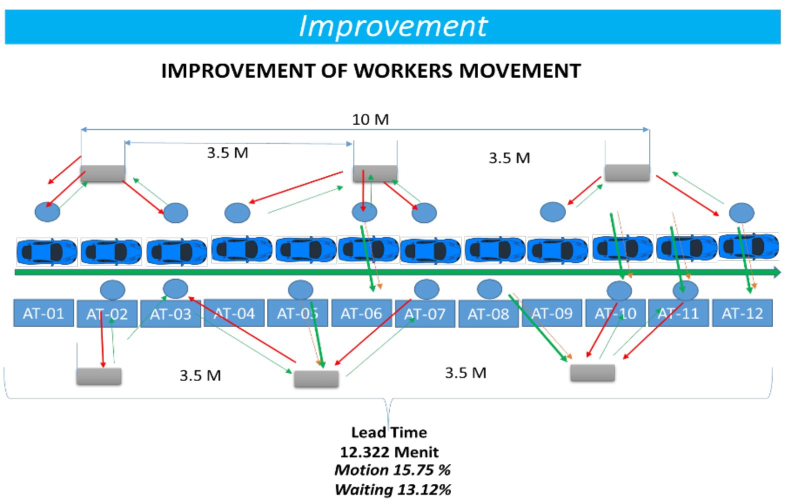

Figure 10. Improvement of Workers Movement

Improvements made is to change the system of worker movement to be as in Figure 10. above. Changes in the worker's movement system is to divide the workload on each worker in unity with time less than 2.00 minutes based on time data from the speed of the workers applied to the training training program workers at PT. Astra Daihatsu Motor Learning Center.

4.7 FIFO (First In First Out)

Improvements by considering the results obtained from the initial VSM (Value Stream Mapping) mapping is by the method of changes in the movement of workers in the assembly process of car electronic components. From the movement of the original workers ie the system moves freely according to jobdesknya, now they must follow the line assembly that is adjusted with the workload. So it will get more efficient time result. Then the proposed improvements are applied FIFO (First In First Out) on the assembly process of car electronic components. The division of the car body into the front, middle, and rear (1st Section, 2nd Section, and 3rd Section)

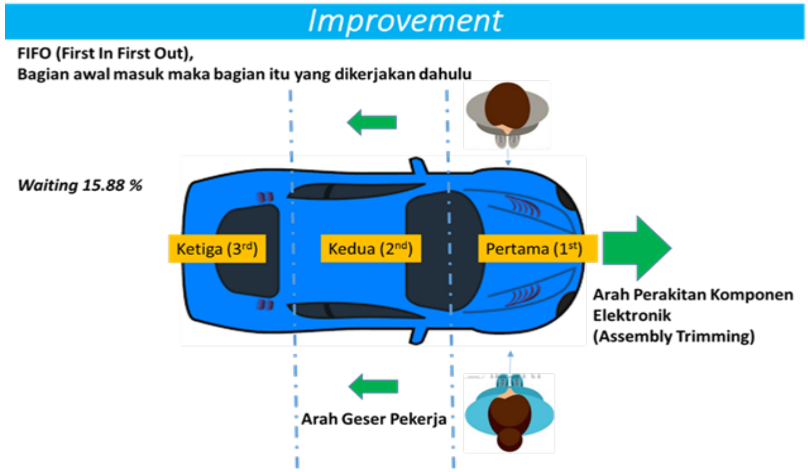

Figure 11. First In First Out (FIFO)

4.8 Process Activity Mapping (PAM)

Activity Mapping process is a tool used to describe the order fulfillment process in detail step by step. The depiction of this map aims to find out what percentage of the activities undertaken are value-added activities and what percentage is not added value, whether that can be reduced or not. The depiction of this map can be used to help identify waste in the value stream, to identify whether the process can be made more efficient, and to identify parts of the process that can be improved by eliminating unnecessary activity, making it simpler and also possible by combining between Process if possible so that the process can run more efficiently. From the data that has been collected then processed into a process activity mapping from the work station assembly trimming area in the car production process. From this PAM, it can be known to classify the work included in the category, value added activity (VA), non-value added activity (NVA), and non-value added activity but necessity (NNVA). In the process of assembly trimming in this line of car production process many things that are in the category of value added activity because all assembly is the installation of the main components for the overall control system of the car. The main controls of the car consist of Dashboard Control System, Stering Main Control, and Sensor Reporting.

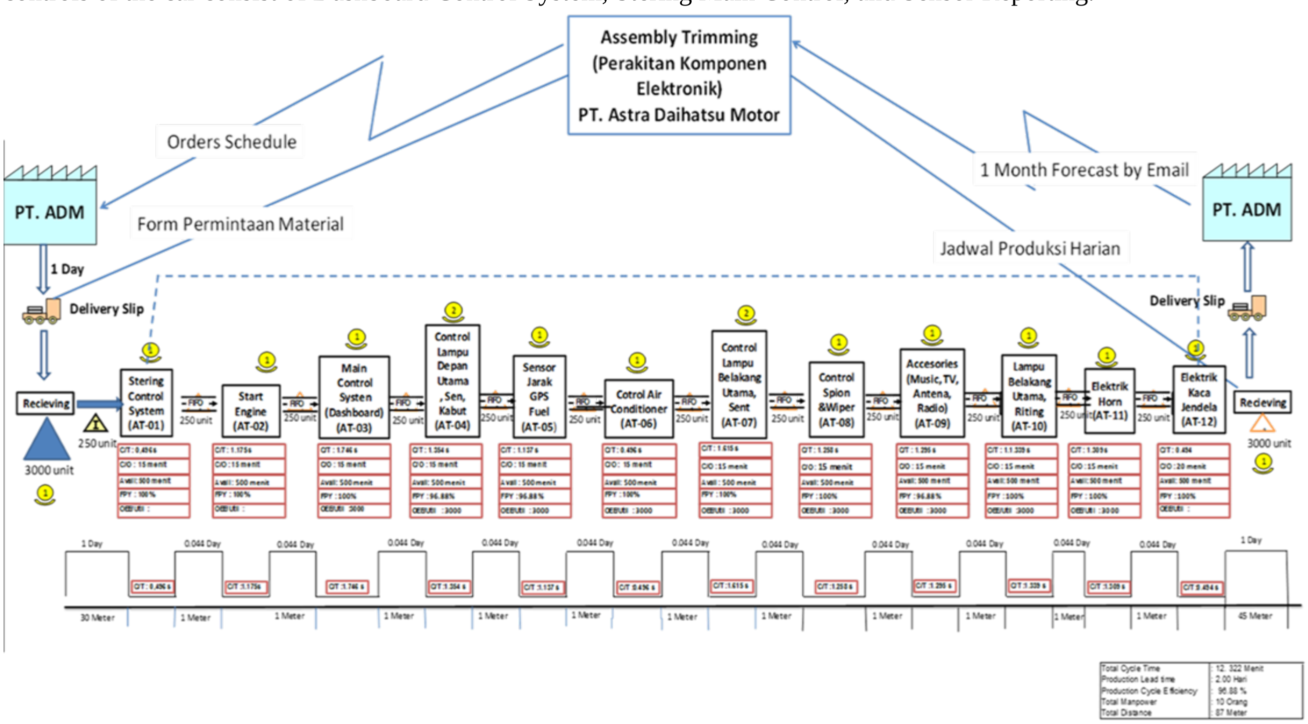

Figure 12. Proposed Value Stream Mapping (VSM)

Analysis

Waste relationship matrix (WRM) is used to determine the degree of relationship between waste. There are 7 stages in using waste relationship matrix (WRM), that is:

1. Distribution of questionnaires to related parts of the company
2. Conducting weighting of the questionnaire results (tabulation)
3. Create a waste relationship matrix (WRM)
4. Questionnaire will be filled by part of PPIC & warehouse, Qulitas, Special production in assembly parts of car electronic components.
5. Questionnaire of PPIC & Warehouse section concerning waste O_I, O_D, O_M, O_T, O_W, I_O, I_D and I_MO
6. Quality section fills the questionnaire of the relationship between Defect and other waste that is D_O, D_I, D-M, D_T, and D_W.
7. Production section fills out the questionnaire of the relationship between Motion, Transportatin, Waiting, and Overproduction with other waste: M_I, M_D, MW, M_P, T_O, T_I, T_D, T_M, T_W, P_O, P_I, P_D, P_M, P_W, W_O , W_I, and W_D.

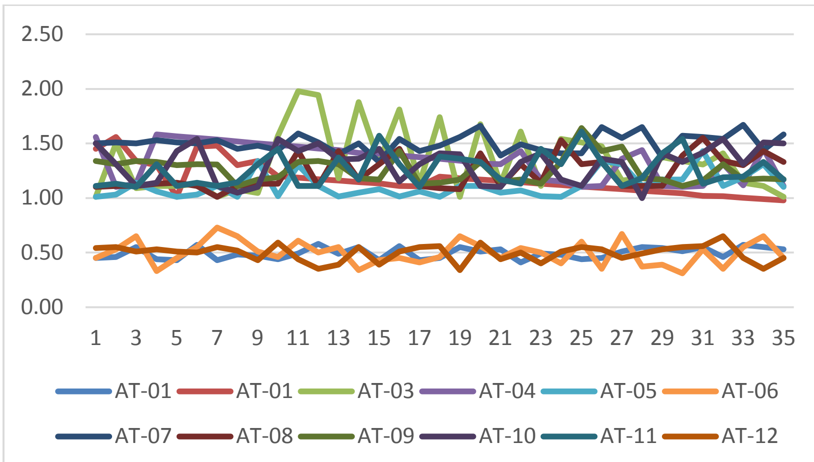

Figure 13. Time of Assembly After Improvement

From the results of improvements made are the application of FIFO system, Change Design Minor Layout, and also Line Balancing. From the data in Figure 4.3 shows that the average time required by the worker to complete his work in each WIP or sub-assembly trimming process is less than 2 minutes which means below the company's predefined time standard is 2.05 minutes. The average of the new cycle time after the improvement shows good results that is in bawwah time standard that has been determined. This means that the improvements made affect the efficiency of working time on the assembly trimming process assembly line in Daihatsu SIGRA, DOHC Dual VVT-i car production process at PT. Astra Daihatsu Motor.

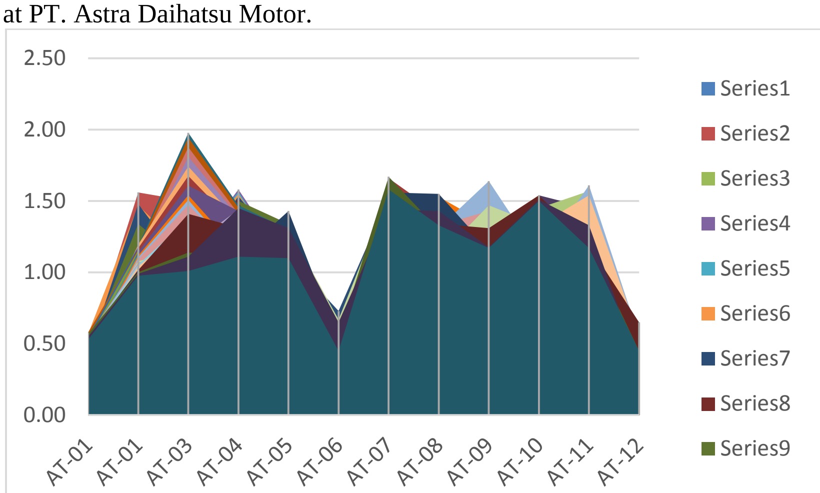

Figure 13. New Cycle Time After Improvement

Significant changes also occur in AT-03 and AT-07 where each has an initial average of 2.45 minutes and 2.65 minutes before an improvement. After the repair of the time to 1.89 minutes and 1.56 minutes so that the significant decline can have a good impact in the production process and does not exceed the standard time.

Table 7. New Inventory of Improved Results

Kind	Place	SUM (unit)	SUM (day)
Raw Material	Warehouse	3000	1
WIP	AT-01	250	0.044
WIP	At-02	250	0.044
WIP	AT-03	250	0.044
WIP	AT-04	250	0.044
WIP	AT-05	250	0.044
WIP	AT-06	250	0.044
WIP	AT-07	250	0.044
WIP	AT-08	250	0.044
WIP	AT-09	250	0.044
WIP	AT-10	250	0.044
WIP	AT-11	250	0.044
WIP	AT-12	250	0.044
Finish Good	Final Inspection	250	1

a. Analysis of Proposed Value Stream Mapping (VSM)

The focus of the proposed improvement is based on an earlier analysis using the activity mapping process and the supply chain response matrix. In both tools is clearly illustrated that the Inventory caused by waste motion and waiting is a problem in the emergence of long lead production time. This is also supported by the results of the WRM questionnaire assessment which gives results that waste motion and waiting occupy the first type of waste. In Proposed Value Stream Mapping (VSM) this proposal is applied that is Line Balancing and FIFO (First in Fisrt Out) by dividing the car into 3 parts, namely: 1st section, 2nd section, and 3rd section.

b. Waste Motion Elimination

In the Waste Relationship Matrix (WRM) and Value Stream Mapping (VSM) it appears that the large number of WIPs must wait for the assembly process in AT-03 and AT-07 in PT. Astra Daihatsu Motor is for 14,202 minutes and this waiting process is not a value-added or non value added activity (NVA) activity. From table 4.12 it can be seen that the material of the assembly process on AT-03 can not be directly transferred to AT-04 work station, also from AT-07 can not directly go to AT-08 according to the time specified, because in process AT-03 And AT-07 this happens bottleneck. The process on AT-03 is done by one worker in the assembly trimming process of car electronic components in PT. Astra Daihatsu Motor. The PPIC and Production Division sections agree that this process greatly leads to large lead times because the loads are less balanced with WIP before or after and the unorganized work movements which move on all sides of the car so that there is time removed to move from one side point Car to the other side. From that the occurrence of Inventory temporarily due to the bottleneck. Inventory takes place at the point of AT-02 and AT-06. With the arrival cycle 1-1-1 then, cause PT. Astra Daihatsu Motor must make WIP safety stock for 2 days useful as buffer so that process can run normally on 1 day before and after. Because during the process of assembly trimming running of course the production of PT. Astra Daihatsu Motor should not stop. Implementation Improvement of worker movement and the division of workload (Line Balancing) and also safety stock for 2 days this was effective enough to overcome the problem. Namely by applying and simulate it directly on the PT. Astra Daihatsu Motor Training Center or employee training ground. Plant PT. Astra Daihasu Motor Training Center, Sunter, North Jakarta. The results obtained from the results of improvements made time study to produce a decrease of waste motion from 17.65% to 15.75%.

c. Waste Waiting Elimination

Waiting is the second largest waste of 15.88% by the Questionnaire Aassessment of the Waste Relation Matrix (WRM). In Value Stream Mapping (VSM) the waiting process occurs when raw material from AT-02 waiting to be processed when the operator at AT-03 is doing the assembly of dashboard and main power control system that takes a long time because it is done by one worker Premises heavy workload. The AT-07 process also contributes to the occurrence of waste waiting in the process of assembling the whole sensor-sensor components of the proximity sensor, the speedometer, the engine tachimeter, the fuel sensor and other components that are components Car sensor. The process in AT-07 is also done by one worker. Especially for waiting in the area of AT-02 and AT-06 where waiting to be processed on AT-03 and AT-07 authors do their own analysis to provide input to the production. The analysis is to measure the cycle time between the three work stations (AT-02, AT-03, AT-04) and (AT-06, AT-07, AT-08) to determine the actual cycle time of the three operations. From the measurement found that the average CT for AT-02: is equal to 0.571 minutes, AT-03: 2,506 minutes and AT-04: 1.125 minutes. The work area of AT-03 and AT-04 is done by the same operator so that it works sequence (sequential) from AT-03 process after that just doing assembly on AT-04.

When measuring the time of this cycle the material resulted from the work by the AT-02 process operator must wait for AT-03 to complete assembly. Because in fact the standard time for this process is only 2.05 minutes (standard time specified by PT Astra Daihatsu Motor). While the CT on AT-06 is 1013 minutes, AT-07: 2.134 minutes, and AT-08: 0.673 minutes. AT-07 and AT-08 are performed by one operator so that it is sequenced sequentially. This results in waste from one point causing another waste at another point. The AT-07 is still more than the standard time set by the company. The conclusion is the work of the operators in all three WIPs at point (AT-06, AT-03, AT-04) and (AT-06, AT-07, AT- 08) is not balanced. For that to balance the work of the operator so there is no waiting time the authors suggest to combine these three machines with the concept of first in first out or FIFO and Line Balancing for the division of workload on each operator so that the system works will be balanced in one line prduksi assembly electronic components This car. From the implementation results applied to PT. Astra Daihatsu Motor Training Center, the result of the repair of the original waste waiting 15.88% decreased to 13.12%. From the results of these improvements on waste reduction and waiting waste impact on the total lead time of this car trimming assembly process. Lead Time fell from 14,202 minutes to 12,322 minutes in a single line of assembly trimming process in the car production process. In other words from the application of improvements can be concluded that is able to eliminate the time of 1 sub process on the assembly line trimming of the time for 12 assembly process that is AT 1-12 becomes the time for 11 assembly process that is AT 1-11 that is decreased 1.88 minutes or 1 Minute 52.8 seconds.

4. Conclusions

Based on the results of research with the method of Waste Relationship Matrix (WRM) and Value Stream Mapping (VSM) can be drawn the following conclusions:

1. Waste identification result using WRM (Waste Realtionship Matrix) and VSM (Vakue Stream Mapping) method on assembly trimming process resulted 3 biggest waste that happened that is Inventory, Motion, and Waiting.
2. Waste type "from" that is Motion and Waiting has the largest percentage of 17.65% and 15.88% which means that waste Motion and Waiting if it happens then have a large enough effect to cause other waste that will increase the production lead time.
3. Waste type "to" the Inventory has the largest percentage of 18.24% this indicates that waste inventory is the waste that most affected other waste.
4. From the improvements made to eliminate waste motion & waiting is by improving the FIFO system (First in First Out), Improving changes in the movement of workers, and Line Balancing in the assembly trimming process produces some efficiency such as:
   - Reduced Motion waste from 17.65% to 15.75%, and
   - Waste Waiting from 15.88 to 13.12%, and
   - Lead Time fell from 14,202 minutes to 12,322 minutes in a single line of assembly trimming process in the car production process.

In other words from the application of improvements can be concluded that is able to eliminate the time of 1 sub process on the assembly line trimming of the time for 12 assembly process that is AT 1-12 into the time for 11 assembly process is AT 1-11 that is decreased 1.88 minutes or 1 Minute 52.8 seconds.

5. Recommendations

For future research related to the current research, the authors provide some suggestions as follows:

1. Preferably the object of research is not only limited to the area of assembly trimming course because this area is only one of the whole 5 line car production process.
2. Conducted an overall analysis with regard to factors in other production lines because there is a possibility in the process of production of the car there is another waste that occurs therein.
3. Created simulations with software with several production process scenarios to determine the impact or benefit of any repair recommendations and for the purpose of saving the cost of checking the improvements made.

4. Cost analysis is required in terms of whether the improvements made have a significant cost impact so that it can be seen that the improvements made provide measurable benefits from the previous. So it can be seen whether worth it enough to be repaired or not.

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Include author bio(s) of 200 words or less.

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