International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 36 No. 2 January 2023, pp. 312-321

Reducing Lead Time In The Wet Line Of Automotive Parts Production

Adib[1], Abdul Muzammil[2], Iing Pamungkas[1], Heri Tri Irawan[1], Gaustama Putra[1], Arrazy Elba Ridha[1]

[1]Industrial Engineering Department, Engineering Faculty, Universitas Teuku Umar, Indonesia

[2]Agribusiness Department, Agriculture Faculty, Universitas Teuku Umar, Indonesia

adib@utu.ac.id

Abstract – The goal is to identify the variables that contribute to the wet line's high lead time, including tray jams in and out of the oven dryers, operator work habits, wet line stagnation, and operator irregular jobs. Utilizing a fishbone diagram during the analyze process, the problem's root cause was discovered (Ishikawa diagram). The final step is to use 5W-1H to enhance step. Minimizing non-value-added activities and enhancing wet line throughput are the suggestions for reducing lead time. There are six recommendations: teaching the operator in the work process, creating work instructions for the wet line, changing the tray size, rearranging the quantity per tray, including the operator in the wet line, and changing the workspace. As a result of this development, the lead time of a wet line has increased significantly, from 3550 seconds to 411.63 seconds. The efficiency of the process cycle rises from 14.06% to 68%.

Keywords – Fishbone Diagram; 5W-1H; Process Cycle Efficiency; Lead Time; Non-Value-Added Activity; Flow Process

I. INTRODUCTION

Companies now compete with one another to meet client demands in today's highly competitive business climate, particularly in the automobile sector. Due to this circumstance, the business has been compelled to enhance its operations in order to please customers and increase profits in the future.

The automotive component manufacturer PT. X specializes in producing pulley dampers and anti-vibration components for automobiles. The majority of their goods are produced for the assembly of automobiles for various brands, including Toyota, Daihatsu, Mitsubishi, Honda, Hino, and Suzuki.

Numerous non-value-added processes take place in the preparation metal line, particularly in the wet line, which adds to the line's lead time and delays the following process that receives output from the wet line. The lead time reduction practiced at PT. X through kaizen activities will be the subject of this research. Previous research on lead time reduction has been widely applied, such as in the court shoe production line [1], the auto-ancillary industry [2], textile industry [3], and a number of manufacturing industries in India [4].

This study's primary goal is to decrease the lead time in the wet line by examining the root causes of the issue and coming up with solutions and preparing for the improvement's deployment and evaluation by the Jishuken Activity group A4 Cycle and Toyota Production System Department of PT. X.

II. THEORITICAL STUDY

2.1. Value-Added-Activity and Non-Value-Added Activity

An activity that adds value to the goods is referred to as a value-added activity, whereas an activity that adds no value to the goods is referred to as a non-value-added activity. Based on what the client actually wants, value-added activity may be distinguished from non-value-added activities. The factory floor includes non-value-added activities like inspection and transportation. Two of the examples offer nothing extra to the content, while other times it is present in the process for a specific reason. Activities that bring value and those that don't both use time and other resources. They are both seen as costs. However, only value-added activities actually add to the process' value [5].

There are situations, nonetheless, where non-value-added activities must be included in the business process. In this situation, the non-value added components of the process won't be eliminated by the business until a new tool or advanced method is found. To put it simply, the optimal approach to managing any business process is to aim to minimize non-value-added activities as much as feasible [6].

2.2. Cause – and - Effect Diagram (Fishbone Diagram)

Diagrams that connect causes and effects are known as cause-and-effect diagrams. The fishbone diagram's goal is to illustrate how various factors affect the outcomes. This graphic was created using the idea of historical facts and brainstorming. Because Professor Kaoru Ishikawa introduced it in 1953, this graphic is also known as the Ishikawa diagram [7-8].

Basically, cause and effect diagram is used for [9]:

- Helping to identify the root cause of problem.
- Helping to find the solution of problem.

The root causes of the problem are noted in cause effect diagram and the categorize as;

- Man/ Personnel

It related to lessen of lesson, lack of basic creativity that relates to physically, exhausted and stress.

- Machines

It related to none of preventive maintenance towards the machines, include the facility and other tools not appropriate with specification of job, less of calibration, and complexity.

- Methods

It related to there are no procedure or correct of method, less of clarity, unpredictable, unsuitable, and not standardized methods.

- Materials

It consists of availability of raw material and other supporting material and also material handling.

- Environment

It relates to place (cleanliness, healthy, safety) and working hour that unconcern also other environment aspects that might affect the production process.

Generally, there are five factors have to be concerned in making diagram as we can see in the following figure 1.

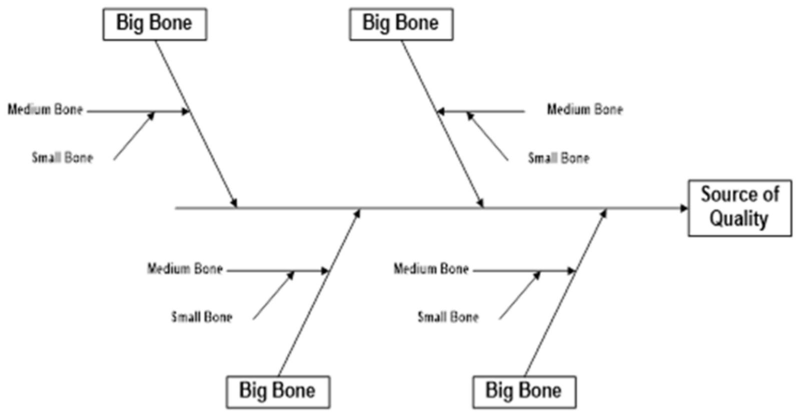

Figure 1. Fishbone Diagram (Ishikawa)

2.3. 5W-1H Method

In order to construct the plans, analysis employing the 5W-1H approach might be employed. What, Why, Where, When, Who, How, and How Much (5W-1H) [10-11]. As shown in table 1, the 5W-1H technique can be used to develop steps for improvement;

Table 1. Method for developing steps for Improvement

Types	5W-1H	Description	Action
Main Goal	What?	What is main goal of quality improvement	Formulate the target as customer's need
Function	Why?	Why the planning of action is executed? Explain about the function of planning action	Formulate the target as customer's need
Location	Where?	Where is planning of action is executed? Is the activity have to be executed in there?	
Sequence	When?	When is planning of action is executed? Is the activity can do in the next?	
People	Who?	Who will execute action planning? why should be that person who takes action planning	
Method	How?	How is the action planning is executed? Is the current used is the best method? Is there any easy ways?	Simplify current activities
Cost/Benefit	How Much?	How much is the cost paid to execute action planning? Is it giving positive effect after action planning	Decide effective and efficient action planning

2.4. Process Cycle Efficiency

Process Cycle Efficiency is a metric or measurement that used in lean manufacturing to see the time efficiency of a process towards the cycle in overall [9]. Calculating the process cycle efficiency can be used formula as;

$$\text{Process Cycle Efficiency} = \frac{Value\ Added\ Time}{Total\ Lead\ Time} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Notes:

- Value Added Time = time needed to do the all process activities that giving value added to the product.
- Total Lead time = time needed to do the all process activities without seeing the activity is giving value added or not.

2.5. Process Lead Time

Lead time process is the amount of time needed to finish a product. Below is the formula for lead time process [9];

$$\text{Lead Time Process} = \frac{Number\ of\ activity\ in\ process}{Completion\ per\ hour} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Notes:

Number of Activity in the Process=Amount activities in a process.

III. Method

Direct factory floor observation is used for the research's introduction, particularly for the wet line. Based on the observation made at the start of the research, the issue in PT. X's wet line is that the flow process does not flow smoothly and has a lot of non-value-added activities, which results in lead time in this line of 3550 seconds. The three major goals of this study are to identify value-added and non-value-added activities, identify the reasons of problems in the wet line, and evaluate the causes of problems using cause and effect diagrams. The goal is to prepare an improvement implementation based on 5W-1H analysis that will be created based on the elements that were discovered by cause effect diagram after identifying value-added and non-value-added activity. To minimize lead time in the wet line, the recommendation from the 5W-1H analysis will guide the implementation of the improvement. Improvements were implemented in accordance with the 5W-1H analysis's recommendations. Analyze the outcome of the improvement to determine whether the enhancement's deployment helped shorten the lead time. Evaluation is carried out by contrasting the pre-improvement state with the post-improvement state with regard to the overall lead time and cycle efficiency. The research concludes with recommendations for businesses to pursue in the future.

IV. Result & Discussion

Receiving material for metal, rubber, and chemical products is one of the operations that is divided up among PT. X's many activities on the factory floor. The preparation line, which is separated into two primary materials processing for rubber and metal, is the following procedure. The wet line, which is the subject of this study, is situated in the preparation metal line. The next step is a mounting line, where metal and rubber from the preparation line's output are combined to create one final product. The type of bracket used in the mounting process also depends on the product's characteristics. The full finished product will be packaged and ready to be picked up by the customer's vehicle or delivered to the customer by PT. X in accordance with the delivery schedule during the final major process. All of the information used in this study came from PT. X's wet line, which served as the project's focus line

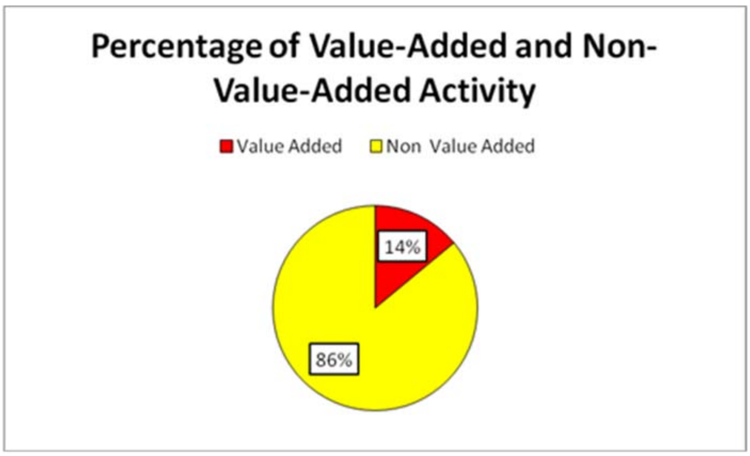

Figure 2. Percentage of Value-Added and Non-Value-Added Activity

Lead Time data service is fundamental in calculation of lean manufacturing which are Process Cycle Efficiency (PCE) and Velocity Process. As seen in the grouping of Value-Added-Activity and Non-Value-Added-Activity there is stagnation in the process that consumes very long time for this line.

The time needed to finish the applying process for one tray in the wet line is 3550 seconds or 59.17 minutes or 0.99 hours. Total lead time is the total process in all activities to apply chemical liquid for metal plate. The longest time in the applying process is certain by the stagnation after oven dryer 205 to the second applying process (chemical liquid 6125). The longest time is 2580 seconds to wait until the metal plate in tray processed by the operator because in the wet line there are many parts to be processed including theme part itself. Further, the *Throughput* is 2580 seconds = 43 minutes.

$$\text{Finishing in an minute} = \frac{1\ minute}{Total\ lead\ time\ per\ tray\ (minute)}$$

$$= \frac{1\ minute}{59.17\ minute} = 0.017$$

Finishing in a single minute is calculated to identify rate of finishing a process in a minute. Process Cycle Efficiency is a metric or measurement to know the time efficiency in a process towards the cycle time in whole process. In calculating Process Cycle Efficiency, Value-Added-Activity (Value Added Time) and the time to finish in whole process (Total Lead Time) are needed.

$$\text{Process Cycle Efficiency} = \frac{Value\ Aded\ Time}{Total\ Lead\ Time}$$

$$= \frac{499}{3550} = 14.06\%$$

Value Added Time in al process is just 14.06 % from the total time to finish it. Based on the calculation, it show the efficiency in cycle process is 0.1406 or 14.06 % which it means that cycle process is very low and terrible because Value Added Time is less than Non Value Added time.

Process Lead Time is used to know time elapsed to.

$$\text{Process Lead Time} = \frac{Amount\ of\ Product\ in\ Process}{Finishing\ in\ a\ Single\ Time}$$

$$= \frac{1}{0.017} = 58.82\ minutes$$

The result Process Lead Time is 58.82 minutes in finishing one cycle of process (one tray).

Cause Effect diagram shows five (5) factors that cause an effect; man, method, machine/ tools, and environment. Cause Effect Diagram is set up based on the information collected from brainstorming and interviewing with related department also direct observation in the factory floor. Below is cause effect diagram that causing high lead time in the wet line;

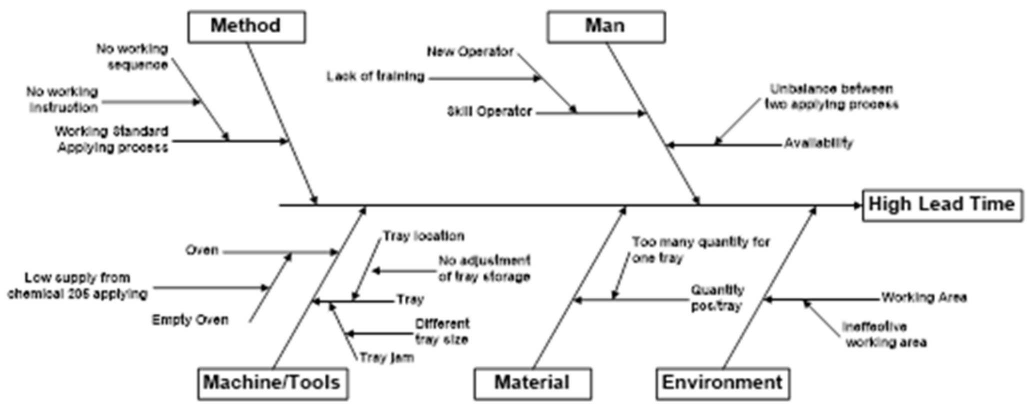

Figure 3. Ishikawa Diagram: Factors of High Lead Time

Finishing of cause effect diagram, it concludes that there are four factors that cause high lead time in the wet line:

1. Man

The Man (people)/ operator is one of the factor that cause high lead time in the wet line, because of skill of operator. Furthermore, it cause the output of product that produced in this line tend to be low. This situation occur because in the wet line there are some new operator delegated to do the applying process and they get lack of training before they placed in this line. Operator availability has also given contribution to the stagnation which occurs in the applying chemical 6125 where number of operator in this process is two persons. In the other hand, in the applying chemical 6125 is three persons.

2. Method

After observing the working area, there are no working standard found in the wet line and it causes some irregular job which time consuming in this case. For example, there are no working standard that arrange all the process systematically from start to the end.

3. Machine/ Tools

Here, high lead time caused by the oven dryer 205 is often in the empty condition because the metal plate that come from chemical 205 applying are not smooth. This condition occurs because there is a problem of tray adjustment. Furthermore, there are no standard for tray size and cause the tray stuck in the conveyor. The other problem which caused by tray adjustment is tray location is hard to reach and hard to placed in the working table.

4. Material

Length of time process for material in one tray cause high lead time in the applying process. Here, quantity per tray of material which to be processed in this line is too many. There are 30 pieces to be processed in one tray and it needs a tray that does not fit to the conveyor of this line.

5. Environment

An effective working area can boost the productivity also decrease lead time. Working area of wet line is considerably ineffective because it also contribute problems that mentioned in the previous points.

Improvement recommendation in order to solve the problems above is using 5W-1H method; *What, Why, Who, Where, When, How.*

Table 2. Estimation of Improvement Recommendation

Problems	Process	Problem Solving	Ways to Improve
Operator Skill	All process wet line	Increase operator skill	Work process training for operator
Working Method	All process wet line	Establishing work instruction	Making Work Instruction that cover all process wet line
Empty Oven	Oven dryer	Tray size adjustment	Modify Tray size
Quantity per tray	All process wet line	Quantity per tray adjustment	Re-arrange quantity per tray
Operator availability	Chemical 6125 applying process	Balance with operators in chemical 205 applying process	Add operator in Chemical 6125 applying process
Working Area	All Process Wet line	Effective working area to support all process in wet line	Modify working area to be effective

1. *What*

   Improvement suggestion for lead time is:

   - Work Process training
   - Establish Work instruction
   - Modify tray size
   - Re-arrange quantity per tray
   - Add the operator for applying chemical 6125
   - Modify working area

2. *Why*

   The reasons about improvement suggestion are:

   - Work process training for the operator is expected to boost the skill of operator and their productivity and reduce non-value-added activity
   - Work instruction is expected to keep the work of operator in sequence and reduce non-value-added activity
   - Modifying tray size is expected to eliminate stagnation that often occur in the conveyor to the oven dryer
   - Re-arranging quantity per tray is expected to reduce processing time of applying process in the wet line both chemical 205 and 6125.
   - Adding the operator is needed to make balance with operator availability in chemical 205 applying in order to reduce irregular job that occur in the chemical 6125 applying.
   - Modifying working area is expected to be more effective to support all process in the wet line

3. *Who*

   Responsible person/ department in improving this problem are:

   - Toyota Production System department in PT. X
   - Team Members *of Jishuken Activity group A4 Cycle*

4. *Where*

   Improvement Place:

   - Wet line of PT. X.

5. *When*

   Time to Improvement:

   - Work Process Training could be done as soon as possible and expected to improve productivity of operator and reduce non-value-added activity.
   - Work instruction can be made after modify working area is finished.
   - Modifying tray size should be discussed with the department and team members.
   - Re-arranging quantity per tray should be discussed with the department and team members.
   - Adding the operator should be discussed with the department and team members.
   - Modifying working area should be discussed with the department and team members

6. *How*

Steps how to do it:

- Work process training can be done by Toyota Production System Department.
- Work instruction can be made by Toyota Production System Department.
- Re-arranging new tray size developed by team member and ask maintenance department to make tray with new size.
- Discuss about new quantity per tray with PPIC department and team member to find out new quantity for one tray that will be applied.
- Discuss about operator addition in the wet line with Production department and team member.
- Discuss about modifying working area with Production department and team member.

5W-1H method is used to describe implementation plan of improvement.

Below are plans of improvement:

- Work process training for operator in dedicated process.
- Making Work Instruction for wet line.
- Making new tray with new size in order to eliminate tray jammed in the oven conveyor.
- Re-arranging quantity per tray in order to reduce processing time in applying chemical 205 and 6125.
- Adding operator in the wet line to make balance between applying chemical 205 and 6125.
- Modifying working area.

All these plans of improvement are created in purpose to lessen stagnation and decrease lead time in the wet line.

Improvements are implemented based on the problem found in analyze phase by using Ishikawa diagram and 5W-1H method. Furthermore the improvement is expected to reduce lead time of wet line with target as describe in the table below.

Table 3. Improvement Target

Post	**Process**	**Lead time(second)**
1	Applying Chemical 205(Brush)	194
2	Oven Dryer 205	29
Stagnation		**1**
3	Applying Chemical 6125(Brush)	200
Conveyance		**1**
4	Oven Dryer 6125	29
5	Visual Inspection and Packing	154.12
TOTAL		**525.3**

There are some improvements that suggested in reducing lead time in the wet line which are:

- Work Process Training for operator

Work process training should be done because there are placements of new operator in wet line. This training done by direct observation of the operator works within the line and give an example to the operator about correct work process. After giving an example to the operator, afterwards, giving back work process to the operator for dedicated process in the wet line. This kind of way is taken in purpose to give depth comprehension to the operator in the wet line and expected to reduce non-value-added activity.

- Work Instruction for wet line

Before improvement is implemented, wet line does not have work instruction which regulate the sequence of work process in wet line. This situation has resulted non standardized sequence of work process and irregular job which occurred in this line. In fact, work instruction is really indispensable for this line. Therefore, Work Instruction which made for this line covered all process starts from applying process chemical 205 and chemical 6125 which consist of brush, semi auto, spray and also visual inspection and packing process. Figure below illustrate Work instruction in wet line.

- Modifying Tray Size

In order to overcome tray jammed when come in and come out from oven dryer through conveyor and to eliminate stagnation which occurred in this automatic process, tray size should be standardized for all part. The new tray size for this line is 49cm length and 49 cm length where current tray that used in this line is not standardized. Tray itself made of plywood and being used as a transportation tool for metal part from one process to another process in wet line.

- Re-arranging Quantity per tray

Despite the fact that the previous tray could accommodate thirty pieces of metal plate, its size is not uniform which ultimately lead to the stagnation. The current tray has been re-arranged to accommodate fifteen pieces of metal plate and allow a smooth flow of in bound and out bond from oven dryer

- Adding Operator in Wet Line

Wet line condition before improvement activity were operated by six operators which three operators placed in the applying chemical 205, two operators placed in applying chemical 6125 and one operator placed in visual inspection and packing. Adding one operator is dedicated to balance the work load in the applying process 6125 become one operator for each process in there.

- Modify Working Area

Here, wet line is needed to improve its working area in order to support flow process run smoothly due to some improvements that implemented for this line. Furthermore, this improvement also covers adjustment of empty tray placement that will be located under the applying Chemical 205 working table of brush process and semi auto process. Meanwhile for spray process, empty tray storage will be added in the front of spray booth.

After completing the implementation of the suggestion for improvement, it can be calculated to find out the results of these implementations. As the result of implementation, the following table is a comparison between the situation before and after Improvement Implementation in the wet line.

Table 4. Comparison between current and project piloting

	Current (Seconds)	**Project Piloting (seconds)**
Lead Time	3550	411.63
Value-Added Time	499	278.50
Process Cycle Efficiency	14.06 %	68 %

Finishing in a single time = $\frac{1\ minute}{6.86\ minute} = 0.146$

Process Lead Time = $\frac{1}{0.146} = 6.85\ minutes$

Process Cycle Efficiency = $\frac{278.50\ seconds}{411.63} = 68\%$

The result shows that there is improvement for 53.6 % from 14.06 % turn out to 68%. The result shows that cycle efficiency process going smoothly with some unavoidable non-value-added-activity that cannot be eliminated. With the result of 68 % lead time process is good.

V. Conclusion

Based on the current condition and data analysis, it shows that wet line of PT. X has total lead time 3550 seconds. Value-added-activity is 499 seconds also process cycle efficiency is 14.06%. There are five actions which have been done in the wet line.

- Performing Work Process Training for operator.
- Making Work Instruction for process in the wet line.
- Modifying Tray Size become 49 cm x 49 cm.
- Re-arranging Quantity per tray from 30 pieces per tray become 15 pieces per tray.
- Adding one operator in the wet line for applying chemical 6125 process.
- Modifying working area based on the suggestion.

Based on suggested improvement, lead time decreases from 3550 seconds turn into 525.3 seconds. Process cycle efficiency increases from 14.06% turn into 56.73%. Project piloting in non-value-added activity. Lead time decreasing from 3550 seconds turn into 411.63 seconds. Process cycle efficiency increases from 14.06% turn into 68%.

References

[1] MIA, M. A. S., Nur-E-Alam, M. D., & UDDIN, M. K. Court shoe production line: improvement of process cycle efficiency by using lean tools. *Revista de Pielărie Încălţăminte*, (2017): *17*, 3.

[2] Jasti, N. V. K., Kota, S., & Sangwan, K. S. An application of value stream mapping in auto-ancillary industry: A case study. *The TQM Journal*, (2019): *32*(1), 162-182.

[3] Prasad, M. M., Dhiyaneswari, J. M., Jamaan, J. R., Mythreyan, S., & Sutharsan, S. M. A framework for lean manufacturing implementation in Indian textile industry. *Materials today: proceedings*, (2020): *33*, 2986-2995.

[4] Randhawa, J. S., & Ahuja, I. S. An investigation into manufacturing performance achievements accrued by Indian manufacturing organization through strategic 5S practices. *International Journal of Productivity and Performance Management*. (2018).

[5] Lubis, D. A., Pamungkas, I., & Irawan, H. T. (2020, December). Lean Manufacturing Approach to Minimize Waste in The Process of Sorting Palm Oil Using the Value Stream Mapping Method. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1003, No. 1, p. 012028). IOP Publishing.

[6] George, M.O., The Lean Six Sigma Guide to Doing More With Less,. New Jersey: John Wiley and Sons, 2010.

[7] Pamungkas, I., Irawan, H. T., & Arkanullah, L. Implementasi Statistical Process Control Untuk Pengendalian Kualitas Garam Tradisional Di Kabupaten Pidie. *Jurnal Optimalisasi*, (2020): *4*(2), 108-118.

[8] Akmal, A. K., Irawan, R., Hadi, K., Irawan, H. T., Pamungkas, I., & Kasmawati, K. (2021). Pengendalian Kualitas Produk Paving Block untuk Meminimalkan Cacat Menggunakan Six Sigma pada UD. Meurah Mulia. *Jurnal Optimalisasi*, *7*(2), 236-248.

[9] Gasperz, Vincent, Statistical process control Manajemen Bisnis Total,. Jakarta: PT. Gramedia Pustaka Utama, 1998.

[10] Brue, Greg, Six Sigma for Managers,. Jakarta: Canary, 2002.

[11] Pamungkas, I., & Iskandar, I. Defect Analysis for Quality Improvement in Fishing Boat Manufacturing Processes through the Integration of FMECA and Fishbone: A Case Study.