Production Process Waste Analysis with Lean Manufacturing Approach in Copper Crafts Industry

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Abstract

Competition in the industrial world is increasingly making manufacturing companies to continue to improve continuously the quality, price, quantity of production and timely delivery of their products to provide satisfaction to consumers/customers. In the research analyzed, namely the waste that occurs in thecopper craft industry UD. Setya Budhi, and this study aims to analyze waste and what are the factors causing it. This study uses a Lean Manufacturing approach with data processing using the Value Stream Mapping (VSM) and Failure Mode and Effect Analysis (FMEA) methods. The data needed for this research starts fromobservations of the work environment, facility lay-out, production flow and production time. As well as the stages of interviews and questionnaires to completethe required data. From the analysis using the Value Stream Mapping (VSM) method, the results obtained are 71.60% value added, 7.39% non-value added, andnecessary but non value added 21.01%, then the analysis uses the Failure Mode and Effect method. Analysis (FMEA) obtained the highest RPN value from Waste Defect of 252 points, Waste Waiting 590 points, Waste Transportation 600 points, and Waste Motion 700 points, which means that there is still waste that occurs in the company. So, it is necessary to have a significant evaluation of the layout of the facility or production layout and the provision of SOP classification in each department.

Keywords : waste, lean manufacturing, VSM, FMEA

INTRODUCTION

The current industrial era 4.0, along with time and technology that has developed with the times, competition in the industrial world is increasingly making the manufacturing industry continuously improve the quality, price, amount of production and timely delivery of its products to provide satisfaction to consumers/customers. One of the real efforts of the company from the production of goods to provide the best to consumers or customers is to reduce waste that has no added value in various matters including the provision of raw materials, material traffic, movement of equipment and machinery, movement of production operators, waiting for the process, rework and repair. The main idea is to achieve overall product efficiency by reducing waste.(Hazmi et al., 2012) The waste in question includes all excessive activities that have no added value in carrying out work activities. 7 waste in Japanese is known as MUDA, which was first introduced by Taiichi Ono (Siregar et al., 2019). Setya Budhi copper craft industry is located in Tumang Village, Cepogo District, Boyolali Regency. It is engaged in manufacturing, serving the manufacture of household appliances, mosque domes, and other home interiors, which are mainly made of copper and brass. To meet consumer demand, the copper craft industry uses the Make To Order (MTO) concept as a type of production.(Carlson, 2014)Where the product is done if there is an order through bargaining from the buyer and the company as well as by providing DP (Down Payment) to the company. Likewise, when taking the product ordered by each customer is different, the processing time is different because there are queues between work stations to work on a product, repair of defective products, the location of tools that are far from the operator which causes the production process to take longer. the percentage of the number of defective products is presented in table 1:

Table 1. The number of defective products in UD. Setya Budhi

Period	Number of Defects
March 2021	2.56%
April 2021	2.69%
May 2021	2.60%

Period	Number of Defects
Total	7.85%

The causes of product defects during the combustion process and the formation of copper are types of products that have a high level of difficulty, such as making lampshades and mosque domes. Within three months, the percentage of defective products is 7.85%.

Based on the problems that exist in the copper craft industry UD. Setya Budhi in Boyolali belonging to Mr. Yuli above, a solution is needed to reduce waste through a lean manufacturing approach where the concept of lean is needed. Thus, reducing wastage at UD. Setya Budhi, good product quality will be obtained and the goal in producing products according to consumer demand will be achieved properly and also provide satisfaction to consumers.

LITERATURE REVIEW

Research conducted by Reza (2018), with the research title "Identification of waste using the waste assessment model (WAM) method in the application of lean manufacturing to improve production processes". The purpose of this research is to provide a description of the existing glove production process, identify critical waste of the glove production process, identify critical waste problems and can recommend improvements for glove production. With the results of providing suggestions for improvements to the reduction of production defects, system maintenance, and improvement of management and production systems. In Research by Revelation (2013), with the title "Identification of waste on the production floor with the application of lean manufacturing at PT. Istana Tiara Surabaya". This research uses the Value stream mapping (VSM) method and the Failure mode and analysis effect (FMEA) method. With the aim of research to identify waste that occurs to minimize waste that occurs on the production floor, find the causes of waste at PT. Istana Tiara Surabaya, and provide the necessary technical responses. From his research, the results obtained are minimizing production time by reducing activities that are not needed during the production process, providing suggestions for improvement by minimizing waste on the production floor.

Armyanto et al., 2020 conducted a study entitled "Application of lean manufacturing with VSM (Value Stream Mapping) and FMEA (Failure Mode and Effects Analysis) methods to reduce Sardine production waste". With the results obtained found 3 types of waste identified, namely waiting time, unnecessary inventory, and defects. As well as providing recommendations for improvements to the production process and human resources. Research that has been done by Nasuha (2018) with the research title "Analysis of waste in the *wingko* production process using the Value Stream Mapping (VSM) method with the concept of lean manufacturing". With the conclusion, it provides a proposed improvement plan, namely worker discipline and clear and precise SOPs, eliminating waiting time, and providing forecasting based on historical data and calculating the safety stock.

Farah (2012) has conducted research entitled "The application of lean manufacturing to reduce waste at PT. ARISU". With the aim of research to identify waste that can cause non-value added at PT. ARISU, knowing what factors are the causes of waste at PT. ARISU, provides appropriate improvement proposals for the company. With the results of the study obtained 41.18% non-value-added activity in the production process. Provide suggestions for improvements including procurement of warning labels at each station, training on autonomous maintenance, making scheduled daily maintenance of machines (planned maintenance), and having a read tagging system.

The Lean concept is an ongoing effort to eliminate or minimize waste and the level of product added value in order to share value with consumers or customers. Lean's goal is to always increase customer value through continuous improvement of the ratio, including added value to waste (Gaspersz, 2007). Lean Manufacturing has the main goal of reducing waste. In their book Womack and Jones (1996) defines that waste is any human activity that uses energy sources but does not create added value" (Purnama RI et al, 2013). Value Stream Mapping aims to identify and reduce errors, losses, waiting times and increase added value leading to an increase in the company's production quality so that company productivity is expected to increase. Mapping process from current state mapping where each process in the material flow path becomes the object of the mapping. (Rother & shook, 2003). Failure Mode and Effect Analysis (FMEA) is a systematic method of identifying and preventing the formation of problems in products and processes. FMEA focuses on preventing defects, improving workforce safety and also providing satisfaction to consumers (Mcdermott, 2009).

RESEARCH METHODS

This research was conducted at the UD. Setya Budhi copper craft industry owned by Mr. Yuli, located in Tumang Village, Cepogo District, Boyolali Regency. The object of this research is waste analysis with a lean manufacturing approach carried out in the copper craftsman industry UD. Setya Budhi. The first stage is data collection. Collecting data in this study using the following methods:

1. Observation

   Conducting observations in the production section of the copper craft industry. This method is carried out in order to gain direct knowledge on the copper craft production line, to identify problems and waste in the company's current condition of the object of research.

2. Interview

Interviews to obtain about the availability of the necessary data in problem solving and analysis. In this study, the data collected are primary and secondary data, primary data is data obtained directly from the company by direct observation and interviews with related parties.

3. Study of literature

Literature study is useful in obtaining theoretical data. Literature study aims as a basis in solving problems in this study. The purpose of the literature study in this study was to determine the causes of waste.

DATA PROCESSING

The stages carried out in this study regarding the occurrence of waste are as follows:

1. Creating Value Stream Mapping (VSM).

At this stage, observations are carried out in advance to find out the time it takes for each department to complete a product, from the process of cutting, burning, forming, burning, initial finishing and then final finishing. Value Stream Mapping aims to identify and reduce errors, losses, waiting times and increase added value leading to an increase in the company's production quality (Carlson, 2014).

2. Creating Your Failure Mode Effect Analysis (FMEA).

At this stage a potential analysis is carried out - the potential for product defects or effects that can result in failure in the production process to be able to determine the severity, occurrence, and detection. After that calculate the Risk Priority Number (RPN) to be able to determine the next action to reduce or eliminate the potential for high-risk failure (Armyanto et al., 2020)

RESULTS AND DISCUSSION

Value Stream Mapping (VSM)

Based on the flow of information as well as the flow of material that has been made, then draw the VSM in its entirety. The following is a picture of the results of Value Stream Mapping in the copper craft production process:
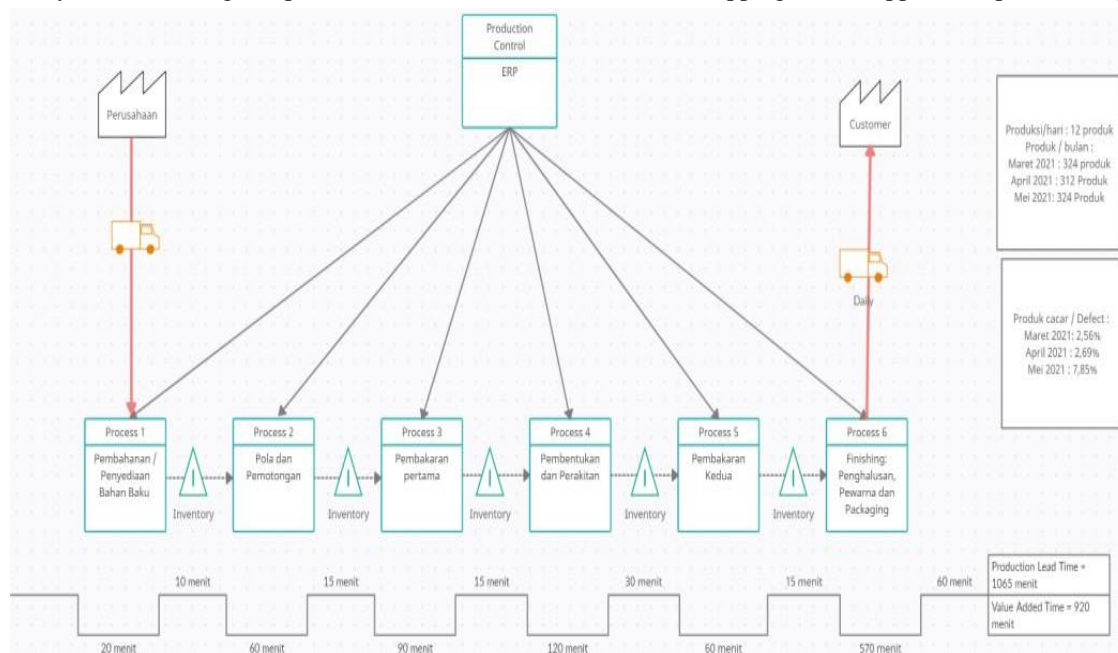
Figure 1. Value Stream Mapping

From the results of Figure 1 value stream mapping (VSM) it can be identified by description of the waste or waste that occurs in 6 stages of the production process. As many as 9 workers in the production section, the value of the level or 7 types of waste that occurs is calculated and the results are obtained as shown in table 2 below (Tetteh & Uzochukwu, 2014).

Table 2. Analysis of the calculation of the value of 7 Waste

No	Name	Part	Over Pro-duction	Wait-ing	Transporta-tion	Excess Pro-cessing	Inven-tory	Mo-tion	De-fect
1	Mugi Harjito	Assem-bly	2.67	4	4.67	2.67	4.33	5.00	3
2	Igna-tius Kristia	For-mation Copper	2.00	2	3.33	2.33	3.33	4.00	2.2
3	Abdul Rosyid	Coloring Finish	3.67	3,667	4.67	3.33	3.67	4.33	3.8
4	Heru Jatmiko	Finishing	1.33	2,667	4.33	2.00	2.67	4.00	1.8
5	Suyadi	Burning	2.33	2,667	4.33	2.00	3.00	4.33	2.4
6	Giyanto	Pattern and cut-ting	1.33	2,333	4.33	2.33	2.67	4.33	4
7	Pardi	Cutting	1.33	2,667	3.67	2.00	2.67	4.00	1.8
8	Eko Harsono	Formation Copper	2.67	3,667	4.33	3.33	3.67	5.00	3.2
9	Joko Susilo	Finishing	2.00	2,333	4.67	2.00	3.33	4.33	1.8

One of the calculation formulas carried out is as follows:

The formula for 7 forms of waste:

$$\frac{number\ of\ respondents'answer}{number\ of\ respondents'question}$$

After carrying out the value/weight analysis process of the 7 forms of waste, the following steps are carried out by calculating the weight of the waste using the value stream mapping (VSM) base reference table (Rochmoeljati et al., 2019).

Based on the results of the analysis of the production mapping activity process, it can be seen that the type of VA (Value Added) activity is 12 activities. More details are shown in percentage form in table 6.

Table 3. Results of Analysis of VA, NVA, and NNVA values

Activity Type	Production Process Time	Weight	Percentage
VA	920 minutes	0.72	71.60%
NVA	95 minutes	0.07	7.39%
NNVA	270 minutes	0.21	21.01%
TOTAL	1285 minutes	1	100

Based on the results of the analysis above, it shows that the dominance of VA is still 71.6%, then NNVA is 21.01% and NVA is 7.39%. This means that there are still activities that need to be improved because these activities do not have meaningful activities such as the types of NVA and NNVA activities.

Failure Mode and Effect Analysis (FMEA)

In the design of failure countermeasures that are tried by the industry. Criteria for severity, occurrence, and detection are presented in the table below:

Table 4. Criteria for Severity in general

Severity	Information	Rating
There isn't any	Does not affect the production process.	1
There is	Has an influence on the production process, but can be ignored.	2
There always is	Giving effect to the production process,	3

Severity	Information	Rating
Very low	Give effect to the production process and provide a delay of <15 minutes.	4
Low	Stop the production process for 15-30 minutes.	5
Currently	Stop the production process for 30-60 minutes.	6
Tall	Stopping production > 60 minutes, but < 1 day	7
Very high	Stopping the production process for 1-3 days.	8
Dangerous	Stopping the production process for > 3 days.	9
Very dangerous	Stop the production process > 10 days.	10

Table 5. FMEA Table of Critical Defect Waste, Critical Waiting. transportation critical and critical Transportation

Potential Failure	Potential Effect	Severity	Potential Cause	Occurrence	Control	Detection	RPN
Waste Critical Defect							
There are holes or breaks in the part of the product that is cracked	The product has holes or breaks so it must go to the repair process	4	Not-too-Specific Thickness Measure	8	Copper Size Check	6	192
		4	Process Burning Too Long	7	Given a specific time and temperature measurement for combustion in accordance	9	252
Waste Critical Waiting							
Waiting for repair of defective products	Production has been delayed or even stopped in time certain	6	Scheduling for technicians is only done at certain times	8	No specific recommendation has been made yet company	5	240
	Production process gets stuck on one line	7	There is no SOP for classification and handling of defective products	10	No specific recommendations have been made by the company yet	5	350
Waste Critical Transportation							
Transport of raw materials to the production floor is long	Delivery of raw materials to the production process is hampered	5	There are no tools to transport raw materials and it is done manually	10	Added trolley and pallet facilities	5	250
Transportation of semi-finished products from one process to another takes a long time	Delivery of semi-finished products takes a long time so it slows down production process	7	Poor layout arrangement, and the presence of tools or materials that are not in the right place	10	Evaluating production layouts and giving light advice to workers	5	350

Potential Failure	Potential Effect	Severity	Potential Cause	Occurrence	Control	Detection	RPN
			Waste critical motion				
Workers go back and forth looking for tools or materials	The production process can result in delays	7	Poor layout arrangement, and the presence of tools or materials that are not in the right place	10	Make a SOP regarding production equipment	5	350
Layout conditions that are not yet ergonomic and efficient	Lots time-consuming when transporting half products so	7		10	Evaluate production layout	5	350

Based on the RPN value in the FMEA questionnaire, the root cause of the problem that produces the highest RPN value is obtained. Then carried out an analysis of proposed improvements that can be implemented by the company. Corrective steps are taken according to the RPN value of more than 198 obtained from the total waste weight score.

Discussion

The results show that there are 6 production processes or stages of copper manufacture in lamp cover products, as well as copper cocktail tables. In the manufacturing process, the value stream mapping analysis shows that there are production process activities that are identified as experiencing waste due to the difference between the existing lead time and the value added of 145 minutes/day (1065 minutes – 920 minutes) so that with 7 waste items, analyzed with 7 activity mappings, a rating of 1 is produced on the process activity mapping with a total waste value of 6.36 points, meaning that the greatest waste or waste occurs in the production process activities that have been carried out by the company.

Table 6. Recommendations for Improvement

Waste	Sub Waste	RPN	Repair steps
Defect	There are holes or cracks in the product that is cracked.	252	Given a specific time and temperature measurement for combustion in accordance
	Production has been delayed or even stopped within a certain time	240	More specific defect product handling scheduling.
Waiting	The production process becomes hampered in one line.	350	Making SOP for classification and handling of defective products
	Transporting semi-finished products from one process to another takes a long time	350	Evaluating production layout and giving light advice to worker
Transportation	Freight *raw materials* to the old production floor	250	Added trolley and pallet equipment facilities.
Motion	Workers go back and forth looking for tools or materials	350	Making SOPs regarding production equipment.
	Layout conditions that are not yet ergonomic and efficient	350	Evaluate the production layout.

CONCLUSION

and data processing that has been analyzed, then obtained some conclusions. The conclusions obtained from the research that has been done are as follows:

1. Based on the results of the waste analysis using the Lean Manufacturing approach, it can be seen that the company got the highest score in the types of Waste Transportation and Waste Motion, namely 1,739 and 1,785. The impact and failure of the product occurs in the process of the first combustion stage.

2. The cause of waste in the Waste Defect is because in the first combustion stage there is an uneven thickness size and because there is no combustion control.

3. Proposed improvements made to minimize waste that occurs. The Waste Defect category is given a specific time and temperature measurement so that the combustion is appropriate, the Waste Waiting category is a more specific schedule for handling defective products and making SOPs for classification and handling defective products, the Waste Transportation category evaluates production layouts and gives light advice to workers and adds equipment facilities trolleys and pallets, and the category of Waste Motion for making SOPs regarding production

equipment.

REFERENCE

Armyanto, HD, Djumhariyanto, D., & Mulyadi, S. (2020). Application of Lean Manufacturing with VSM and FMEA Methods to Reduce Sardine Production Waste. Journal of Energy And Manufacturing, 13(1), 37–42. https://doi.org/10.24843/jem.2020.v13.i01.p07.

Carlson, CS (2014). Understanding and Applying the Fundamentals of FMEAs. 2014 Annual Reliability and Maintainability Symposium (RAMS), 12.

Hazmi, FW, Dana, P., & Supriyanto, H. (2012). Application of Lean Manufacturing to Reduce Waste at PT ARISU. Journal of Its Engineering, 1(1), F-135-140.

Rochmoeljati, R., N, Y., & Firmansyah, RD (2019). Waste Analysis In Edamame Production With Lean Manufacturing Method At Pt. Mitratani Dua Tujuh Jember. Tekmapro : Journal of Industrial Engineering and Management, 14(2), 51–59. https://doi.org/10.33005/tekmapro.v14i2.55.

Siregar, K., Ariani, F., Ginting, E., & Trie Dinda, MP (2019). Lean six sigma for manufacturing industry: A review. IOP Conference Series: Materials Science and Engineering, 505(1). https://doi.org/10.1088/1757-899X/505/1/012056.

Tetteh, EG, & Uzochukwu, BM (2014). Lean Six Sigma Approaches in Manufacturing, Services, and Production. In Lean Six Sigma Approaches in Manufacturing, Services, and Production. https://doi.org/10.4018/978-1-4666-7320-5.

McDermott, RE (2009). The Basic of FMEA 2nd Edition. USA: CRC Press.

Gaspersz, V. (2007). Lean Six Sigma for Manufacturing and Services Industries. Jakarta: PT Gramedia Pustaka Utama.