LEAN AND GREEN MANUFACTURING DESIGN AT SMES'S MADURA SHIPYARD WITH VALUE STREAM MAPPING TOOL AND SIMULATION MODEL

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ABSTRACT

Madura shipyard has a responsibility to improve the efficiency of its production system. The problems faced in increasing the efficiency of the production system are: (1) The existence of waste work shop such as product defect, over production, excessive transportation, Inappropriate Processing, Unnecessary inventory, Unnecessary motion, and waiting time occurring in the production process Madura vessel (2) Still non value adding activity that happened ship production process at Madura shipyard. and (3) Due to the absence of waste work shop and non value adding activity, the efficiency of ship production process in Madura shipyard can not be reached maximally

In this research, it will be designing the system in ship production process using Simulation method, Value Stream Analysis Tool (VALSAT) to solve the inefficiency problem that happened in ship production process at Madura shipyard. The design process is by integrating the Simulation method, Value Stream Analysis Tool (VALSAT), Response Surface Methodology, and Analitycal Hierarchy Analysis (AHP). The simulation method is used to model the ship production system and lean manufacturing system designed in Madura shipyard, while the VALSAT method is used to identify waste workshops, map the value adding activity and non value adding activity that occurs in the ship production process in the Madura shipyard. To measure the performance of designed lean manufacturing system is done experiment and optimization with Response Surface Methodology method. Multi performance criteria measurement using Analitycal Hierarchy Process (AHP) method with work in process, waiting time, and flow time criteria is used to determine optimal lean manufacturing system.

For the first year of research, the highest waste weights in SME shipyard of Bangkalan Madura are Excessive Transportation with 2.4 weight, Unnecessary Inventory with weight of 1.66, and Over Production 1.26. From the Value Stream Analysis Tool, the highest value mapping tool is activity process mapping, supply chain response matrix, and demand amplification mapping. Based on the activity mapping process for hull construction, outfitting machinery, electrical outfitting obtained value adding activity in SMEs's Bangkalan Madura shipyard is still low. Value adding activity based on operating time is 70%. To know the root cause of waste in this research used fishbone diagram for each type of waste

Keywords: Lean Manufacturing, simulation model, VALSAT, waste workshop, non value adding activity, Analytical Hierarchy Process (AHP)

INTRODUCTION

Madura shipyard, which has a core business in ship building and ship repair, is a national shipbuilding company that has international standard and has standard ISO 9001. The sharp depreciation of the rupiah gives a considerable export market opportunity for the national shipyard that has been standardized national such as the Madura shipyard. Given the increasing need for new ships in the world of around 35 million BRT / yr, while the production capability of only about 15 million BRT / year, including about 100,000 BRT / year supported by the national ship industry, provides substantial opportunities for growth Madura shipbuilding industry. In addition to these opportunities, many challenges to be faced by the national shipbuilding industry such as:

i. The development of shipyards (towards) to the same market segment, including the growth of shipyards with PMA facilities around the island of Batam and Karimun islands.
ii. The development of shipyards in the Philippines that are geographically close to Indonesia.
iii. Limited technological mastery, and the quality of existing human resources, make Madura's shipyard still difficult enough to compete in the global market.
iv. Difficulties in bidding and fulfilling payment systems that are generally applicable to international orders, as a result of weak long-term funding.

In the face of the rapid demand and competition in the ship industry in Indonesia and the world today, let alone supported by the needs and opportunities of the new shipbuilding sector to strengthen the national fleet and national economy in the future, the Madura shipyard is expected to immediately make changes- changes in the company it has. These changes are not only done in the managerial system of the company but also the most important must make changes to the system of production, especially efforts to improve the efficiency of production systems.

The design of lean manufacturing system to solve the inefficiency problem in ship production process at Madura shipyard, considering that in a whole manufacturing process from product design, raw material purchasing, process to delivery of finished product, almost always can be found the real thing need not be done, do not give added value or things that are too much in doing it. This is commonly called "wastehold" or waste workshop. Lean's approach aims to eliminate waste elimination and non-value added activity, smooth the flow of material, products and information, and continuous quality improvement. According to Gaspersz and Fontana (2011), Lean explains that it is a continous improvement effort to eliminate waste, and to increase the value added of products (goods and or services), in order to deliver results to customers (customer value).According to Heizer and Render (2009), Waste occurs in the factory business processes that are often found such as defective products, excess inventory, time wastage and so forth.

RESEARCH OBJECTIVES

Specific objectives of this research are as follows:

1. Designing Lean Manufacturing System on ship production process at madura shipyard by integrating Value Stream Analysis Tool (VALSAT) and Simulation Method.
2. Create value stream mapping for ship production process at Madura shipyard.
3. Designing lean manufacturing system simulation model on ship production process at madura shipyard.

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4. Identify waste workshops and non value adding activity in ship production process at madura shipyard.
5. Maximize the efficiency of ship production system in Madura shipyard with minimize product defect, over production, Excessive transportation, In appropriate Processing, Unnecessary inventory, Unnecessary motion, and waiting time on ship production process at Madura shipyard.

RESEARCH METHODOLOGY

Lean Manufacturing System Design

Determining Products and Family Products (Part Family)

The first important step to do when developing a value stream map is to identify the product and the family of the product or part family (the product group that passes the same process and use the same public equipment and resources). There are two methods used to identify the family of products (Part family):

Product Quantity Analysis

Product quantity analysis is used to see which product has the highest production volume. In this method is made pareto diagram to see which product which production reach 80% from total production.

Product Route Analysis (Production Process Matrix)

Production Process Matrix is a matrix that contains all types of products that are in a value stream.

Value Stream Mapping (VSM) -Current State

At this stage it is done by mapping individual products, product groups and product lines along the value stream process. VSM is an important planning tool for identifying critical improvements that can contribute to and influence business significantly by seeking companies to identify waste and sources to value a process stream. When creating a value stream map, it is important to focus on one product family at a time. The rule of thumb is to create a map for the highest-volume product first.

Identify Waste Workshop

Stages of identification of waste, in this penelitin intended to obtain information about waste that occurs in global systems using questionnaires. The questionnaire is based on the conditions and characteristics of the system on possible waste (Environment, Healtyand Safety (EHS), Defect / Rework, Overproduction, Waiting Time, Not Utilizing Employee Knowledge, Skill and Ability, Excessive Transportation, Unnecessary Inventories Unnecessary Motion, Inappropriate Processing.

Determination of the Key Performance Indicator

Determination of some key performance measures of value stream process such as process cycle efficiency, lead time, Overall Equiment effetiveness.

Value Stream Analysis Tool (VALSAT)

At this stage that is done is:

1. Determine tools with value stream mapping tool to identify the waste that occurs, and to know the group of non-value added activities of each process along the value stream.

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2. Conduct factor analysis to determine the factors causing waste that occurs in the system by using fishbone diagram.
3. Analyze the failure mode using Failure Mode and Effect Analisys (FMEA) by looking at the greatest value of RPN to find out the most serious problems that occur.

Value Stream Mapping-Future State

Describe the future state map based on predetermined priority solutions, to understand the state of the upcoming system plan.

Preparation of Simulation Program

The selection of software to be used in the simulation will have a major impact on the success of the researcher. This will affect the model's accuracy, model validity, execution time, and overall research completion time.

RESULTS AND ANALYSIS

Big Picture Mapping

Big Picture Mapping is a high-level process mapping that encompasses a broad process but with a low level of detail. This tool is very helpful in identifying waste in SME Madura shipyard. Wasting can be known by knowing the physical flow and information of the company and describing it in one unity. Picture big picture mapping for SME Shipyard Madura as shown in Figure 1

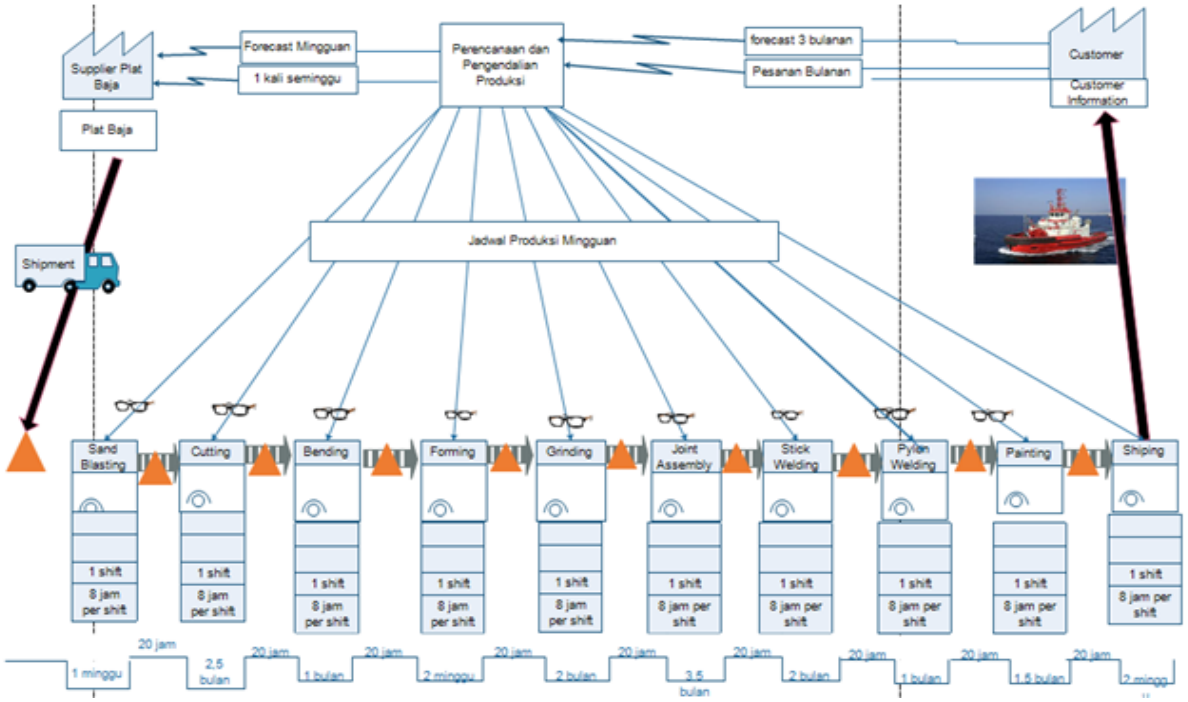

Figure 1 Big Picture Mapping for SME shipyard of Bangkalan Madura

Identify Waste Workshop

VALSAT begins with a Waste Workshop that is the method of extracting information to obtain as much input as possible about the waste that occurs in the system. The main objective and Waste Workshop is to equate perceptions about waste so as to obtain common goals that will facilitate improvement.

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In this study, Waste Workshop is done by interviewing process by filling questionnaires on personnel who are considered representative of Value Stream production system in SME Madura Shipyard. The person reads a description of every waste and gives a score for each waste according to what they observe in the company. The Waste Workshop questionnaire format is listed in the appendix. The results of the Waste Workshop questionnaire can be seen in table 1

Table 1. Waste Workshop

No	*Waste*	*Skor*	*Ranking*	*Description*
1	*Over Production*	1.26	**3**	For the scores obtained from the total waste of all activities obtained from the dissemination waste workshop, selected the smallest to be used as a divider.
2	*Waiting*	1.16	**4**	
3	*Excessive Transportation*	2.40	**1**	
4	*Inappropriate Processing*	1.14	**5**	
5	*Unnecessary Inventory*	1.66	**2**	
6	*Unnecessary Motion*	1.00	**7**	
7	*Defects*	1.08	**6**	

Value Stream Analysis Tools (VALSAT)

Value stream analysis tools is obtained from the multiplication of the average of each type of waste, the results of waste identification with the correlation value between tools with waste occurred, for more details can be seen in the table value stream analysis Example table calculation of the correlation of waste tools:

Table 2. Correlation Waste Against Tool

	Tools						
Waste	*Process Activity Mapping*	*Supply Chain Response Matrix*	*Production Variety Funnel*	*Quality Filter Mapping*	*Demand Amplification matrix*	*Decision Point Analysis*	*Phisical Structure*
Over Production	*L*	*M*		*L*	*M*	*M*	
Waiting	*H*	*H*	*L*		*M*	*M*	
Transport	*H*						*L*
Inappropriate Processing	*H*		*M*	*L*		*L*	
Unnecessary Inventory	*M*	*H*	*M*		*H*	*M*	*L*
Unnecessary Motion	*H*	*L*		*H*			
Defects	*L*						
Overall Structure	*L*	*L*	*M*	*L*	*H*	*M*	*H*

Where *H : High Correlation, M: Medium Correlation, L : Low Correlation*

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Table 3. VALSAT

Waste	Bobot	Tools						
		Process Activity Mapping	Supply Chain Response Matrix	Production Variety Funnel	Quality Filter Mapping	Demand Amplification matrix	Decision Point Analysis	Phisical Structure
Over Production	1.26	1,3	3.9		1,3	3,9	3,9	
Waiting	1.16	10,44	10,44	1,16		3,48	3,48	
Transport	2.40	21,6						2,4
Inappropriate Processing	1.14	10,26		3,42	1,14		1,14	
Unnecessary Inventory	1.66	4,98	14,94	4,98		14,94	4,98	1,66
Unnecessary Motion	1.00	9	1		9			
Defects	1.08	1,08						
Total Bobot		57,66	30,28	9,56	11,44	22,32	13,5	4,06
Ranking		*1*	*2*	*6*	*5*	*3*	*4*	*7*

So based on VALSAT (Value Stream Analysis Tool) method, then the mapping tool used is Process Actifity Mapping, Supply Chain Response Matrix, and Demand Amplification Matrix

Process Activity Mapping for Hull Outfitting

Based on observation on production process of outfitting system, can be made activity mapping process for hull outfitting system as follows:

Table 4(Part-I).. Proses Activity Mapping for Hull Outfitting

No.	*Phase*	*Activity*	*Activity Type*					*Machine /facility*	*Distance (m)*	*Time (days)*	*Amount f Labor*
			O	*T*	*I*	*S*	*D*				
1	Werehouse	Handling Material		T				Forklip & Crane	40	2	8
2		Shop Blasting & Shop Primer	O					sandblast, air compressor, paint	50	10	10
3		Handling material		T				Forklip	10	3	2
4		Ident Material			I			Pencil & paper	50	5	2
5	Fabrication shop	Handling material	O					Forklip & Crane	8	2	2
6		Marking	O					Solid Marker	15	17	5
7		Handling material		T				Forklip & Crane	10	3	8
8		Cutting manual	O					Cutting Blander	6	21	12
9		Handling Material		T				Over Head Crane 10 ton	15	3	8

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Table 4(Part-II). Proses Activity Mapping for Hull Outfitting

No.	Phase	Activity	Activity Type					Machine /facility	Distance (m)	Time (days)	Amount f Labor
			O	T	I	S	D				
10		Bending	O					Bending Machine	15	12	6
11		Waktu tunggu					D			2	8
12		Pengiriman bahan baku ke lapangan		T				Forklip & Crane	35	2	8
13		Fit Up Scantling Part	O						10	14	12
14	Sub Assembly Shop	Welding	O					Welding Machine & Personal protective equipment	10	15	12
15		On Board Test			I			Stop Watch & Thermometer	25	3	6
16		Painting	O					Air Compressor, paint	16	4	10
Total										*118*	
Operation			8	5	2		1			*95*	
% Value Adding			50	31	13		6			*80*	

Table 5. Activity Type on 10 Hull Outfitting Time Needs

	Operation	*Transportation*	*Inspection*	*Storage*	*Delay*	*Total*
Total Time	95	13	8		2	118
Prosentase (%)	80	11	6,7		1,6	100

Based on the observations made for Hull Outfitting, there were 16 activities with a total time of 118 days. Table 4 shows the mapping activity for hull outfitting, while table 5 shows the time required for each type of activity on hull outfitting.

Demand Amplification Mapping

In the face of the rapid demand and competition in the ship industry in Indonesia and the world today, let alone supported by the need and opportunities of the new ship building sector to strengthen the national fleet and national economy in the future, the SME Madura Shipyard, is expected to immediately conduct changes in the production system, especially efforts to improve the quality of the products it produces and the need to provide defect-free products, ie products that work as expected and meet customer requirements.

To complete the process of activity mapping and to know the fluctuations in demand for tug boats commonly produced in Madura shipyard during the last year then in this study also made demand amplification mapping.From the demand amplification mapping it can be seen

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that the fluctuations in demand for the world's tug boat boat occupy the largest percentage. Tugs is the largest part of the world's ship fleet with 16,804 vessels. The next largest part is taken by the General Cargo ship (8,777 ships). Followed by passenger ferry (4,902 ships), small product tank (2,678 ships), Dredgers (1,365 vessels). Demand for tugs is projected to grow by 3.6% - 4.0% p.a. in 2015-2017. Dengan see the situation and conditions such SME Shipyard Madura, must restructure, both restructuring in the field of management and in the field of production system. Restructuring in the production field means making efficiency in its production system. In this research, efficiency in the production system is directed to the creation of lean manufacture, by eliminating waste workshop and non value adding activity in the production system.

Cause and Effect Analysis

Cause and Effect analysis (fishbone diagram) is a tool that can be used to identify the root cause of the problem. Fishbone diagram in this research is used to analyze the root cause of waste that occurred in Madura shipyard. Filling the waste questionnaire is addressed to employees who really know the condition of ship production process in SME Madura shipyard. The result of the questionnaire is a critical waste of 7 waste that occurs. From these results can be built a cause and effect analysis to identify the impact and root causes. Cause and effect analysis in this research can be seen in figure 2. as follows:

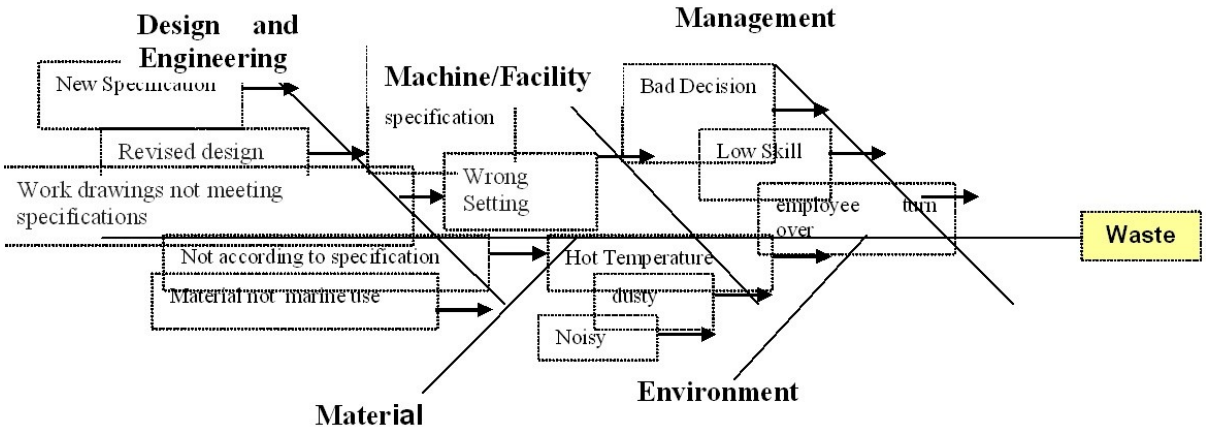

Figure 2. Cause and Effect Analysis

CONCLUSION

Conclusions drawn from the research on lean manufacturing design in SME shipyard Bangkalan Madura are as follows:

1. Based on Big picture mapping for current state condition, ship production process in UKM shipyard of Bangkalan Madura still not optimal, because there are still many ship time of completion still not on time. So it creates a penalty cost, which causes a big loss for the company.
2. From the results of waste identification obtained waste that has the highest weight in SME shipyard Bangkalan Madura is Excessive Transportation with weight 2.4, Unnecessary Inventory with weight 1.66, and Over Production 1.26.
3. From the Value Stream Analysis Tool, the highest value mapping tool is activity process mapping, supply chain response matrix, and demand amplification mapping
4. Based on the activity mapping process for hull construction, outfitting machinery, electrical outfitting obtained value adding activity in SMEs Bangkalan Madura shipyard is still low. Value adding activity based on operating time is about 70%.

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5. To know the root cause of waste in this study used fishbone diagram for each type of waste.

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