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by Yugowati Praharsi

Lean Management and Analysis - An Empirical Study of a Traditional Shipbuilding Industry in Indonesia

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Abstract

Indonesian shipbuilding industry is a labor intensive business. There are several stages and activities in shipbuilding that needs process efficiency and cost reduction. In this study, we implement the lean management to eliminate waste and create value. We start by identifying the critical wastes in the traditional shipbuilding industry. Subsequently, we prioritize the waste using analytical hierarchy process and investigate the source and reason by fishbone diagram. The result showed that the process of dropping the ship into the sea that causes the bottom of the ship break down is the most critical waste. Several root causes are analyzed by fishbone diagram, such as: men, material, method, and environment. Based on the results of the Risk Priority Number assessment, it can be inferred the highest priority of broken-down vessel that is the rocky environmental conditions when the ship drops to sea. The lowest priority is the limitation of equipment, which causes the process of dropping ships to sea not straight. Furthermore, all the main causes are given an improvement proposal in order to minimize the risk of the bottom of the ship break down during the process of dropping ship to sea.

Keywords: Lean management, shipbuilding industry, Analytical Hierarchy Process, Indonesia

1. Introduction

The focus of lean management is to eliminate wastes and create value. The seven wastes in lean management concept most relevant to shipbuilding industries are: (1) transportation, (2) inventory, (3) motion, (4) waiting, (5) over-processing, (6) overproduction, and (7) defects. The waste of transportation refers to the movement of products in between processes. Processes should be as close as possible and material flow directly from process to process without any significant delays in between. The waste in transportation can be a very costly since transportation does not add any value to the product. The other waste which should be reduced as much as possible is inventory which increases redundant materials and add the cost without adding any value to the product. The waste of motion refers to the movement within a process that does not add value. The waste of waiting refers to any idle time produced when two interdependent processes are not completely synchronized. Waiting time is due to unsynchronized machines, products, people, and information that results in ineffective process. The waste of overproduction is due to the overproduction of a product that results in work-in-process and surplus stock. The waste of over-processing is caused by a lack of standard operations practice (SOP) and unclear specification/quality acceptance standards. Since product defects require rework or replacement, it results in a waste of resources and materials. Therefore, it is more effective to eliminate or reduce defective products.

There are several studies about lean management. Cherrafi et al. (2017) studied the barriers in green lean implementation. They found that there were fifteen significant barriers which were classified into linkage and dependent ones. Villareal et al. (2016) studied lean in road transport operations. The results showed that the number of distribution routes and distance travelled were reduced by 21% and 32%, respectively. Garza-Reyes et al. (2018) investigated the impact of lean methods, such as Just In Time, autonomation, kaizen/continuous improvement, total productive maintenance and value stream mapping on four utilized measures for the compliance of environmental performance, such as material use, energy consumption, non-product output, and pollutant releases. Sharma and Gandhi (2017) studied and verified scope and impact of implementing lean in shipbuilding. Babur et al. (2016)

proposed a lean-oriented occupational health and safety system in shipbuilding industry. This study is motivated by their initiatives.

In this study, we will start by identifying the critical wastes in the traditional shipbuilding industry. Through the application of lean concepts, we hope to improve manufacturing process efficiency and cost reduction. The final objective is to create value for the shipbuilding industry. To improve the overall efficiency of the industry, performance measures and evaluations are conducted on important criteria such as on time project delivery, material procurement, waste reduction, continuous improvement and production process. We will then investigate the source and reason for the wastes. We will start with the waste that is most critical, and try to eliminate it by using Analytical Hierarchy Process (AHP) method and fish bone diagram. We hope to deliver some practical improvement in the industry. Finally, we will help the industry to develop a framework to reduce cost and add value to the industry.

The rest of the paper is organized as follows. The research methodology is presented in section 2. Section 3 discusses the waste activities, the weighting results of waste with AHP, the Failure Mode and Effect Analysis (FMEA) method, and the proposed improvements. Finally, section 4 presents conclusions, limitations, and direction of future research.

2. Research Methodology

The research methodology used is shown by Figure 1. Based on Figure 1, this research study was started with brainstorming about activities that cause waste in the form of delays in completing the construction of traditional wooden ships followed by grouping activities including waste into the seven waste categories. Then, the seven waste category and subcategory in the form of waste activities are given a value for weighting by 3 expert judgments, where weighting is done by AHP through Expert Choice software 11. The highest weight will be analyzed for the root cause through fishbone diagrams. Then the root causes based on fishbone diagrams will be assessed by RPN (Risk Priority Number) using FMEA. The results of the RPN assessment are proposed by improvements in order to minimize the risk of the causes that happen in the future.

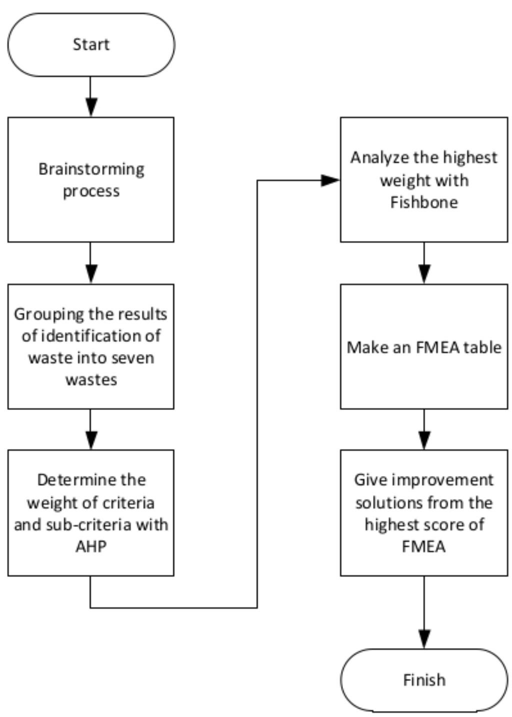

Figure 1. Research methodology

3. Result and Discussion

3.1 Waste activities of building traditional ships

The following in Table 1 is an activity grouping that causes waste based on 7 wastes

Table 1. Grouping activities based on 7 wastes

Seven Waste Category	Causes of Waste Activities
Inventory	There are lots of nails left in the storage
	There are lots of bolts left in the storage
	There are lots of glues left in the storage
	There are lots of paints left in the storage
Waiting	
	waiting for the arrival of slabs from suppliers
	waiting for making a net pulling machine holder
	Waiting for the bending process of wood using firewood
	Waiting for the removal of wood by human power to be installed on the part of the ship
	Waiting for the re-clapping process
	Use of rest times that pass the specified time limit
	Use of stairs that are not permanent
Over Processing	Use of putty which is too thick
	The use of the second layer with epoxy is too thick
	The use of the third layer with red paint is too thick
Defect	The combustion process to bend the wood which makes cracked wood
	Inaccurate wood cutting causes leftover woods
	Installation the certain parts of the ship causes cracked wood
	The process of dropping the ship into the sea causes the bottom of the ship break down
Over production	Too many bending of wood
	Too many wood cutting
Motion	Smoking activities when working hours are still ongoing
	The worker cooking fish because there are people who bring fish from the sea until they forget that they don't work at all

Based on Table 1, there are 4 activities that cause waste in the inventory category; 7 activities that cause waste in the waiting category; 3 activities that cause waste in the category of over processing; 4 activities that cause waste in the defect category; 2 activities that cause waste in the category of overproduction; and 2 activities that cause waste in the motion category. Furthermore, the weighting of AHP was carried out to determine the highest risk activity. In this study, the waste of transport cannot be found in the building process of traditional boats because all the materials needed have been prepared nearby those boats.

3.2 Weighting Result of Waste with AHP

Ships construction activities that cause waste was conducted an assessment by expert judgment with AHP and the result obtained are processed with Expert Choice 11 software. There are two weightings was conducted, weighting the biggest risk comparison between the seven waste categories, and weighting the comparison between the activities of each of the seven waste categories. The weighting results are shown in Table 2.

Table 2. Weighting of AHP

Seven Waste Category	Weight	Causes of Waste Activities	Weight	Global Weight
Inventory	0.081	There are lots of nails left in the storage	0.050	0.00405
		There are lots of bolts left in the storage	0.546	0.04423
		There are lots of glues left in the storage	0.225	0.01823
		There are lots of paints left in the storage	0.179	0.01450
Waiting	0.101	Waiting for the arrival of slabs from suppliers	0.110	0.01111
		Waiting for making a net pulling machine holder	0.436	0.04404
		Waiting for the bending process of wood using firewood	0.128	0.01293
		Waiting for the removal of wood by human power to be installed on the part of the ship	0.037	0.00374
		Waiting for the re-clapping process	0.177	0.01788
		Use of rest times that pass the specified time limit	0.081	0.00818
		Use of stairs that are not permanent	0.032	0.00323
Over Processing	0.27	Use of putty which is too thick	0.489	0.13203
		The use of the second layer with epoxy is too thick	0.344	0.09288
		The use of the third layer with red paint is too thick	0.167	0.04509
Defect	0.283	The combustion process to bend the wood which makes cracked wood	0.080	0.02264
		Inaccurate wood cutting causes leftover woods	0.098	0.02773
		Installation the certain parts of the ship causes cracked wood	0.076	0.02151
		The process of dropping the ship into the sea that causes the bottom of the ship break down	0.745	0.21084
Over production	0.106	Too many bending of wood	0.309	0.03275
		Too many wood cutting	0.691	0.07325
Motion	0.159	Smoking activities when working hours are still ongoing	0.108	0.01717

Seven Waste Category	Weight	Causes of Waste Activities	Weight	Global Weight
		The worker cooking fish because there are people who bring fish from the sea until they forget that they don't work at all	0.892	0.14183

Based on Table 2, it can be known from the weighting of AHP conducted, that the level of risk among the highest categories is a defect with a weight of 0.283. Next is a global weighting calculation. Global weighting is the multiplication of seven wastes category weights with the weight of the causes of waste activities that have been compared with each other within the same category. The result is the highest-risk level of the activity that causes waste which is the process of dropping the ship into the sea which makes the bottom of the ship break down with a weight value of 0.21084. This highest weighting activity will be analyzed for the root cause in the Fishbone diagram (Ishikawa, 1994) and given a proposed improvement after the expert assigns a value to the FMEA in Table 3.

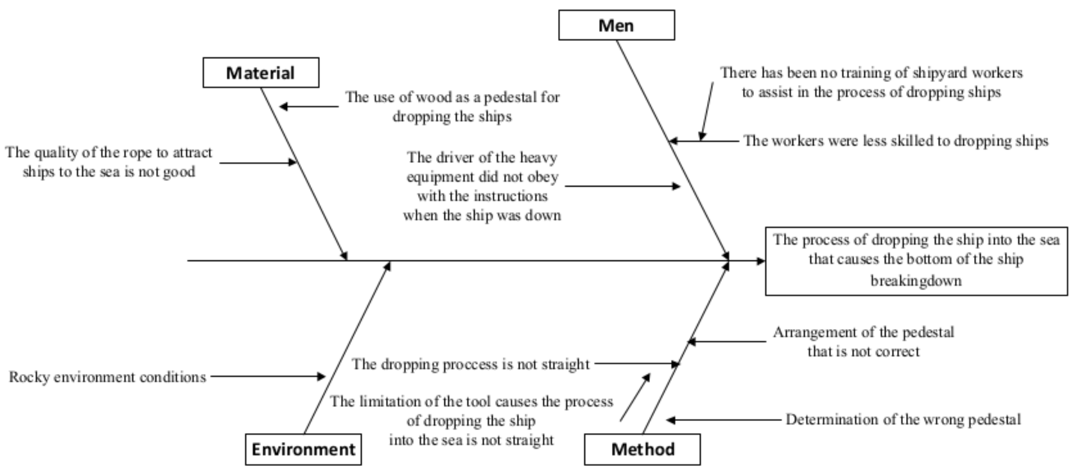

Figure 2. Fishbone diagram of causes in ship break down

In Figure 2, it can be seen that there are root causes of waste as follows:

1. Men
   Related the workers who conducted the process of dropping ships into the sea. Based on observations in the field, the researchers found out that workers who conducted the process of dropping ships into the sea were less skilled and the drivers of the equipment were less obedient to the instructions when the ship dropped, which could cause the bottom of the ship is breakdown.
2. Material
   Related the use of wood materials used to dropping ships into the sea were inappropriate, and the use of poor quality rope to attach ships causes the broken bottom of the ship because of friction.
3. Method
   Related the method used to dropping ships into the sea. Based on observations in the field, the researchers found that the process of dropping ships into the sea could not go straight because of the limitations of the tool. In addition, the method of determining the pedestal used an improper arrangement, it can also cause the risk of the bottom of the ship being broken.
4. Environment
   Related the environmental conditions of the surrounding area at the time dropping ships into the sea. Based on observations in the field, the researchers found rocky environmental conditions that made it difficult for the ship to drop into the sea and caused the risk of the ship's bottom breaking due to friction with the rocks.

3.3 FMEA Method

This stage is done after analyzing the causes of the Fishbone diagram. The next step is to evaluate the RPN using the FMEA method. The data used for calculation of the RPN is the result of the assessment of questionnaires related to the severity (S) of how much the perceived impact of the cause, the occurrence (O) is the frequency of causes, and detection (D) is the detection causes that interpreted into numerical units using the formula:

RPN = S x O x D

Table 3 is the result of calculating the RPN from each potential failure mode at the bottom of the broken-down vessel waste:

Table 3. FMEA

Potential failure mode	Causes	RPN Value Resp.1	RPN Value Resp.2	RPN Value Resp.3	Total Average Value of RPN
The bottom of the ship broke down	There has been no training of shipyard workers to assist in the process of dropping ships	80	25	20	41.67
	The driver of the heavy equipment did not obey with the instructions when the ship was down	48	90	7	48.33
	The use of wood as a pedestal for transferring marine vessels	48	90	18	52.00
	The quality of the rope to attract ships to the sea is not good	56	40	2	32.67
	The limitation of the tool causes the process of dropping the ship into the sea is not straight	20	28	30	26.00
	Arrangement of the pedestal that is not correct	8	90	8	35.33
	Determination of the wrong pedestal	36	90	24	50.00
	Rocky environment conditions	245	45	7	99.00

Based on the results of the RPN assessment above, it can be recommended to prioritize the handling of the problem to be resolved, namely the type of lower part of the broken-down vessel with the main cause of the highest RPN value, namely rocky environmental conditions when the ship drops to sea with an RPN value of 99.00 The lowest RPN is the limitation of equipment, which caused the process of dropping ships to sea is not straight with a value of RPN 26.00. Furthermore, all the main causes will be given an improvement proposal in order to minimize the risk of the bottom of the ship break down during the process of dropping ship to sea.

3.4 Proposed Improvements

Based on the FMEA method that has been applied, the researcher can provide recommendations for improvements to the company for 3 causes with the highest RPN value. The proposed improvements provided by the researcher can be used to minimize the risk of break down the ship when the ship drops to the sea. The following proposed improvements can be seen in Table 4 below.

Table 4 Recommended improvement

No	Failure Causes	RPN	Recommended Improvement
1	Rocky environment conditions	99.00	• Structuring the layout of the site for ship construction, where the shipbuilding area is close to the coast and selecting areas with little rock and more beach sand to facilitate the decline of ships to the sea.

No	Failure Causes	RPN	Recommended Improvement
			• Cleaning of the surrounding area when the ship will be dropping into the sea from high-risk rocks causes the bottom of the ship breakdown
2	The use of wood as a pedestal for transferring marine vessels	52.00	• Replacing the use of wood as a pedestal with an airbag that can minimize the risk of break down the bottom of the ship.
3	Determination of the wrong pedestal	50.00	• Conducting a risk analysis of the pedestal that has been used for the process of dropping ships at sea so that the shipyard can consider using a pedestal that has a small risk to cause the bottom of the ships breakdown.
4	The driver of the heavy equipment did not comply with the instructions when the ship was down	48.33	• There is a prior discussion with all parties relating to the process of dropping ships into the sea, to be agreed upon so that they can avoid misinformation that occurs during the process of dropping ships at sea.
5	Arrangement of the pedestal that is not correct	35.33	• There is a discussion about the arrangement of the pedestal that will be used to drop ships into the sea by expert workers to medium workers and beginner workers so that they can also decide on what methods can be used in the arrangement of pedestal so as to minimize the risk of break down the ship.
6	The quality of the rope to attract ships to the sea is not good	32.67	• Balancing the maximum strength of the rope that is used with the ship to be pulled, so that the rope that is used will not cause the risk of the bottom of the ship break down.
7	The limitation of the tool causes the process of dropping the ship into the sea is not straight	26.00	• Utilizing used tire media which is placed on the ground that can be used as a benchmark for the ship to run straight, and the balance between the numbers of workers on the side of the ship must also be considered. • Recommendations for other proposals, namely investment in heavy equipment purchases

4. Conclusion and Implications

We have described the waste activities in building traditional boats. All of waste activities are classified into 6 wastes. By using AHP, we found that the process of dropping the ship into the sea that causes the bottom of the ship break down is the most critical waste. Several root causes are analyzed by fishbone diagram, such as: men, material, method, and environment. Based on the results of the RPN assessment, it can be prioritized the main cause of broken-down vessel that is the rocky environmental conditions when the ship drops to sea. The lowest priority is the limitation of equipment, which causes the process of the ships dropping into the sea to be not straight. Furthermore, all the main causes are given an improvement proposal in order to minimize the risk of the bottom of the ship break down during the process of the ships dropping into the sea. The future research can be done by implementing the lean-six sigma to improve the performance of building traditional ships.

Acknowledgements

This research was supported by Directorate General of Research and Development, Ministry of Research, Technology, and Higher Education, Indonesia under grant Basic Research in 2019, No. 1616.10/PL19/LT/2019.

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Biographies

Yugowati Praharsi is an Assistant Professor in Business Management Department at Shipbuilding Institute of Polytechnic Surabaya, East Java, Indonesia. She earned B.Sc. in Mathematics from Satya Wacana Christian University, Indonesia; M.Sc in Electronic Engineering and Computer Science and Ph.D in Industrial and System Engineering from Chung Yuan Christian University, Taiwan. She has published national and international journals and conference papers. Her research interests are in the field of operation research, production system, quality management, and supply chain management.

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