Defect Analysis for Quality Improvement in Fishing Boat Manufacturing Processes through the Integration of FMECA and Fishbone: A Case Study

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Abstract:- This study uses the Failure Mode, Effect and Criticality Analysis (FMECA) method in determining the priority of failure modes that affect the quality of fishing boats produced, and fishbone techniques to improve the quality of fishing boats.WahanaKarya is a wooden fishing boat production business that has been operating for a long time in West Aceh, Indonesia.The quality of the boat is one of the main factors for consumers in choosing and determining the boat to be used.Manufacturing defects, such as gaps and cracks, are unavoidable in wood-based boats.Failure Mode, Effect and Criticality Analysis (FMECA) methods and fishbone diagrams can be applied in the quality control process to minimize defects on fishing boats.FMECA is the development of the Failure Mode, Effect and Effect Analysis (FMEA) method by adding critical analysis which is used to determine the priority of the failure mode.While the fishbone technique uses diagrams to identify the root cause of a problem in a process.The results of FMECA obtained three production process activities that have a critical degree of high category that can affect the quality of the resulting ship and need to be improved, namely uneven cutting of wood in buritan bow manufacture, linggi bow manufacture,and uneven cutting of the board on the hull board installation.Improvements with the fishbone technique that utilize four factors, namely humans, machines, materials and methods, produce several recommendations, including choosing raw materials or materials that are of higher quality than before,doing things like more regular worker supervision,set time to do work,make changes or shifts of workers during the production process so that workers do not get tired quickly,provide training to every workers,implement Standard Operational Procedures (SOP) so that every production process runs well and uses better machines or equipment and the latest technology for better production results.

Keyword:- *Fishing Boat, Quality, FMECA, Fishbone Diagram.*

I. INTRODUCTION

Fishing boats are a means of transportation used to catch and transport fish in the waters.Fishing boats are made of wood and traditionally made by fishermen with simple facilities and infrastructure.On average, shipbuilding with a capacity of 3 gross tons (GT) takes 35 days to produce.Aceh Province is one of the regions in Indonesia that produces a lot of traditional fishing boats and is widely used by local fishermen.The quality of the ship is one of the main factors for consumers in choosing and determining the ship to be used (Kwon, 2019).Manufacturers must strive to maintain existing quality standards to meet consumer desires(Pamungkas, 2020). If the quality of the ship produced is not in accordance with quality standards, it will cause losses for the company and also for customers (Guo, 2018). Quality can be interpreted as the level or measure of the suitability of a product with its users, in a narrow sense quality is defined as the level of conformity of the product with predetermined standards (Pamungkas, 2020). Good quality will result from good processes and in accordance with predetermined quality standards based on market needs.

WahanaKarya is a wooden fishing boat production business that has been operating for a long time in West Aceh, Indonesia.Defects in production, such as gaps and cracks are unavoidable in wood-based boats.Wood raw materials and workers are the main factors causing this defect.In addition, quality control factors also need to be carried out and applied in the production process of fishing boats.Quality control aims to determine which part of the production process causes defects in production boats, so that quality improvements can be made both in one process and as a whole.

Failure Mode, Effect and Criticality Analysis (FMECA) methods and fishbone diagrams can be applied in the quality control process to minimize defects on fishing boats.FMECA is a procedure performed after failure mode effect analysis to classify each potential failure effect according to its severity and likelihood of occurrence (Spreafico, 2017). FMECA is the development of the Failure Mode, Effect and Effect Analysis (FMEA) method by adding critical analysis which is used to determine the priority of the failure mode(Pamungkas, 2019). This method is a method used to measure and analyze the safety of a product or process.FMECA input in the form of severity, frequency of occurrence and detection, and produces output in the form of risk priority number (RPN) with the highest

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value (Chen, 2012). Fishbone diagram or causal diagram is a diagram used to identify the root cause of a problem in a process.The cause of problems is often caused by five elements, namely human, method, machine, material, and environment(Li, 2011).Fishbone diagrams are useful for finding the factors causing a problem.

Several previous studies used FMECA and fishbone methods in an effort to improve process and product quality, including improving the quality of the ultrasonic mold cleaning system(Fragassa, 2016), product quality in the food industry (Bertolini, 2006), indoor air quality management in home mechanical ventilation (Faiella, 2016), improvement of the quality of maintenance planning (Pancholi, 2017), quality in process analysis (Bertolini, 2006),quality in clinical laboratory procedures (Serafini, 2016), and distribution transformer product quality (Singh, 2019).

The purpose of this study was to determine the priority of failure modes that affect the quality of fishing vessels produced by the FMECA method and to improve the quality of fishing vessels using the fishbone technique.

II. RESEARCH METHOD

This research was conducted at the WahanaKarya business located in West Aceh Regency, Aceh Province, Indonesia.The type of research used is descriptive research, namely research conducted by analyzing the work and activities on an object.In this descriptive study, data collection was obtained from observation, literature study and field research in the form of interviews from confirmed sources to find out information about the production process at WahanaKarya.The condition of the existing production process will be analyzed and recommendations for quality improvement are sought.The data used in this study include primary data and secondary data.The primary data needed are boat defect data and labor data. The secondary data needed are the Failure Mode, Effect and Criticality Analysis (FMECA) method and fishbone diagrams.

Data processing is carried out in three stages. The first stage is to identify defects using the Failure Mode Effect and Analysis (FMEA) method which is processed by determining the severity, occurrence, detection and RPN values.The RPN value is the product of the severity (S), incidence (O) and detection (D), as shown in equation 1 below.

$$\text{RPN} = Severity \text{ x } Occurence \text{ x } Detection \ldots\ldots \quad (1)$$

Then proceed with Critically Analysis (CA) which is used to determine the priority of the failure mode. The following table 1 is used in determining the priority of critical analysis.

No	Critical Degree	Score	Risk
1	Minor	0-30	Acceptable
2	Medium	31-100	Acceptable
3	High	101-180	Unacceptable
4	Very high	181-252	Unacceptable
5	Critical	> 252	Unacceptable

Table 1: Critical

In the second stage, it is continued by using the Pareto diagram to determine the main priority of the failure mode.The principle of the Pareto diagram applies the 80/20 rule, which means that 20% of defects can cause 80% of process failures.In the third stage using fishbone diagrams to find out the root causes of problems from defects in the production process.The cause of the problem is often caused by five elements, namely human, method, machine, material, and environment.(Lipol, 2011).

III. RESULT AND DISCUSSION

In this study, the initial step taken was to collect defect data on the boat directly from the results of observations and interviews during production, precisely in the production section.The data collected in this study is based on the total production in the period July 2021 to March 2022, namely ten boats with a capacity of 3 grosstons produced. Figure 1 shows the number of defects in the manufactured boat.

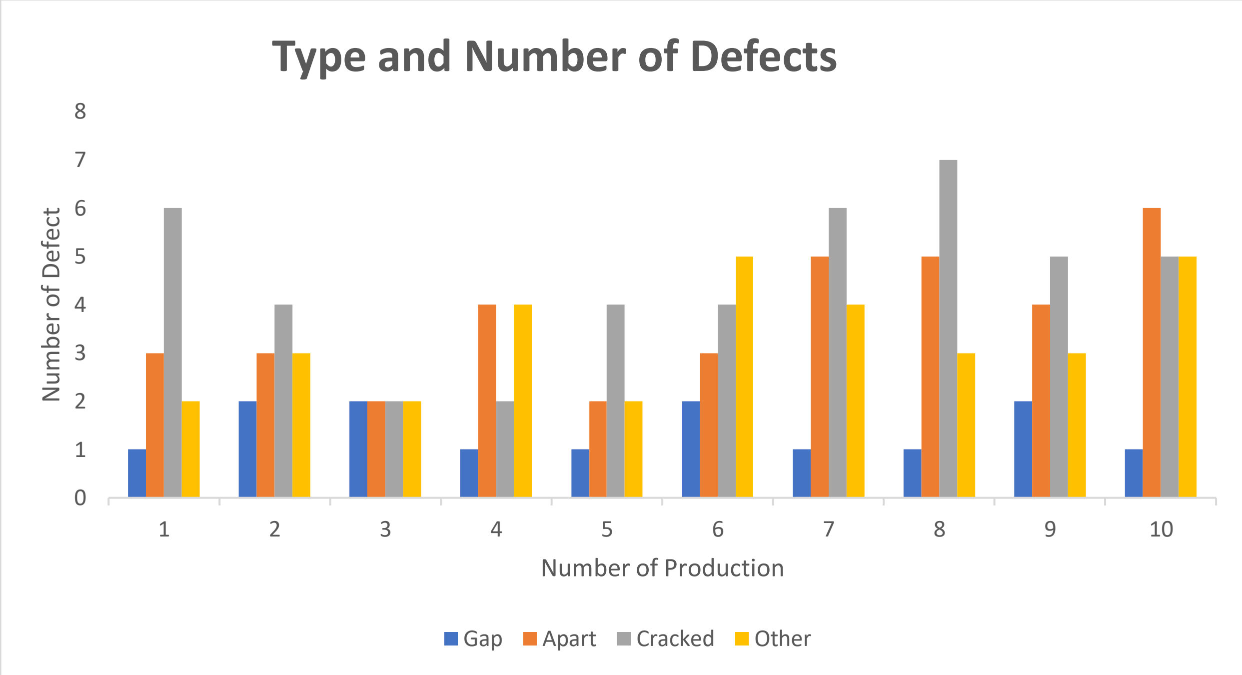

Fig. 1:Types and Number of Defects in BoatsProduced (3 Gross Tons)

Figure 1 shows that the types of defects in manufacturing vessels are dominated by defects in the form of small gaps in the boat, apart or gaps between wood or board joints, and cracks caused by the raw materials used.The three types of defects can be traced through the failure mode, cause and effect using the FMECA method which is an integration of failure mode and effect analysis (FMEA) and critical analysis (CA).To find out these three things, the shipyard production process will be described from the beginning to the end of the work through direct observation and then analyzed the mode, causes and impact of failure.The description of the boat's production process along with the mode, causes and impact of failure is shown in Table 2.

No.	Process	Code	Failure Mode	Cause of Failure	Impact of Failure
1	Keel manufacture	1.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		1.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
2	Linggi bow manufacture	2.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		2.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		2.3	Drilling wood is too strong	Operators are not careful	Cracked
3	Buritan bow manufacture	3.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		3.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		3.3	Drilling wood is too strong	Operators are not careful	Cracked
4	Hull Board Installation	4.1	Improper board size due to wrong measurement	Operators are not careful	Apart
		4.2	Uneven board cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		4.3	Nailing the board too strong	Operators are not careful	Cracked
5	Base frame installation	5.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		5.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		5.3	Drilling wood is too strong	Operators are not careful	Cracked
6	Tajuk frame installation	6.1	Improper wood size due to wrong measurement	Operators are not careful	Apart

		6.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		6.3	Drilling wood is too strong	Operators are not careful	Cracked
7	Fender installation	7.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		7.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		7.3	Drilling wood is too strong	Operators are not careful	Cracked
8	Hull board installation	8.1	Improper board size due to wrong measurement	Operators are not careful	Apart
		8.2	Uneven board cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		8.3	Nailing the board too strong	Operators are not careful	Cracked
9	Tajuk frame installation	9.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		9.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
10	Naga-naga manufacture	10.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		10.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		10.3	Drilling wood is too strong	Operators are not careful	Cracked
11	Deck bearing installation	11.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		11.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		11.3	Drilling wood is too strong	Operators are not careful	Cracked
		11.4	Nailing the deck bearings too strong	Operators are not careful	Cracked
12	Deck floorboard installation	12.1	Improper board size due to wrong measurement	Operators are not careful	Apart
		12.2	Uneven board cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		12.3	Nailing the board too strong	Operators are not careful	Cracked
13	Machine bench manufacture	13.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		13.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		13.3	Drilling wood is too strong	Operators are not careful	Cracked
14	Houseboat frame construction	14.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		14.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		14.3	Nailing the wood too strong	Operators are not careful	Cracked
15	Deck bearing manufacture	15.1	Improper wood size due to wrong measurement	Operators are not careful	Apart
		15.2	Uneven wood cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		15.3	Nailing the wood too strong	Operators are not careful	Cracked
16	Boat house board installation	16.1	Improper board size due to wrong measurement	Operators are not careful	Apart
		16.2	Uneven board cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		16.3	Nailing the board too strong	Operators are not careful	Cracked
17	Nailing deck bearing boards	17.1	Improper board size due to wrong measurement	Operators are not careful	Apart
		17.2	Uneven board cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart

		17.3	Nailing the board too strong	Operators are not careful	Cracked
18	Machine room board installation	18.1	Improper board size due to wrong measurement	Operators are not careful	Apart
		18.2	Uneven board cutting	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		18.3	Nailing the board too strong	Operators are not careful	Cracked
19	Attaching the rope to the joint of the board	19.1	Hitting the rope into the pores of the board that is too strong	Operators are not careful	Cracked
20	Bonding resin at the joints of the boards	20.1	Mixing the oil and applying too much resin makes it non-sticky	Operators are not careful	Gap between boards
21	Hull board bolt installation	21.1	Over-pressed bolt hole drilling	Operators are not careful	Cracked
22	Asphalt bonding at the joints of the boards	22.1	Applying asphalt to uneven board pores	Operators are not careful	Apart
23	Plastic tarpaulin installation	23.1	Unequal tarpaulin measurements	Operators are not careful	Apart
		23.2	Improper cutting of tarpaulin	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		23.3	Nailing tarpaulin too strong	Operators are not careful	Cracked
24	Aluminum zinc coating installation	24.1	Unequal zinc aluminum measurement	Operators are not careful	Apart
		24.2	Improper cutting of zinc	The saw is blunt so the wood that is cut is not the desired size or shape	Apart
		24.3	nailing zinc too strong	Operators are not careful	Apart
25	Painting	25.1	mixing too much paint oil	Operators are not careful	Uneven paint

Table 2: Description of the BoatProduction Process 3 Gross Ton

Based on Table 2 there are defects in the form of small gaps in the boat, gaps between wood or board connections, and cracks. Defects that arise are caused by workers who are not careful, lack of standards or SOPs, and inadequate tools or machines.

Evaluation of the failure score can be done by using the Risk Priority Number (RPN).Determination of the RPN value is done by multiplying the severity, occurence, and detection values. This value is the result of identification after conducting observations and interviews with the production department.After obtaining the RPN value from the results of the Failure Mode Effect and Analysis (FMEA) calculation, then an analysis is carried out based on the critical table, whether it is acceptable (no problem), tolerable (not prioritized for repair), or unacceptable (needs improvement).The results of the calculation of the Risk Priority Number (RPN) and the FMECA analysis are shown in Table 3.

No.	Process	Code	Severity	Occurrence	Detection	RPN	Critical Degree	Risk
1	Keel manufacture	1.1	5	4	4	80	Medium	Tolerable
		1.2	5	5	4	100	Medium	Tolerable
2	Linggi bow manufacture	2.1	6	4	4	96	Medium	Tolerable
		2.2	6	6	4	144	High	Unacceptable
		2.3	6	5	2	60	Medium	Tolerable
3	Buritan bow manufacture	3.1	7	4	3	84	Medium	Tolerable
		3.2	6	4	5	120	High	Unacceptable
		3.3	5	3	2	30	Minor	Acceptable
4	Hull Board Installation	4.1	5	4	3	60	Medium	Tolerable
		4.2	7	5	2	70	Medium	Tolerable
		4.3	6	4	3	72	Medium	Tolerable
5	Base frame installation	5.1	7	5	2	70	Medium	Tolerable
		5.2	6	5	3	90	Medium	Tolerable
		5.3	5	5	2	50	Medium	Tolerable
6	Tajuk frame installation	6.1	6	5	2	60	Medium	Tolerable
		6.2	6	4	1	24	Minor	Acceptable
		6.3	6	5	1	30	Minor	Acceptable

7	Fender installation	7.1	4	4	2	32	Medium	Tolerable
		7.2	5	5	2	50	Medium	Tolerable
		7.3	6	4	2	48	Medium	Tolerable
8	Hull board installation	8.1	4	5	2	40	Medium	Tolerable
		8.2	6	5	4	120	High	Unacceptable
		8.3	6	4	2	48	Medium	Tolerable
9	Tajuk frame installation	9.1	5	4	2	40	Medium	Tolerable
		9.2	6	5	2	60	Medium	Tolerable
10	Naga-naga manufacture	10.1	6	4	2	48	Medium	Tolerable
		10.2	5	5	3	75	Medium	Tolerable
		10.3	6	4	2	48	Medium	Tolerable
11	Deck bearing installation	11.1	4	4	2	32	Medium	Tolerable
		11.2	6	5	1	30	Minor	Acceptable
		11.3	5	4	2	40	Medium	Tolerable
		11.4	4	4	2	32	Medium	Tolerable
12	Deck floorboard installation	12.1	3	4	2	24	Minor	Acceptable
		12.2	6	5	3	90	Medium	Tolerable
		12.3	5	4	2	40	Medium	Tolerable
13	Machine bench manufacture	13.1	6	5	2	60	Medium	Tolerable
		13.2	5	5	3	75	Medium	Tolerable
		13.3	4	5	2	40	Medium	Tolerable
14	Houseboat frame construction	14.1	6	4	2	48	Medium	Tolerable
		14.2	7	6	1	42	Medium	Tolerable
		14.3	5	5	2	50	Medium	Tolerable
15	Deck bearing manufacture	15.1	7	4	2	56	Medium	Tolerable
		15.2	5	5	1	25	Minor	Acceptable
		15.3	2	4	2	16	Minor	Acceptable
16	Boat house board installation	16.1	6	4	3	72	Medium	Tolerable
		16.2	7	5	2	70	Medium	Tolerable
		16.3	6	5	3	90	Medium	Tolerable
17	Nailing deck bearing boards	17.1	5	4	2	40	Medium	Tolerable
		17.2	4	4	2	32	Medium	Tolerable
		17.3	5	5	1	25	Minor	Acceptable
18	Machine room board installation	18.1	6	4	2	48	Medium	Tolerable
		18.2	7	3	2	42	Medium	Tolerable
		18.3	7	4	2	56	Medium	Tolerable
19	Attaching the rope to the joint of the board	19.1	5	4	2	40	Medium	Tolerable
20	Bonding resin at the joints of the boards	20.1	6	5	1	30	Minor	Acceptable
21	Hull board bolt installation	21.1	6	4	2	48	Medium	Tolerable
22	Asphalt bonding at the joints of the boards	22.1	7	5	1	35	Medium	Tolerable
23	Plastic tarpaulin installation	23.1	6	4	1	24	Minor	Acceptable
		23.2	2	4	1	8	Minor	Acceptable
		23.3	3	5	2	30	Minor	Acceptable
24	Aluminum zinc coating installation	24.1	2	4	2	16	Minor	Acceptable
		24.2	2	4	2	16	Minor	Acceptable
		24.3	2	4	1	8	Minor	Acceptable
25	Painting	25.1	2	5	1	10	Minor	Acceptable

Table 3: Risk Priority Number (RPN), Criticality Level and Risk

Based on Table 3, most of the shipbuilding process activities have a relatively low RPN value, this is illustrated by a critical degree category which includes minor and medium which means it is acceptable and tolerable.However, there are three process activities with the highest RPN value, namely in code 2.2 uneven wood cuttingin the linggi bow manufacture with an RPN value of 144, code 3.2 namely uneven wood cuttingin the buritan bow manufacture with an RPN value of 120, and in code 8.2, namely uneven board cuttingon the hull board installation with an RPN value of 120.The three production process activities are classified as high critical degrees,

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meaning that improvements need to be made (Unacceptable).

Improvements will be made using a cause-and-effect diagram or a fishbone diagram. Fishbone diagram in this study will analyze several factors, namely material, method, human, and machine factors.Figure 2 is a fishbone diagram for process activities 2.2 and 3.2, namely the uneven wood cutting in linggi bow andburitan bow manufacture. Fishbone diagram analysis on process activities 2.2 and 3.2 will be equated because the only difference between the two activities is the execution time.

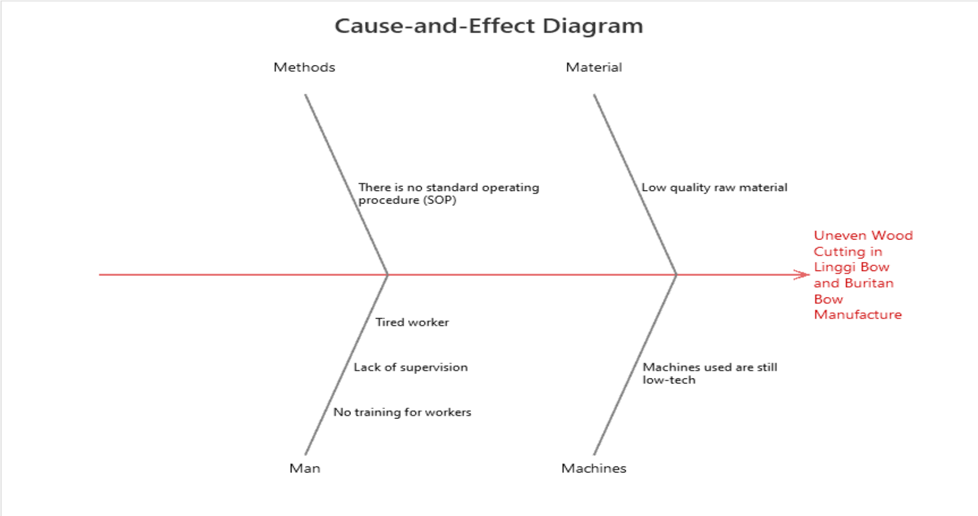

Fig. 2: Fishbone Diagram of Uneven Wood Cutting in LinggiBow andBuritanBow Manufacture

Based on Figure 2, the proposed improvement of uneven wood cutting in linggi bow andburitan bow manufacture is based on 4 factors, namely:

- The material factor, choose a higher quality raw material, be it wood or other supporting materials.
- The worker factor is being able to do several things such as more regular supervision for workers, managing time in doing their work, changing workers or carrying out a shift system when the production process is carried out so that workers are not tired, and conducting training for workers.
- The method factor, can apply standard operating procedures (SOP) so that each production process runs well.
- Machine or equipment factor, using the latest technological machines or equipment for better production results.

Figure 3 is a fishbone diagram of the 8.2 process activity, namely uneven board cuttingon the hull board installation.

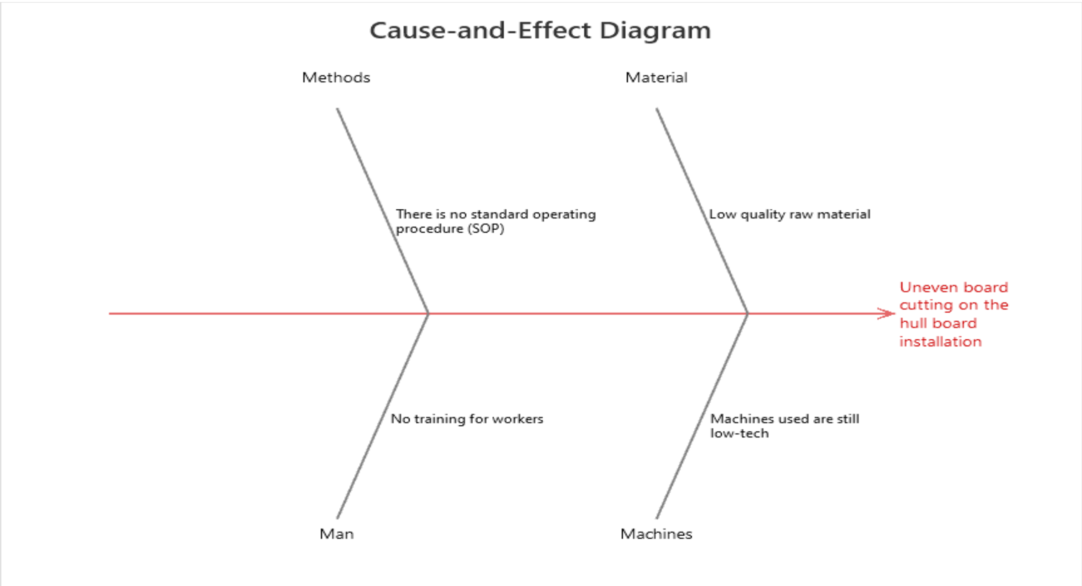

Fig. 3: Fishbone Diagram of Uneven Board Cuttingon the Hull Board Installation

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Based on Figure 3, the proposed improvement of uneven board cuttingon the hull board installation is based on 4 factors, namely:

- The material factor, choose a higher quality raw material, be it wood or other supporting materials.
- The worker factor is being able to do several things such as more regular supervision for workers, managing time in doing their work, and conducting training for workers.
- The method factor, can apply standard operating procedures (SOP) so that each production process runs well.
- Machine or equipment factor, using the latest technological machines or equipment for better production results.

IV. CONCLUSION

WahanaKarya is a wooden fishing boat production business that has been operating for a long time in West Aceh, Indonesia.The quality of the boat is one of the main factors for consumers in choosing and determining the boat to be used.Manufacturing defects, such as gaps and cracks, are unavoidable in wood-based boats.Failure Mode, Effect and Criticality Analysis (FMECA) methods and fishbone diagrams can be applied in the quality control process to minimize defects on fishing boats. The results of FMECA obtained three production process activities that have a critical degree of high category that can affect the quality of the resulting ship and need to be improved, namely uneven cutting of wood in buritan bow manufacture, linggi bow manufacture,and uneven cutting of the board on the hull board installation.Improvements with the fishbone technique that utilize four factors, namely humans, machines, materials and methods, produce several recommendations, including choosing raw materials or materials that are of higher quality than before,doing things like more regular worker supervision,set time to do work,make changes or shifts of workers during the production process so that workers do not get tired quickly,provide training to every workers,implement Standard Operational Procedures (SOP) so that every production process runs well and uses better machines or equipment and the latest technology for better production results.

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