ANALYSIS OF DEFECT CAUSES AND IMPROVEMENT IN CABINET CASE DIVISION USING FAILURE MODE AND EFFECT ANALYSIS (FMEA) AND ANALYTICAL HIERARCHY PROCESS (AHP) (CASE STUDY: WOOD WORKING DEPARTMENT – PT. YAMAHA INDONESIA)

THESIS

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Yogyakarta, October 2020

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DEDICATION

In dedication to my beloved parents, sister and brother, Mr. Imam Suhadi, Mrs. Ninis Senirah, Dinar Afif and Ulil Albab, whose affection and prays of day and night make me able to get through all of these. Thank you who have always provided during every endeavor in my life. I am grateful for the constant love and encouragement my parents, without whom this thesis would not have been completed earlier.

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Also, this thesis is dedicated to those who loves me unconditionally, who makes my life wonderful, thanks, thanks!

MOTIVATIONAL QUOTES

"O you who have believed, fear Allah. And let every soul look to what it has put forth for tomorrow – and fear Allah. Indeed, Allah is Acquainted with what you do"

(Quran Surah Al Hashr verse 18)

"Indeed, the wasteful are brothers of the devils, and ever has Satan been to his Lord ungrateful."

(Quran Surah Al Isra' verse 27)

"Man jadda wajada, Man shabara zhafira, Man saara ala darbi washala."

(Mahfudzat)

PREFACE

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ABSTRACT

Common problem often found by company in improving product quality is the occurrence of defective product. In the presence of defective products, the company is required to repair those defective products that will have impact on increasing cost, manpower, and time required. Increasing cost, manpower, and time will indirectly result in decreased production efficiency. The goal of this research is developing production process improvement in Cabinet Case division, PT Yamaha Indonesia based on cause of defect to reduce defective product and analysis of it. The method used in this research is Failure Mode and Effect Analysis (FMEA) with supporting tools such as Fishbone diagram and Pareto diagram. FMEA is a method used to identify the root causes of quality problems. However, FMEA often gives the same RPN result, but represents a different risk representation. To solve this problem, weighting of the criteria is carried out using the AHP (Analytical Hierarchy Process) method. Based on the result of Pareto diagram, the most dominant type of defect occur in Cabinet Case division is rift defect, while the most dominant type of cabinet is Fall Back. The factors cause to defect in Cabinet Case division can be divided into 5 factors are material, method, environment, manpower, and machine. Therefore, the proposed alternative that could be conducted by the company, it should pay more attention to scheduling replacement of parts on each machine and assign operator of machine user to be in charge of the machine. Moreover, the company should improve the quality of training for new operator and to tighten the selection also placement of new operator based on their skill and interest.

Keyword: Quality control, Defective product, Failure mode and effect analysis, Analytical hierarchy process, Fishbone diagram, Pareto diagram

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CHAPTER I

INTRODUCTION

In this chapter, it will be presented the preliminary research which is be decomposed into six sub-chapters namely background, problem formulation, research objectives, research limitation, research benefit, and systematic writing.

1.1 Background

Today, the tight competition in the industrial world forces companies to conduct improvements in order to be survive. The companies are required to be able to compete with similar company. Moreover, in order to hold the customer, the company should be able to fulfil customer needs also satisfy and gives the best for them. One of the ways to achieve it is through improving product quality. Quality is the compatibility or suitability of the product with its users (Lubis et al., 2013). Under good product quality control, the product which received by the customers is a product that complies with appropriated quality standard.

Common problem often found by company in improving product quality is the occurrence of defective product. Defective products are products which are produced in the production process, where those products are not in accordance with established quality standard, but can still be fixed by additional cost budgeting (Bustami & Nurlela, 2007). In the presence of defective products, the company is required to repair those defective products that will have impact on increasing cost, manpower, and time required. Increasing cost, manpower, and time will indirectly result in decreased production efficiency.

The relationship between production efficiency and product quality can be measured in the number of defective products produced by the company. When percentage of defective product is high, then it can be concluded that the quality of production process is not optimal enough. Therefore, the existence of quality control is extremely important in a company in order to maintain even improve the production process. According to Sofjan Assauri (1998), the definition of quality control is an effort to maintain a quality of the product, so it meets product specification that have been determined by management in a company.

PT Yamaha Indonesia is a manufacturing company which produces piano instrument. Generally, the product that produced in PT Yamaha Indonesia can be categorized into two types of piano are UP Right Piano and Grand Piano where haves their own derivative variation. UP Right Piano is a piano that has an upright shape or vertical position while Grand Piano has a horizontal position. In the production process, PT Yamaha Indonesia apply a combination of humans and machines which has a potential to cause error in the production process especially in Cabinet Case division. The most often problem founded out in Cabinet Case division is the appearance of defective product with several types of defect such as curved, rift, chipped, broken, bubble, and cracked which reaches hundreds per month.

Table 1. 1 Number of defects for 6 months

No	Month	Total Defect
1	October	689
2	November	485
3	December	378
4	January	142
5	February	136
6	March	218

During the period of October 2019 to March 2020 the amount of defect was 1.07% of the total production in the Cabinet Case division. When defective product appears, the company should conduct repair to those products. Repair is an activity to fix defective product that can still be fixed or must be replaced. The more defective product, the more additional cost needed to fix it.

In order to reduce repair of defective product, the cause of defective product needs to be analysed by observing at the performance of operator, work guidance, work environment, and other factors that directly influence the appearance of defective product. In this case, analysing the problem could be achieved through Failure Mode and Effect Analysis (FMEA). FMEA is a method used to identify the root causes of quality problems. The calculation parameter of potential failures in FMEA is based on the Risk Priority Number (RPN) value. RPN is obtained from the multiplication of three values are severity, occurrence, and detectability.

FMEA often gives the same RPN result but represents a different risk representation. The calculation of the FMEA method weighs severity (S), occurrence (O), and detectability (D) equally in proportion, but in real cases these criteria have different weights (Aslani, 2014). To solve this problem, weighting of the criteria is carried out using the AHP (Analytical Hierarchy Process) method. AHP is one of the multi-criteria decision-making models that can help human thinking framework where the factor of logic, experience, knowledge, emotion, and taste are optimized into a systematic process. Furthermore, this method used to determine the proper improvement that will be proposed to PT Yamaha Indonesia as an effort to reduce defective product in Cabinet Case division.

1.2 Problem Formulation

Based on the exposure of the background above, there were some problems in the research to be conducted. Then, the problem formulation is derived to be built as follows:

1. What types of defect and cabinet are frequently found in the Cabinet Case division?
2. What are the factors cause defects in Cabinet Case division?
3. What are proper improvement to reduce defective product in Cabine Case division?

1.3 Research Objective

The goal of this research is developing production process improvement in Cabinet Case division based on cause of defect to reduce defective product and analysis of it.

1.4 Research Limitation

Research limitation is the scope of the study, this needs to be done, so that research, to become more focused. The scope of the research is as follows:

1. The object of research is the production process in the Cabinet Case division of the Wood Working department of PT. Yamaha Indonesia.
2. In this research, the cost aspect is not discussed.

3. Improvement is only a recommendation, not implemented directly.

1.5 Research Benefit

Based on the description and problem formulation it is expected that the results obtained in this study will provide benefits, such as:

1. The research can provide the development of scientific knowledge, especially in the field of production and quality control.
2. The company can improve the productivity by reduce defective product.
3. The result will be considered as decision making of further action to improve quality control.

1.6 Systematically Writing

Systematics of writing this thesis and then proceed as follows:

CHAPTER I **INTRODUCTION**

This chapter explains the background and problem characteristic that need to be solved. It shows some reasons and urgency in conducting quality control assessment and choosing these as the method. Also explains what are going to be found and solved. The background of problem that will derive to problem formulation. This chapter also provides the scope or limitation of the study, so it would not exceed these borders.

CHAPTER II **LITERATURE REVIEW**

Literature review provides information on previous studies and other theories related to the research. There are three main topics in this chapter including previous study, basic theories and conceptual model of the research. The objective is to seek the novelty of this research.

CHAPTER III RESERACH METHODOLOGY

This chapter will present the detail of methodology that used in this research. The data is divided into 2 parts, namely primary and secondary data. Furthermore, this chapter will explain about the techniques of data collection and analysis. This chapter also will explain research objects, system development, research design, research procedure, data collecting, data processing and analysing the data.

CHAPTER IV RESULT OF RESEARCH

This chapter presents information of data that have been collected during the research. It also contains problem solving using the methods and tools that are implemented in the data processing as well the analysis. This chapter is a reference for the discussion of the results that will be written in Chapter V.

CHAPTER V DISCUSSION

This chapter provides a discussion after data analysis. It will be the core discussion in order to get a comprehensive understanding about the whole research.

CHAPTER VI CONCLUSION AND RECOMMENDATIONS

The conclusion and recommendations for further research will be described in this chapter

REFERENCES

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CHAPTER II

LITERATURE REVIEW

In this chapter will be explaining the literature review. The literature review will be divided into two types which are empirical review and theoretical study. Empirical review is a previous research, this study contains of the research articles that haves been done. In addition, theoretical study is study that contains related theories of the research that will be conducted. Both of them have to be done to find out the gap between this research and previous research.

2.1 Empirical Review

Empirical review or commonly known as previous research studies has objective to find studies from previous researchers, so that the direction of research and studies that have been conducted by previous researchers can be known.

Research conducted by Sirisawat & Kiatcharoenpol (2018) focused on the classification of reverse logistics barriers and ranking of both barriers and solutions of reverse logistics implementation in the electronics industry. Due to an increasing demand for green products and also pressures from customers and other players along the supply chain, which now pay more attention to environmental awareness and sustainable management, many companies especially in the electronics industry have begun to realize the importance of applying green supply chain management concepts into their activities; reverse logistics (RL) practice is one of the important strategies to provide efficient resource utilization and minimize waste from end of life (EOL) products by following legislation and green concepts. But recently reverse logistics practices are faced with some barriers which make the implementation of reverse logistics difficult and unsuccessful. To increase efficiency in reverse logistics adaptation of the electronics industry, companies need to understand and consider the priorities of both barriers and solutions for developing policies and strategies to overcome these barriers. This study proposes a methodology based on fuzzy analytical hierarchy process (Fuzzy AHP) and fuzzy technique for order performance by similarity to ideal solution (Fuzzy TOPSIS) in which fuzzy AHP is applied to get the weights of each barrier by using pair wise comparison, and fuzzy TOPSIS is applied for the final ranking of the solutions of reverse logistics implementation. The case of Thailand's electronics industry is used in the proposed method. To illustrate the robustness of the method, sensitivity analysis is used in this study. In the end of this study, through literature review and expert views 29 barriers and 14 solutions have beenidentified.Theresults ofthestudy presentedthat topmanagement awareness and support is the highest ranking value of solutions in this case study which Thailand electronics industry was used in the proposed framework. The ranking of solutions can be a guideline and support decision makers or top management to determine policy and strategies to solve RL practices barriers implementation.

The study conducted by Hsieh et al. (2018) has propose to identity the important human error factors in emergency departments (ED) in Taiwan. Human factors analysis and classification system (HFACS) was used to analyse 35 ED adverse events to define the error factors. Multiple criteria decision making (MCDM) methods such as analytic hierarchy process (AHP) and fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) were applied to evaluate the importance of error factors. Results showed that decision errors, crew resource management, inadequate supervision, and resource management were the important human error factors related to ED adverse events. This study recommends that MCDM should be applied to further analyse the results based on the criteria.

Gupta et al. (2018) conducted research in coal mining. Due to increased attention to coal mining, the industrial transport in most countries including India necessitated search for sustainable transportation leading to environmental protection, maximum speed of delivery, minimum cost of transportation, and enhanced traffic safety. In this research, they formulate an integrated multiobjective optimization model for an extended capacitated sustainable transportation problem in a coal mining industry using the analytic hierarchy process (AHP) and data envelopment analysis (DEA) techniques. The AHP technique is used to estimate the weights of different types of vehicles available for transportation on the basis of all three parameters of sustainability, namely economic, environmental, and corporate social responsibility. The DEA technique is used for calculating efficiency scores of vehicles on various routes of the given transportation network using inputs and outputs considered critical in the industrial sector particularly the mining industry. Furthermore, they reduce dependency on carbon based fuels for transportation leading to reduction in greenhouse gas emissions. A fuzzy interactive optimization approach is presented to get preferred compromise transportation solutions including the optimal number of vehicles employed for sustainable transportation. A real-world case of a mining industry in India is discussed to demonstrate applicability of the proposed optimization model and solution method. Moreover, some comparisons are done with existing transportation models in order to present advantages of their approach. The result of this research shows that integration of AHP and DEA techniques in the proposed model provides both the weights and efficiency scores of the vehicle types, which is more realistic when compared with existing literature. The prioritization of the vehicle types using AHP is based upon attributes such as air pollution, noise pollution, cost, comfort, safety, and fuel efficiency. The parameters such as time reliability of the vehicles, rate of product being damaged during transportation by vehicles, operating revenue, freight turnover, and accident rates have been considered to obtain the efficiency scores of vehicle types on different transportation routes using DEA. The obtained transportation solutions through a fuzzy interactive method have been found to be consistent with the individual preferences of the decision maker.

Dewi Shofi. M (2015) used the Seven Quality Control Tools and FMEA methods in its research on Improved Control. The results obtained from her research are that with intensive product quality control, it can improve the quality of a good product, so will create customer satisfaction. Therefore, the quality control function plays a very important role for the company in improving product quality to match what has been planned, because the quality of a product is a factor that determines the speed and development of a company that applies control.

Saivaew & Butdee (2020) conducted the research which is propose AHP and Fuzzy Logic for Assembly part for making a decision and selecting optimal plans for stage of assembly. Statistically based process engineering is applied for a case study. Multicriteria decision making is concerned with location, quality, material. AHP and Fuzzy Logic for assembly need to concern with the first stage of machined part design which is created by CAD. AHP and Fuzzy Logic is applied for effective making decision combined with experts and rules of methods modelling case of fitting parts. Finally the result of research presented decision making tools for effective assembly machined parts selection using Fuzzy AHP and Fuzzy Logic. Housing and standard bearing are studied as an example in 4 cases. FAHP can assist a decision maker decides which criteria is the most critical to be taken into account such as material type, surface roughness, and compression load. The Fuzzy logic modelling can used for selecting the suitable fitting pairwise between the shaft and hole housing.

Research conducted by Putra et al. (2013) examined the causes of motorboat defects in the Hull Construction section with the result was a class / owner surveyor inspection on the assembly process in KM. Furthermore, the result shows the largest number of defects are in HC with 129 defects, then HO 60 defects, then MO 32 defects and EO 22 defects. An analysis of the type of disability is most influential on the high number of defects in the HC section to produce an implementable repair solution. The results of the FMEA method showed three types of defects with the highest RPN values, are missing bracket with RPN value 384, missed weld with RPN value 240, and misalignment with RPN 224 value. Improvements were made namely check sheet improvement and SOP design, welding area marking, supervision of welder recruitment, welding current regulation, and electrode storage control.

Research conducted by Polat et al. (2017) aimed to identify the current land management and cadastre system in Turkey and detemine the most appropriate strategy for integrating the current structure with the principles of the Cadastre 2034 vision. In this work, the legal, institutional, and technical (LIT) status of the existing land management and cadastre system in Turkey was determined using a method based on Strengths, Weaknesses, Opportunities, and Threats (SWOT) and Analytical Hierarchy Process (AHP). Initially, the advantages or weaknesses of the existing land management and cadastre system in Turkey using this matrix was integrated into AHP and the most appropriate strategy was determined in terms of LIT aspects. For the existing land management and cadastre system in Turkey, from the legal point of view, the best strategy with a weighting of 30% was to update the land administration legislation according to the condition of the day. The best strategy in terms of institutionalization was to disseminate in-vocational training for the training of qualified personnel (28% weighting) and the best strategy from the technical perspective was identified as, the use of technical and technologically advanced measurement techniques in spatial data collection (38% weighting). The goal in implementing the AHP-Based SWOT method is to improve the qualitative information basis of strategic planning process. So, SWOT provides the basic outline within which to perform an analysis of the decision situation, and the AHP assist in carrying out SWOT more analytically and in elaborating the analysis so that alternative strategic decision can be prioritized.

In the study Rama & Evi (2014) integrated the FMEA method with TOPSIS to analyse the risk of accidents in the frame and fork welding process. The results of the study showed that there were 5 potential risks of accidents: scratching the grinding machine (RPI: 0.928), the eyes were exposed to grams in the polishing process (RPI: 0.668), the eyes were exposed to splashing of the grinding (RPI: 0.661), the eyes were affected by grams on cutting process (RPI: 0.657), the eye is exposed to grams on a champer / taper machine (RPI: 0.641). From these results the researchers provide suggestions to overcome the existing failure methods, among others: providing training to workers, tightening regulations, providing PPE and safety of existing machines.

Research conducted by Mharte & Dhake (2012) has an objective to identify and eliminate current and potential problems from a bending process of a case company. Ishikawa diagram and the Failure mode effect analysis is aimed to reduce errors and shorten the development duration, increased product reliability. It creates knowledge base in a sheet metal parts manufacturing company. It prioritizes potential failures according to their risk and drives actions to eliminate or reduce their likelihood of occurrence. FMEA provides a discipline/methodology for documenting this analysis for future use and continuous process improvement. It is a structured approach to the analysis, definition, estimation, and evaluation of risks. Following a standard set-up procedure will reduce set-up time and improve part accuracy thereby increasing the press break efficiency. Many measures like standard operating procedures, incoming material variation control, auto monitoring of blank insertion, designing of frame stackers, integration of logbook, quality training, immerged to be the most important issues in this project work.

Research conducted by Tsarouhas & Arampatzaki (2016) uses Failure mode and effect analysis (FMEA) to understand the failure behaviour of component in the production process and to adapt suitable management practices to improve the performance and the quality of the ceramic tiles. To achieve that aim, the researcher also use several tools are pareto diagrams for the depiction of the frequency and importance of causes that may cause a problem were applied, Ishikawa diagrams for the real potential main causes of possible failures in the production of ceramic tiles are showed. The results of this research shows that the machines Oven and Press have the highest RPN. To find the main cause of the problem for Oven and Press the Ishikawa diagrams were showed. Furthermore, Pareto diagrams for the depiction of the frequency and importance of causes that may cause a problem were applied, prior to corrective actions and after corrective actions with a new RPN. Therefore, the incorporation of PFMEA, Ishikawa and Pareto diagrams in the ceramic manufacture tiles are considered imperative as these could be useful quality tools for improving the quality and the performance of the tiles.

In the research conducted by Theresita Herni Setiawan et al. (2017) focused on identifying strategy to overcome the risk in the fabrication process of hollow core slab. Failure Mode and Effect Analysis (FMEA) method implemented in this study in order to achieve the aim of the research. This study found 23 failure modes and the highest risk priority is the realizing-agent spraying which is not evenly distributed on the mould in mould cleaning process. The strategy to overcome this failure mode risk is to spray the releasing-agent two layers. Meanwhile the most frequent failure mode is the overhead-crane hoist-cable broken off and machine breakdown. The strategy to overcome this failure mode is to employ mechanical engineer to carry out regular inspections and maintenance.

Research conducted by Dudek & Szewieczek (2007) under the title Application of FMEA Method in Enterprise Focused on Quality combine failure mode and effect analysis (FMEA) with continuous quality improvement of organization. This research has a purpose to monitor production process in organization. Finally, this result shows at the present time the enterprises should integrate quality management and quality control with customer's requirements, production process's requirements and also quality methods. Such kind of strategy will enable to achieve success for these companies.

The research conducted by Heri Wibowo & Emy Khikmawati (2013) wanted to examine the quality problems of bottled drinking water producers which experienced defective products in every production, especially in the 240 ml glass packaging production line which experienced the most defects. In this study, the researchers used the Six Sigma method with the DMAIC approach (define, measure, analyse, improve, and control). From this study, it was found that for the key critical to quality based on the Pareto diagram is 80%, the highest defect is in the type of lid defect where the lid defect itself consists of leaky lid, broken lid and tilted lid. For the six sigma level is 4.96, which means it has not yet reached the six sigma levels due to the high defective products. Then proceed with analysing the causes of lid defects using a causal diagram and failure mode and effect analysis (FMEA). From the analysis of cause and effect diagrams that the causes of disability are derived from machine, material and human factors. After that with FMEA it can be seen that the highest cause of failure is a dirty seal disc when the production process is running. To remedy the problem, it is necessary to check the condition of the sealing unit before carrying out the production process and sanding the sealing unit once a week on an uneven surface.

Research conducted by Himma & Tri (2015) with the application of the FMEA (Failure Mode and Effect Analysis) method to control the risk of failure that might occur in the refrigerator testing process. According to researchers FMEA is a method that can be used in risk analysis for failure. From the application of the FMEA method, a RPN (Risk Priority Number) value will be obtained from the multiplication of three values, namely S (severity), O (Occurrence), and D (Detection). From the results of the analysis it was found that the highest RPN value is 85 on the thermocouple component with the failure mode measured temperature inaccuracy. From the results of the analysis the researchers showed priorities for the treatment or prevention of failure modes, namely the thermocouple component.

2.2 Current Research

The current research is examining the factors that led to the many defect findings that occurred in the Cabinet Case division, PT. Yamaha Indonesia. In this research, the object and location of the research is different from previous research. Therefore, this research can be categorized as original without imitating another research. In this research, data of the number of defect, the type of defect, and the causes of the defect, as well as the dominant factors that are prioritized for solving the problem, will be obtained. Failure Mode and Effect Analysis (FMEA) is the method used in this research, which can prevent the problem and improve the production process. Other than that, it is also supported by several tools such as fishbone diagram and pareto diagram. FMEA weighs severity (S), occurrence (O), and detectability (D) equally in proportion, but in real cases these criteria have different weight. To solve this problem, FMEA criteria such as severity, occurrence, and detection will be weighted using the Analytical Hierarchy Process (AHP) method. The expected result in the research conducted now is the reduction of the number of defect that occur during production process in Cabinet Case division.

2.3 Theoretical Study

2.3.1 Definition of Quality

According to the International Organization for Standardization (ISO) quality defined as the totality of features and characteristics of a product or service that relies on its ability to meet the needs of companies, markets and customers consistently. In practice, the term quality can have many meanings, depending on the product or service and the stage of the production process and the level of value perceived by the customer that is associated with its features and characteristics (International Labor Organization, 2013).

With the existence of quality control in the production process can be used as controlling in planning as well as implementing quality assurance of a product. Quality assurance is part of quality management where it provides certainty and confidence that quality requirements have been met (Hadi, 2007). After quality control conducted, it can be known how the quality of the product produced during the production process is in accordance with company regulations or not, if the product is considered good enough, it can be distributed to the customers, but if the product is defective, it is necessary to take several actions so that the next product does not experience same defects. This is one of the advantages in implementing quality control, if there are defective products, it can be identified which parts are not in accordance with the specifications desired by the company so that several alternative actions can be taken to minimize defects in subsequent production processes and get the right product specifications.

The implementation of quality control is conducted by monitoring and checking continuously in order to ensure that the system runs effectively. So it is not recommended to conduct quality control only in a certain period of time which has a gap between the inspection before and then a long enough adrift. This quality control conducted to ensure that product quality can be monitored both in terms of the quality produced and its accuracy. In addition, proper documentation of inspections and test results is important for analysing and reporting sources of defects so actions can be taken to reduce defects.

2.3.2 Quality Control

Quality control is a combination of all the tools and techniques used to control the quality of a product with the most economical costs possible and meet customer requirements. Quality control is an engineering and management activity, through these activities, characteristics of product quality can be measured, compare them with specifications or requirements and take appropriate action if there is a difference between the actual appearance and the standard.

In controlling the process, investigation must be conducted quickly if there is a process disturbance. Moreover, corrective action can be done immediately before too many units are not in accordance with production standards.

Factors affecting quality control include:

1. In terms of operators : the skills and expertise of people who handle products.
2. In terms of raw materials : raw materials supplied by the seller.
3. In terms of machines : types of machines and machine elements used in the production process.

In general, quality control can be interpreted as an effective system to integrate the development, maintenance and quality improvement efforts of various groups in an organization so that engineering, production and services, and marketing can be at the most economical level so that consumers get full satisfaction. So quality control means:

1. Using quality control as the basis for every activity.

2. Integrated cost, price and profit control.
3. Control of quantities, including the amount of production, sales and inventory as well as delivery time to customers.

Dr. Juran (1962) supported the delegation of quality control to the lowest level in the organization through the placement of employees in self-control. Quality control involves several activities, namely:

1. Evaluating the actual work (actual performance)
2. Comparing the actual with the target
3. Taking action on the difference between the actual and target.

Basically, quality performance can be determined and measured based on quality characteristics consisting of several properties or dimensions, namely:

1. Physical, such as length, weight, diameter, stress, thickness.
2. Sensory (related to the five senses) such as taste, appearance, color and shape.
3. Time orientation such as reliability, service capability, ease of maintenance, timeliness of product delivery.
4. Cost orientation as related to the cost dimensions that describe the price or cost of a product that must be paid by consumers.

Basically, a measurement of quality performance can be conducted at three levels, namely process level, output level and outcome level. Statistical process control can be applied at the level of quality performance measurement. However, the measurement of quality performance that will be conducted should take into account every aspect of the operational process that affects customer perceptions about the value of quality. It should also be noted that information about customer needs obtained through market research must be defined in a precise and definite form through attributes and variables. Furthermore, the attributes and variables of the product are then the basis of statistical process control. As for the considerations in measuring quality performance are:

1. Performance, related to the functional aspects of the product

2. Features, related to the choices and development
3. Reliability, related to the failure rate in using the product
4. Serviceability, related to the ease and cost of repairs
5. Conformance, related to the level of conformity of the product to specifications that have been predetermined based on customer desires
6. Durability, related to the durability or lifetime of the product
7. Aesthetics, related to the design and packaging of the product
8. The perceived quality is subjective, related to customer feeling in consuming the product such as increasing prestige, morals, and others.

2.3.3 The Importance of Quality Control

a. Quality Control Needs

Quality control of products is an effort to minimize defective products from products produced by the company. Without quality control, the product will cause a large loss for the company, because irregularities are not known so that improvements cannot be done and ultimately the deviation will be sustainable. Conversely, if quality control can be implemented properly, any deviation can be immediately corrected and can be used to improve the production process in the future. Thus, the production process that takes into account the quality of the product will produce a quality product free from damage and defects, thus making the price more competitive.

The role of product quality is very important in an increasingly competitive marketing situation, because it can affect the progress or failure of the company. Companies not only pay attention to the quality of the production also the quality of these products. For companies that do not pay attention to the quality of the products produced will experience many obstacles in marketing, so the product is less saleable and has decreased sales.

b. Quality Control Objects

In line with the development of technological, scientific and economic progress, the manufacturing environment is shifting towards more advanced ones. The competition is also getting tougher. In order to be able to survive and even compete in this tight competition, business people should be able to continuously improve the production process and the product itself to be able to create new advantages. For that the company must continuously make improvements to the quality of the products produced. Hence, every company really needs a quality control that is done continuously. Quality control is a way to produce goods or services economically in accordance with the wishes of the customer. In the process of quality control not only to find out the quality of the product but also requires quality control of the performance of employees who work at the company.

CHAPTER III

RESEARCH METHODOLOGY

This chapter will be explaining methods that will be used in this research. This chapter contains of several sub-chapter including research object, data requirement, data collection method and flow chart.

3.1 Research Object

This research was conducted at PT Yamaha Indonesia (YI) located on Rawa Gelam I street No. 5 Kawasan Industri Pulo Gadung, East Jakarta, Indonesia 13930. PT. Yamaha Indonesia is a manufacturing industry which produces piano instruments. The object of this research is the type of potential failure and improvement in production process in Cabinet Case division, which produces several parts of Up Right piano.

3.2 Data Requirement

There are two types of the data that will be used on this research including:

3.3 Primary Data

Primary data are data that obtained directly from the object of research. This data will be obtained through interviewing experts who are used as a means to obtain information. This research uses primary data to obtain direct information about the findings of defects that often occur in the Cabinet Case both from upstream to downstream of the process so that the things that cause the defects are obtained. In addition, data are also obtained through filling out the FMEA questionnaire by the expert to determine the weight of potential failure based on criteria of severity, occurrence, and detectability, and also filling out the AHP questionnaire to determine the preference of the expert against FMEA criteria using pairwise comparison matrix in AHP method.

3.4 Secondary Data

Secondary data is obtained by using the existing data. The defective product data obtained from Production Engineering department of PT Yamaha Indonesia and other department related to production process. The secondary data is used to compile the information related to the topic that discussed in this study to complete the research.

3.5 Research Instrument

The research instrument is the tools used to facilitate the data collection, processing and data analysis. The instrument used in this research are interview and questionnaire to determine severity, occurrence, and detection also weighting them.

3.6 Data Collection Method

Data collection methods used in this research are:

3.6.1 Interview

Interviews were conducted to experienced operators and head of group (experts) in the Cabinet Case division, Wood working department at PT Yamaha Indonesia (YI) regarding the production process flow and matters that could potentially cause defects.

3.6.2 Observation

Observation was conducted by collecting data which was carried out by a direct review of PT Yamaha Indonesia's business processes.

3.7 Data Processing Method

At this stage, the data obtained from data collection will be processed by several method:

3.7.1 Pareto Diagram

Pareto diagram is a bar chart based on the Pareto principle, which states that when several factors influence a situation, a handful of factors account for most of the impact. The pareto principle describes a phenomenon in which 80 percent of the observed variation in everyday processes can be explained by only 20 percent of the causes of variation.

Pareto diagram provides the facts needed to set priorities. Organizes and displays information to show the relative importance of various problems or causes of problems. Basically, the pareto diagram is a special form of vertical bar chart that places an item in an order from highest to lowest relative to an effect that can be measured in importance: frequency, cost, time.

Sorting an item in descending order of frequency makes it easy to separate problems from the main problem that causes most impact. Therefore, the pareto chart helps teams focus their efforts on fixing the problem that has the greatest potential impact.

In this research, researcher uses pareto diagram to determine the percentage of defective product that are made from production process in Cabinet Case division. Furthermore, from these percentage, it is known the frequent type of defect which should be handled as soon as possible.

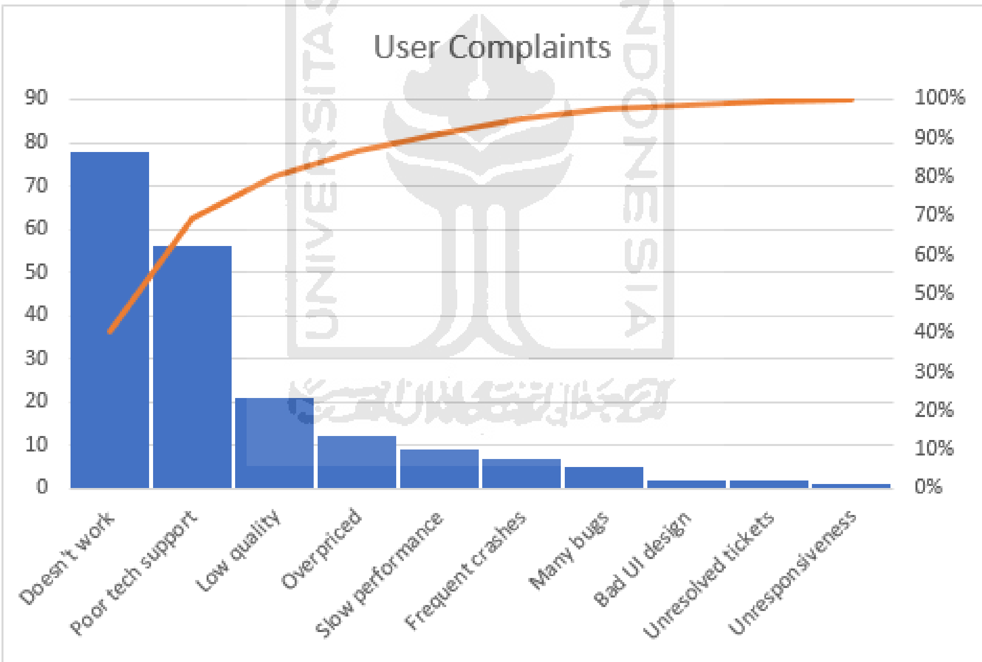


Figure 3. 1 Example of Pareto diagram

3.7.2 Fishbone Diagram

Fishbone diagram is often referred to as Ishikawa diagram. The designation of this diagram as the Ishikawa Diagram because the one who developed this diagram model is

Dr. Kaoru Ishikawa in around the 1960's. The designation of this diagram as the fishbone diagram because this diagram is shaped like a fishbone skeleton which parts include the head, fins, and spines.

The Fishbone diagram is a visual tool to identify, explore, and graphically describe in detail all the causes associated with a problem. The basic concept of the fishbone diagram is that the basic problem is placed on the right side of the diagram or on the head of the fishbone skeleton. The causes of the problem are described in the fins and spines. Categories of causes of problems that are often used as an initial start include material, machine and equipment, manpower, method, mother nature or environment, and measurement. The six causes of this problem are often abbreviated as 6M. Other causes of the problem other than the 6M can be selected if needed. To find the cause of the problem, both from the 6M as described above and other possible causes, brainstorming techniques can be used. The steps for making a cause and effect diagram are as follows:

1. Identify the main problem.
2. Place the main problem to the right of the diagram.
3. Identify the minor causes and put them on the main diagram.
4. Identify the minor causes and placing them on the major causes.
5. After the diagram is complete, then conduct an evaluation to determine the real cause.

According to Pande, et al (2003), there are six factors that can be the causes in this fishbone diagram. The six factors are as follows:

1. Material

   Material is the raw input that will be used in the process or converted into finished goods through processes.
2. Method

   Method is procedure, process, and work instruction in a company.
3. Machine and Equipment

   The machine means equipment including computer and tool used in processing material.
4. Measurement

Measure is a technique used in assessing the quality or quantity of work within a company, including the inspection process.

5. Mother Nature or Environment

   Mother nature is the environment in which processes take place or are carried out. Mother nature can include the natural environment and facilities in the work environment.

6. ManPower

   Man are people who influence the processes carried out by the company.

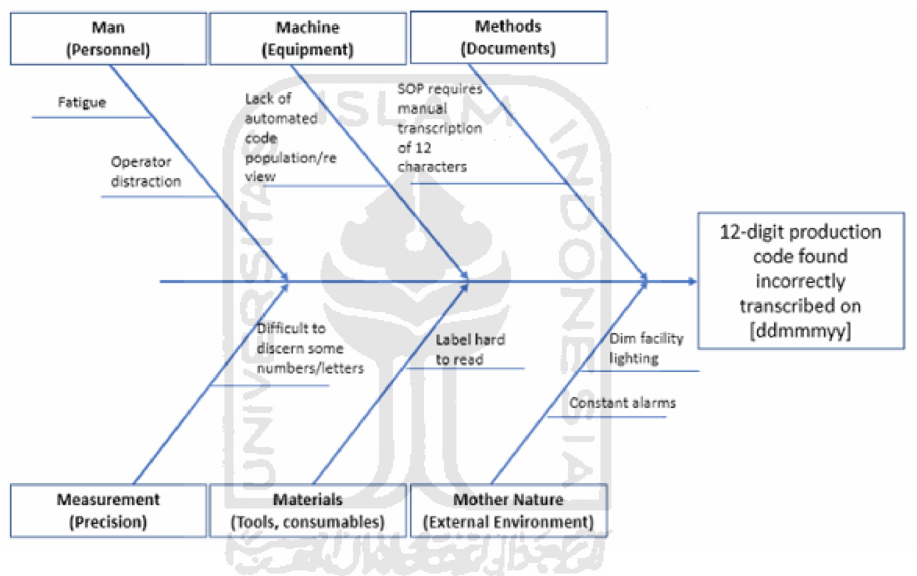


Figure 3. 2 Example of Fishbone diagram

After obtaining a defect that must be prioritized, the researcher identifies the root cause of the problem. Understanding the root of the problem will help researcher to find action that should be taken to handle the causes of the defect. The method used by researchers in identifying problems is using a fishbone diagram based on the 6M factor, are the Method, ManPower, Measurement, Material, Mother Nature or Environment, Machine factor.

3.7.3 Failure Mode and Effect Analysis (FMEA)

According to Mc Demott (2009) Failure Mode Effect Analysis (FMEA) is a systematic method for identifying and preventing product and process problems before they occur. It is focused on preventing defects, increasing safety, and increasing customer satisfaction. Ideally, FMEA is held in the product design or process development stage, although holding FMEA in existing products and processes can also generate profits.

The purpose of FMEA is to prevent problems in products and production processes before they occur. FMEA is used in the design and production process, so that it can reduce costs by identifying product and process improvements before the development process. The goal is to find all ways of process or products can be failed. Defective product occurs when the product does not function as it should or when it fails to use in several ways. Even the simplest products have several opportunities for failure.

Furthermore, FMEA predicts whether it can detect defects and estimate the severity. Defects can vary between minor annoyances and disasters. FMEA estimates its defects and relative risks in a structured format. FMEA is a tool used to analyse the reliability of a system and the causes of its failure to achieve system, design and process reliability and security requirements by providing basic information on predictions of system, design, and process reliability. According to Stamatis (1995) who cites Omdahl and ASQC, FMEA is a technique used to define, recognize and reduce failures, known problems, errors and potential of a system, design, process and service before reaching the consumer.

From all the above FMEA definitions, which are more about quality, it can be concluded that FMEA is a method used to identify and analyse a failure and its consequences from the source and root causes of the problem to avoid the failure. FMEA can be done by means of (Chrysler, 1995):

1. Recognize and evaluate the potential failure of a product and its effects.
2. Identify actions that can eliminate or reduce the chance of a potential failure occurring.

3. Document the process.

The uses of FMEA are as follows:

1. When precautions are needed before the problem occurs.
2. To know or record the existing detection devices if a failure occurs.
3. Use of new processes
4. Change of equipment components
5. Moving components or processes in a new direction

While the benefits of FMEA are as follows:

1. Cost-effective. Because it is systematic, the solution is aimed at potential causes of a failure error.
2. Save time, because it is more on target.

The objectives can be achieved by companies with the application of FMEA:

1. To identify failure modes and the severity of their effects
2. To identify critical characteristics and significant characteristics
3. To sort potential design orders and process deficiencies
4. To help engineer focus in reducing product attention and process, and help prevent problems.

In making FMEA there are ten stages. There are several processes and identification that must be done in the FMEA process. The following are the things that were identified in the FMEA process namely (Besterfield, 1995).

The first is to review the process (Process function requirements). Describe the process being analysed. The objectives of the process must be given as complete and clear as possible. If the process being analysed involves more than one operation, each operation must be mentioned separately along with its description.

The second is to identify the potential failure mode in the process (potential failure mode). In the FMEA process, one of three types of errors must be mentioned here. The first and most important is the way in which a possible process can fail. The other two forms include the form of potential errors in subsequent operations and the effects associated with potential errors in previous operations.

Third is to make a list of the potential effects of each mode of failure (potential effect of failure). Similar to FMEA design, the potential effect of an error is the influence received by the consumer. The effect of error must be described in relation to what is experienced by consumers. The potential effect of failure must also state whether safety will affect a person's safety or violate some product regulations.

The fourth is to determine the severity ranking for each defect that occurs (Severity). The value of the severity of the consequences caused to consumers and to the continuity of the subsequent processes which indirectly also detrimental. Severity value consists of rating 1-10. Table 3.1 shows the criteria for each rating severity. The worse the effect is, the higher the rating value is given.

Table 3. 1 Ratings for severity

Severity	**Criteria**	**Ranking**
Hazardous Without Warning	Failure would endanger machine or operator without a warning	10
Hazardous With Warning	Failure would endanger machine or operator with a warning	9
Very high	Product would experience complete loss of primary function. 100% of the product may have to be scrapped	8

Severity	Criteria	Ranking
High	Product would be operable with reduced primary function. Product may have to be sorted and a portion (<100%) scrapped	7
Moderate	Comfort/convenience item(s) would be inoperable. A portion (<100%) of the product may have to be scrapped	6
Low	Comfort/convenience item(s) would be operable at a reduced level of performance. 100% of the product may have to be reworked	5
Very low	Defect would be noticed by most customers. 100% of the product may have to be sorted and a portion (<100%) reworked	4
Minor	Defect would be noticed by average customers. A portion of the product (<100%) may have to be reworked on line but out of station	3
Very minor	Defect would be noticed by most discriminating customers. A portion of the product may have to be reworked on line but out of station	2
None	No effect	1

The fifth is to determine the cause of the error with the greatest likelihood for each failure mode and the consequences that occur (Potential Cause). A potential cause of an error is defined as how an error can occur, illustrated from everything that can be fixed or controlled. Every possible cause of error for each mistake made must be as complete and clear as possible.

The sixth is to determine the occurrence rating for each failure mode (Occurrence). How often the possible causes of failure occur. This occurrence value is given for each cause of failure consisting of a rating of 1-10. Table 3.2 shows the criteria for each occurrence rating value. The more often the cause of failure occurs, the higher the rating value given.

Table 3. 2 Ratings for occurrence

Occurrence	Criteria	Ranking
Very High	1 in 2	10
Very High	1 in 3 Almost certain to occur	9
High	1 in 8	8
High	1 in 20 High probability that the event will occur	7
Moderate	1 in 80	6
Moderate	1 in 400 Moderate chance to occur	5
Moderate	1 in 2000	4
Low	1 in 15000 Unlikely to occur	3
Low	1 in 150000	2
Remote	1 in 1500000 Very unlikely to occur	1

Seventh is making a description of the control to prevent errors (Current Process Control). Current process control is a description of the control that can prevent as far as possible the form of an error from occurring or detect the form of an error that occurred.

Eighth is to take action to find out the extent of the root of the problem (Detection). Represents how far the cause of failure can occur consisting of rating 1-10. Table 3.3 shows the criteria for each rating detection value. The more often the cause of failure occurs, the higher the rating value given.

Table 3. 3 Rating for detection

Detection	Criteria	Ranking
Absolutely Impossible	Design control will not and/or cannot detect or analyse a potential cause/mechanism and subsequent failure mode	10
Very Remote	Detection controls have a weak detection and very remote likelihood that current controls will detect/prevent the failure mode	9
Remote	Failure mode detection post-processing by operator through visual means and current controls will detect/prevent the failure mode	8
Very Low	Product validation after design freeze and prior to launch with test to failure testing that current controls will detect /prevent the failure mode	7
Low	Product validation after design freeze and prior to launch with degradation testing and that current controls will detect/prevent failure mode	6
Moderate	Product validation prior to design freeze using pass or fail testing and that current controls will detect/prevent the failure mode	5
Moderately High	Product validation prior to design freeze using test to failure and that current controls will detect/prevent the failure mode	4

Detection	Criteria	Ranking
High	Failure mode detection in station by automated controls that will detect discrepant part and automatically lock part in station to prevent further processing	3
Very High	Error detection in station by automated controls that will detect error or prevent the failure mode	2
Almost Certain	Current Controls are almost certain to detect/prevent the failure mode	1

Ninth is to calculate the RPN (Risk Priority Number). Risk priority number (RPN) is a mathematical system that translates a set of effects with serious severity, so as to create a failure related to these effects (occurrence), and has the ability to detect failures (detection) before reaching the consumer. RPN is the multiplication of rating occurrence (O), severity (S) and detection (D).

$$RPN = O\ x\ S\ x\ D$$

RPN values range from 1-1000, with 1 being the smallest possible design risk. The RPN value can be used as a guide to find out the most serious problems, with the indication that the highest number requires serious handling priority.

Tenth is the action that must be performed (Recommended Action). Recommended Action has the objective to reduce one or more criteria that make up the RPN. Ranking in the design validation level will result in a reduction in the detection level. Only moving or controlling one or more of the causes mode through a design revision can have an effect on the downgrade occurrence. And only design revisions that can bring severity reduction.

Failure Mode and Effect Analysis (FMEA) is a structured procedure to identify and prevent as many failure modes as possible. FMEA is used to identify the sources and root causes of quality problems and to identify the risk of failure that may arise. In this method there are several weighting criteria are Severity (S), Occurrence (O), and Detectability (D) value.

3.7.4 Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) was developed by Thomas L. Saaty in the 1970s. This method is one of the multi-criteria decision making models that can help human thinking frameworks where the factors of logic, experience, knowledge, emotions, and taste are optimized into a systematic process. AHP is a decision-making method developed to prioritize alternatives when several criteria must be considered, and allow decision makers to arrange complex problems into a hierarchical form or integrated set of levels.

Basically, AHP is a method used to solve complex and unstructured problems into groups, by organizing the groups into a hierarchy, then entering numerical values as a substitute for human perception in making relative comparisons. With a synthesis it can be determined which element has the highest priority. AHP is often used as a method of solving problems compared to other methods for the following reasons:

1. The hierarchical structure, as a consequence of the selected criteria, reaches the deepest sub-criteria.
2. Calculates the validity up to the tolerance limit of the inconsistencies of various criteria and alternatives chosen by the decision maker.
3. Take into account the resilience of the decision-making sensitivity analysis output.

The stages of Analytical Hierarchy Process (AHP), in the AHP method, the steps are as follows:

1. Arrange the hierarchy of the problem.

The problem to be solved is broken down into elements, are criteria and alternatives, then arranged into a hierarchical structure as illustrated by Figure 3.3 below:

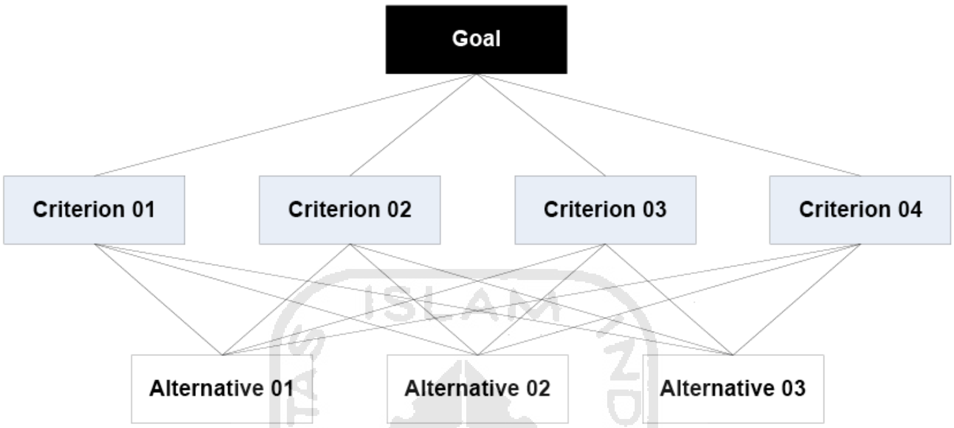


Figure 3. 3 Example of hierarchy

2. Assessment of criteria and alternative

Criteria and alternatives are assessed through pairwise comparisons. According to Saaty (1988), for various problems, a scale of 1 to 9 is the best scale in expressing opinions. The values and definitions of qualitative opinions from the Saaty comparison scale can be seen in Table 3.4 below:

Table 3. 4 Pairwise comparison rating scale

Importance	Definition	Explanation
1	Equal importance	Contribution to objective is equal
3	Moderate importance	Attribute is slightly favoured over another
5	Strong importance	Attribute is strongly favored over another
7	Very strong importance	Attribute is very strongly favoured over another
9	Extreme importance	Evidence favouring one attribute is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed

Comparisons are made based on decision maker of policy by assessing the importance of one element to other elements. Comparison process pairs start from the top level of the hierarchy, which is intended to select criteria, for example A, then elements to be compared are taken, for example A1, A2, and A3. Then the arrangement of the elements being compared will look like in the matrix below:

Table 3. 5 Example of a pairwise comparison matrix

	A1	A2	A3
A1	1		
A2		1	
A3			1

To determine the relative importance between elements, a number scale from 1 to 9 is used, as shown before. This assessment is carried out by a decision maker who is an expert in the area of the problem being analysed and has an interest in it. If an element is compared with itself, then it is given a value of 1. If element i compared to element j gets a certain value, then element j compared to element i is the opposite. In this AHP, alternative assessments can be carried out by the direct method, which is the method used to enter quantitative data. Usually these values come from a previous analysis or from experience and detailed understanding of the decision problem. If the decision maker has experience or a large understanding of the decision problem at hand, then he can immediately enter the weighting of each alternative.

3. Priority determination

For each criterion and alternative, pairwise comparisons need to be done. The relative comparison values are then processed to rank alternative alternatives for all alternatives. Both qualitative criteria and quantitative criteria can be compared in accordance with pre-determined assessments to produce weights and priorities. Weights or priorities are calculated by matrix manipulation or through the completion of mathematical equations. Considerations regarding pair comparisons are synthesized to obtain overall priorities through the following stages:

a) Squaring the pairwise comparison matrix.
b) Calculate the sum of the values from each row, then normalize the matrix.

4. Logical Consistency

All elements are logically grouped and consistently warned according to a logical criterion. The weight matrix obtained from the pairwise comparison results must have a cardinal and ordinal relationship. The relationship can be shown as follows (Suryadi & Ramdhani, 1998):

Cardinal relations: aij. ajk = aik

Ordinal Relationship: Ai> Aj, Aj> Ak then Ai> Ak

The relationship above can be seen from two things as follows:

a) By looking at multiplicative preferences, for example if grape is four times better than mango and mango is twice as good as banana, grape is eight times better than banana.
b) By looking at transitive preferences, for example, grape is better than mangoes and mangoes are better than bananas, grape is better than bananas.

In reality, there will be some deviations from the relationship, so the matrix is not perfectly consistent. This happens because of inconsistencies in one's preferences. The calculation of logical consistency is done by following the steps as follows:

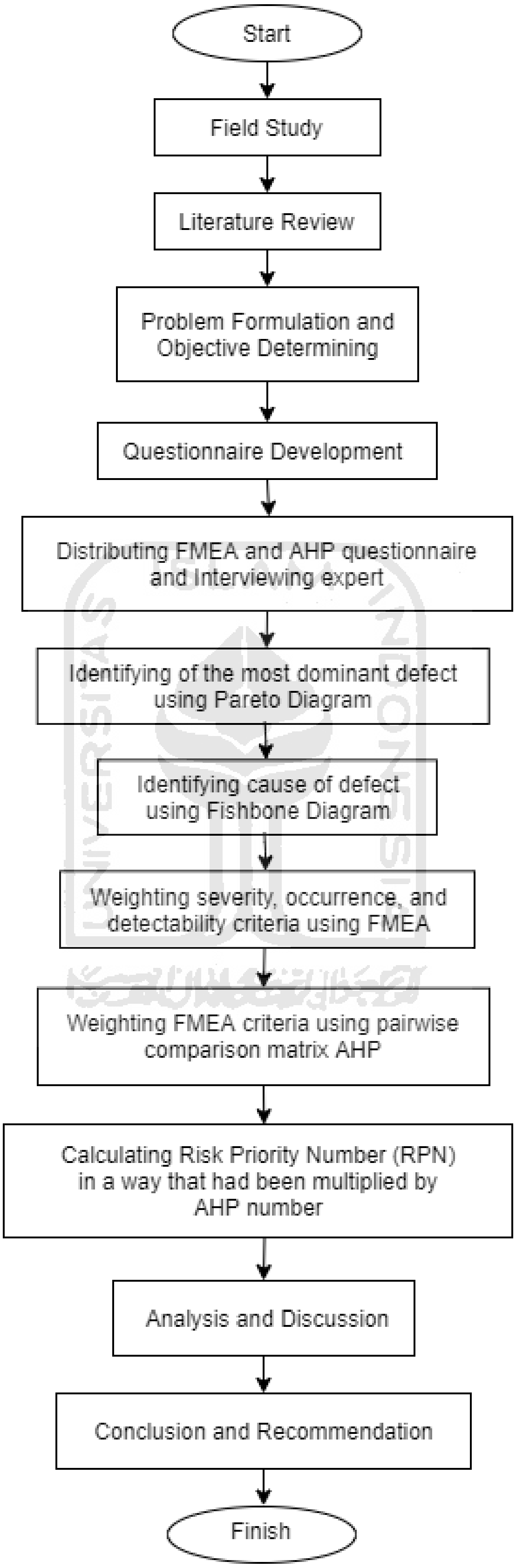
a) Multiplying the matrix with the corresponding priority.
b) Add up the multiplication results per line.
c) The sum of each row is divided by the priority concerned and the results added up.
d) Results c divided by the number of elements, λmax will be obtained.
e) Consistency Index (CI) = (λmax-n) / (n-1)
f) Consistency Ratio = CI / RI, where RI is the random consistency index. If the consistency ratio is ≤ 0.1, the results of the data calculation can be justified. List of RI can be seen in Table 2.6

Table 3. 6 Random index value

n	1	2	3	4	5	6	7	8	9	10
RC	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

After weighting with FMEA, AHP (Analytical Hierarchy Process) will be weighted towards the FMEA criteria. AHP weighting is carried out because these factors have different effects. Thus, the severity, occurrence, and detectability value will be multiplied by the AHP weight before ranking the RPN (Risk Priority Number) with the AHP weight.

3.8 Flow Chart



Explanation of flow chart:

As seen in the research flowchart above that the research was conducted in the Cabinet Case division PT Yamaha Indonesia. The first step that the researcher took was conducting a field study by conducting direct survey. The field study was conducted to determine the problem that exist in the production process in the Cabinet Case division PT Yamaha Indonesia, then provide a clear picture of the research object and develop a framework for problem solving. After conducting a field study, the next step is to conduct a literature study by studying previous research and theories related to the topic of the problem which can support in solving the problem. After conducting observation and literature study, the researcher decided to identify defective product produced during the production process in the Cabinet Case division PT Yamaha Indonesia. Identification is conducted on all type of defect and type of cabinet produced in the Cabinet Case division.

The next stage is a questionnaire development. At this stage, the researcher uses two types of questionnaire that are commonly used, are the FMEA and AHP questionnaire which will be distributed to the expert. The FMEA questionnaire is used to determine the severity, occurrence, and detection value of failure mode that occur in the production process in the Cabinet Case division. In addition, the researcher also uses an AHP questionnaire which is useful for determining the weight of each criterion in the FMEA method. Furthermore, the researcher also conducted interview with the head of the group as an expert to determine potential failure and cause of failure in the Cabinet Case division.

After knowing the variable from the defect finding data, then the researcher analyse the highest defect using the Pareto diagram. After doing the calculation, the researcher analyse the cause of defective product using Fishbone diagram. This analysis is done by recording and identifying all of factor that cause defective product that exist in the company. In the next stage, the researcher process the FMEA data by giving weight to all the severity, occurrence, and detectability criteria. Using FMEA often gives the same RPN result but represents a different risk. The calculation of the FMEA method traditionally calculate the weight of Severity (S), Occurrence (O), and Detectability (D) equally, but in real case these criteria have different weight (Aslani, 2014). To solve this problem, the FMEA criteria were weighted using the AHP method.

At the next step, the researcher analyse the result of RPN in a way that had been multiplied by the AHP number. After analysing the failure mode which has the highest value, an analysis of the causes of failure is conducted. The conclusion and suggestion stage contains conclusion from result of research and suggestion from the researcher to the company and further research in accordance with the focus of the problem based on the improvement action plan for the company to reduce defective product found in the production process at Cabinet Case division.

CHAPTER IV

RESULT OF RESEARCH

This chapter describes the data processing process used in this research and the result will be known. There are four stages of processing data which are determining the dominant defect occur using Pareto diagram, root cause identification of problem using Fishbone diagram, failure mode identification using FMEA, and determining proper improvement by weighting AHP toward FMEA criteria.

4.1 Types of Defect

In this stage contains data that haves been collected by researcher. The types of defect are rift, curved, chipped, bobber, broken, bubble, backer NG, ripped, cracked, and drill NG. The following data are detail the defects that occur in the Cabinet Case division's production process. The defects are described as follows:

Table 4. 1 Defect definition

No	Defect Type	Definition
1	Rift	A defect in the form of a wavy and irregular surface cabinet cut and must be replicated in the pressing process
2	Curved	Defect caused by the long storage of material and causing the cabinet to curve due to humidity
3	Chipped	Defect caused by the residual press following press process which hit the storage shelf
4	Bobber	Defect type in the form of a loose press on the inside of the part caused by irregular glue application
5	Broken	Defect caused by cabinet effect on storage shelf or other heavy objects
6	Bubble	Defect that occurs due to the high temperature of heating process which causes small bubbles to appear in the paint
7	Backer NG	Defect in the form of browning on the backer which has impact on the painting process
8	Ripped	A defect in the form of irregular cut on the cabinet edge and small long chunks
9	Cracked	Defect that found in solid material. It occurs because of unrecognized wood processing error
10	Drill NG	Defect that occurs due to wrong drilling point

Defect data was taken from October 2019 to March 2020. The following is defect data that occurred in October 2019 to March 2020 shown in table 4.2.

Table 4. 2 Defect finding data in Cabinet Case division

No	Cabinet Type	Rift	Curved	Chipped	Bobber	Broken	Bubble	Backer NG	Ripped	Cracked	Drill NG	Grand Total
1	Fall Back	140	0	68	6	3	3	0	0	0	1	221
2	Key Slip	67	16	49	11	7	2	0	6	2	0	160
3	Fall Front	85	0	31	13	1	14	2	0	0	1	147
4	Top Frame	46	10	51	22	11	0	0	1	0	0	141
5	Hinge Strip	60	22	11	0	4	0	0	2	5	0	104
6	Top Board	40	2	30	14	5	0	1	1	0	0	93
7	Fall Center	41	0	43	5	2	0	0	1	0	0	92
8	Key Block	13	0	7	3	2	0	1	0	0	0	26
9	Bottom Frame	0	1	17	0	4	0	2	0	0	1	25
10	Side Sleeve	9	0	3	1	1	0	0	0	0	0	14
11	Fall Board	5	0	5	0	1	0	0	0	0	0	11
Grand Total		**506**	**51**	**315**	**75**	**41**	**19**	**6**	**11**	**7**	**3**	**1034**

4.2 Determining Priority of Defect

In this stage, it contains the analysis conducted by the researcher to determine the most dominant type of defect that occurs during the production process in the Cabinet Case division. The analysis is conducted using Pareto diagram

After the researcher obtains the defect data, the researcher then determines the most dominant type of defect and must seek immediate repair. In table 4.3 and Figure 4.1, the result of the diagram that the researcher has created will be presented.

Table 4. 3 Resume of defect type

Type of Defect	Number of Defect	Percentage	Cumulative
Rift	506	48,94%	48,94%
Chipped	315	30,46%	79,40%
Bobber	75	7,25%	86,65%
Curved	51	4,93%	91,59%
Broken	41	3,97%	95,55%
Bubble	19	1,84%	97,39%
Ripped	11	1,06%	98,45%
Cracked	7	0,68%	99,13%
Backer NG	6	0,58%	99,71%
Drill NG	3	0,29%	100,00%
Total	**1034**		

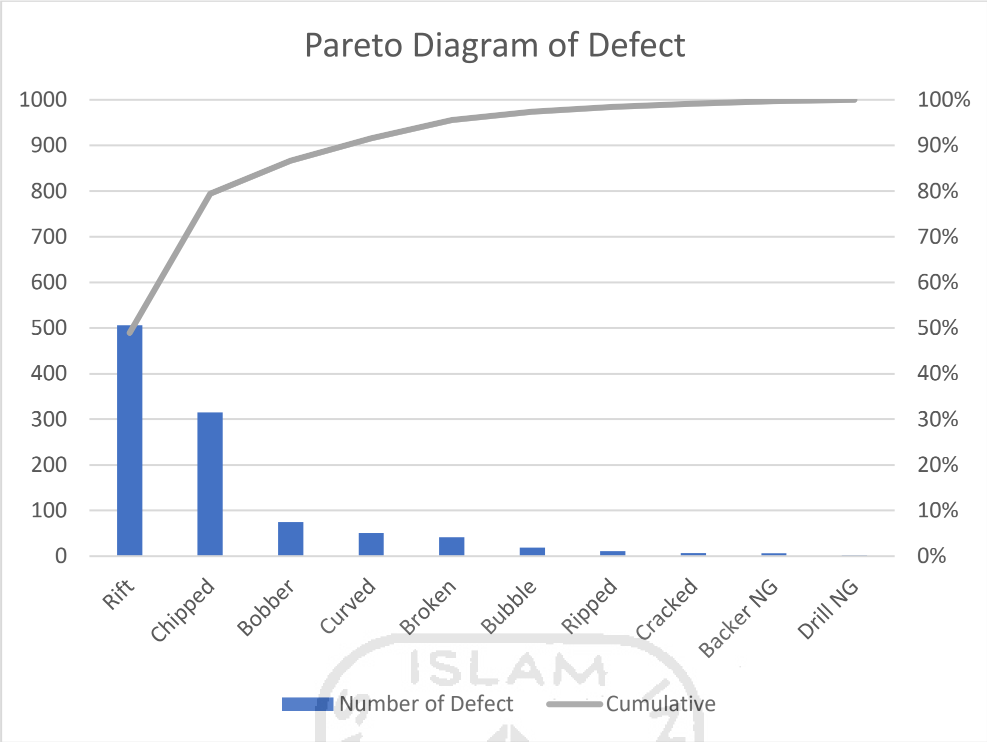


Figure 4. 1 Pareto diagram of defect type

Based on the data of the defect finding from Quality Control of Wood Working department and after analysis using the Pareto diagram, the result shows that the rift defect is the most dominant defect type with 48,94% and must be prioritized for made improvement. After the priority type of defect has been identified, data processing will be done with the Pareto diagram for the cabinets produced in Cabinet Case division. Following are tables 4.4 and 4.5 contains data of cabinet along with the resume of the defect:

Table 4. 4 Data defefct on each cabinet

No	**Cabinet**	**Month**						**Total**
		Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	
1	Fall Back	88	62	43	6	9	14	**222**
2	Hinge Strip	68	13	9	5	7	4	**106**
3	Key Slip	46	49	42	12	0	6	**155**

No	Cabinet	Month						Total
		Oct	Nov	Dec	Jan	Feb	Mar	
4	Fall Front	41	47	30	7	4	18	**147**
5	Fall Center	36	24	18	7	3	4	**92**
6	Top Frame	34	45	43	10	5	6	**143**
7	Top Board	26	29	29	3	2	4	**93**
8	Bottom Frame	9	10	4	0	0	2	**25**
9	Side Sleeve	8	2	3	1	0	0	**14**
10	Key Block	5	8	3	4	3	3	**26**
11	Fall Board	4	5	2	0	0	0	**11**
Total		**365**	**294**	**226**	**55**	**33**	**61**	**1034**

Table 4. 5 Resume of defect each cabinet

No	Cabinet	Number of Defect	Percentage	Cumulative
1	Fall Back	222	21,47%	21,47%
2	Key Slip	155	14,99%	36,46%
3	Fall Front	147	14,22%	50,68%
4	Top Frame	143	13,83%	64,51%
5	Hinge Strip	106	10,25%	74,76%
6	Top Board	93	8,99%	83,75%
7	Fall Center	92	8,90%	92,65%
8	Key Block	26	2,51%	95,16%
9	Bottom Frame	25	2,42%	97,58%
10	Side Sleeve	14	1,35%	98,94%
11	Fall Board	11	1,06%	100,00%
Total		**1034**		

After obtaining the data as above, then the researcher makes a Pareto diagram to find out which cabinet will be prioritized as shown in Figure 4.2 below:

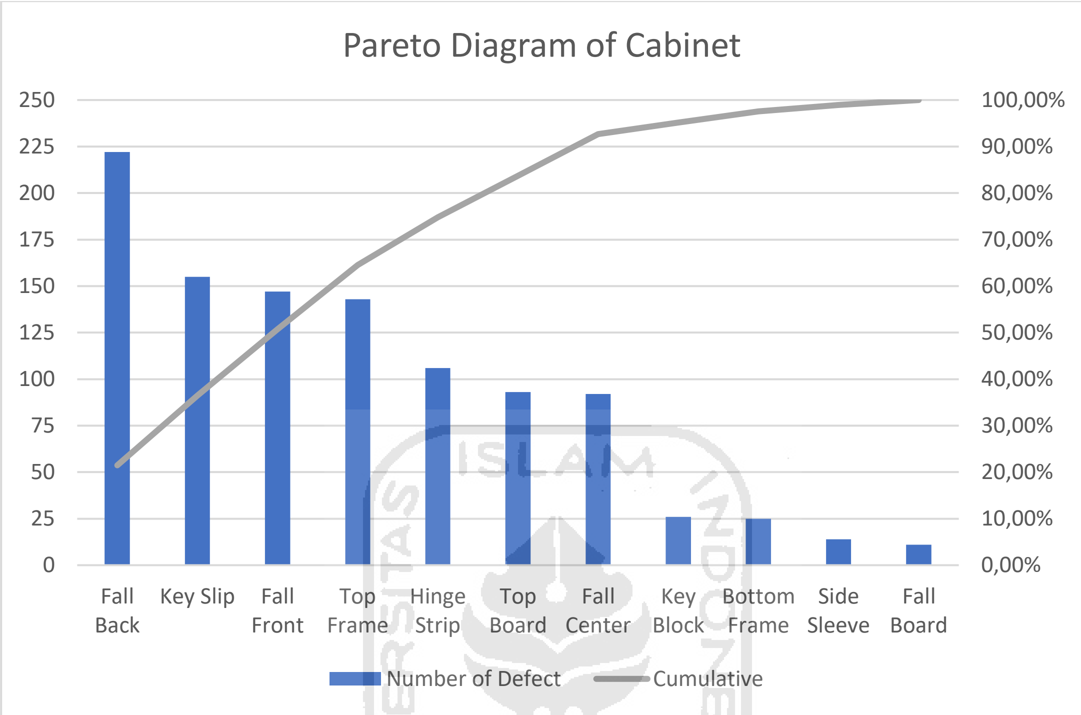


Figure 4. 2 Pareto diagram of defect each cabinet

Based on data processing with Pareto diagram for cabinets produced in Cabinet Case division, the result shows that the Fall Back is the cabinet with the most frequent defect with a percentage of 21,47%.

4.3 Analysing The Cause of Defect

In this stage, it contains the analysis conducted by the researcher to identify the causes that lead to defective product in Cabinet Case division. Furthermore, the root cause analysis is conducted using the Fishbone diagram.

After finding defect that must be prioritized, the researcher identifies the root cause of the problem. Understanding the root of the problem will help researcher find action that can be taken to overcome the causes of the defect. The method used by researcher in identifying problem is Fishbone Diagram based on the 6M factor, are method, manpower, measurement, material, mother nature or environment, and machine factor.

The following is an analysis of the defect causes that occur in Cabinet Case division. The researcher conducted interview and brainstorming with related VSM & IE staff and head of group as expert so that the data obtained was more accurate. The Fishbone diagram below illustrates the cause of defects in the cabinet.

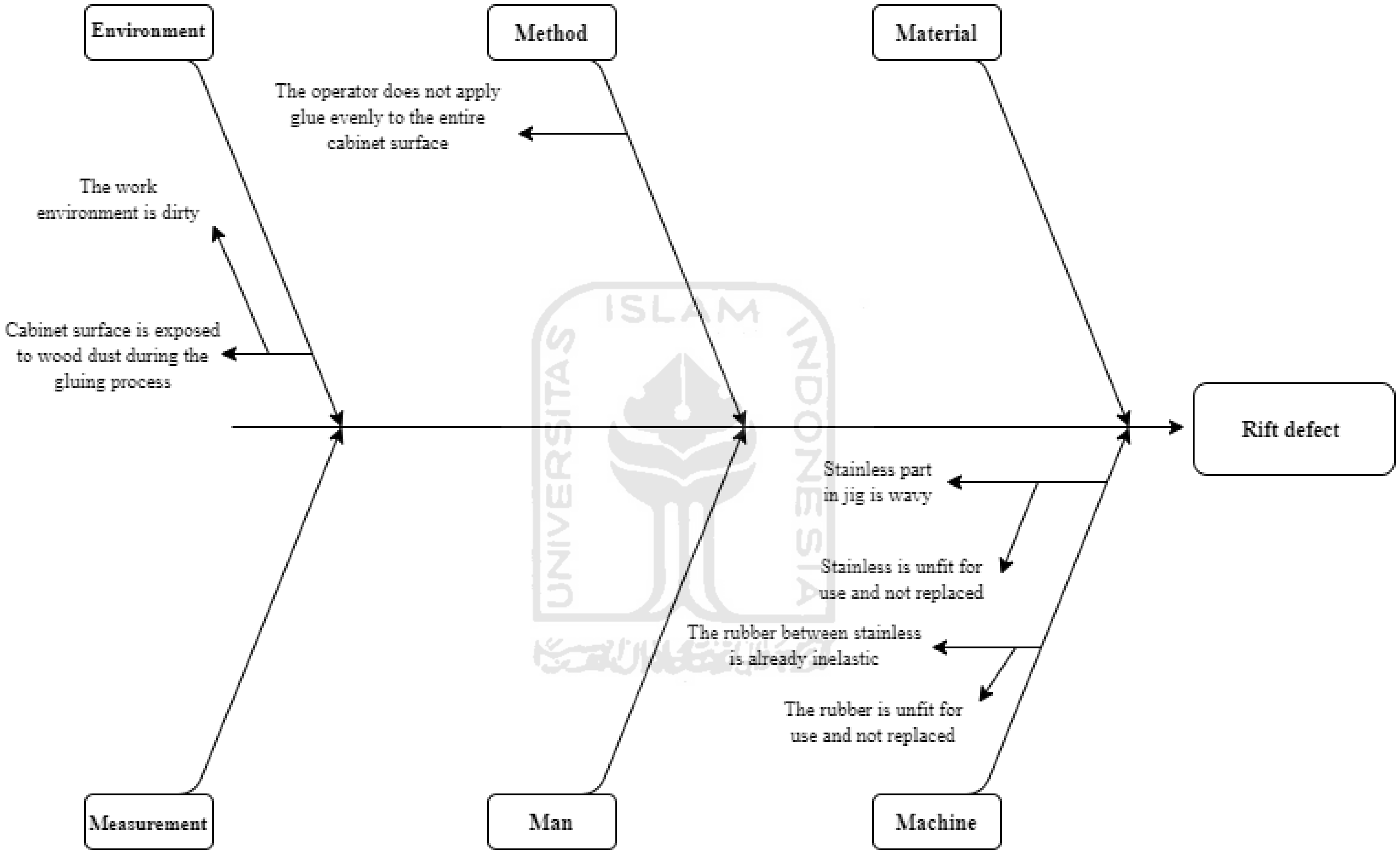


Figure 4. 3 Fishbone diagram of rift defect

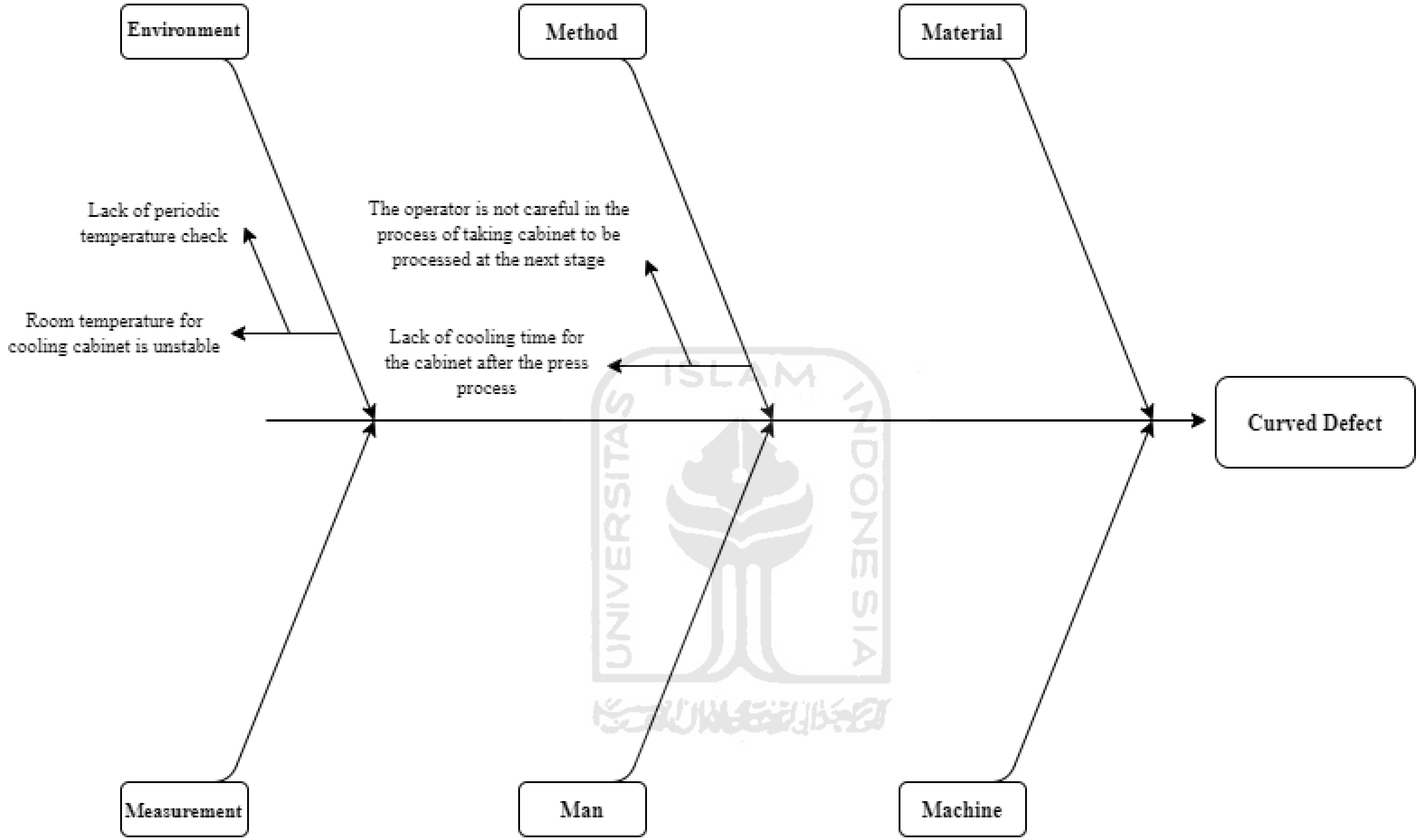


Figure 4. 4 Fishbone diagram of curved defect

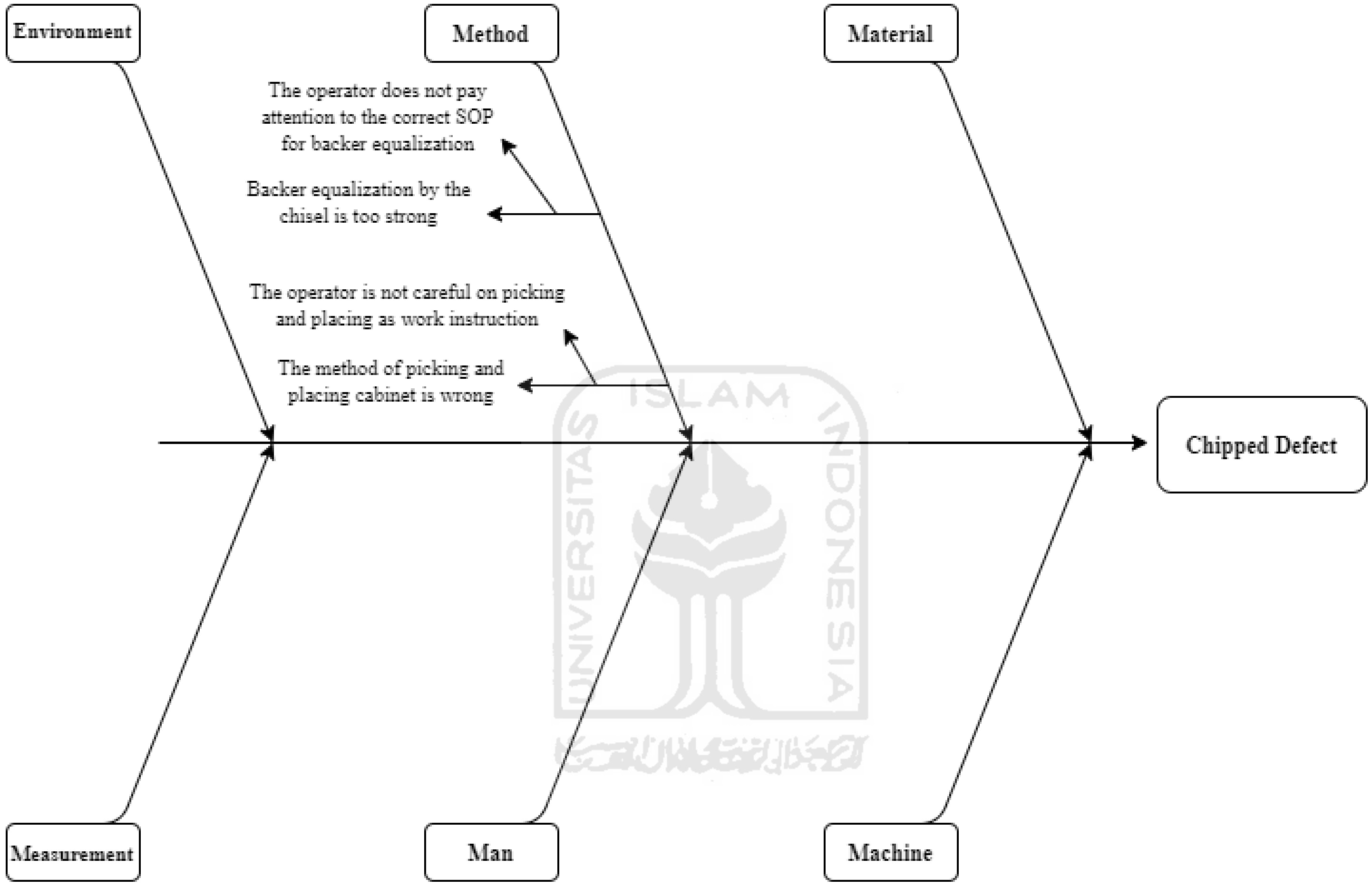


Figure 4. 5 Fishbone diagram of chipped defect

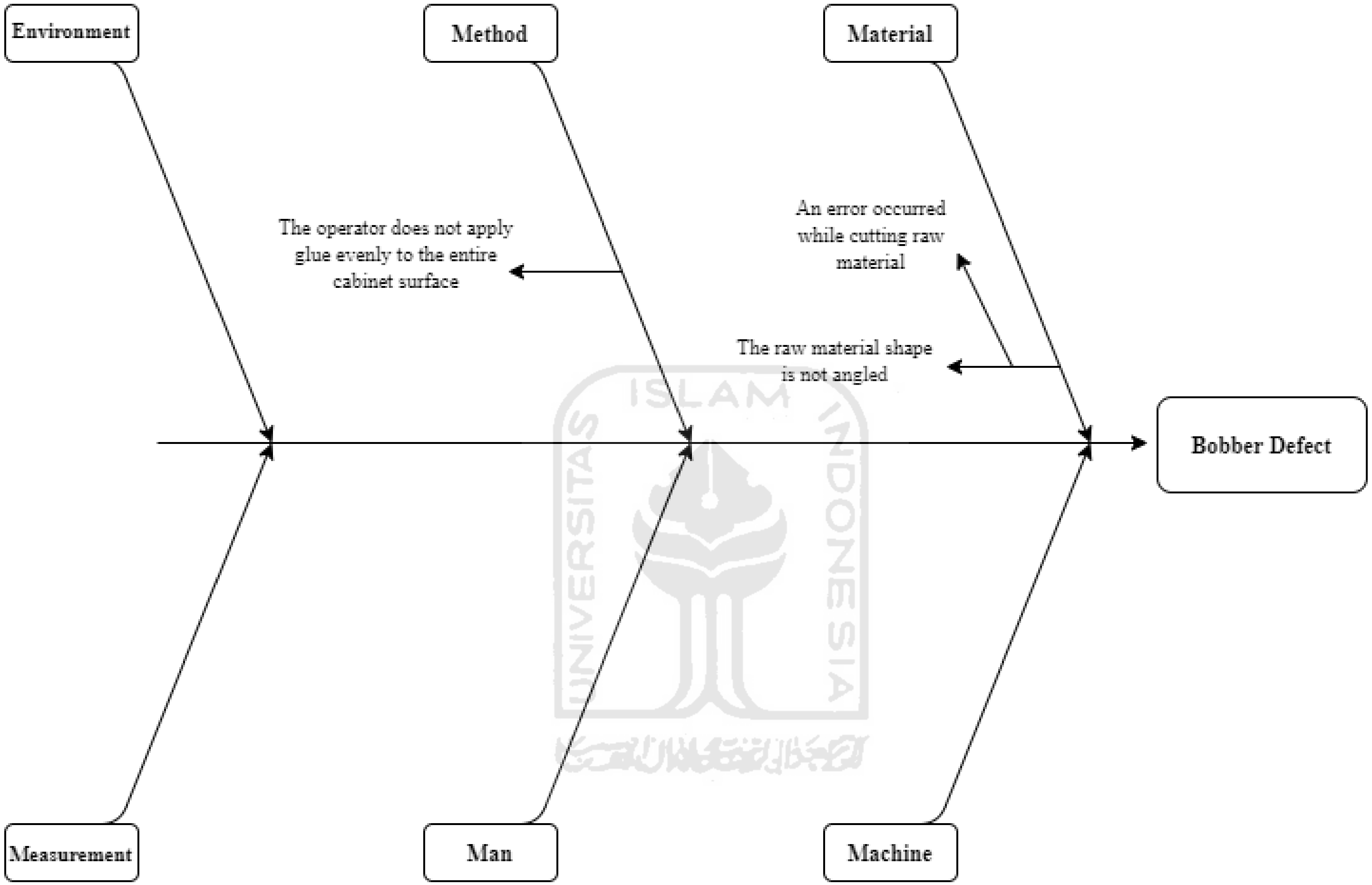


Figure 4. 6 Fishbone diagram of bobber defect

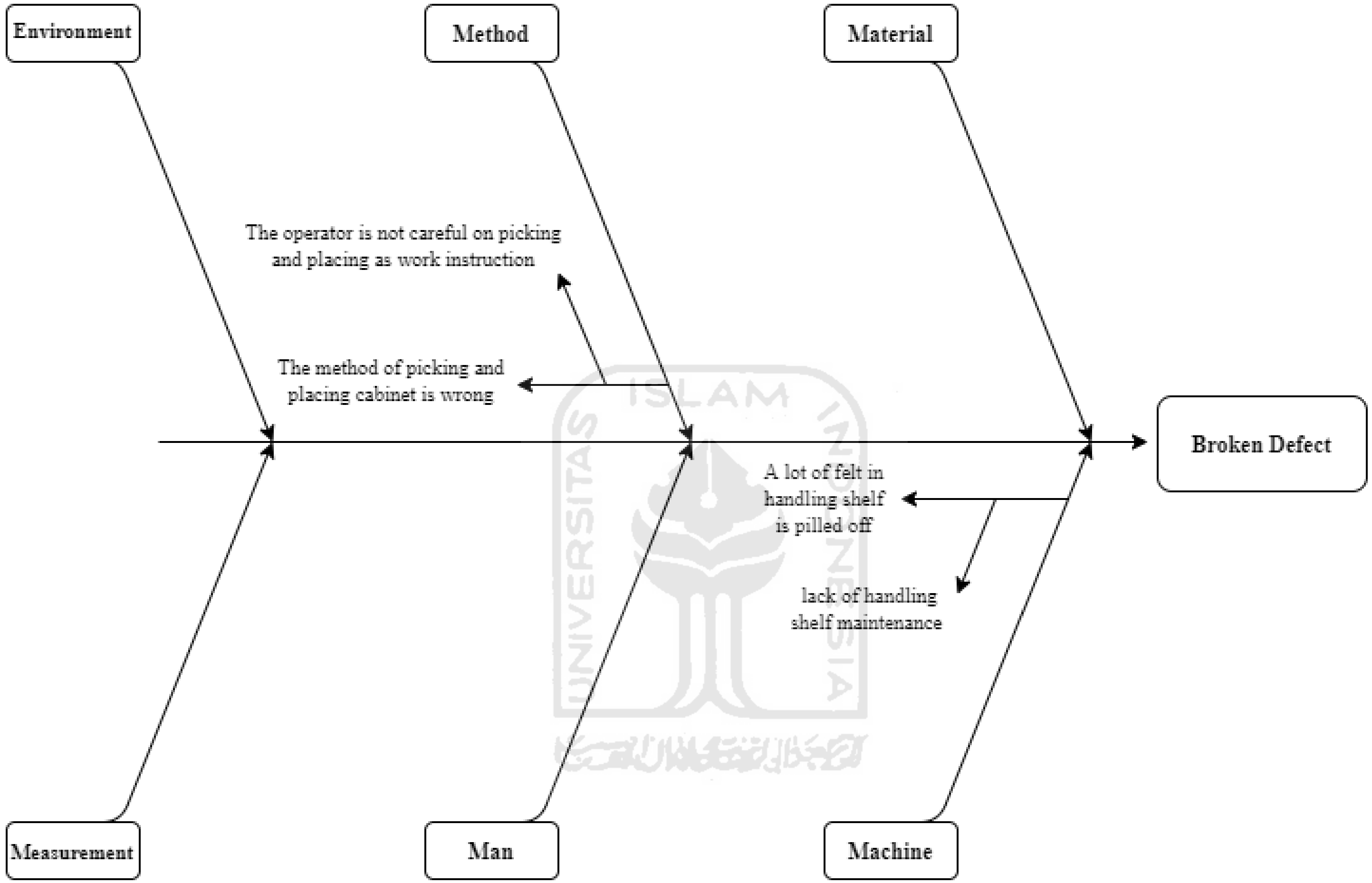


Figure 4. 7 Fishbone diagram of broken defect

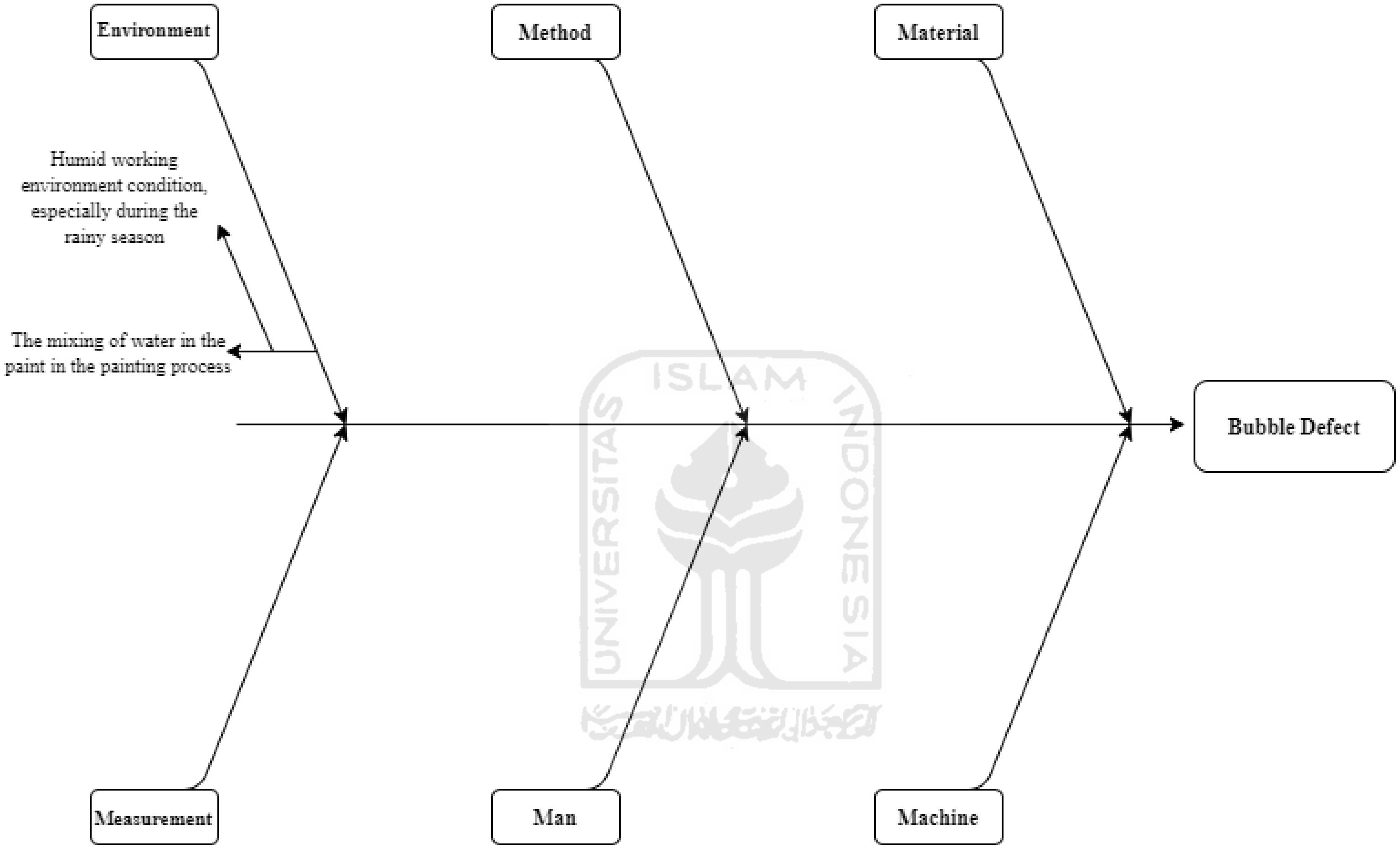


Figure 4. 8 Fishbone diagram of bubble defect

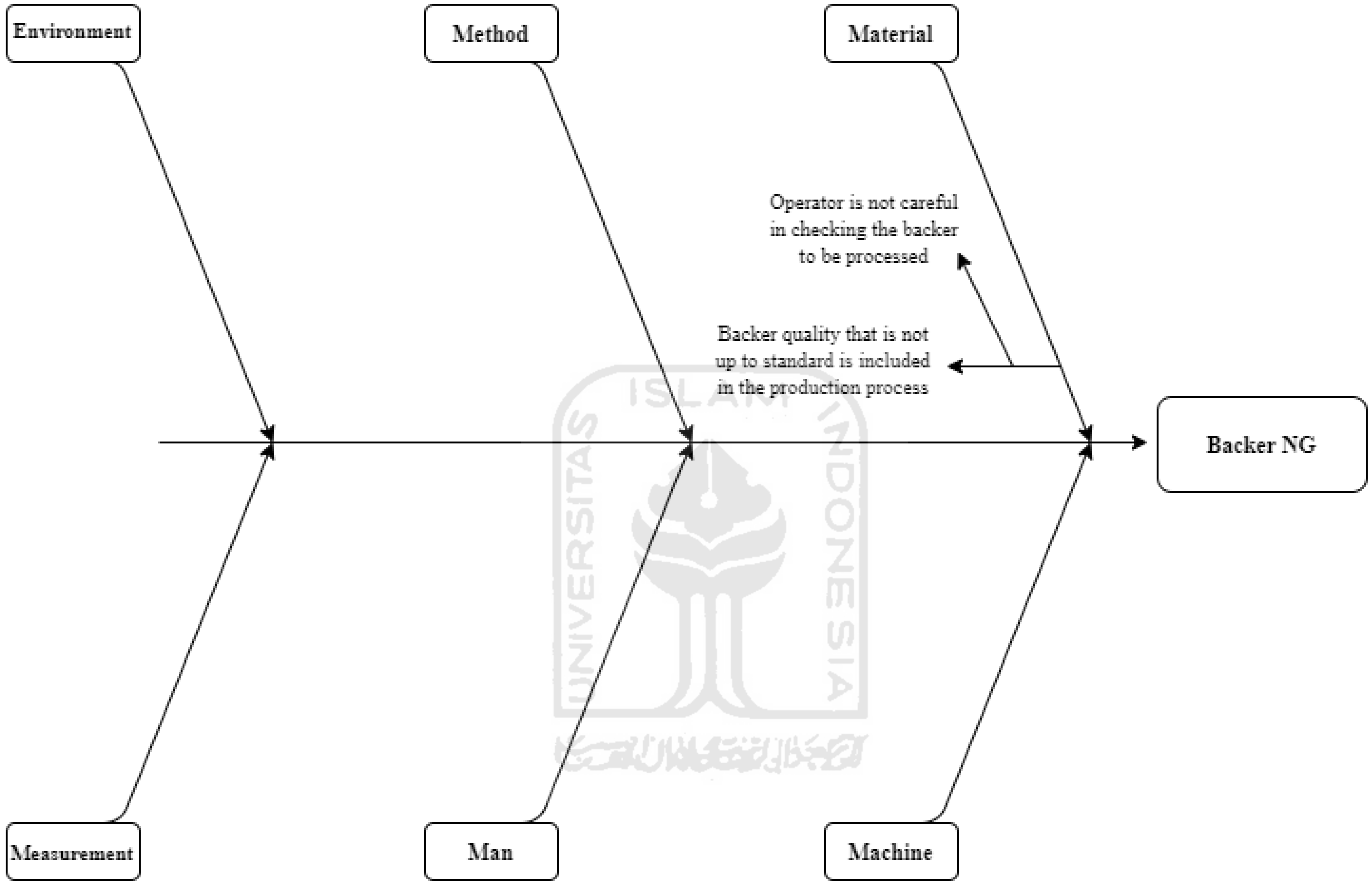


Figure 4. 9 Fishbone diagram of backer NG defect

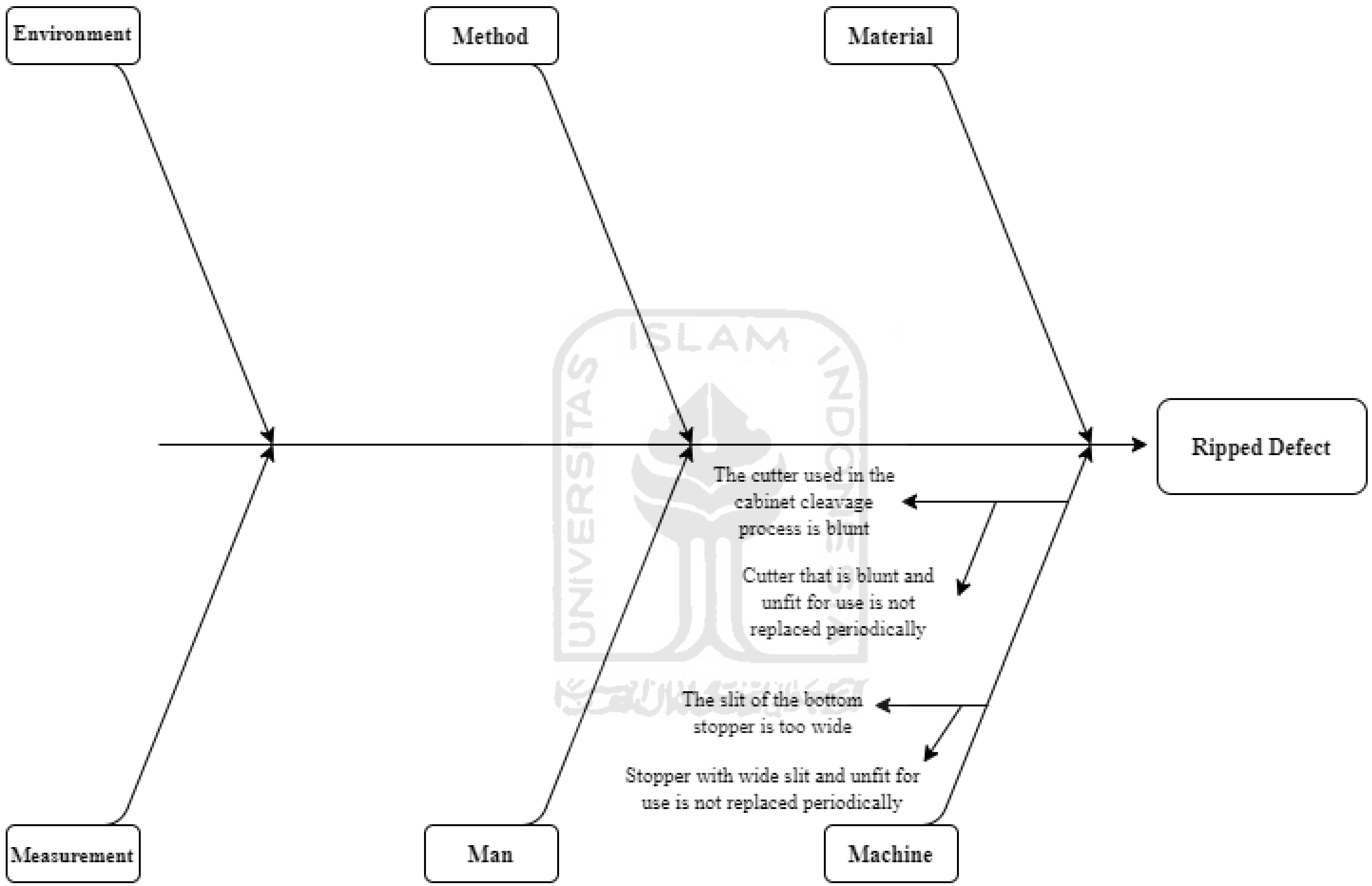


Figure 4. 10 Fishbone diagram of ripped defect

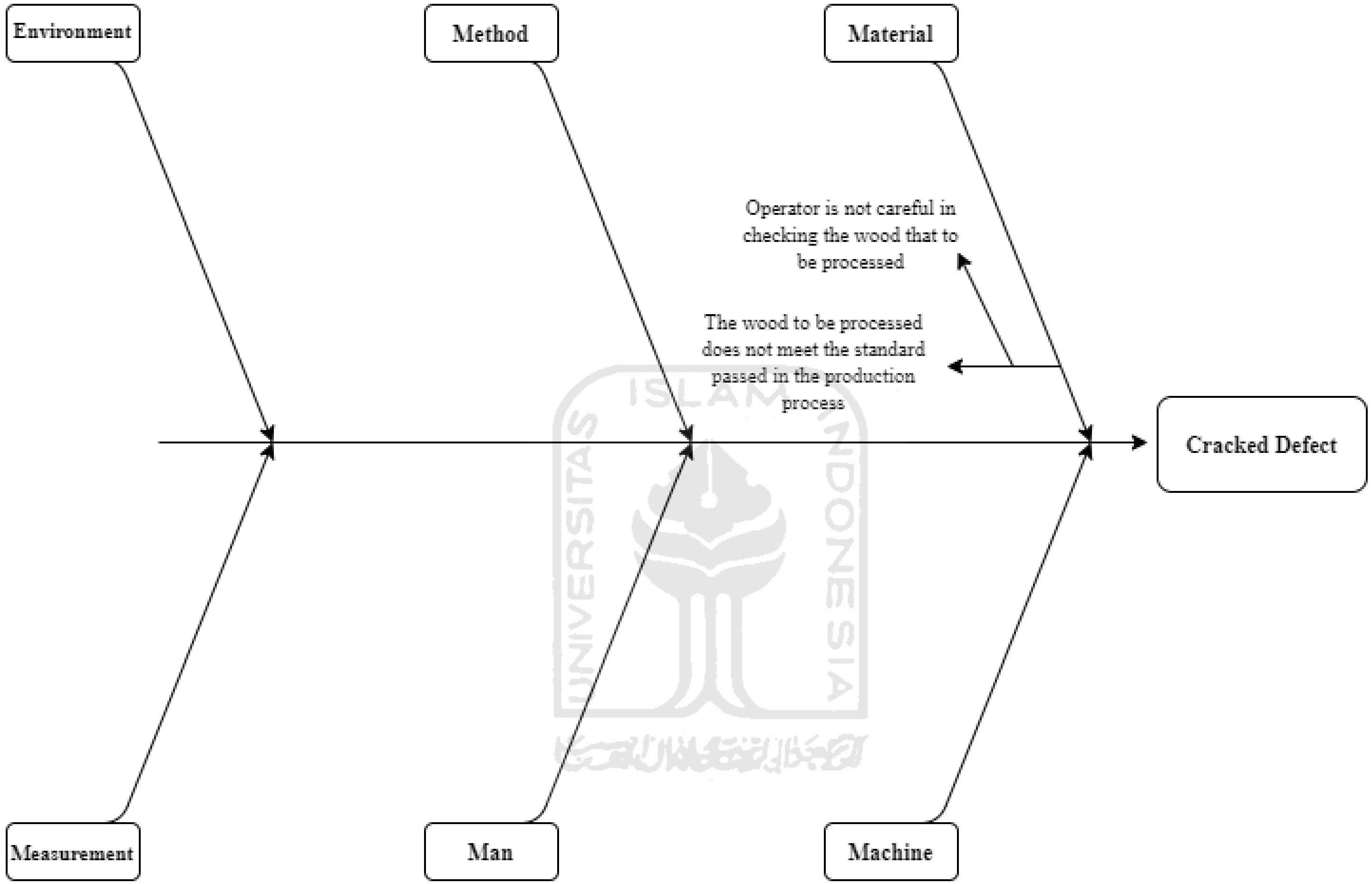


Figure 4. 11 Fishbone diagram of craked defect

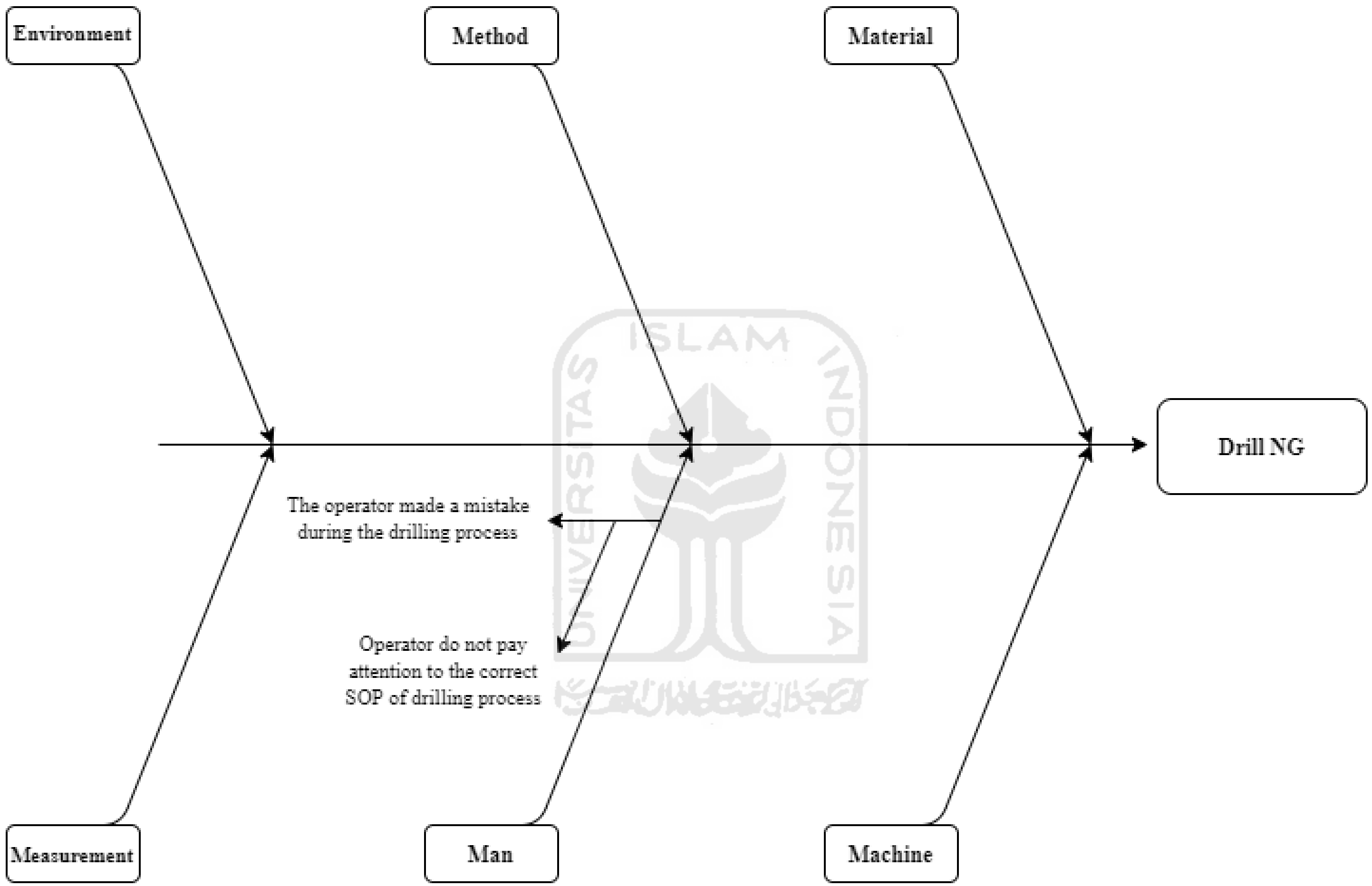


Figure 4. 12 Fishbone diagram of drill NG defect

Based on the Fishbone diagram results from brainstorming and interview with the head of the related group, it was found that in terms of 6M (Method, Machine, Man, Measurement, Material, Mother Nature or Environment) the causes of defect on cabinets are derived from the material, method, environment, machine, and manpower. The explanation is as follows:

1. Material

   The root of problem included in the method factor that causes defect in the cabinet are:

   i. The raw material that will be manufactured is not angled as predetermined standard. This error occurred during the raw material cutting process in the Wood Process division.
   ii. The quality of backer is not up to standard included in the production process.
   iii. Raw material wood to be processed does not meet the standard passed in the production process.

2. Method

   After the researcher has conducted brainstorming and interviewing the head of group as an expert who had mastered the production process and understood the problem in the production process in Cabinet Case division, it was found that there were several causes of rift defect in term of method.

   i. The operator does not apply the gluing process evenly to the entire cabinet surface so that there are parts of the surface that do not stick properly.
   ii. The operator made a mistake during the process of picking and placing the cabinet because they did not follow Yamaha's working instruction for picking and placing.
   iii. Lack of cooling time for the cabinet as standard after the press process.
   iv. Backer equalization process by the chisel is to strong then causes chipped defect in other side of cabinet

3. Environment

When observed from environmental factor, the cause of the defect in the cabinet are:

i. Dusty working environment. The flying dust sticks to the surface of the glue during the gluing process, thereby reducing the stickiness of the glue during the pressing process.
ii. The temperature condition in the seasoning room is unstable.
iii. The humid air condition in the work environment of painting causes water mix with the paint during painting process, especially in rainy season.

4. Machine

Then in terms of machine or tools factor, there are two causes of rift defect in Fall Back cabinet, including:

i. The condition of the stainless part in the jig which is used during pressing process is wavy and not suitable for use.
ii. The condition of the rubber between the stainless on the jig used during the pressing process is not elastic and no longer suitable for use.
iii. A lot of felt in handling shelf is piled off due to lack of maintenance.
iv. The cutter used in the cabinet cleavage process is blunt.
v. The slit of bottom stopper is too wide.

5. ManPower

In terms of manpower the root of problem that causes defect on the cabinet is operator who makes mistake during the drilling process, which is often done by new operator due to their lack of skill in drilling process.

4.4 Determining the Potential Failure

Failure Mode and Effect Analysis (FMEA) is a structured procedure to identify and prevent as many failure modes as possible. FMEA is used to identify the sources and root causes of quality problem and to identify the risk of failure that may arise. The researcher weights the FMEA parameters including severity, occurrence, and detectability as seen in the table below.

Table 4. 6 FMEA defect on cabinet

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
Rift defect	Stainless parts on jig is wavy	8	Stainless in jig which is no longer suitable for use is not replaced	7	Conducting checklist on jig and machine periodically	6
	The rubber between the stainless is already inelastic, causing the press process to be not optimal	6	The rubber between the stainless which is already inelastic and unfit for use is not replaced	7	Conduct the check using scale film periodically	5

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
	The cabinet does not adhere properly during the pressing process	7	The operator does not apply glue evenly to the entire cabinet surface	9	Sticking picture as example of how to apply glue correctly	3
	The cabinet surface is exposed to wood dust during the gluing process	8	Lack of operator attention in maintaining a clean work environment	3	Putting a cover on the glue spreader machine	4
Curved defect	Lack of cooling time for the cabinet as standard after the press process	4	The operator is not careful in the process of taking cabinet to be processed at the next stage	2	Giving a label contains the date in every stack of cabinet in seasoning room	3

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
	The temperature in seasoning room for cooling cabinet is unstable	2	Operator is not conduct checking room temperature periodically	1	Conducting checklist to ensure the temperature periodically	2
Chipped defect	Backer equalization by the chisel is too strong	1	The operator does not pay attention to the correct SOP for backer equalization	2	Conduct socialization and training to new operator	2

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
	There is friction between the cabinet and the shelf bulkhead during the picking and placing process	4	The method of picking and placing from the handling shelf is wrong, because the operator is not careful and does not take and place it according to work instruction	3	Teach the operator how to pick and place the cabinet correctly	2
Bobber defect	The cabinet material shape is not angled	10	There was an error in the cabinet cutting process in the previous division	3	Conduct arrangement per 10 cabinets to find out which cabinet is not angled	2

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
	The cabinet does not adhere properly during the pressing process	7	The operator does not apply glue evenly to the entire cabinet surface	9	Sticking picture as example of how to apply glue correctly	3
Broken defect	A lot of felt in handling shelf is pilled off	2	Lack of handling shelf maintenance and do not change felt periodically	3	Check the handling shelf before using it and separate it where the felt is broken	5

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
	There is friction between the cabinet and the shelf bulkhead during the picking and placing process	4	The method of picking and placing from the handling shelf is wrong, because the operator is not careful and does not take and place it according to work instruction	3	Teach the operator how to pick and place the cabinet correctly	2
Bubble defect	The mixing of water with paint during painting process	2	Humid working environment condition, especially during rainy season	4	Saving the cabinet in seasoning room before get into the painting process	2

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
Backer NG	Backer quality which is not up to standard is included in the production process	1	Operator is not careful in checking the backer that to be processed	2	Giving a label on the backer NG and return it to vendor	2
Ripped defect	The cutter used in the cabinet cleavage process is blunt	2	Cutter that is blunt and unfit for use is not replaced periodically	3	Change the cutter every 2 days for maximum	1
	The slit of bottom stopper is too wide	2	Stopper with wide slit and unfit for use is not replaced periodically	3	Conducting checklist on machine periodically	1

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Current Control	Detectability
Cracked defect	Raw material of wood to be processed does not meet the standard passed in the production process	5	Operator is not careful in checking the wood that to be processed	3	Allocating wood raw material to be processed into another cabinet	2
Drill NG	The operator makes a mistake during the drilling process	1	The operator does not pay attention to the correct SOP of drilling process	1	Teach the operator how to drill the cabinet correctly	2

The value above is obtained from the judgment of the expert regarding the three criteria in the Failure Mode and Effect Analysis method, are severity which states the severity when a failure mode occurs, occurrence which states the probability of occurrence of a failure mode, and detectability which states the detection rate of a failure mode. Values are given in the range 1-10 according to the FMEA standard table.

4.5 Determine Proper Improvement

In addition to weighting with FMEA, Analytical Hierarchy Process (AHP) will be weighed against the FEMA criteria. AHP weighting is conducted because these factors have different effect. Thus, the severity, occurrence, and detectability weight will be multiplied first by the AHP weight before the Risk Priority Number (RPN) ranking is carried out with the AHP weight. The following is data processing with AHP.

Table 4. 7 Weighting of severity, occurrence, and detectability criteria

Criteria A	Scale																	Criteria B
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Severity							3											Occurrence
Severity					5													Detection
Occurrence									1									Detection

The weighting above is based on the weighting determination by Thomas L. Saaty by giving weight 1-9 in the comparison between criteria. With the following conditions:

Table 4. 8 Interest intensity criteria of AHP

Importance	Definition	Explanation
1	Equal importance	Contribution to objective is equal
3	Moderate importance	Attribute is slightly favoured over another
5	Strong importance	Attribute is stongly favoured over another
7	Very strong importance	Attribute is very strongly favoured over another
9	Extreme importance	Evidence favouring one attribute is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed

In table 4.7, the head of group as expert argues that the severity criteria are slightly more important than the occurrence criteria, the severity criteria are more important than the detectability criteria, and the occurrence criteria as important as the detectability criteria.

4.5.1 Weighting Calculation of AHP

The FMEA (Failure Mode and Effect Analysis) method usually weights Severity (S), Occurrence (O), and Detectability (D) equally or proportionally. However, in real cases these criteria have different weights (Aslani, 2014). To answer these problems, the AHP (Analytical Hierarchy Process) method is used. The following are the results of the AHP weighting given by the expert:

a) Severity factor slightly more important than occurrence factor (3)
b) Severity factor more important than detectability factor (5)

c) Occurrence factor same important as detectability factor (1)

From the expert opinion above, the comparison between the criteria is presented in the table below:

Table 4. 9 Expert opinion towards criteria

	Pairwise Comparation		
Criteria	**Severity**	**Occurrence**	**Detection**
Severity	1	3	5
Occurrence	0,33	1	1
Detection	0,20	1	1
Total	1,53	5	7

Phase 1: Calculation of Priority Weight

This value is obtained by dividing the value in every cell by the number of each corresponding column, then adding and averaging each row. Average shows the priority weight value for each line concerned. Here are the results of calculating priority weight:

Table 4. 10 Priority weight calculation

Priority Weight	Severity	Occurrence	Detection	Total	Eigen Vector
Severity	0,6536	0,6000	0,7143	1,9679	0,6560
Occurrence	0,2157	0,2000	0,1429	0,5585	0,1862
Detection	0,1307	0,2000	0,1429	0,4736	0,1579
Total	1	1	1	3	1

Phase 2: Calculation of Consistency Ratio

Multiplying matrix by the corresponding priority

$$\begin{vmatrix} 1 & 3 & 5 \\ 0,33 & 1 & 1 \\ 0,20 & 1 & 1 \end{vmatrix} \text{ x } \begin{vmatrix} 0,6560 \\ 0,1862 \\ 0,1579 \end{vmatrix} = \begin{vmatrix} 0,66 & 0,56 & 0,78 \\ 0,22 & 0,19 & 0,16 \\ 0,13 & 0,19 & 0,16 \end{vmatrix} = \begin{vmatrix} 2,0038 \\ 0,5605 \\ 0,4752 \end{vmatrix}$$

Dividing the result of matrix calculation by Priority Weight

$$D = \frac{2,0038\ \ 0,5605\ \ 0,4752}{0,6560\ \ 0,1862\ \ 0,1579} = 3,0548\ \ 3,0105\ \ 3,0105$$

Calculating λ max (the sum of the multiplication above divided by the number of element)

$$\lambda\text{max} = \frac{3,0548 + 3,0105 + 3,0105}{3} = 3,0253$$

Calculating Consistency Index (CI) = (λ max – N) / (N-1)

$$CI = \frac{(3,0253 - 3)}{(3 - 1)} = 0,0126$$

To obtain the Consistency Ratio value, the Consistency Index (CI) and the Random Index (RI) are divided. If the consistency ratio is ≤ 0.1, the data calculation result can be justified. Here is a table of random indices defined:

Table 4. 11 Index random value

n	1	2	3	4	5	6	7	8	9	10
RC	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

From the random table above, it is obtained for n = 3, with an RI value of 0.58. Then the Consistency Ratio value = 0.0126 / 0.58 = 0.0218. Because the consistency ratio value is 0.0218 and the value is less than 0.1, the comparison is consistent and can be justified.

4.5.2 Calculation of RPN Value with AHP Weighting

According to Ari Basuki (2015), the RPN (Risk Priority Number) value is the result of multiplying the conventional RPN value with the AHP weighting that has been carried out. The amount of the new RPN value is:

$$RPN = (W_S \times S) + (W_O \times O) + (W_D \times D)$$

Where:

W_S, W_O, and W_D is relative weight of severity, occurrence, and detectability factor

The following is the result of multiplying the relative weight with the severity, occurrence, and detectability of defect in the cabinet:

Table 4. 12 RPN calculation with AHP weight

No	Potential Failure	Sev	Occ	Det	Ws	Wo	Wd	RPN	Ranking
1	Stainless parts on jig is wavy	8	7	6	0,6560	0,1826	0,1579	7,4736	1
2	The rubber between the stainless is already inelastic, causing the press process to be not optimal	6	7	5	0,6560	0,1826	0,1579	6,0037	5
3	The cabinet does not adhere properly during the pressing process	7	9	3	0,6560	0,1826	0,1579	6,7091	3
4	The cabinet surface is exposed to wood dust during the gluing process	8	3	4	0,6560	0,1826	0,1579	6,4274	4
5	Lack of cooling time for the cabinet as standard after the press process	4	2	3	0,6560	0,1826	0,1579	3,4629	8
6	The temperature in seasoning room for cooling cabinet is unstable	2	1	2	0,6560	0,1826	0,1579	1,8104	13

No	Potential Failure	Sev	Occ	Det	Ws	Wo	Wd	RPN	Ranking
7	Backer equalization by the chisel is too strong	1	2	2	0,6560	0,1826	0,1579	1,337	14
8	There is friction between the cabinet and the shelf bulkhead during the picking and placing process	4	3	2	0,6560	0,1826	0,1579	3,4876	7
9	The cabinet material shape is not angled	10	3	2	0,6560	0,1826	0,1579	7,4236	2
10	A lot of felt in handling shelf is pilled off	2	3	5	0,6560	0,1826	0,1579	2,6493	9
11	The mixing of water with paint during painting process	2	4	2	0,6560	0,1826	0,1579	2,3582	11
12	Backer quality which is not up to standard is included in the production process	1	2	2	0,6560	0,1826	0,1579	1,3370	15
13	The cutter used in the cabinet cleavage process is blunt	2	3	1	0,6560	0,1826	0,1579	2,0177	12

No	Potential Failure	Sev	Occ	Det	Ws	Wo	Wd	RPN	Ranking
14	The slit of bottom stopper is too wide	3	2	1	0,6560	0,1826	0,1579	2,4911	10
15	Raw material of wood to be processed does not meet the standard passed in the production process	5	3	2	0,6560	0,1826	0,1579	4,1436	6
16	The operator makes a mistake during the drilling process	1	1	2	0,6560	0,1826	0,1579	1,1544	16

CHAPTER V

DISCUSSION

5.1 Priority Defect Analysis in Cabinet Case Division

Based on the table 4.2 in chapter 4 there are ten types of defect that are constantly occurred, which are curved, bobber, broken, rift, bubble, chipped, ripped, cracked, drill NG, and backer NG. Based on the Pareto Diagram which has been discussed in table 4.3, it can be seen that the most dominant type of defect is rift defect since it has the highest number of defect finding, including 506 findings with a percentage of 48.94% of the total number of defects that occur in the Cabinet Case division. Afterwards, the next type of defect is accompanied by chipped defect with a total of 315 findings with a percentage of 30,46%, bobber defect with a total of 75 findings with a percentage of 7,25%, curved defect with a total of 51 findings with a percentage of 4,93%, broken defect with a total of 41 findings with a percentage of 3,97%, bubble defect with a total of 19 findings with a percentage of 1,84%, ripped defect with a total of 11 findings with a percentage of 1,06%, cracked defect with a total of 7 findings with a percentage of 0,68%, backer NG defect with a total of 6 findings with a percentage of 0,58%, and the last is drill NG defect with a total of 3 findings with a percentage of 0,29%.

In addition, based on the result of Pareto Diagram for the type of cabinet with defect in table 4.5, it shows that the most dominant type of cabinet with defect is Fall Back since it has the highest number of defect finding, including 222 findings with a percentage of 21,47% of the total number of cabinet with defect that occur in the Cabinet Case division. Furthermore, the next type of cabinet is Key Slip with a total of 155 findings with a percentage of 14,99%, Fall Front with a total of 147 findings with a percentage of 14,22%, Top Frame with a total of 143 findings with a percentage of 13,83%, Hinge Strip with a total of 106 findings with a percentage of 10,25%, Top Board with a total of 93 findings with a percentage of 8,99%, Fall Center with a total of 92 findings with a percentage of 8,90%, Key Block with a total of 26 findings with a percentage of 2,51%, Bottom Frame with a total of 25 findings with a percentage of 2,42%, Side Sleeve with a total of 14 findings with a percentage of 1,35%, Fall Board with a total of 11 findings with a percentage of 1,06%,

5.2 The Cause of Defect Analysis in Cabinet Case Division

There are several factors that cause defect in production process of the Cabinet Case division. Furthermore, the researcher found that there are 5 factors that influence the occurrence of defect on the cabinet, which are material factor, method factor, mother nature or environment factor, machine or tool factor and manpower factor. The following is an explanation of the Fishbone Diagram in Figure 4.3. - Figure 4.12 regarding the possible causes of defect in the Cabinet Case division:

1. Material

   The root of problem included in the method factor that causes defect in the cabinet is the raw material that will be manufactured is not angled as predetermined standard. This error occurred during the raw material cutting process in the Wood Process division. Cabinet raw material that will be processed in the cabinet case is the cabinet that come from Wood Process division. In some case, the raw material which is sent to cabinet case division has not angled edge as dimension standard that has been determined by the company because of error in the cutting process in Wood Process division. This condition can cause the pressing process to be not optimal because the shape of the cabinet does not match the existing pressing jig. Other than that, the quality of backer is not up to standard included in the production process. The backer usen in the pressing process comes from vendor that has been determined by the company. In some cases, the backer shipped to Cabinet Case division is still immature and has feathery texture. Therefore, those immature backers cannot be used in the production process because it will not be ideal for the result of the press that will be generated. Furthermore, raw material wood to be processed does not meet the standard passed in the production process. For some coloured pianos use solid wood for material. The raw material of wood sometimes has hair cracks that invisible. However, these cracks will be more obvious when the material has been processed in the Cabinet Case division.

2. Method

After the researcher has conducted brainstorming and interviewing the head of group as an expert who had mastered the production process and understood the problem in the production process in Cabinet Case division, it was found that there were several causes of rift defect in term of method. The operator does not apply the gluing process evenly to the entire cabinet surface so that there are parts of the surface that do not stick properly. This incident usually occurs because of the operator does not apply glue in accordance with the procedure determined by the company. Moreover, the operator made a mistake during the process of picking and placing the cabinet because they did not follow Yamaha's working instruction for picking and placing. Besides that, lack of cooling time for the cabinet as standard after the press process. Based on the standard determined by the company, cabinet that have processed through the pressing process must be cooled in the seasoning room for 3 days so that the cabinet is really at a normal temperature. When the cabinet has been taken before 3 days for further processing, there will be a potential for defect. The last, backer equalization process using the chisel is to strong then causes chipped defect in other side of cabinet.

3. Environment

When observed from environmental factor, the cause of the defect in the cabinet is dusty working environment. The flying dust sticks to the surface of the glue during the gluing process, thereby reducing the stickiness of the glue during the pressing process. Besides, the temperature condition in the cooling room is unstable. Unstable seasoning room temperature condition will interrupt temperature stabilization process of cabinet after going through pressing process. Furthermore, the humid air condition in the work environment of painting causes water mix with the paint during painting process, especially in rainy season. The state of the humid air allows the cabinet no to dry completely so that it can disrupt the absorption of paint into the cabinet.

4. Machine

Then in terms of machine or tools factor, there are two causes of rift defect in Fall Back cabinet, including the condition of the stainless part in the jig which is used during pressing process is wavy and not suitable for use. The condition of wavy jig will cause the pressure of the press machine to be inconsistent in the cabinet. Therefore, there are several parts of the cabinet that are not perfectly adhered. Besides, the condition of the rubber between the stainless on the jig used during the pressing process is not elastic and no longer suitable for use. While the rubber between the stainless steel is not elastic, the pressure applied will not be maximum and flexible throughout the cabinet. Afterwards, a lot of felt in handling shelf is pilled off due to lack of maintenance. The pilled off of the felt on the handling shelf will cause the handling shelf to be unfriendly to the cabinet since the cabinet does not have support to directly contact the hard wood of the handling shelf. Furthermore, the cutter used in the cabinet cleavage process is blunt. When the blunt knife is not replaced immediately, the cabinet cleavage process will not be optimal. Since the knife was blunt, the cut cabinet had not been cut perfectly and neatly. The last is the slit of bottom stopper is too wide. When the gap is too wide, it will cause the blade wobble and not rotate equally. Therefore, this situation will also affect the result of the cabinet cutting.

5. ManPower

In terms of manpower the root of problem that causes defect on the cabinet is operator makes mistake during the drilling process, which is often done by new operator due to their lack of skill in drilling process. The mistake that often occurs is the operator does not place the drill point precisely.

5.3 Potential Failure Analysis in Cabinet Case Division

After identifying the potential failure and the cause of failure in table 4.6, there are 16 types of potential failure which become priorities to be solved in production process of Cabinet Case division. The following is explanation for the result of Failure Mode and Effect Analysis.

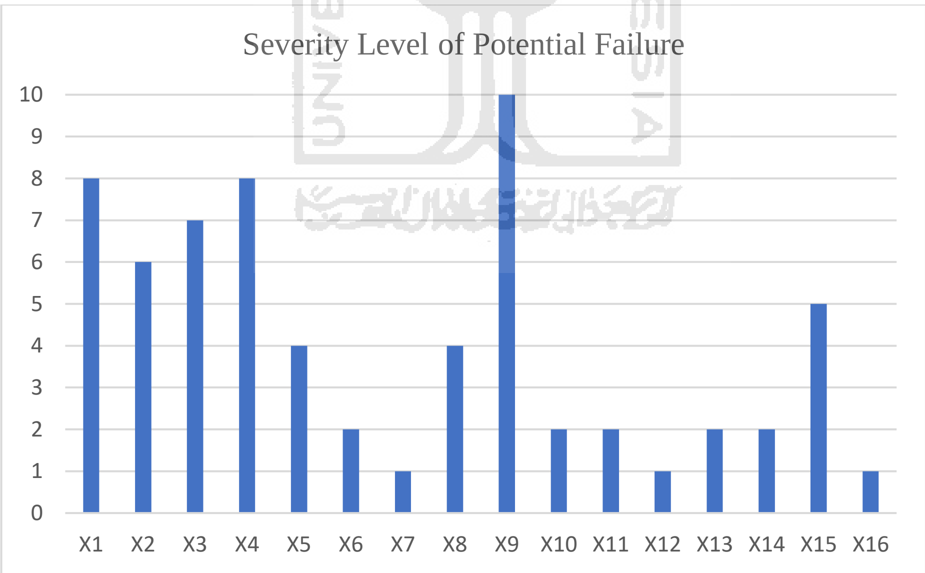


Figure 5. 1 Graph of severity level of each potential failure

The graph in figure 5.1 is a resume of the severity levels in table 4.6. It is known from figure 5.1 that the highest severity level of potential failure is X9 (the cabinet material shape is not angled) with severity value 10 which means this failure will cause to the other failure. Next there are X1 (stainless parts on jig is wavy) and X4 (cabinet surface is exposed to wood dust during the gluing process) both have the same value of 8 which means the resulting of defect is beyond tolerant limit. After that there is X3 (the cabinet does not adhere properly during the pressing process) with severity value of 7 which means the resulting of defect is beyond tolerant limit as well. X2 (the rubber between the stainless is already inelastic, causing the press process to be not optimal) with value of 6 which means the impact will decrease quality but still in tolerant limit. The next is X15 (raw material of wood to be processed does not meet the standard passed in the production process) with severity value of 5 which means the effect can be resolved in a short time. X5 (lack of cooling time for the cabinet as standard after the press process) and X8 (there is friction between the cabinet and the shelf bulkhead during the picking and placing process) get the severity value 4 which means the likelihood still classified as moderate. Before the last, X6 (the temperature in seasoning room for cooling cabinet is unstable), X10 (a lot of felt in handling shelf is pilled off), X11 (the mixing of water with paint during painting process), X13 (the cutter used in the cabinet cleavage process is blunt), and X14 (the slit of bottom stopper is too wide) obtain the severity value 2 which means the consequence categorized as mild and repair could be done during regular maintenance. The last are X7 (backer equalization by the chisel is too strong), X12 (backer quality which is not up to standard is included in the production process), and X16 (the operator make a mistake during the drilling process) obtain the severity value 1 which means the impact is not giving the effect too much.

The graph in figure 5.2 is a resume of the occurrence level in table 4.6. The following is a comparison of the level of occurrence at each potential failure:

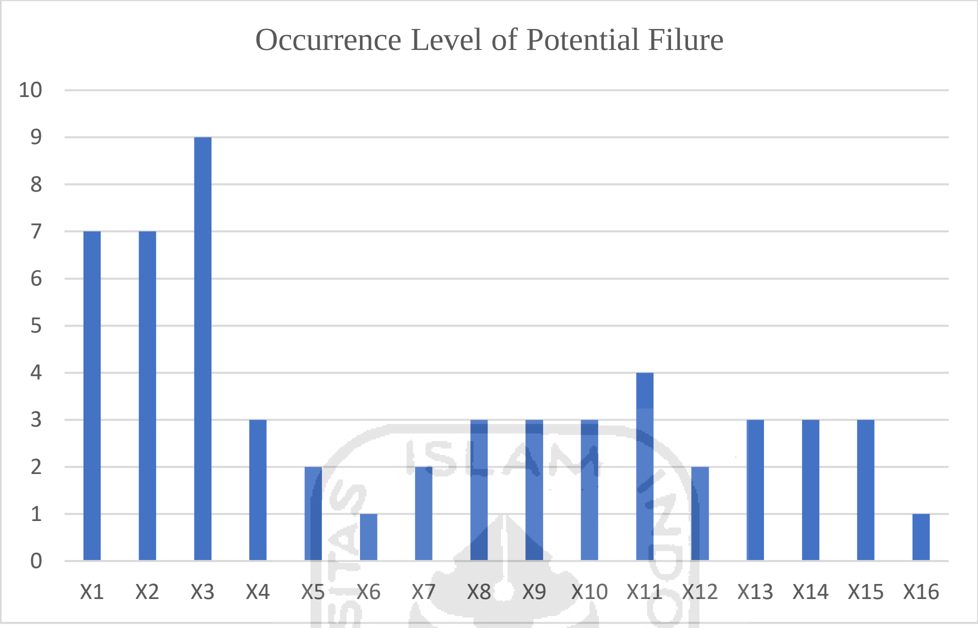


Figure 5. 2 Graph of occurrence level of each potential failure

Based on the figure 5.2 above, X3 (the cabinet does not adhere properly during the pressing process) has the highest occurrence level of 9 which is categorize as very high means almost certain to occur. Next is X1 (Stainless parts on jig is wavy) and X2 (The rubber between the stainless is already inelastic, causing the press process to be not optimal) have the same occurrence value of 7 which is categorize as high means the probability that event will occur. X11 (the mixing of water with paint during painting process) with occurrence value of 4 which means categorize as moderate. After that there are X4 (the cabinet surface is exposed to wood dust during the gluing process), X8 (there is friction between the cabinet and the shelf bulkhead during the picking and placing process), X9 (the cabinet material shape is not angled), X10 (a lot of felt in handling shelf is pilled off), X13 (the cutter used in the cabinet cleavage process is blunt), X14 (The slit of bottom stopper is too wide), X15 (raw material of wood to be processed does not meet the standard passed in the production process) obtain occurrence value 3 which means the failure is rarely happening. Before the last there are X5 (lack of cooling time for the cabinet as standard after the press process) and X12 (backer quality which is not up to standard is included in the production process) obtain occurrence value 2 which means categorize as low and rarely happening as well. The last one there are X6 (the temperature in seasoning room for cooling cabinet is unstable), and X16 (the operator make a mistake during the drilling process) have same occurrence value of 1 which means categorized as remote and these factor are not actually the main cause of failure.

The graph in figure 5.3 is a resume of the detectability level in table 4.6. The following is a comparison of the level of detectability at each potential failure:

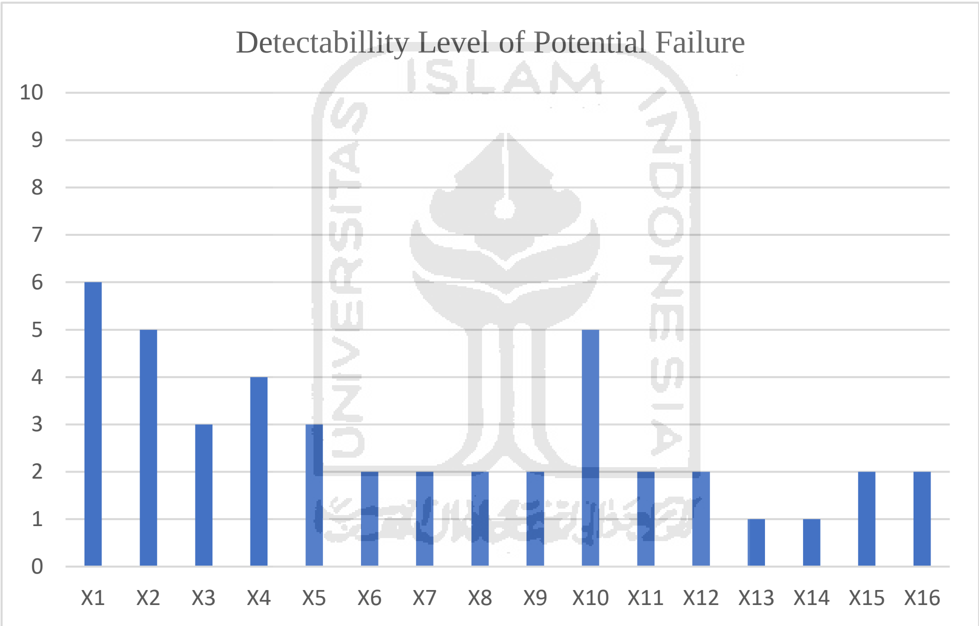


Figure 5. 3 Graph of detectability level of each potential failure

From the graphic in figure 5.3 shows that X1 (stainless parts on jig is wavy) has the highest detectability value with 6 which means low likelihood that current controls will detect or prevent failure mode. After that, there are X2 (the rubber between the stainless is already inelastic, causing the press process to be not optimal) and X10 (a lot of felt in handling shelf is pilled off) where both of them have the same value of 5 which means moderate likelihood that current controls will detect or prevent the failure mode. Next, X4 (the cabinet surface is exposed to wood dust during the gluing process) with detectability of 4 which means moderately high likelihood that current controls will detect or prevent the failure mode. X3 (the cabinet does not adhere properly during the pressing process) and X5 (lack of cooling time for the cabinet as standard after the press process) obtain detectability value 3 which means high likelihood that current controls will detect the failure mode. Before the last, there are X6 (the temperature in seasoning room for cooling cabinet is unstable), X7 (backer equalization by the chisel is too strong), X8 (there is friction between the cabinet and the shelf bulkhead during the picking and placing process), X9 (the cabinet material shape is not angled), X11 (the mixing of water with paint during painting process), X12 (backer quality which is not up to standard is included in the production process), X15 (raw material of wood to be processed does not meet the standard passed in the production process) and X16 (the operator make a mistake during the drilling process) with detectability value of 2 which means very high likelihood that current controls will detect or prevent the failure mode. The last one there are X13 (the cutter used in the cabinet cleavage process is blunt) and X14 (the slit of bottom stopper is too wide) both of them has same detectability value of 1 which means current controls are almost certain to detect or prevent the failure mode.

5.4 Proper Improvement Analysis

Based on the opinion of an expert who holds the position of head of the group in the Cabinet Case division, the severity criteria are the most influential criteria in determining the Risk Priority Number (RPN) value. Below is the result of weighting for each criterion.

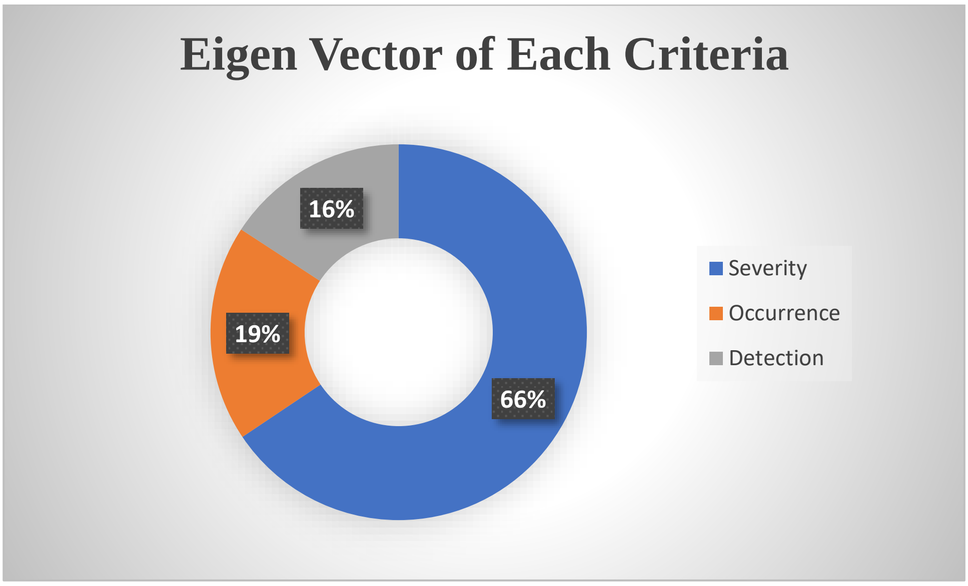


Figure 5. 4 AHP weighting result

The graph above shows that the head of group sees a much higher severity weight than the other two weights. The expert views the value associated with the effect that can be had on the error mode as more important than the probability of causing the error to occur and the initial control set.

The criterion weight value is assumed to be the same in standard FMEA method. However, in fact the same RPN value may have different impact. The value of severity, occurrence, and detectability, for example are 5, 3 and 4 respectively, while the other failure mode value is 10, 3, and 2 respectively. Both values have the same RPN value but different impacts. Therefore, the AHP weighting result from the criteria of severity, occurrence, and detectability will be multiplied by the initial weight with the formula:

$$RPN = (W_S \times S) + (W_O \times O) + (W_D \times D)$$

The following is a sequence of RPN value ranking of potential failure using AHP method:

Table 5. 1 Sequence of RPN value with RPN-AHP method

Potential Failure	RPN	Ranking
Stainless parts on jig is wavy	7,4736	1
The cabinet material shape is not angled	7,4236	2
The cabinet does not adhere properly during the pressing process	6,7091	3
The cabinet surface is exposed to wood dust during the gluing process	6,4274	4
The rubber between the stainless is already inelastic, causing the press process to be not optimal	6,0037	5
Raw material of wood to be processed does not meet the standard passed in the production process	4,1436	6
There is friction between the cabinet and the shelf bulkhead during the picking and placing process	3,4876	7
Lack of cooling time for the cabinet as standard after the press process	3,4629	8
A lot of felt in handling shelf is pilled off	2,6493	9
The slit of bottom stopper is too wide	2,4911	10
The mixing of water with paint during painting process	2,3582	11

The cutter used in the cabinet cleavage process is blunt	2,0177	12
The temperature in seasoning room for cooling cabinet is unstable	1,8104	13
Backer equalization by the chisel is too strong	1,3370	14
Backer quality which is not up to standard is included in the production process	1,3370	15
The operator makes a mistake during the drilling process	1,1544	16

5.5 Improvement Based on RPN-AHP Weighting

In this section the researcher will propose improvements in order to minimize the number of defects on the cabinet. Furthermore the researcher will provide suggestion based on the FMEA-AHP RPN ranking. The following are some suggestions for improvement that can be used to reduce defect finding on the cabinet.

a. Stainless part on jig is wavy with RPN-AHP value 7,4736. This type of failure mode with the highest RPN-AHP value occurs because the stainless part of the jig has exceeded the time of use and need to be replaced with a new one. However, the operator is not paying attention in checking the stainless part. So that when the stainless part has been wavy, the operator still uses it which result defect. In addition, the operator only realize that the stainless part is already wavy when there is a defect in the cabinet. In order to minimize the occurrence of this failure, a solution must be applied by company. The most appropriate improvement is to schedule the replacement of stainless-steel part on the jig without having to wait for the stainless steel to wavy. Scheduling will be useless if not implemented and enforced. Therefore, it is necessary to have the role of the group head to monitor so that this activity is carried out and the employees comply with the course of this activity. Furthermore, appoint each operator who uses press machine to be person in charge can also be done to strengthen a sense of belonging.

b. The cabinet material shape is not angled with RPN-AHP value 7,4236. Failure mode with the second highest RPN AHP value is caused by the raw material that will be processed in the Cabinet Case Division is not angled like the standard set by the company. This failure occurred during the wood processing process in the Wood Process division. Therefore, the improvement in the Cab Case division is that the operator must always check the raw material before entering the gluing and pressing process. In addition, the emphasis on the Wood Press division on the cabinet that is processed is also needed so that the cabinet from the Wood Press sent to the Cabinet Case division is confirmed according to standard.

c. The cabinet does not adhere properly during the pressing process with RPN-AHP value 6,7091. In this problem, according to the opinion of the head of the group, it occurs because the operator does not do the gluing process evenly over the entire surface of the cabinet. If the glue is spread unevenly on the entire surface, then there are spaces between the part that do not stick properly and cause rift defect. Improvement that can be done is to emphasize the role of the head of group on operator to be more thorough in the gluing process, and not only emphasize quantity but also quality.

d. The cabinet surface is exposed to wood dust during the gluing process with RPN-AHP value 6,4274. This potential failure occurs due to the dusty working environment around the Cabinet Case division. The dust that is around the work environment can fly and hit the glue during the gluing process. The dust on the glue during the gluing process will result in a glue nor perfectly strong between cabinet. Improvement action that can be taken is to emphasize the role of the head of group on operator to always keep the working environment clean around the Cabinet Case division. In addition, scheduled cleaning of work environment may also be carried out, so the dust from the cutting residue does not collect and fly around.

e. The rubber between the stainless is already inelastic, causing the press process to be not optimal with RPN-AHP value 6,0037. This type of failure mode occurs because the rubber between the stainless is already inelastic and need to be replaced with a new one. However, the operator is not paying attention in checking the rubber part. So that when the rubber part has been inelastic, the operator still uses it which result in rift defect. In addition, the operator only realize that the rubber part is already inelastic when there is defect in the cabinet. In order to minimize the occurrence of this failure, a solution must be applied by company. The most appropriate improvement is to schedule the replacement of rubber part on the jig without having to wait for the rubber become inelastic. Scheduling will be useless if not implemented and enforced. Therefore, it is necessary to have the role of the group head to monitor so that this activity is carried out and the employees comply with the course of this activity.

f. Raw material of wood to be processed does not meet the standard passed in the production process with RPN-AHP value 4,1436. The wood raw material used in the production process come from vendors that have been determined by the company. It was discovered in many cases that the wood was found with a hair crack, which could potentially cause defect in the cabinet. To avoid this incident, it is necessary to emphasize the vendor to conduct quality control on the raw material before it is sent. In addition, the inventory staff also has to double-check the raw material before entering the production floor. For operator, they must always check the wood raw material before using it.

g. There is friction between the cabinet and the shelf bulkhead during the picking and placing process with RPN-AHP value 3,4876. The process that has an effect on this potential failure is the taking and placing of the cabinet from the Wood Press division. The correct way to take the shelf and according to the standard operational procedure (SOP) is by taking the cabinet from the shelf and not pulling it, but the bottom of the cabinet must be lifted a little so it doesn't touch the bottom of the shelf. After brainstorming with the head of group, it was found that the operators sometimes did not comply with the SOP when picking up and holding the cabinet. With the condition of peeling and thinning felt shelves coupled with the wrong taking and placing of the cabinet, it will increase the risk of defective cabinet. The suggestion that can be given to this problem is to emphasize the role of the Group Head in managing operator to always pay attention to the work guideline that have been made regardless of the conditions.

h. Lack of cooling time for the cabinet as standard after the press process with RPN-AHP value 3,4629. The cabinet that has finished entering the press process must be cooled in the seasoning room to stabilize the cabinet temperature to be normal. The time needed in this cooling process is for 3 days. If the cabinet cooling process is less than 3 days then the cabinet is taken for further processing, there will be a potential for defect. In order to prevent this condition, the operator must always put a label containing complete data about the cabinet on the stack of cabinets that have been finished through the press process and are being cooled in the seasoning room. In addition, operator must always be careful when taking cabinet in the seasoning room to be sent to the next process.

i. A lot of felt in handling shelf is pilled off with RPN-AHP value 2,6493. In the process of transporting cabinet from one process to another, the operator uses the handling shelf as a means of transportation. In order to maintain the quality of the cabinet, the surface of the handling shelf must be covered with felt to avoid any collision or friction between the cabinet and the handling shelf. When the shelf layer is peeled off, the potential for defect in the cabinet will increase due to impact or friction with the surface or edges of the handling shelf. To avoid this incident, operator and related staff as head of group should always check the felt on the handling shelf before and after using it. However, when operator find a handling shelf condition where the felt has pilled off so they are forbidden to use it and immediately report it to the maintenance department for corrective action.

j. The slit of bottom stopper is too wide with RPN-AHP value 2,4911. The condition when the slit of the cutter and the stoper is too wide will cause the rotation of the blade to be unbalanced. As a consequence, the result of the cabinet cleavage did not match the standard. To avoid this condition, machine maintenance, especially checking on the bottom stopper, must be scheduled regularly and replace the stopper when the gap in the stopper is too wide.

k. The mixing of water with paint during painting process with RPN-AHP value 2,3582. Mixing water in the paint often occurs due to the humid working environment, especially during the rainy season. This humid working environment condition affects the level of cabinet dryness. A cabinet that is in humid condition will be prone to causing defect in the form of bubbles when entering the painting process. To ensure that the cabinet that will enter the painting process is at the usual dry level, the cabinet that will enter the painting process must be placed in the seasoning room.

l. The cutter used in the cabinet cleavage process is blunt with RPN-AHP value 2,0177. A dull cutter when used in the cabinet purchase process will cause defects and the cabinet will not split completely. This incident is usually found after a defect due to a dull knife. In order to avoid this incident, cutter replacement must be carried out periodically and on a scheduled basis, namely every 2 days. If the operator feels that the cutter is not performing well, the operator must immediately replace the cutter without waiting for defects in the cabinet due to blunt cutters.

m. The temperature in seasoning room for cooling cabinet is unstable with RPN-AHP value 1,8104. The air condition and temperature in the seasoning room must be stable in order to make sure the cooling process of cabinet works optimally and finish according to the predetermined schedule. If the air condition and temperature in the seasoning room are unstable, the cooling process of cabinet after pressing process will be longer. In order to avoid this incident, a daily check list is needed in the seasoning room to ensure the temperature and air condition are in accordance with the standard set by the company.

n. Backer equalization by the chisel is too strong with RPN-AHP value 1,3370. In the backer equalization process, the operator uses chisel as a tool. When the operator gives too much pressure on one side during backer equalization process, it will cause defect on the other side. Therefore, it requires accuracy and careful calculation when performing the backer equalization in accordance with the SOP determined by the company. More than that, head of group must always control and provide training in correct equalization techniques, especially for new operator.

o. Backer quality which is not up to standard is included in the production process with RPN-AHP value 1,3370. The backer raw materials used in the production process come from vendor that have been determined by the company. In several cases it was found that an immature backer was found on the production floor, which could potentially cause defect in the cabinet. To avoid this incident, it is necessary to emphasize the vendor to conduct quality control on the backer before it is sent. In addition, inventory staff also has to double-check the backer raw material before entering the production floor. For operators, they must always check the backer raw material before using it.

p. The operator makes a mistake during the drilling process with RPN-AHP value 1,1544. This potential failure occurs due to frequent operator changes in the Cabinet Case division. This change can occur due to a temporary transfer from another division to the cabinet case division or vice versa. In addition, it is also due to new employees who fill in the vacancies due to the old employee leaving or moving permanently. As a result of the frequent presence of new employees, where their skill in the drilling process is still not very good, it has an impact on the frequency of defect. Furthermore, some operators also do not conduct the drilling process according to the work instruction set by the company. Suggestion that can be given to overcome this problem is to further improve the quality of training for new operator and to tighten the selection and placement of new operator based on their skill. In addition, the head of group must always emphasize the operator to always carry out work in accordance with the work instructions set by the company.

CHAPTER VI

CONCLUSION

6.1 Conclusion

The conclusions are withdrawn based on the research result and analysis, as follows:

1. Based on the result of Pareto Diagram, the most dominant type of defect occur in Cabinet Case division is rift defect, while the most dominant type of cabinet is Fall Back.
2. The factors cause to defect in Cabinet Case division can be divided into 5 factors. The first is material factor consists of the raw material that will be manufactured is not angled as predetermined standard, the quality of backer is not up to standard included in the production process, raw material wood to be processed does not meet the standard passed in the production process. The second is method factor that covers the condition when the operator does not apply the gluing process evenly to the entire cabinet surface, the operator made a mistake during the process of picking and placing the cabinet, lack of cooling time for the cabinet as standard after the press process, backer equalization process by the chisel is to strong. The third is environment factor consist of dusty working environment, the temperature condition in the seasoning room is unstable, the humid air condition in the work environment of painting. The fourth is machine factor consist of the condition of the stainless part in the jig which is used during pressing process is wavy and not suitable for use, the condition of the rubber between the stainless on the jig

used during the pressing process is not elastic, a lot of felt in handling shelf is pilled off, the cutter used in the cabinet cleavage process is blunt, the slit of bottom stopper is too wide. The last is manpower factor that caused by the operator who makes mistake during the drilling process.

3. The proper improvement that could be implemented by company in order to minimize defective product are scheduled the replacement of stainless steel part on the jig without having to wait for the stainless steel to wavy and appoint each operator who uses press machine to be person in charge to strengthen a sense of belonging, operator must always check the raw material before entering the gluing and pressing process, emphasize the role of the head of group on operator to be more thorough in the gluing process, scheduled cleaning of work environment so the dust from the cutting residue does not collect and fly around, scheduled the replacement of rubber part on the jig without having to wait for the rubber become inelastic, emphasize the vendor to conduct quality control on the raw material before it is sent, emphasize the role of the Group Head in managing operator to always pay attention to the work guideline that have been made regardless of the conditions, operator must always be careful when taking cabinet in the seasoning room to be sent to the next process, operator and related staff as head of group should always check the felt on the handling shelf before and after using it, machine maintenance, especially checking on the bottom stopper, must be scheduled regularly and replace the stopper when the gap in the stopper is too wide, the cabinet that will enter the painting process must be placed in the seasoning room, cutter replacement must be carried out periodically and on a scheduled basis, a daily check list is needed in the seasoning room to ensure the temperature and air condition are in accordance with the standard set by the company, control and provide training in correct equalization techniques, especially for new operator, emphasize the vendor to conduct quality control on the backer before it is sent, improve the quality of training for new operator and to tighten the selection and placement of new operator based on their skill.

6.2 Recommendation

The suggestions that can be given as input are as follows:

1. The company should improve the quality of training for new operator and to tighten the selection also placement of new operator based on their skill and interest.
2. At the morning meeting, it was emphasized again on the accuracy and discipline at work. If necessary, showing details on the defective product that have occurred every day and even the total losses suffered by the company caused by the defective product. Furthermore, giving direction in order to increase the awareness to always perform the best.
3. The company should pay more attention to schedule the replacement of parts of each machine and assign operator of machine user to be in charge of the machine.
4. For further research, it is expected to be able to identify other failure modes that arise during the piano production process and consider it from a cost perspective.

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APPENDIX

KUESIONER FMEA

Kuesioner ini bertujuan untuk melakukan penilaian mode kegagalan pada aktivitas produksi pada divisi Cabinet Case PT Yamaha Indonesia. Hasil kuesioner akan diolah lebih lanjut dan digunakan untuk kepentingan akademik (penelitian tugas akhir). Hasil dari kuesioner akan diolah lebih lanjut dan digunakan untuk kepentingan akademik yaitu penelitian tugas akhir. Atas kerjasama dan kesediaan Bapak/Ibu dalam mengisi kuesioner ini, saya ucapkan terima kasih.

Kuesioner ini akan digunakan untuk menghitung tiga kriteria yang digunakan dalam penelitian ini untuk mencari nilai *Risk Priority Number*, yang terdiri atas :

- Kriteria *Severity* : Tingkat Keparahan dari Kegagalan yang ditimbulkan
- Kriteria *Occurrence* : Frekuensi kemungkinan terjadinya penyebab kegagalan
- Kriteria *Detectability* : Pengontrolan deteksi terjadinya kegagalan

Berikut daftar untuk mengisi kuesioner FMEA

1. Dari mode kegagalan yang terjadi, seberapa parah akibat yang ditimbulkan (*severity*) terhadap kabinet *Fall Back*?
2. Dari mode kegagalan yang terjadi, seberapa sering (*occurence*) hal tersebut dapat menyebabkan renggang permukaan pada kabinet *Fall Back*?
3. Dari mode kegagalan yang terjadi, seberapa jauh (*detection*) penyebab kegagalan dapat menyebabkan renggang pada kabinet *Fall Back*?

Skala penilaian untuk mengisi kriteria yang digunakan adalah sebagai berikut :

Severity

Severity	Criteria	Ranking
Hazardous Without Warning	Kegagalan akan membahayakan mesin atau operator tanpa peringatan	10

Severity	Criteria	Ranking
Hazardous With Warning	Kegagalan akan membahayakan mesin atau operator dengan peringatan	9
Very high	Produk akan mengalami kehilangan fungsi utama sepenuhnya. 100% produk mungkin harus dibuang	8
High	Produk akan dapat dioperasikan dengan fungsi utama yang dikurangi. Produk mungkin harus disortir dan sebagian (<100%) dibuang	7
Moderate	Barang kenyamanan / kemudahan tidak dapat dioperasikan. Sebagian (<100%) produk mungkin harus dibuang	6
Low	Item kenyamanan / kemudahan akan dapat dioperasikan pada tingkat kinerja yang dikurangi. 100% produk mungkin harus dikerjakan ulang	5
Very low	Cacat akan diperhatikan oleh sebagian besar pelanggan. 100% produk mungkin harus disortir dan sebagian (<100%) dikerjakan ulang	4
Minor	Cacat akan diperhatikan oleh pelanggan biasa. Sebagian dari produk (<100%) mungkin harus dikerjakan ulang secara online tetapi di luar stasiun	3
Very minor	Cacat akan terlihat oleh sebagian besar pelanggan yang diskriminatif. Sebagian produk mungkin harus dikerjakan ulang secara on-line tetapi keluar dari stasiun	2
None	Tidak berpengaruh	1

Occurrence

Occurrence	Criteria	Ranking
Very High	1 dari 2	10
Very High	1 dari 3 Hampir pasti akan terjadi	9
High	1 dari 8	8
High	1 dari 20 Kemungkinan besar peristiwa itu akan terjadi	7
Moderate	1 dari 80	6
Moderate	1 dari 400 Kesempatan sedang untuk terjadi	5
Moderate	1 dari 2000	4
Low	1 dari 15000 Tidak mungkin terjadi	3
Low	1 dari 150000	2
Remote	1 dari 1500000 Sangat tidak mungkin terjadi	1

Detectability

Detection	Criteria	Ranking
Absolutely Impossible	Kontrol desain tidak akan dan / atau tidak dapat mendeteksi penyebab / mekanisme potensial dan mode kegagalan selanjutnya	10

Detection	Criteria	Ranking
Very Remote	Kemungkinan yang sangat kecil bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	9
Remote	Kemungkinan jauh bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	8
Very Low	Kemungkinan Sangat Rendah bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	7
Low	Kemungkinan kecil bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	6
Moderate	Sedang Kemungkinan bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	5
Moderatel y High	Kemungkinan cukup tinggi bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	4
High	Kemungkinan besar bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	3
Very High	Kemungkinan yang sangat tinggi bahwa kontrol saat ini akan mendeteksi / mencegah mode kegagalan	2
Almost Certain	Kontrol Saat Ini hampir pasti untuk mendeteksi / mencegah mode kegagalan	1

Beri penilaian pada pertanyaan yang tersaji pada nilai *severity*, *occurrence*, dan *detectability* untuk setiap mode kegagalan dibawah.

Potential Failure (Potensi Kegagalan)	**Cause of Failure (Penyebab Kegagalan)**	**Severity (Keparahan)**	**Occurrence (Frekuensi)**	**Detectability (Deteksi)**
Kurangnya waktu pendinginan kabinet yang sesuai dengan standard yang telah ditentukan	Operator kurang teliti pada saat pengambilan kabinet yang telah didinginkan yang mana akan diproses ke tahapan selanjutnya			
Tidak stabilnya suhu ruangan pendinginan kabinet	Operator tidak melakukan pengecekan suhu ruangan secara berkala			
Pengepresan backer terlalu kuat sehingga membuat gompal pada sisi lainya	Operator tidak memperhatikan SOP pengepresan			
Terdapat banyak felt pada rak yang terkelupas.	Kurangnya perawatan terhadap rak handing dan tidak melakukan penggantian felt secara berkala.			

Potential Failure (Potensi Kegagalan)	**Cause of Failure (Penyebab Kegagalan)**	**Severity (Keparahan)**	**Occurrence (Frekuensi)**	**Detectability (Deteksi)**
Tercampurnya air pada bahan cat pada proses painting	Keadaan lingkungan kerja yang lembab terutama pada musim hujan			
Kualitas backer yang tidak sesuai standard masuk dalam proses produksi	Operator tidak teliti dalam melakukan pengecekan backer yang akan di proses			
Cutter yang digunakan pada proses pembelahan kabinet tumpul	Tidak digantinya cutter yang sudah tumpul dan tidak layak pakai secara berkala			
Celah stoper penahan bagian bawah terlalu terlalu lebar	Tidak digantinya stoper yang celahnya sudah lebar dan tidak layak pakai secara berkala			
Bahan mentah kayu yang akan di proses tidak memenuhi standard lolos dalam proses produksi	Operator tidak teliti dalam melakukan pengecekan bahan baku kayu yang akan di proses			

Potential Failure (Potensi Kegagalan)	**Cause of Failure (Penyebab Kegagalan)**	**Severity (Keparahan)**	**Occurrence (Frekuensi)**	**Detectability (Deteksi)**
Adanya gesekan antara Fall Back dan sekat rak pada saat proses pengambilan dan peletakan	Cara pengambilan dan peletakan dari rak salah, karena operator kurang teliti dan tidak melakukan pengambilan dan peletakan sesuai dengan petunjuk kerja			
Kabinet Fall Back tidak merekat secara sempurna pada saat proses pengepresan	Operator tidak mengoleskan lem secara merata pada seluruh permukaan kabinet Fall Back			
Part stainless pada jig bergelombang	Tidak digantinya stainless pada jig yang sudah tidak layak pakai			
Karet diantara stainless sudah tidak elastis menyebabkan proses press tidak maksimal	Tidak digantinya karet di antara stainless yang sudah kaku dan tidak layak pakai			

Potential Failure (Potensi Kegagalan)	Cause of Failure (Penyebab Kegagalan)	Severity (Keparahan)	Occurrence (Frekuensi)	Detectability (Deteksi)
Bentuk material kabinet Fall Back tidak siku	Terjadinya kesalahan proses pemotongan kabinet pada divisi sebelumnya			
Permukaan kabinet Fall Back terpapar debu kayu pada saat prosess pengeleman	Kurangnya perhatian operator dalam menjaga kebersihan lingkungan kerja			
Operator melakukan kesalahan pada saat proses pengepresan	Kurangnya skill pada operator baru			

BIODATA RESPONDEN

Mohon Bapak/Ibu berkenan untuk mengisi biodata responden yang bertujuan untuk pendataan biografi responden. Data akan dirahasiakan dan tidak akan disebarluaskan.

Nama : …………………………………………………………

Jabatan : …………………………………………………………

Bagian : …………………………………………………………

Lama Bekerja : ……………………………………………………….

Terima kasih atas kesediaan Bapak/Ibu untuk mengisi kuesioner penelitian ini.

Jakarta, … September 2020

(………………….…………….)

KUESIONER AHP

Nama :

Jenis Kelamin :

Jabatan :

Bagian :

Lama Bekerja :

Kuesioner ini akan digunakan untuk menghitung tiga kriteria yang digunakan dalam penelitian ini, yang terdiri atas :

- Kriteria *Severity* : Tingkat Keparahan dari Kegagalan yang ditimbulkan
- Kriteria *Occurrence* : Frekuensi kemungkinan terjadinya penyebab kegagalan
- Kriteria *Detectability* : Pengontrolan deteksi terjadinya kegagalan

Skala penilaian kriteria yang digunakan adalah sebagai berikut :

1 : Kedua kriteria sangat penting

3 : Kriteria A sedikit lebih penting dibanding kriteria B

5 : Kriteria A lebih penting dibanding kriteria B

7 : Kriteria A jelas lebih mutlak penting dibanding kriteria B

9 : Kriteria A mutlak penting dibanding kriteria B

2,4,6,8 : Nilai-nilai antara dua nilai pertimbangan-pertimbangan yang berdekatan

Petunjuk pengisian :

Beri tanda *Checklist* (V) pada nilai perbandingan kriteria yang menurut anda tepat!

Kriteria A	Skala																	Kriteria B
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Severity																		*Occurrence*
																		Detectability
Occurrence																		*Detectability*