DEFECT ANALYSIS USING PDCA (PLAN-DO-CHECK-ACTION) AND FMEA (FAILURE MODE AND EFFECT ANALYSIS) ON CABINETS OF UP (UPRIGHT PIANO)

(CASE STUDY: FINAL CHECK AND REPAIR UP – PT. YAMAHA INDONESIA)

UNDERGRADUATE THESIS

Submitted to the International Undergraduate Program in Industrial Engineering in Partial Fulfillment of Requirement for the Degree of Sarjana Teknik at Faculty of Industrial Technology

Universitas Islam Indonesia

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UNIVERSITAS ISLAM INDONESIA

YOGYAKARTA

2023

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I state that in the writing of this thesis, it is purely my work and there is no work belonging to other people that has been submitted to obtain a bachelor's degree in a university, except those that have been mentioned in the citation and reference. If one day this statement is proved not true and violates the copyright regulation, then I can accept any consequences according to the applied regulations.

Yogyakarta, August 15th 2023

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RESEARCH COMPLETION LETTER

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Assalamu'alaikum wr. wb

Dear Sir/Madam,

We are writing to inform you that the student of International Program, industrial Engineering, Universitas Islam Indonesia Yogyakarta, listed below:

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would like to conduct **internship program** as one of the requirements in accomplishing the Bachelor of Engineering Degree. For your information, International Program is a program established by Faculty of Industrial Technology, Universitas Islam Indonesia that all academic activities are performed entirely in English in order to enrich the student skills and competences, especially for their international language ability. For addition, Industrial Engineering, FIT, UII have already achieved the A accreditation.

Regarding to that, we would like to recommend our student to be able to perform the internship program in your company. Beside the capability in performing great communication in English, Student of International Program, furthermore equipped with another skills and expertise as follows: SAP/R3, SPSS and CAD.

We do hope that you can consider our student to perform the internship program in your company since we completely certain with their competences; he can provide many contributions to your company.

We do hope this cooperation can be a starting point of the development of International Program and the company so that in the future time it can give benefits to all of us.

Thank you very much for your pleasant attention and consideration, hopefully we can hear confirmation from you soon.

Wassalamu'alaikum wr. wb

Yogyakarta, March 10, 2020

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Yogyakarta, August 15th 2023

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EXAMINER'S APPROVAL PAGE

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DEDICATION PAGE

This thesis is dedicated to my beloved parents Mr. Agus Basuki, Mrs. Retno Handayani, my beloved mom who has passed away, Mrs. Rining Wardhani, and my beloved brothers and sisters who always give me love, support, and prayers. I am very grateful to have them in my life to go through all these journey.

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Dr. Taufiq Immawan, ST., MM.

Last but absolutely not the least, this thesis is also dedicated to all souls who love me unconditionally, who make my life feels brighter.

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The Author realizes that this thesis is not perfect and has weaknesses. Thus, suggestions and criticism are accepted. The Author hopes that this thesis will bring benefits to all in need.

Wassalamu’alaikum Warahmatullahi Wabarakatuh.

Yogyakarta, August 2023

Raden Cahya Magistra Putra

(16522156)

MOTTO

"Allah does not burden a soul beyond that it can bear."

(Quran Surah Al Baqarah verse 286)

"Do not lose hope, nor be sad."

(Quran Surah 3:139)

"For indeed, with hardships (will be) ease."

(Quran Surah Ash-Sharh verse 5)

ABSTRACT

The growth of industrial enterprises has continued as increasingly complex technologies are created and have a significant impact on the global economy. A manufacturing corporation is among the most mature business entities. Indonesia has grown to be the largest industrial base in ASEAN, contributing 20,27% to the country's overall GDP, according to investindonesia.go.id. In general, a manufacturer's objective is to create the best product possible so that the customer can profit. A manufacturing business also needs a continual development production process to ensure the survival of the business. PT Yamaha Indonesia is a manufacturing company that produces piano music instruments. There are two types of pianos produced: upright piano and grand piano. The purpose of this research is to enhance the production process at PT Yamaha Indonesia's Cabinet Case division based on an analysis of the causes of defects in order to decrease the production of defective products. The method used in this research is PDCA (Plan, Do, Check, Action) and FMEA (Failure Mode and Effect Analysis) with several supporting tools such as a Pareto diagram, fishbone diagram, 5W + 1H analysis, and check sheet. Based on the result of pareto diagram, most defect found is deformed and the cabinet with most of this defect is the top frame. The factors of this defect are shown in the fishbone diagram which consists of 6M (methods, material, measurement, machine, manpower, environment). Therefore, the recommended actions that need to be done by the company are checking every material before being sent to the next process, taking care and storing the cabinet in a proper place, and employing workers who have been well trained according to the job description. Furthermore, conducting effective training periodically and further assessments are essential to be implemented by the company.

Keyword: Defect Product, Quality Control, Plan-Do-Check-Action, Failure Mode and Effect Analysis, Pareto Diagram, Fishbone Diagram, 5W+1H, Check Sheet

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INTRODUCTION

1.1 Background

The development of industrial companies has grown continuously as more sophisticated technologies are invented and have a massive impact on the world. One of the most grown-up company is a manufacturing company. According to investindonesia.go.id, Indonesia has become the largest basis of the manufacturing industry in ASEAN by contributing 20,27% to the national economic scale. Generally, the goal of a manufacturing product is to produce the best product for costumer to gain income and benefits. A manufacturing company also requires a continuous development and production process so that the company's life is guaranteed. All companies are forced to be more competitive in order to survive in the competition. The competition is getting tougher as knowledge and innovation among competitors are enhanced. The tight competition triggers companies to provide a competitive product to fulfill costumer's needs. Customers will choose a product with the best quality corresponds to the price of the product.

A manufacturing company must have standards in their production process in order to produce the best product quality to gain profit. If the product can fulfill customer's needs and specifications without flaws, then the product quality is good enough. To achieve zero defects, every quality control in the production process quality control is very important.

According to Parasuraman (1985), quality can be expressed as a comparison between services that consumers expect with the services they receive. To gain customer's trust, quality control and product innovation are needed. Quality control is a system of verification and maintenance of a desired level of product or process quality by means of careful planning, use of appropriate equipment, continuous inspection, and corrective action when necessary. Thus the results obtained from quality control activities can actually improve the quality of a product and meet the standards that have been planned/set by the customer (Sulaeman, 2014).

A manufacturing company always finds out that the most common problem in their products is the defects' appearance. A defective product is a failed product that technically or economically can still be repaired into a product that complies with the established quality standards but requires additional costs. Defective products are goods that are produced that cannot meet predetermined standards but can still be repaired (Kholmi & Yuningsih, 2009). In the production process, this defective product can be caused by two things, namely due to ordering specifications (abnormal) and caused by internal factors (normal). The problem that arises for this defective product is the treatment of rework.

PT Yamaha Indonesia is a manufacturing company that produces piano music instruments. There are two types of pianos produced: upright piano and grand piano. An upright piano is a piano that has a vertical position and is quite smaller than a grand piano. Vice versa, the grand piano is a horizontal position piano that has a bigger size, especially for its soundboard. In the production process, PT Yamaha Indonesia has both machines and human sources. Potential defects cannot always be avoided as they combine both machines and human sources. The most common problem found in the production process is the appearance of defects in both upright piano and grand piano such as cracked, dirt, scratched, chipped, and groove.

Table 1.1 Number of Defects for 6 Months

No.	Month	Total Defects	Total Production
1	October	2523	2736
2	November	2399	2658
3	December	2115	2335
4	January	1449	1807

5	February	1556	2254
6	March	1236	2242
Percentage of Defects		80%	

During the 6-month period from October 2019 up to March 2020, the defect percentage is 80% of total production. The high percentage of defects will cause higher repairing costs also. However, PT. Yamaha Indonesia needs to repair any defective cabinet that may affect customer satisfaction with their products. The repairing process involves fixing a cabinet that can still be fixed or even needs to be replaced.

This research will use two methods which are Failure Mode and Effect Analysis (FMEA) and PDCA (Plan-Do-Check-Action) which is included in Six Sigma mainly. The root cause of the quality problem could be identified using the FMEA method. Aisyah (2011) mentioned that FMEA is a method for identifying and analyzing potential failure and its aftermath to plan the production process properly and avoid process failure production and unwanted losses. FMEA has a Risk Priority Number (RPN) that will be obtained by identifying the level of severity, occurrence, and detectability.

Isniah et al. (2020), stated that a common continuous improvement tool in the service and manufacturing industries is the PDCA quality management system. Plan, Do, Check, and Action are the four phases that make up a PDCA activity, and they are repeated stages that create a circle. This is a simple but effective tool for continuous improvement. Furthermore, those two methods are going to be used to determine the proper improvement that will be proposed to PT Yamaha Indonesia in an effort to reduce product defects in the cabinet of UP (Upright Piano).

1.2 Problem Formulation

Based on the explanation of the background above, there are several problem formulations that can be raised, as follows:

1. What types of defects and cabinets are frequently found in the Cabinet Case of UP?
2. What are the factors that cause defects in the Cabinet Case of UP?
3. What is proper improvements to reduce defective products in Cabinet Case of UP?

1.3 Research Objectives

This research has the following objectives:

1. Determine defects frequently found in the cabinet case of UP
2. Analyze the factor cause of defect in cabinet case of UP
3. Provide recommendations for improvement in the cabinet case of UP

1.4 Research Limitation

In order to focus the study, the scope of research must be conducted. The research limitations are as follows:

1. The division as an object of this research is the Final Check and Repair department in PT. Yamaha Indonesia
2. The researcher does not discuss the cost aspect
3. The improvement proposed by the researcher is only a recommendation, not implemented directly.

1.5 Research Benefit

This research is expected to have some benefits to all parties involved in it. These are the following research benefits:

1. Developing scientific knowledge about the defects that appear in the product, especially in production and quality control.

2. Enhancing the ability of the company to manage data as a base to solve problems or a decision making toward company development.
3. Increase knowledge and information as a reference for further research.

1.6 Systematical Writing

In order to make this research easier to understand, the researcher uses a writing system as follows:

CHAPTER I	**INTRODUCTION**
	This chapter explains the research background, the problem that appears and needs to be solved, reason and urgency of using the method. The background will lead to problem formulation. This chapter also provides research limitations, research benefits, and systematical writing.
CHAPTER II	**LITERATURE REVIEW**
	The literature review provides concepts and basic theories from journals to support this research. It also has previous studies that will relate to this research.
CHAPTER III	**RESEARCH METHODOLOGY**
	Research methodology provides the overall framework of this research in detail such as research objects, data types, and research flow.
CHAPTER IV	**DATA COLLECTING AND PROCESSING**
	This chapter presents the data obtained during the research. It explains data analysis and methods implemented to solve the problem that exists. This chapter will also provide a reference for the discussion of the results to be written in chapter V.

CHAPTER V **DISCUSSION**

The discussion will provide a further and comprehensive understanding of data analysis in chapter IV.

CHAPTER VI **CONCLUSION AND RECOMMENDATION**

This chapter consists of the conclusion of the analysis and provides recommendations based on the result that could be given to the company for further research.

REFERENCES

APPENDIX

CHAPTER II

LITERATURE REVIEW

The literature review explains the basic theories to support this research. There are two types of literature review used in this research which are inductive study and deductive study. An inductive study is about to collect data relevant to this research. While deductive study is an explanation about methods that are going to be used in this research.

2.1 Inductive Study

Firdaus & Widianti (2015) conducted research on the testing process of a refrigerator in a laboratory that might have failure. The method used in this research was FMEA which can determine the level of risk represented by RPN (Risk Priority Number). The RPN value is obtained from the multiplication of three indicators, namely S (severity), O (occurrence), and D (detection). The results of the analysis show that the highest RPN value is 85 (on thermocouple components with failure mode: measured temperature inaccuracy). Then successively the four high RPN values are 75 (on the thermocouple component with failure mode: temperature is not measured), 69 (on the walk-in chamber component with failure mode: chiller not working), and 63 (on the power source component). with failure mode: voltage does not come out), and 57 (on RCL meter components with failure mode: resistance not measured). The results of the analysis show that the priority of maintenance or prevention of failure modes that need to be considered are the components of the thermocouple, RCL meter, walk-in chamber, and power source because these components have high RPN values.

Handoko (2017) conducted research using PDCA and seven tools in PT. Rosandex Putra Perkasa about product defects during wooden floor and wood panel wall production. The research was held on March – June 2016 that has made the company suffer losses of Rp. 1,552,500,000. Quality control analysis uses the PDCA approach and seven tools in the form of check sheets, histograms, Pareto diagrams, p-control charts, causal diagrams, and FMEA. The tool will be implemented at the company PT. Rosandex Putra Perkasa Surabaya. The results showed that the quality problem at PT. Rosandex Putra Perkasa can be minimized by using the PDCA approach and Seven Tools. In addition, the total loss from defects in wood flooring products decreased by Rp. 185,500,000 and the total losses from defects in wood panel wall products decreased by Rp. 210,000,000.

Sudarwati, Wijaya (2015, p.9) conducted a study at PT. ADM Press-Plant, which is a company that manufactures car component products, in its business process there are still many obstacles that must be addressed in terms of quality. In this case, the defect that flows to the next process (Metal Finish) is quite high, namely 1724 pcs with 0.005 DPU from the specified target of 0.0008. This study aims to reduce the occurrence of defects in the process to no more than 3.4 DPMO. The method used to solve the problem is Six Sigma with the Define-Measure-Analyze Improve-Control stage. The research begins with the Define stage to identify the products and processes to be improved, namely the Outer Rh Side Panel, and then make a statement of the Six Sigma project objectives, namely Reducing flowing defects. After that in the Measure phase, look for key characteristics and calculate the company's sigma capability. After knowing the performance, in the Analyze phase, Failure Modes and Effect Analysis (FMEA) is used to analyze the root causes of high defects. From the results of data processing, there is one type of defect that is critical to quality, namely lump defects. With the improvement data, namely the decrease in DPU which was originally from 0.005 to 0.002, and a decrease in defects that flowed by 62.3%.

Alfatiyah (2019, p.39) conducted research at PT KMK Global Sports 2. This company produces shoes named Converse. PT. KMK Global Sports 2 produces more than one million shoes per year for both good and defective products, which are caused by defective products caused by various factors such as human error, raw materials, machine errors, and others. To overcome this, the author applies Plan-Do Check-Action (PDCA), PT method, failure mode, and performance analysis (FMEA). After applying the two methods obtained, the material under the average defect ratio decreased by 0.87% from the previous average defect value in 2017 of 1.48%, and after an increase in the average defect percentage during the next eight months was 0.61%.

Bastuti (2017, p.113) conducted research in PT XYZ (not the real company's name) at Tangerang. The researcher collects the data which consists of data rejection, marking type data, and interview data. The author analyzes the internal quality claim of the marking section which is the highest by making alternative improvements using the Plan, Do, Check, Action (PDCA) approach with seven tools. This research uses quantitative and qualitative data and descriptive exploratory analysis. Based on the results of the improvement, the internal claims of the marking section decreased from 73 claims to 26 claims or if calculated on average before repair 6.08 claims, and after repairing 3.25 claims decreased by 53%.

2.2 Deductive Study

2.2.1 FMEA (Failure Mode and Effect Analysis)

The American military first created the Failure Mode and Effect Analysis (FMEA) technique in 1949, with the goal of analyzing the likelihood of failures that influence individual safety and mission achievement. The FMEA technique is used to examine the failure mode in a process or product. The Failure Mode and Effect Analysis is used to conduct risk management.

Failure Mode and Effect Analysis (FMEA) is a proven method for determining the possible causes of disturbances or damage that pose a danger to a complex system. In the industry, FMEA-based risk management analysis can be utilized to avert unwanted incidents or consumer unhappiness (Wang, 2008). An FMEA report can be created for a variety of reasons in the industry. A strong FMEA report can help these parties by reducing dependency on a dominant factor, reducing structural changes, improving quality rates, increasing production volumes, or implementing more efficient methods, and lowering production costs. Conventional FMEA research or analysis is normally carried out by experts in their respective professions. Several components of the FMEA method, namely recognizing the methods of dissatisfaction and problems that occur, namely; surveying an action that allows for an error to occur; evaluating the level of risk of defective or deficient results; calculating the level of hazard proportion; sorting or positioning of defects based on the resulting risk; checking the feasibility of the activity, and taking advantage of them (Ahsen, 2008).

FMEA is an analytical methodology for ensuring that potential concerns are recognized and addressed during process and product development, according to the Automotive Industry Action Group (AIAG). The most prominent outcome is the cross-functional teams' collective documentation. This is one method for determining the severity of the error while prioritizing countermeasures. This is accomplished by creating severity, occurrence, and detection values. This number is known as a Risk Priority Number (RPN). The higher the number of values obtained, the higher the system failure rate (AIAG, 2008).

RPN values are classified into three categories: green (low risk, no action necessary), yellow (medium risk, at least one action required), and red (high risk, at least one action required) (high risk, one or more measures are urgently needed). To be able to resolve this, all yellow and red risks require periodic corrective actions and are regularly monitored using the PDCA (Plan-Do, Check, Act) cycle until they reach an acceptable risk level, taking into account the manufacturer's permission and the assembly process (Andre ´ Segismundo & Paulo Augusto Cauchick Miguel, 2008).

2.2.2 FMEA Implementation Steps

The application of the FMEA approach, according to D'Ettorre (2014), is separated into three phases:

1. Qualitative Analysis, which entails identifying all possible failure modes, causes, and consequences.

2. Quantitative study based on the RPN index evaluation.

3. Analysis of improvement based on the implementation of the improvement strategy with the goal of lowering the risk level.

The FMEA method is divided into three phases for implementation. The first phase is a qualitative analysis that involves identifying all probable failures, their causes, and their consequences. The second phase is a quantitative analysis based on the RPN value evaluation. The Risk Priority Number (RPN), which is obtained from the multiplication of the three risk factor values, severity, occurrence, and detection, determines the ranking of each failure mode in 19 standard FMEA approaches. Occurrence (O) is the probability of failure, severity (S) is the severity of the failure, and detection (D) is the probability of knowing the failure before it occurs. The three risk factors each have a scale of 1 to 10. The failure mode with the highest RPN value is prioritized for corrective action. Then after the corrective action is implemented, it is necessary to recalculate the RPN value to determine the effectiveness of the corrective action (Reza Fattahi & Mohammad Khalilzadeh, 2018).

2.2.3 Benefits of FMEA

According to Ramli (2010), the FMEA technique has the following advantages:
1. The cost of facility maintenance and operation can be lowered.
2. The FMEA technique can be used to describe a component's or subsystem's level of vulnerability to failure scenarios.

2.2.4 Criteria in FMEA

There are three criteria in the FMEA, namely severity, occurrence, and detection. These three parameters are used to calculate the relative risk and impact of each failure. Severity is a consequence of the occurrence of failure, occurrence is defined as the probability or frequency of failure, and detection is defined as the probability of failure being noticed before an impact occurs (Robin E. McDermott et al., 2009). The description of each ranking from the criteria of severity, occurrence, and detection is shown in Table 2.1

Table 2. 1 Severity Ranking

Ranking	Severity	Description
10	Danger without warning	System failure causes a very dangerous effect.
9	Danger with warning	System failure causes dangerous effects.
8	Very high	The system is not operating.
7	High	The system is operated safely but cannot be fully executed.

6	Moderate	The system operates and is safe but suffers from a decrease in performance which affects the output
5	Low	Experiencing a gradual decline in performance.
4	Very Low	Small effect on system performance.
3	Minor	Minor effect on system performance.
2	Very Minor	Neglected effect on system performance.
1	No effect	No effect at all on system performance.

Table 2. 2 Occurrence

Ranking	Occurrence	Description
10	Very high	Failure happens almost all the time (>5 times a day)
9		Failure happens 3-5 times a day
8	High	Failure happens <3 times a day
7		Failure happens once in 2-4 days
6	Moderate	Failure happens once in 5-7 days
5		Failure happens once in 8-14 days
4		Failure happens once in 15-21
3	Low	Failure happens once in 22-30 days
2		Failure happens once in 2-3 months
1	Very low	Failure rarely happens, operators do not remember when the last failure happened.

Table 2. 3 Detection

Ranking	Detection	Description
10	Absolute uncertainty	Impossible to detect failure.
9	Very remote	Very difficult to detect failure
8	Remote	Difficult to detect failure
7	Very low	Very low chance of detecting failure
6	Low	Low chance of detecting failure

5	Moderate	Moderate chance of detecting failure
4	Moderate high	Very high chance of detecting failure
3	High	Control has a possibility to detect failure
2	Very high	Control has a high possibility of detecting failure
1	Almost certain	Control will certainly detect failure

Table 2. 4 Risk Category Determination

Risk Priority Number (RPN)	Category	Treatment
192-1000	High	Do treatment right now
65-191	Moderate	Effort to do treatment
0-64	Low	Risk can be neglected

The purpose of RPN is to rank various parameters. Attention should be paid to each available method of reducing the RPN. The Risk Priority Number (RPN) is the product of Severity (S), Occurrence (O), and Detection (D) and is calculated by the formula (Mirghafoori et al, 2014):

$$RPN = S \times O \times D$$

With,

S = Severity

O = Occurrence

D = Detection

2.2.5 Kaizen (Continuous Improvement)

Kaizen is a Japanese concept that refers to continual improvement involving everyone in an organization, from employees to supervisors. Improvements that come gradually but over time in kaizen might be recognized as a result of the practice of continuous improvement (Imai, 1998). Customer orientation, Total Quality Management (TQM), robotics, Quality Control Circles (QCC), Suggestion Systems, Automation, Workplace Discipline, Total Preventive Management (TPM), Kanban, Quality Improvement, Just-

In-Time, zero defects, small group activities, employee management cooperative relations, and new product development are all covered under the kaizen umbrella (Imai, 1994).

Figure 2. 1 Kaizen
Source: Mazaaki Imai (1994)

Kaizen, when correctly implemented, can encourage workers to have a different mentality about their work, as well as enhance morale and sensitivity to duties, such as people appreciating their workplace. Because top management wields power, employees begin to believe that they are a part of the decision-making and improvement process (Mohd Ghazali Maaro & Fatimah Mahmud, 2016). Only when all departments in the hierarchical structure are participating in the overall development of the system, the PDCA cycle can assist SMEs. This will make small businesses more competitive in the global market in the future (Chakraborty, 2016).

2.2.6 PDCA (Plan, Do, Check, Action)

One of the quality control methods commonly employed in large firms that go through a continuous process is PDCA (Plan-Do-Check-Action). The quality control process can be carried out using the PDCA (Plan-Do-Check-Action) method, which was developed by Dr. W. Edwards Deming, a well-known quality expert from the United States, and is known as the Deming cycle (Deming Cycle / Deming Wheel). The PDCA cycle is commonly used to test and implement product quality improvements (M. N. Nasution, 2015).

The PDCA cycle is the first step in adopting kaizen. It ensures that continuous improvement is implemented and that policies for maintenance and improvement, as well as standard improvement, are accomplished. The PDCA cycle is the most significant idea in the kaizen process (Imai, 1998). PDCA cycle can be shown in Figure 2.2 below:

Figure 2. 2 PDCA Cycle

1. Develop a plan (Plan)
   Quality control is carried out continuously, including planning specifications, setting good and correct specifications or quality standards, informing workers/employees of the importance of product quality, and informing workers/employees of the importance of product quality.
2. Execute a plan (Do)

The developed plans are implemented in phases, beginning on a modest scale and evenly dividing work according to each individual's capacity and skill. Control must be exercised during the plan's execution, namely attempting to ensure that all plans are carried out properly, following the plan, and on time.

3. Check or examine the results achieved (Check)
   Checking or researching refers to verifying whether the implementation is on track or in accordance with the plan, comparing the quality of the production outcomes to the standards that have been set, and then finding the cause of the failure based on research derived from failure data.
4. Perform adjustment actions when needed (Action)
   Based on the results of the aforesaid analysis, adjustments are made if they are deemed required. Adjustment refers to the standardization of new methods in order to avoid the recurrence of the same issue or the establishment of new goals for future improvements.

2.2.7 Benefits of PDCA

PDCA is well-suited to small-scale continuous improvement projects aimed at reducing product failure, eliminating workplace waste, and increasing productivity. While FMEA is good for evaluating and identifying the variables that create difficulties, it is not suitable for analyzing and identifying the factors that cause problems. PDCA has several advantages, including the following:

1. To make the mapping of an organizational unit's power and duty easier.
2. In the enhancement of a process or system in an organization, as a work pattern.
3. To use an organized and methodical pattern to solve and control a situation.
4. To increase quality through continuous improvement efforts.
5. Reduce waste and boost productivity in the workplace.

2.2.8 Pareto Diagram

Bar and line charts are both included in Pareto charts. Vilfredo Frederigo Samoso, an Italian economist, first proposed the Pareto diagram in 1897. Pareto diagrams are graphics that organize data classification from left to right based on highest to lowest ranking (Ramadhani et al, 2014). So that it can assist in distinguishing between problems that must be treated immediately and problems that do not (Ariani, 2004). This can assist management in identifying areas that require additional attention. The Pareto principle, sometimes known as the 80-20 rule, was popularized by Joseph M. Juran and states that 20% of the factors cause 80% of the effect.

Pareto charts can be used as a tool for interpreting:

1. Determine the problem's or the cause of the problem's relative frequency and importance.
2. Focusing focus on vital and serious concerns by assigning a considerable ranking to the problem or causes of the problem.

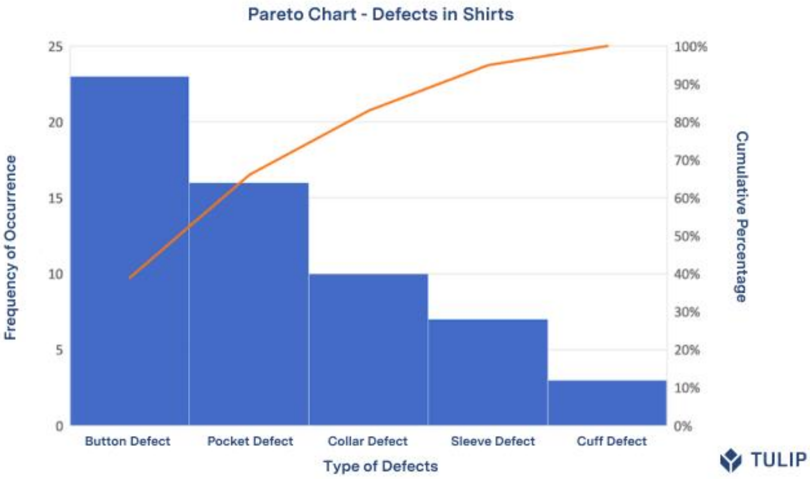

Figure 2. 3 Example of Pareto Diagram

2.2.9 Fishbone Diagram

Dr. Kaoru Ishikawa invented the fishbone diagram in 1943, and it is now known as the Ishikawa diagram. A cause and effect diagram (also known as a fishbone diagram) is a graphical tool for sequencing and relating the interactions between the process's affecting components. This diagram is useful for examining and identifying elements that have a major impact or influence on the quality of work production. This effect can have both a "good" and a "poor" value. It is intended that by understanding the reasons for the effects that occur, the results of the manufacturing process can be improved by altering the process's regulated components. These diagrams can also be used to determine the root cause of a problem. The problem or symptom that is the root cause of the problem is highlighted in fishbone diagrams. By combining the causes of a problem into one, fishbone diagrams can also show the causes of a problem (Fauziah, 2009).

Material, machine and equipment, manpower, method, mother nature or environment, and measurement are all categories of sources of problems that are frequently employed as a starting point. 6M is a common abbreviation for the six causes of this issue. If necessary, other causes of the problem can be chosen in addition to the 6M. Brainstorming approaches can be utilized to uncover the reason for the problem, both from the 6M as indicated above and from other alternative causes. The following are the stages of creating a cause-and-effect diagram:

1. Create a framework for a fishbone diagram or a fishbone analysis.
2. Look for and identify any implications or issues that may exist.
3. List the different types of primary causes.
4. Identifying and evaluating the primary reasons.
5. In the Fishbone Diagram, draw the primary causes.

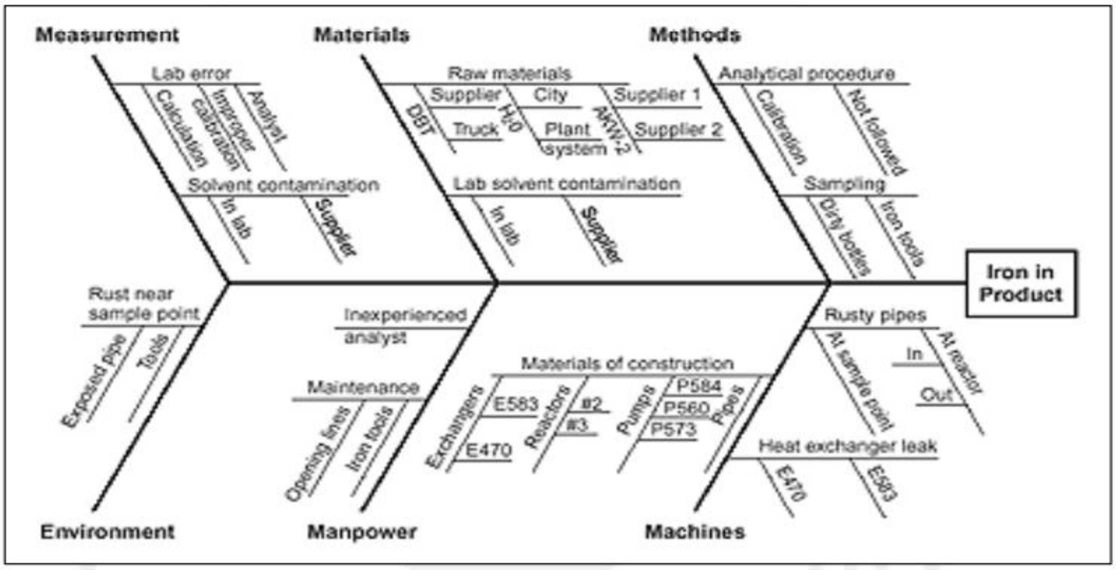

Figure 2. 4 Example of Fishbone Diagram

The following are some of the advantages of fishbone analysis:

1. Clarify the sources of an issue or problem.
2. Can use current conditions to improve product or service quality, make more efficient use of resources, and save money.
3. Can decrease and eliminate situations that lead to product or service non-conformance and customer complaints.
4. Has the ability to standardize existing and planned activities.

5. Can give staff education and training in decision-making activities, as well as take corrective action.

The most prevalent category is 6M, which contains the following items:

1. ManPower: Anyone who is a part of a process.
2. Method: How the process is carried out, as well as the process's special requirements, such as procedures and rules.
3. Material: All of the materials required to complete the operation, including basic materials, pens, and paper.
4. Machinery: All of the machinery, tools, computers, and other equipment required to do the task.
5. Measurement: The way of gathering data from the process in order to establish the process's quality.
6. Mother Nature/Environment: This includes things like air temperature, noise level, humidity, and so on.

2.2.10 5W + 1H (What, Why, Where, When, Who, How)

Gaspersz (2002) defined 5W + 1H analysis as an analytical strategy for addressing each underlying cause:

1. What (what causes product defects)
2. Why (why the action plan needs to be done)
3. Where (where this action plan will be implemented)
4. When (when the action will be taken)
5. Who (who will carry out the action plan)
6. How (how to do the action plan activity)

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Object

This research object is the production activity at the final check and repair division for cabinets of UP (Upright Piano). This study uses Failure Mode and Effect Analysis (FMEA) and Plan, Do, Check, Action (PDCA) as methods to analyze defect found in the cabinets of UP at PT. Yamaha Indonesia.

3.2 Types of Data

This research uses 2 types of data, as follows:

3.2.1 Primary Data

Primary data is obtained by direct observation of the object to be processed. This research uses primary data which consists of types of defects, cabinets, total defects found, and total packing every day in a month for six months. The questionnaire is also used to determine the RPN number calculated from the value of severity, occurrence, and detection filled out by the experts.

3.2.2 Secondary Data

Secondary data includes information obtained from books, archives, records, reports, and general information about the company where the research was undertaken. This research uses company profiles and literature studies as the secondary data.

3.3 Research Flow

The research flow of this research is as follows:

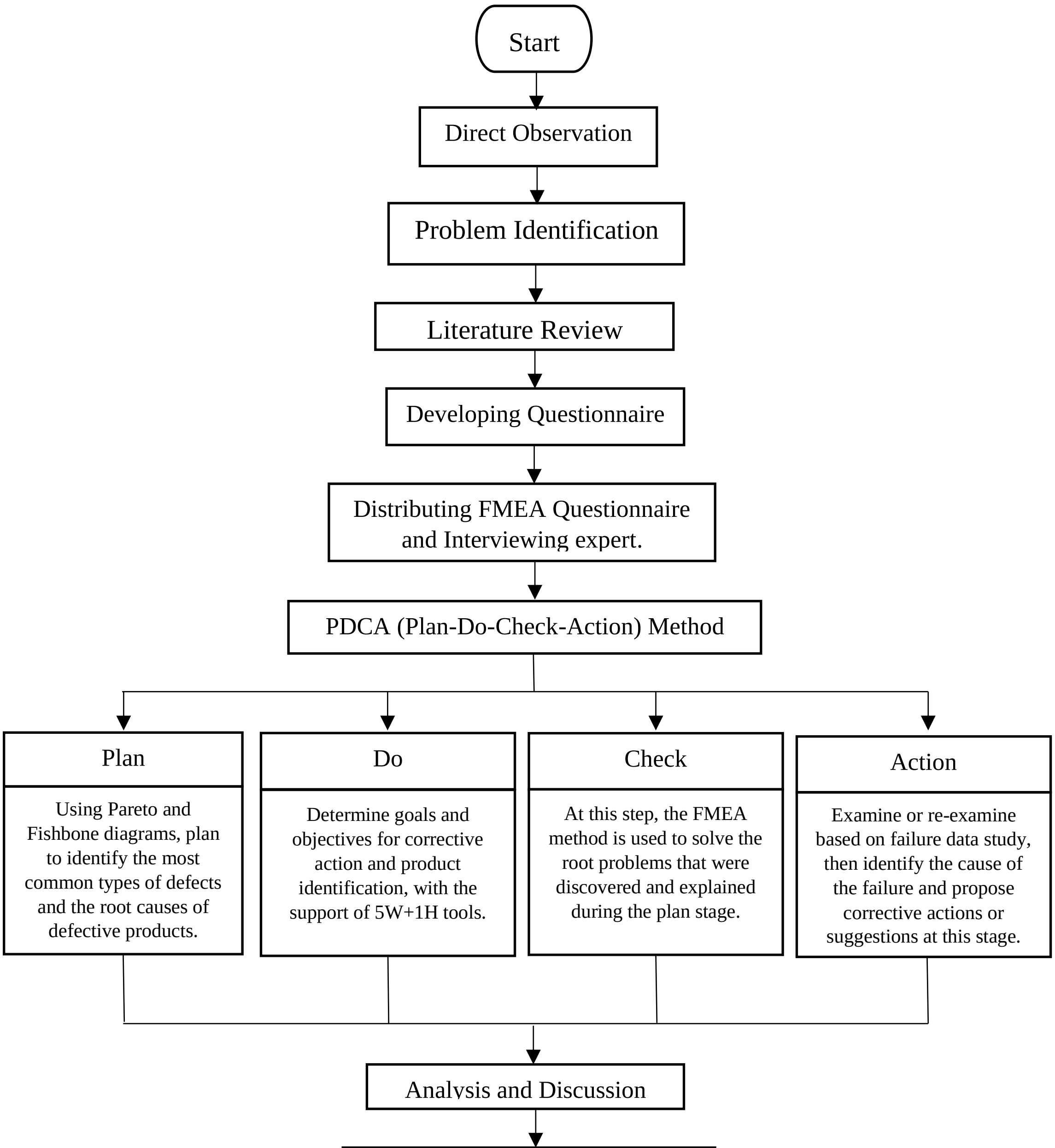

Figure 3. 1 Research Flow

The explanation of the research flow above is as follows:

1. Direct Observation

   Direct observation took place in PT. Yamaha Indonesia, particularly in the final check and repair working group. This step was performed during an internship program batch X held by the cooperation of PT. Yamaha Indonesia and Universitas Islam Indonesia, Department of Industrial Engineering.

2. Problem Identification

   Problem identification is the process of finding issues discovered at the location. In this research, problem identification formulated by the researcher is related to the product defect found in the upper piano which then will be analyzed and discussed. The data obtained includes the amount of defective products, the type of defects, and the type of cabinets.

3. Literature Review

   A literature review is compiled as secondary data as a source related to this research. The literature review is divided into 2, which are, inductive study and deductive study. An inductive study is a review of previous research based on scientific results. Meanwhile, the deductive study explains about theories.

4. Developing Questionnaire

FMEA questionnaire is developed by the researcher which then will be distributed to the expert. The FMEA questionnaire is utilized to identify the severity, occurrence, and detection value of failure modes that occur during the manufacturing process.

5. Distributing FMEA Questionnaire and Interviewing Expert.
   The questionnaire is distributed and filled in by the expert of PT. Yamaha Indonesia. In addition, an interview is also conducted to know the potential failure and cause of failure in the final check and repair.

6. Plan
   The first step in PT. Yamaha Indonesia's improvement strategy is to collect sample data in the form of total production, number of defects, types of defects, and cabinet types. The data was collected from October 2019 up to March 2020. In this Plan stage, a Pareto and fishbone diagram is used to know which cabinet and type of defect will be analyzed and discussed.

7. Do
   The next stage is to carry out and implement proposed improvements to the production process at PT. Yamaha Indonesia after designing improvements to product defects that occur at PT. Yamaha Indonesia. Using the 5W+1H technique (What, Why, Where, When, Who, and How). It attempts to decide what repair items will be carried out based on the data that has been checked, as well as the procedures that will be done to solve the issues that occur, by applying the 5W+1H method.

8. Check
   Following the completion of multiple corrective measures at the Do stage, the next step is to use FMEA analysis to determine whether the corrective actions are working as intended at PT XYZ (Failure Mode and Effect Analysis). The RPN (Risk Priority Number) value is obtained for each problem, and then the RPN value is arranged from largest to smallest. The main source of the difficulties is the cause with the highest RPN value. The RPN value is obtained by multiplying the severity, occurrence, and detection numbers for each problem cause.

9. Action

   The next stage is to preserve the quality control results that have been obtained in order to prevent the same problem from recurring and to further reduce the number of product defects in succeeding manufacturing operations by establishing company standards after making suggestions for improvements.

10. Analysis and Discussion

    The data that has been collected will be analyzed through the PDCA concept. The result of the pareto diagram, fishbone diagram, 5W+1H, and RPN (Risk Priority Number) will be used for further mitigation to be discussed in the next chapter.

11. Conclusion and Recommendation

    The conclusion from the research result and recommendation from the researcher for the company will be discussed in this chapter. The recommendation might be useful for the company's improvement and further research.

CHAPTER IV

DATA COLLECTION AND PROCESSING

4.1 Data Collection

4.1.1 Company Profile

PT. Yamaha Indonesia was founded on June 27, 1974, by a Japanese corporation. This company specializes in the production of piano musical instruments. PT Yamaha Indonesia started making pianos, organs, pianicas, and other musical instruments. In October 1998, PT Yamaha Indonesia began focusing on piano manufacturing on a 15,711 m2 plot of land in East Jakarta's Pulogadung Industrial Estate.

Preparing a workforce with high technology skills and selected basic materials is the most important component of making piano products of the highest quality and beauty. Every workforce, both old and new, goes through a continual review and training procedure in order to develop their abilities. PT YI was awarded the ISO 9001 and ISO 14001 certifications, demonstrating PT YI's commitment to the quality of the best production system in terms of safety and environmental sustainability.

PT. Yamaha's vision is to develop a wide range of products and services that will meet the diverse needs and wishes of Yamaha consumers all over the world, in the form of Yamaha products and services in the domains of acoustics, design, technology, innovation, and customer service. Meanwhile, PT. Yamaha Indonesia has a mission to achieve this vision:

1. Promote and support music education's popularization.

2. Customer-focused operations and management,

3. Product and service perfection;

4. Consistent market development and creation activities,

5. Continuous advancement in Yamaha's research and development, as well as globalization.

6. Maintain good business growth by diversifying your product offerings.

4.1.2 Organization Structure

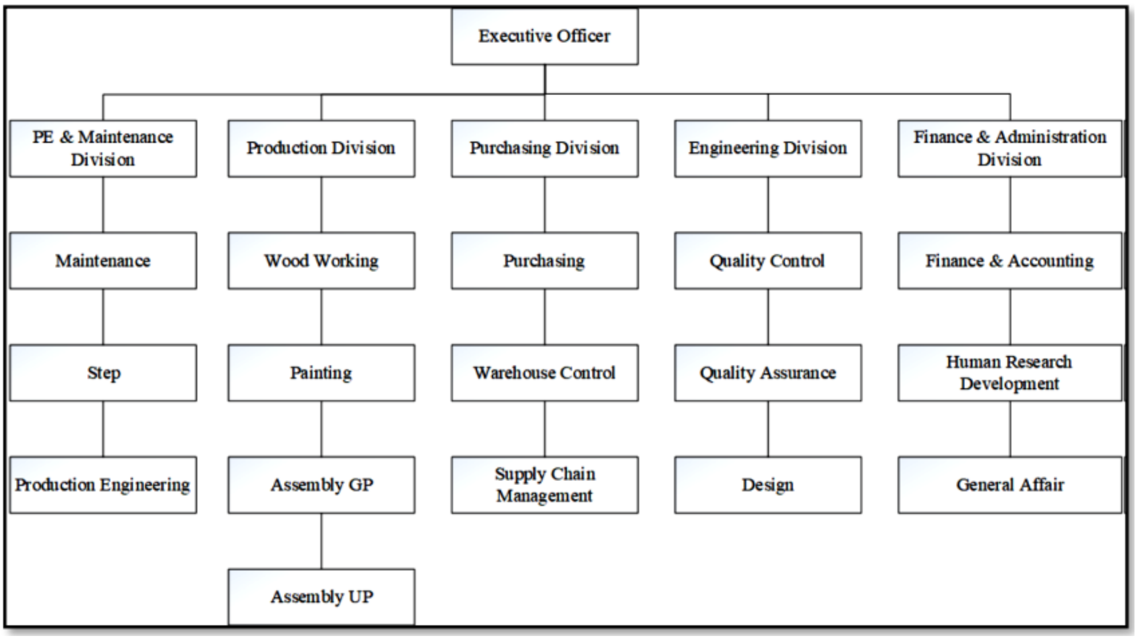

Figure 4. 1 PT Yamaha Indonesia Organization Structure

The organizational structure of PT Yamaha Indonesia is shown in Figure 4.1. As can be seen from the structure, the company has numerous tasks and obligations depending on their roles and authority. The following is an explanation of PT Yamaha Indonesia's organizational structure:

1. Production Engineering and Maintenance Division
   The Production Engineering and Maintenance Division focuses on improvement and continuous improvement (kaizen) (maintenance). Maintenance, STEP (Supporting Team for Engineering Projects), and Production Engineering are the divisions of the PE and Maintenance divisions. Requests for machine upgrades or manufacturing can be sent to this section, which will conduct a review before implementing kaizen. If possible, the request can be made by the company itself, and orders will be placed by third parties (vendors).

2. Production Division
   The Production Division is in charge of the production or fabrication phase of the piano manufacturing process, starting with raw materials and ending with finished goods (Finishing). Woodworking, Painting, Assembly of Upright Piano (UP), and Assembly of Grand Piano make up the production division (GP).

3. Purchasing Division
   The Purchasing Division is in charge of procuring ordered items, including calculating prices, vendors, purchase reports, and corporate expenses (materials, tools, and so on), as well as assuring the availability of goods/materials through control stock audits. SCM, Purchasing, and Warehouse are all handled by the purchasing division.

4. Engineering Division
   The Engineering Division is in charge of design and is accountable for the company's final check issues. Quality Control (QC), Quality Assurance (QA), and Design are the categories that fall under Engineering.

5. Finance & Administration Division

The Finance and Administration Division is in charge of the company's financial issues, including income, expenses, and other financial matters. Finance and Accounting, Human Resource Development, and General Affairs are the divisions that fall under Finance and Administration. Finance and Accounting differ in that Finance has control over financial flows such as money entrance and receipt (the money holder), whereas Accounting is in charge of checking, recording, and reporting incoming and outgoing financial concerns.

4.1.3 Company’s Product

Upright Pianos (UP) and Grand Pianos (GP) are the two varieties of pianos made by PT Yamaha Indonesia (GP). There are around 15 models of upright pianos (UP), and approximately 14 versions of grand pianos (GP). Because of their distinct forms, the two varieties of pianos have different grooves in the process flow. In addition to finished pianos, PT Yamaha Indonesia also manufactures parts that are shipped to a number of nations. This company's pianos come in four different color options, including the following: PW (Polished Walnut) is a somewhat reddish brown color with a wood pattern, followed by PWH (Polished White), PE (Polished Ebony), a black piano, and PM (Polished Mahogany), a dark brown color with a wood design. The image below shows the Upright Piano (UP) in four different colors:

Figure 4. 2 Upright Piano Models

Meanwhile, below is an example of a Grand Piano (GP) in polish ebony (PE) color:

Figure 4. 3 Grand Piano Model

4.1.4 Types of Defect

Table 4. 1 Defect Type and Definition

No	Defect Type	Definition
1	Rift	The distance/gap between the top frame and the fallback is too wide.
2	Space NG	The distance/gap between the fall center and the side arm is too wide
3	Deformed	Defects are findings in the cabinet that cause broken, cracks, paint flakes, and dent.
4	Less Down	The distance/gap between the R/L top frame and the sidearm is too wide.
5	Less Backward	The position of the fall front or the front of the fall board is less backward against the key bed.
6	Less Forward	The position of the fall front or the front of the fall board is less forward against the key bed.
7	Too High	Pressing process which susceptible to cause gap between sideboard and sidearm.
8	Dirty Side Post Paint	The color of the sidepost is contaminated by another color.
9	Less Side Post Paint	The color of the sidepost is too pale and or uneven (striped).

Defect data was obtained from October 2019 until March 2020. Cabinet type, defect type, and the amount of defects found are included in this data during these 6 months' observations.

Table 4. 2 Defect Data from Final Check and Repair

No	Cabinet Type	Defect Type									Total
		Rift	Space NG	Deformed	Less Down	Less Backward	Less Forward	Too High	Dirty Side Post Paint	Less Side Post Paint	
1	Side Sleeve	433	0	0	0	0	0	0	0	0	433
2	Hinge Strip	30	35	0	0	0	0	328	0	0	393
3	Key Block	351	0	0	0	0	0	1	0	0	352
4	Top Frame	1589	340	285	1066	4	0	25	0	0	3309
5	Top Board	0	27	757	5	141	65	0	0	0	995
6	Top Center	0	0	0	0	0	0	0	0	0	0
7	Fall Front	13	0	159	0	430	866	178	0	0	1646
8	Fall Center	0	476	600	0	3	2	357	0	0	1438
9	Fall Board	0	18	9	0	12	16	0	0	0	55
10	Fall Back	0	0	144	0	0	0	0	0	0	144
11	Side Board	0	0	237	0	0	0	0	0	0	237
12	Bottom Frame	0	150	122	0	664	1	0	0	0	937
13	Side Arm	0	0	125	0	0	0	0	0	0	125
14	Back Post	0	0	0	0	0	0	0	842	594	1436
Total		2416	1046	2438	1071	1254	950	889	842	594	11500

4.2 Data Processing

4.2.1 Plan Stage

The Plan stage is the first PDCA method. The purpose of this stage is to analyze the main causes that cause problems in the production process. This stage involves the researcher's analysis to find the most common form of defect that was found during the final check and repair process. The Pareto diagram is used to do the analysis. Following the acquisition of defect data, the researcher must establish the most prevalent form of defect and seek prompt improvement. The number of defects found during six months (October 2019-March 2020) is shown in Table 4.3. The Pareto Diagram of defects is shown in Figure 4.4.

Table 4. 3 Defects Percentage

Type of Defect	Number of Defects	Percentage	Cumulative
Deformed	2438	21%	21%
Rift	2416	21%	42%
Less Backward	1254	11%	53%
Less Down	1071	9%	62%
Space NG	1046	9%	72%
Less Forward	950	8%	80%
Too High	889	8%	88%
Dirty Side Post Paint	842	7%	95%
Less Side Post Paint	594	5%	100%
Total	**11500**		

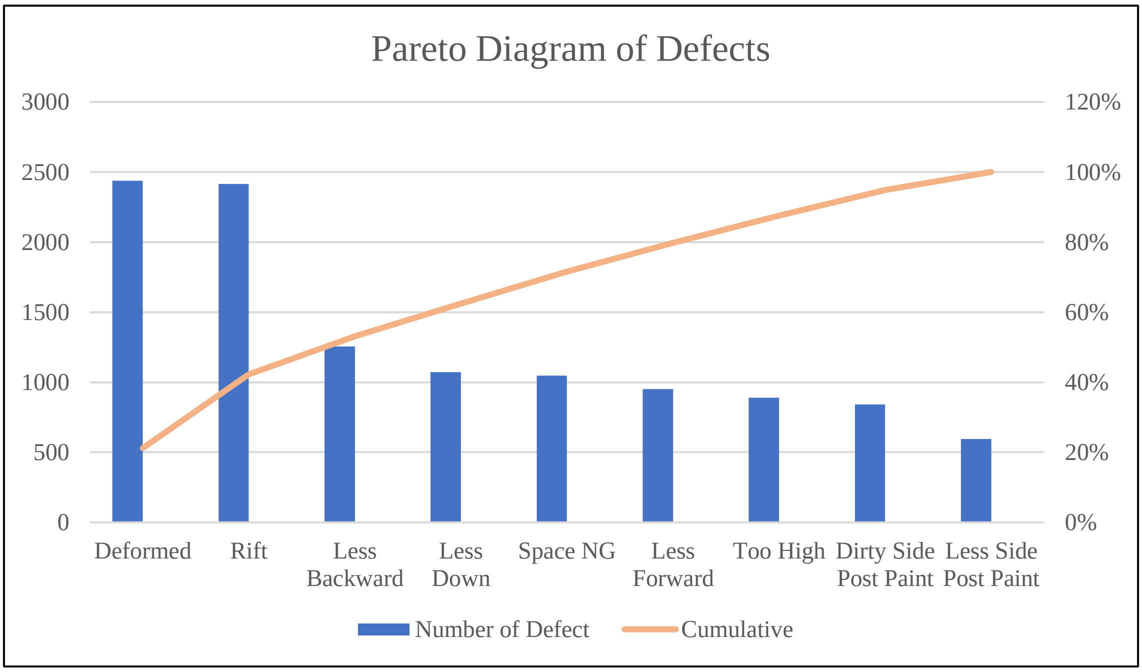

Figure 4. 4 Pareto Diagram of Defect Type

Based on the defect data obtained from the Final Check and Repair department, the Pareto Diagram is used to find the most dominant defect. The result shows that deformed is the defect that needed to be analyzed with a cumulative percentage of 21%. Table 4.4 and 4.5 below show the cabinets with the number of defects found, while Figure 4.5 shows the Pareto Diagram.

Table 4. 4 Data Defect on Each Cabinet

No	Cabinet	Month						**Total**
		Oct	Nov	Dec	Jan	Feb	March	
1	Side Sleeve	68	78	153	133	0	1	**433**
2	Hinge Strip	68	74	72	74	63	42	**393**
3	Key Block	82	70	40	66	40	54	**352**
4	Top Frame	524	660	675	420	556	474	**3309**
5	Top Board	222	203	166	160	139	105	**995**
6	Top Center	0	0	0	0	0	0	**0**
7	Fall Front	526	296	209	180	246	189	**1646**
8	Fall Center	341	322	247	232	163	133	**1438**
9	Fall Board	2	0	4	3	15	31	**55**
10	Fall Back	43	28	31	22	15	5	**144**
11	Side Board	44	43	37	28	39	46	**237**
12	Bottom Frame	284	368	161	57	38	29	**937**
13	Side Arm	22	29	25	19	16	14	**125**
14	Back Post	365	306	262	188	202	113	**1436**
Total		**2591**	**2477**	**2082**	**1582**	**1532**	**1236**	**11500**

Table 4. 5 Defects on Cabinets Percentage

No	Cabinet	Number of Defect	Percentage	Cumulative
1	Top Frame	3309	29%	29%
2	Fall Front	1646	14%	43%
3	Fall Center	1438	13%	56%
4	Back Post	1436	12%	68%
5	Top Board	995	9%	77%
6	Bottom Frame	937	8%	85%
7	Side Sleeve	433	4%	89%
8	Hinge Strip	393	3%	92%
9	Key Block	352	3%	95%
10	Side Board	237	2%	97%
11	Fall Back	144	1%	98%
12	Side Arm	125	1%	100%
13	Fall Board	55	0%	100%
14	Top Center	0	0%	100%
	Total	**11500**		

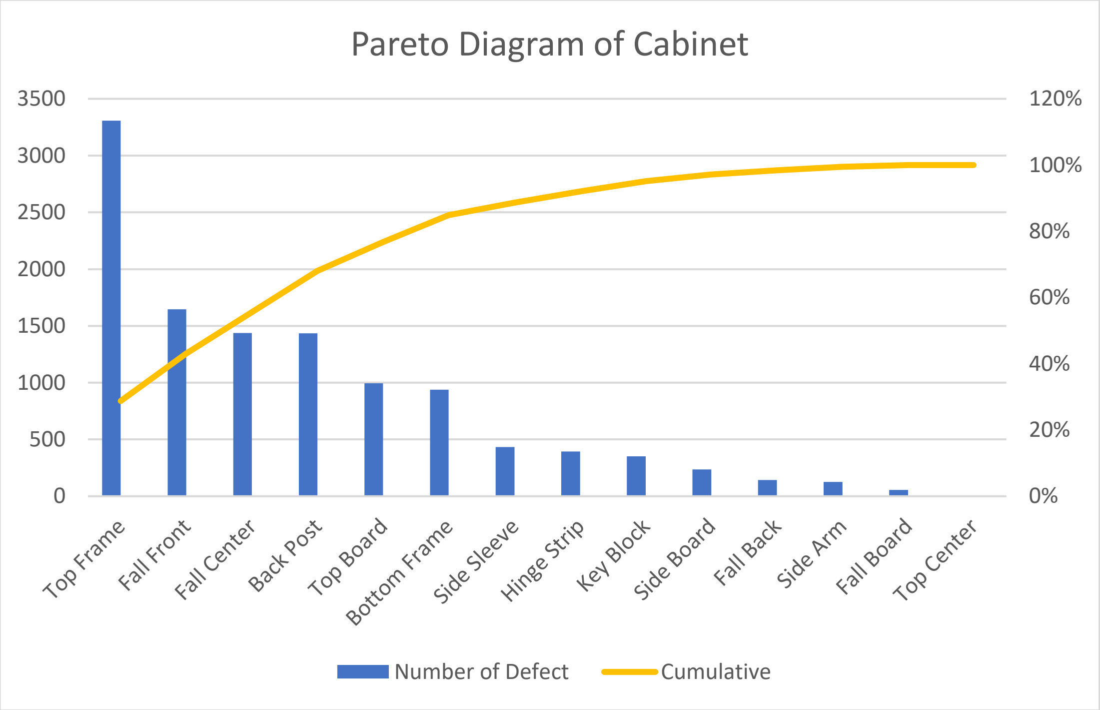

Figure 4. 5 Pareto Diagram of Defect on Each Cabinet

The Pareto Diagram above shows that cabinets with the most defects found are top frames with a cumulative percentage of 29%. The researcher will only focus on the most frequent defect found which is deformation of top frame cabinet. Thus, the top frame cabinet will be analyzed further using the FMEA method in this research.

This stage involves the researcher's analysis in order to determine the causes of defective products. In addition, the Fishbone diagram is used to do the root cause analysis. The researcher determines the root cause of the problem after discovering a defect that must be prioritized. Understanding the source of the problem will help researchers in determining the best course of action for resolving the defect's causes. The Fishbone Diagram, which is based on the 6M factor (method, manpower, measurement, material, mother nature or environment, and machine factor), is the method utilized by researchers in detecting problems. An interview was conducted to construct a fishbone diagram.

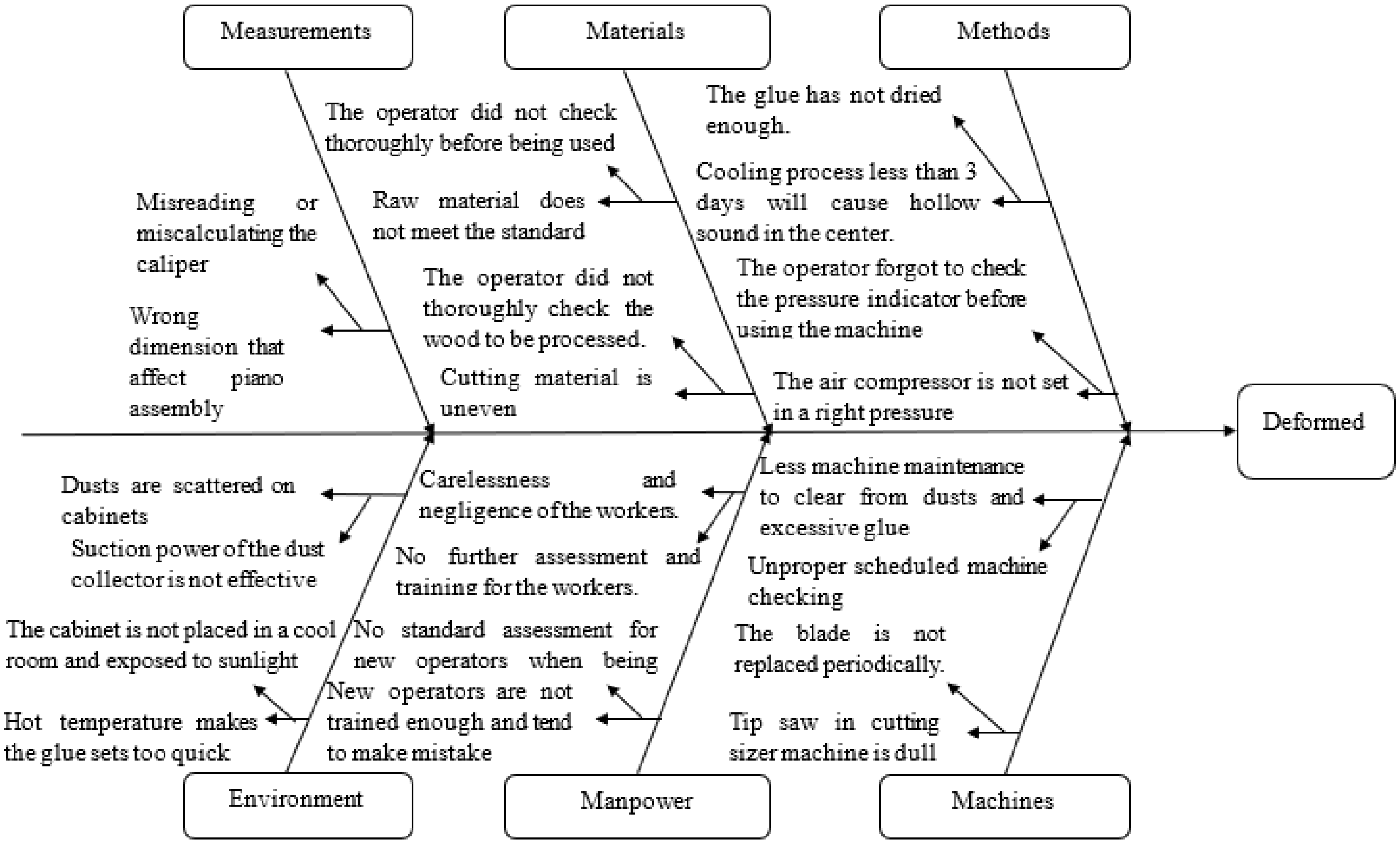

Figure 4.6 Top Frame Cabinet Fishbone Diagram

4.2.2 Do Stage

The second stage in the PDCA method is Do. In this research, 5W + 1H (What, Why, Where, When, Who, How) will be proposed to analyze the previous cause and effect and attempt to make a solution. Below is the table of 5W + 1H used in this research:

Table 4.6 5W + 1H Table Analysis

Factor	What	Why	Where	When	Who	How
1. Methods	The air compressor is not set at the right pressure.	Improper air compressor pressure will cause poor pressing results for the top frame cabinet.	Wood Press Division	Right before turning on the machine or after the morning briefing.	Head and Staff of Wood Press.	Always inspecting the pressure indicator before taking action.
	The cooling process of less than 3 days will cause a hollow sound in the center.	Unset adhesive causes gap or rift in the center	Wood Press Division	Every time store the cabinets into the stack.	Head and Staff of Wood Press.	Record data for the cooling process to be checked by the operator.
2. Materials	Cutting material is uneven or wavy	Misangled cutting material causes defects in the wood-pressing process	Wood Working Division	Each batch of stack being sent	Head and Staff of Wood Working Division	Checking every cutting material before being sent to the next process.
	Raw material does not meet the standard	The unpresentable raw material will lead to an improper cutting process and cause defects.	Inventory Division	1 day after being sent into the warehouse.	Inventory and Wood Working Division	Double-check the raw materials with the vendor before being sent into the warehouse.

Factor	What	Why	Where	When	Who	How
3. Measurements	The wrong dimension that affects piano assembly	Improper assembly of the piano will occur due to misized of the cabinets.	Wood Working Division	After the morning briefing and after the new worker is employed.	Head and Staff of Wood Working Division	Providing a good measuring tool for the worker or conducting proper training.
4. Machines	Less machine maintenance to clear dust and excessive glue	Distracting workers during the working process for unnecessary stuff.	Case Assembly	Daily schedule at the end of working hours.	Head and Staff of Case Assembly Division	Making a schedule or conducting a briefing to keep all machines in clean condition.
	The tip saw in the cutting sizer machine is dull	The cutting process will not be precise which will lead to defects in the cabinet	Wood Working Division	Every two days.	Head and Staff of Wood Working Division	Change the tip saw cutting sizer periodically to maximize the machine's cutting performance.

Factor	What	Why	Where	When	Who	How
5. Manpower	Carelessness and negligence of the workers.	Reducing the occurrence of possible defects and creating a convenient workplace.	All Divisions	Every morning and during working hours.	Human Resource Division.	Making a legitimate SOP and conducting a briefing before working time.
	New operators have insufficient training and making mistakes.	Experienced and motivated workers will minimize mistakes during the working process.	All Divisions	Two weeks of training for new operators.	Human Resource Division.	Conducting sufficient training related to the job description of each worker periodically.

Factor	What	Why	Where	When	Who	How
6. Environment	Dust is scattered on cabinets	Excessive dust disturbs workers and the cutting process of cabinets	Case Assembly	After a break and before the end of working hours.	Head and Staff of Case Assembly Division	Maximize the dust collector utilization and schedule cleaning work environment
	Hot temperature makes the adhesive sets too quick	The pressing result on the top frame will not even and tight enough.	Case Assembly	Every time when store cabinets just being processed with adhesives.	Head and Staff of Case Assembly Division	Storing the cabinets in a cool dry place away from sunlight.

4.2.3 Check Stage

The third step in the PDCA method is the Check stage. The researcher uses FMEA (Failure Mode and Effect Analysis) to identify, weight, and reduce failures for continuous improvement. FMEA analysis uses a table of parameters consisting of severity, occurrence, and detectability. After giving a scale to each parameter, the RPN (Risk Priority Number) will be obtained by multiplying all three parameter numbers. Below is the FMEA table in this research.

Table 4. 7 FMEA Table for Deformed Defect

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Recommended Action	Detection	RPN	Rank
Deformed Defect	The pressure on the air compressor is incorrect.	7	The operator forgot to check the pressure indicator before using the machine	4	Giving a sign on the air compressor for the right pressure to be applied	3	84	4
	Less than three days of cooling will result in a hollow sound in the center.	5	The glue has not dried enough.	3	The date is given on a label that is attached to each cabinet stack	4	60	8
	The material for cutting is uneven.	9	The operator did not thoroughly check the wood to be processed	6	Checking every cutting material before being sent to the next process.	7	378	1

	Raw material does not meet the standard	7	The operator did not check thoroughly before being used	2	Double-checking the raw materials with the vendor before being sent into the warehouse.	4	56	9
	Incorrect dimension that has an impact on piano assembly.	9	Misreading or miscalculating the caliper	2	Employ workers who have been experienced in reading a caliper.	5	90	3
	Less maintenance to remove dust and extra glue from the machine.	4	Unproper scheduled machine checking from dirt	9	Make schedule & ensure to clean the machine and jig before using	2	72	7
	The cutting sizer machine's tip saw is blunt.	7	The blade is not replaced periodically.	3	Change the tip saw every 2 days	2	42	10
	Workers' negligence and carelessness.	5	No further assessment and training for the workers.	5	Emphasize workers to pay attention and focus during work	3	75	6
	Due to their insufficient training, new operators frequently make mistakes.	5	New operators are not trained enough and tend to make mistake	3	New operators are given training for at least two weeks	2	30	11

	The cabinets are covered in dust.	3	Dust is scattered on cabinets	9	Using dust collector	3	81	5
	The cabinet is situated in a sunny area without being in a cool room.	8	Hot temperature makes the glue sets too quick	3	Placing the cabinet on a shelf	5	120	2

4.2.4 Action Stage

In this stage, all aspects of the process have been improved based on the evaluation of the Do and Check phases which identify problems in implementing the plan. This stage is the last stage which aims to control process standardization so that it goes according to the initial purpose. However, the whole process will be repeated again and again on an ongoing basis. After this stage, the PDCA model that has been developed will become the new standard of enterprise processes. Therefore, the researcher proposes a checksheet that can be used as a continuous improvement guidance as follows:

Table 4.8 Check Sheet Recommendation

<table>
<tr><th colspan="5">CHECK SHEET</th></tr>
<tr><th colspan="5">PT. YAMAHA INDONESIA</th></tr>
<tr><td colspan="2">Inspection Date:</td><td>Inspection Time/Shift:</td><td colspan="2">Inspection Site:</td></tr>
<tr><td colspan="5">Notes:</td></tr>
<tr><td>Cabinet</td><td>Types of Defect</td><td>Improvement Action</td><td>Before</td><td>After</td></tr>
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CHAPTER V

DISCUSSION

5.1 Plan Stage

The cabinets, defect types, and number of defects can be seen in this stage. The researcher is using Pareto and fishbone diagrams to analyze most defects found and the root cause.

A. Pareto Diagram Analysis

The Pareto chart aims to determine the main problem that needs to be solved immediately. The data was obtained from October 2019 until March 2020. Based on the Table 4.3 in Chapter 4, the defect data is shown below:

Table 5. 1 Defect Data Percentage

Type of Defect	Number of Defect	Percentage	Cumulative
Deformed	2438	21%	21%
Rift	2416	21%	42%
Less Backward	1254	11%	53%
Less Down	1071	9%	62%
Space NG	1046	9%	72%
Less Forward	950	8%	80%
Too High	889	8%	88%
Dirty Side Post Paint	842	7%	95%
Less Side Post Paint	594	5%	100%
Total	**11500**		

The data for cabinets with defects is also shown below:

Table 5. 2 Cabinet With Defect Percentage

No	Cabinet	Number of Defects	Percentage	Cumulative
1	Top Frame	3309	29%	29%
2	Fall Front	1646	14%	43%
3	Fall Center	1438	13%	56%
4	Back Post	1436	12%	68%
5	Top Board	995	9%	77%
6	Bottom Frame	937	8%	85%
7	Side Sleeve	433	4%	89%
8	Hinge Strip	393	3%	92%
9	Key Block	352	3%	95%
10	Side Board	237	2%	97%
11	Fall Back	144	1%	98%
12	Side Arm	125	1%	100%
13	Fall Board	55	0.5%	100%
14	Top Center	0	0%	100%
	Total	**11500**		

There are 9 defects detected in the process of making the upper piano with the percentage respectively: deformed 21%, rift 21%, less backward 11%, less down 9%, space NG 9%, less forward 8%, too high 8%, dirty side post paint 8%, less side post paint 5%. While there are 14 cabinets with defect percentages respectively as follows: top frame 29%, Fall Front 14%, Fall Center 13%, bak post 12%, top board 9%, bottom frame 8%, side sleeve 4%, hinge strip 3%, key block 3%, sideboard 2%, fall back 1%, side arm 1%, fall board 0.5%, and top center 0%.

B. Fishbone Diagram Analysis

Fishbone diagram (cause and effect) aims to determine the causes caused by the main factors. This diagram has 6 main factors, which are: methods, materials, measurement, machines, manpower, and environment. These factors are also known as 6M which will be shown in the figure below:

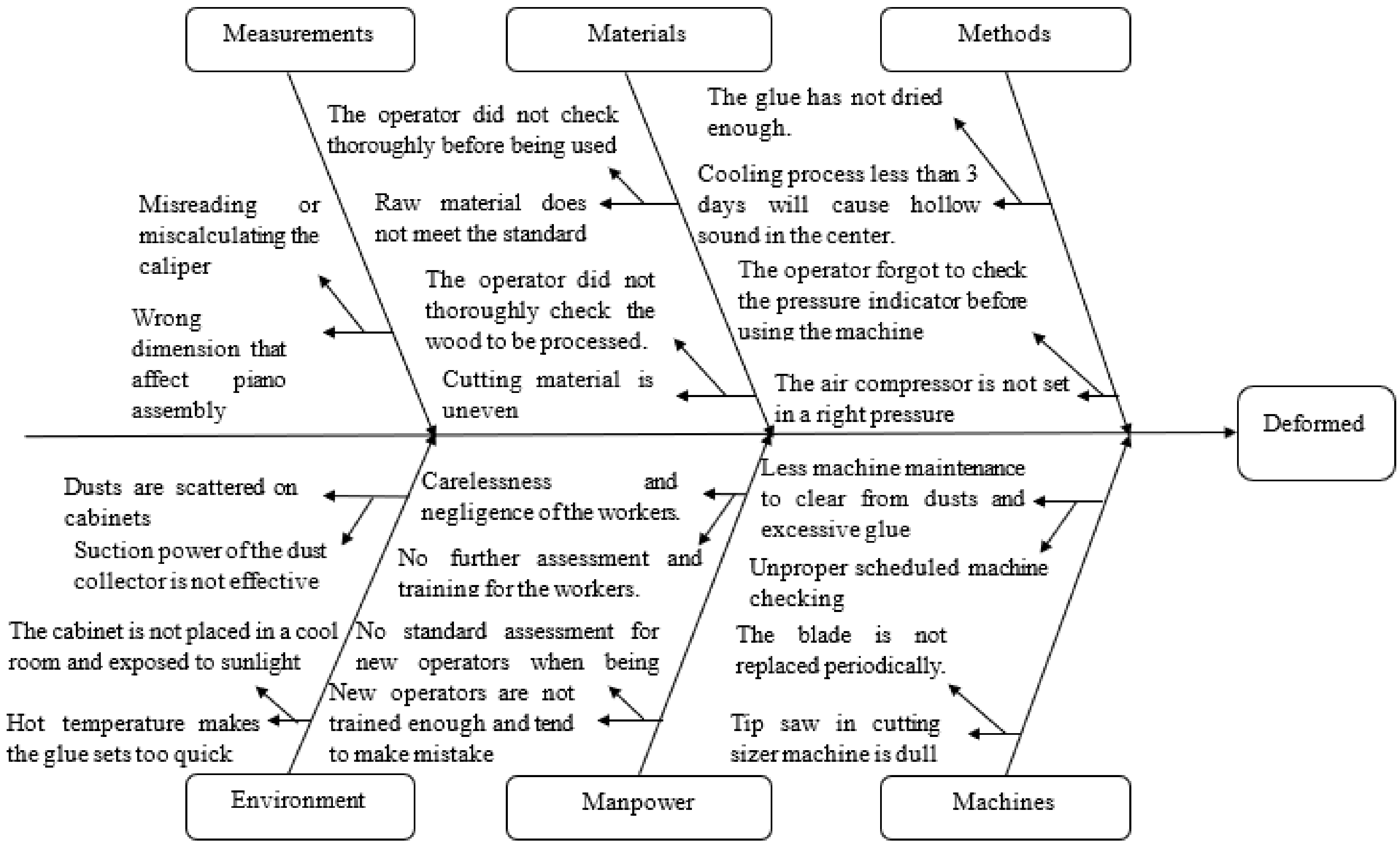

Figure 5. 1 Fishbone Diagram Analysis

After conducting an interview with the staff, the 6 factors causing the defect are explained as follows:

1. Methods

   The method factor is related to the process, procedures, and rules in quality control. The factors related to the method are:

   i. The air compressor is not set at the right pressure. If the pressure is less than standard, the top frame will not form and attach properly.
   ii. The cooling process of less than 3 days will cause a hollow sound in the middle. This is caused by the glue that has not set enough yet.

2. Materials

   This factor is related to the materials being used in order to run the production process. Good materials will most likely have a huge impact directly on the product. The factors found are:

   i. Cutting material is uneven or mishandled. This factor occurred because the tip saw was not centered resulting in a jagged cutting. According to the interviewee, this might happen from the dominant raw material being used that does not meet the standard requirement for material.
   ii. The raw material used in the cutting process sometimes does not meet the standard. This may happen because the operator does not check the material completely before it is processed.

3. Measurements

   Measurement is related to the process of obtaining information from the process to determine the process's quality. It involves physical measurements (pressure, temperature, volume, etc.). The factors found are:

   i. Wrong dimension that affects piano assembly. The workers are using a caliper to measure the dimensions of all cabinets on the piano. It has been figured that one of the mistakes made is misreading or miscalculating the dimension of the cabinet which leads to improper assembly of the piano.

4. Machines

The machine aspect is everything needed to do the operation, including computers, machines, tools, and other tools. Due to technical misalignment, failure to deliver the intended output often occurs. The machine failure factors are:

i. Excessive dust and glue scattered due to less maintenance of the machine. The continuous use of the machine produces a lot of dust and glue attached to the cabinet. According to the interviewee, this might have occurred because of a lack of machine checking periodically.
ii. The tip saw cutting sizer is dull. An overused cutting sizer will cause a blunt to the tip saw. This will lead to an inaccurate cutting for cabinets.

5. Manpower

Manpower involves the operational and functional labor performed by individuals involved in the supply of a good or service. In this case, the failure found is:

i. Carelessness and negligence of the workers cause most defects related to human error.
ii. New operators often make mistakes because they lack sufficient training. A new operator’s skill is mostly not as experienced as an experienced one in using tools or machines. For example, a new operator makes a mistake in mixing glue and hardener. Uneven cabinet surfaces that do not meet the standard will occur if this happens.

6. Environment

Also known as Mother Nature, this aspect is related to anything about the environment, such as temperature, humidity, and noise.

i. Dusts are scattered on cabinets. A lot of tools and machine usage will cause dust to scatter everywhere. It often causes a problem in breathing and seeing for the workers and distracts them. A dust suction used in the workplace does not enough power to clear dust.
ii. The adhesive sets too quickly when the temperature is high. According to the interviewee, the standard time for the adhesive to set is about 30

minutes. If the temperature of the room is too hot, the adhesive will set too fast and make the top frame not tight enough.

5.2 Do Stage

In this stage, the researcher interviewed a staff and used the 5W + 1H method to analyze deeper regarding the fishbone in order to get a better understanding and propose a recommendation for each cause of the defect. The table of 5W + 1H analysis is shown below:

Table 5. 3 5W + 1H Analysis

Factor	What	Why	Where	When	Who	How
1. Methods	The air compressor is not set at the right pressure.	Improper air compressor pressure will cause poor pressing results for the top frame cabinet.	Wood Press Division	Right before turning on the machine or after the morning briefing.	Head and Staff of Wood Press.	Always inspecting the pressure indicator before taking action.
	The cooling process of less than 3 days will cause a hollow sound in the center.	Unset adhesive causes gap or rift in the center	Wood Press Division	Every time store the cabinets into the stack.	Head and Staff of Wood Press.	Record data for the cooling process to be checked by the operator.
2. Materials	Cutting material is uneven or wavy	Misangled cutting material causes defects in the wood-pressing process	Wood Working Division	Each batch of stack being sent	Head and Staff of Wood Working Division	Checking every cutting material before being sent to the next process.
	Raw material does not meet the standard	The unpresentable raw material will lead to an improper cutting process and cause defects.	Inventory Division	1 day after being sent into the warehouse.	Inventory and Wood Working Division	Double-check the raw materials with the vendor before being sent into the warehouse.

Factor	What	Why	Where	When	Who	How
3. Measurements	The wrong dimension that affects piano assembly	Improper assembly of a piano will occur due to misized of the cabinets.	Wood Working Division	After the morning briefing and after the new worker is employed.	Head and Staff of Wood Working Division	Providing a good measuring tool for the worker or conducting proper training.
4. Machines	Less machine maintenance to clear dust and excessive glue	Distracting workers during the working process for unnecessary stuff.	Case Assembly	Daily schedule at the end of working hours.	Head and Staff of Case Assembly Division	Making a schedule or conducting a briefing to keep all machines in clean condition.
	The tip saw in the cutting sizer machine is dull	The cutting process will not be precise which will lead to defects of the cabinet	Wood Working Division	Every two days.	Head and Staff of Wood Working Division	Change the tip saw cutting sizer periodically to maximize the machine's cutting performance.

Factor	What	Why	Where	When	Who	How
5. Manpower	Carelessness and negligence of the workers.	Reducing the occurrence of possible defects and creating a convenient workplace.	All Divisions	Every morning and during working hours.	Human Resource Division.	Making a legitimate SOP and conducting a briefing before working time.
	New operators have insufficient training and making mistakes.	Experienced and motivated workers will minimize mistakes during the working process.	All Divisions	Two weeks of training for new operators.	Human Resource Division.	Conducting sufficient training related to the job description of each worker periodically.

Factor	What	Why	Where	When	Who	How
6. Environment	Dust are scattered on cabinets	Excessive dust disturbs workers and the cutting process of cabinets	Case Assembly	After a break and before the end of working hours.	Head and Staff of Case Assembly Division	Maximize the dust collector utilization and schedule cleaning work environment
	Hot temperature makes the adhesive sets too quick	The pressing result on the top frame will not even and tight enough.	Case Assembly	Every time when store cabinets just being processed withadhesives.	Head and Staff of Case Assembly Division	Storing the cabinets in a cool dry place away from sunlight.

A. Methods

i. The air compressor is not set for the right amount of pressure. This cause of the defect is needed to take action because incorrect air pressure will cause poor pressing results for the cabinet in the next process. This cause of the defect is happening in the Wood Press division at PT Yamaha Indonesia. The recommended action that needs to be done is by always inspecting the pressure indicator before using the machine. The operator of the air compressor often forgot to set the right amount of pressure in which the machine has previously been used for different cabinets with different pressures. This action will be applied by the staff of the wood press division under the guidance of this division leader.

ii. Less than 3 days of cooling process is causing a hollow sound in the center. This sound can be heard because the adhesive is not set yet so it will create a gap in the center. The proposed action is by giving a label containing the date and time of the cooling process and making data of each cabinet so that the worker in the next process will know when to take action. This improvement will be conducted every time the cabinet is stored in a stack. The wood press operators and leader will take charge of this action.

B. Materials

i. The cabinet cutting material is uneven or missing in angle. The uneven cutting material from the previous division will cause a jagged cutting in the wood and direct it to the wrong angle. The recommended action is to check each cabinet material from the previous division before being sent into the next process. For example, each stack containing 10 cabinets will be examined thoroughly to see whether such failure is found. This can be done by inspecting each batch of stack containing cabinets in the working process. The woodworking division will be inspecting this under the supervision of the inventory division.

ii. Raw material does not meet the standard that has been set by the company. Inappropriate raw material that has been sent by the vendor and has been stored in the warehouse is often unchecked by the operators. Therefore, material that does not meet the standard quality is sometimes used and causes unexpected defects. An action that might need to be done is by implementing a double-checking standard with the vendor. For instance, the company sets a high standard and deploys a division particularly to check the quality of the raw material. In the warehouse, operators will check thoroughly the material again after it is sent. This action can be done 1 day after the raw material is stored in the warehouse by the inventory and woodworking division.

C. Measurement

i. Wrong dimension that affects the piano assembly. The urgency of this cause of failure is because the misized cabinet will cause improper assembly of the piano and cause a further defect. The proposed action for this failure is to provide a good measuring tool for the worker and deploy a worker who has been well-trained for this job. Morning briefing before starting work is essential for this case or after employing a new worker. This action will be conducted by the head and staff of the woodworking division.

D. Machines

i. Less machine maintenance to clear from excessive dust and glue. This cause of failure distracts workers during the working process and diverts them to less productive activity. An action that need to be implemented is making a proper schedule or conducting a briefing to keep all machines in clean condition. At the end of working hours may be enough to keep all machines in clean condition for the next day. This improvement will be conducted by case assembly workers.

ii. The tip saw in the cutting sizer machine is dull. The result of cutting will not be precise if the tip saw used in the cutting machine is blunt which will cause a jagged cutting. Changing the tip saw periodically is essential for this case. The tip saw needs to be replaced every 2 days, according to the interviewee. Wood working head and staff will take charge of this action.

E. Manpower

i. Carelessness and negligence of the workers. This cause of failure is very common among workers. An improvement is needed to be done in order to create a productive and convenient working place. The worker’s focus is very important to reduce any possible defect that might occur. The recommended action is to make an SOP (Standard Operating Procedure) and conduct a morning briefing before working to motivate workers and prevent making mistakes. The human resource division will implement this improvement and evaluate it periodically.

ii. New operators do not have sufficient training and tend to make mistakes. New operators need at least 2 weeks of training before taking actual responsibilities in the working workplace. Having proper training and assessment is crucial to employing experienced and motivated new workers. The action that needs to be done might be very common, which is conducting training related to the job description and further assessment periodically. The division responsible for this job is human resources.

F. Environment

i. Dust is scattered on cabinets. The uncovered cabinet will most likely get exposed to dust. The workers might be distracted and had health issues. The recommended action is to maximize the dust collector and schedule workplace cleaning. This action needs to be done by the case assembly division.

ii. Hot temperature makes the adhesive is set too quickly. If this happens, the cabinet will not attach properly and the pressing result will not be tight enough. Placing the cabinet exposed to the sunlight will make this failure happen. Therefore, the improvement that needs to be done is by storing the cabinet in a cool dry place away from the sunlight every time after the cabinet is being processed with adhesives. The case assembly division is taking charge of this action.

5.3 Check Stage

The next stage is the check stage using the FMEA (Failure Mode and Effect Analysis) method to determine which one is the priority for improvement by looking at the largest RPN value on the FMEA table. The FMEA table is shown below:

Table 5. 4 FMEA Table

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Recommended Action	Detection	RPN	Rank
Deformed Defect	The pressure on the air compressor is incorrect.	7	The operator forgot to check the pressure indicator before using the machine	4	Giving a sign on the air compressor for the right pressure to be applied	3	84	4
	Less than three days of cooling will result in a hollow sound in the center.	5	The glue has not dried enough.	3	The date is given on a label that is attached to each cabinet stack	4	60	8
	The material for cutting is uneven.	9	The operator did not thoroughly check the wood to be processed	6	Checking every cutting material before being sent to the next process.	7	378	1
	Raw material does not meet the standard	7	The operator did not check thoroughly before being used	2	Double-check the raw materials with the vendor before being sent into the warehouse.	4	56	9

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Recommended Action	Detection	RPN	Rank
Deformed Defect	Incorrect dimension that has an impact on piano assembly.	9	Misreading or miscalculating the caliper	2	Employ workers who have been experienced in reading a caliper.	5	90	3
	Less maintenance to remove dust and extra glue from the machine.	4	Unproper scheduled machine checking from dirt	9	Make schedule & ensure to clean the machine and jig before using	2	72	7
	The cutting sizer machine's tip saw is blunt.	7	The blade is not replaced periodically.	3	Change the tip saw every 2 days	2	42	10
	Workers' negligence and carelessness.	5	No further assessment and training for the workers.	5	Emphasize workers to pay attention and focus during work	3	75	6

Failure Mode	Potential Failure	Severity	Cause of Failure	Occurrence	Recommended Action	Detection	RPN	Rank
Deformed Defect	Due to their insufficient training, new operators frequently make mistakes.	5	New operators are not trained enough and tend to make mistake	3	New operators are given training for at least two weeks	2	30	11
	The cabinets are covered in dust.	3	Dust is scattered on cabinets	9	Using dust collector	3	81	5
	The cabinet is situated in a sunny area without being in a cool room.	8	Hot temperature makes the glue sets too quick	3	Placing the cabinet on a shelf	5	120	2

Based on the FMEA table shown in Table 5.4, the highest RPN value is 378 which occurs for the material for cutting is uneven. This potential failure has severity of 9, occurrence of 6, and detection of 7. The rest of potential failure with the RPN value respectively are: The cabinet placed in a sunny area (120), incorrect dimension (90), incorrect air pressure (84), cabinet covered in dust (81), worker's negligence and carelessness (75), less maintenance of machine (72), inadequate cooling time (60), raw material does not meet the standard (56), tip saw cutting sizer machine is blunt (42), and insufficient training for new operators (30). Therefore, the most prioritized potential failure that needs to be improved is the uneven material for cutting. A checksheet to control this improvement will be further analyzed.

5.4 Action Stage

This stage is the last stage which aims to control the process so that it goes according to its original purpose. Therefore, several control measures are needed as follows:

1. Making a checksheet to show the progress of the project periodically for continuous improvement.
2. Supervision and improvement of SOP as a reference for operators. The objectives of the Standard Operating Procedure are as follows:
   i. Workers can maintain consistency in carrying out an activity's work procedures.
   ii. Workers can clearly know the roles and positions they have in the company.
   iii. Provide information or clarity about the flow of work processes, responsibilities, and staff involved in the process
3. Increase the frequency of machine checks, especially for machines that often result in defective products. One type of maintenance that can be done is preventive maintenance. Preventive maintenance aims to reduce the occurrence of the possibility of the machine being damaged quickly, and the engine temperature condition is always at a normal level. Also keeping the cutting jig in a good condition is necessary.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The conclusions that can be inferred in this research based on the result and discussion are as follows:

1. Based on the Pareto diagram, the defect that is most likely to happen is deformation and the cabinet that has most of this defect is the top frame.
2. There are 6 aspects that cause this defect, which are: methods, materials, measurement, machines, manpower, and environment. Methods aspect includes incorrect air pressure and insufficient cooling days. Materials aspect includes: cutting material is uneven and raw material does not meet the standard. The measurement aspect is the wrong measurement of the cabinet. The machine's aspect includes: less machine maintenance from dust and glue and the tip saw cutting sizer machine is dull. The manpower aspect includes: carelessness and negligence of the workers and new operators do not have sufficient training. While environmental aspect includes: dust scattered on the cabinet and hot temperature makes the adhesive sets too quick.
3. The improvements that will be offered in this research are as follows: always inspecting the pressure indicator before taking action, recording data for the cooling process to be checked by the operator, checking every cutting material before being sent to the next process, double checking the raw materials with the vendor before being sent into the warehouse, providing a good measuring tool for the worker or conduct a proper training, making a schedule or conducting a briefing to keep all machines in clean condition, change the tip saw cutting sizer periodically to maximize machine's cutting performance, making a legitimate sop and conducting a briefing before working time, conducting a sufficient training related to the job description of each worker periodically, maximize the dust collector utilization and

schedule cleaning work environment, and storing the cabinets in a cool dry place away from sunlight.

6.2 Recommendation

The recommendations that can be obtained from this research are as follows:

1. The workers need to be well-trained and have high discipline. The company will need to conduct training periodically to increase the skills of the workers, continuous assessment, and strict selection and rules. Morning briefing is also important to motivate all workers and direct them according to their job description.
2. Improving and maintaining the condition of machines and the workplace is very important to prevent any possible defect.
3. For further research, it is expected to conduct simulation and evaluation based on the recommended action in this research. By doing so, the mitigation proposal will be more perfect, effective, and efficient.

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