ANALYSIS OF DEFECT REDUCTION OF SOLAR PANEL WATER HEATER PRODUCTION PROCESS BY USING SIX SIGMA APROACH AT PT. WIJAYA KARYA INDUSTRI ENERGI

By:
Widya Yudha Putri
ID No. 004201600042

An Internship report submitted to the Faculty of Engineering President University in partial fulfilment of the requirements of bachelor degree in Engineering Major in Industrial Engineering

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ACADEMIC ADVISOR

RECOMMENDATION LETTER

This internship report is prepared and submitted by **Widya Yudha Putri** in partial fulfillment of the requirements for the degree of Bachelor Degree in the Faculty of Engineering has been reviewed and found to have satisfied the requirements for a report fit to be examined.

Cikarang, November 2019

<u>Ir. Hery Hamdi Azwir, M.T</u>

COMPANY'S SUPERVISOR

RECOMMENDATION LETTER

Widya Yudha Putri has performed and completed an internship in **PT. Wijaya Karya Industri Energi,** in partial fulfillment of the requirements for the degree of Bachelor Degree in the Faculty of Engineering. I therefore recommend this report to be examined.

Bogor, August 2019

Tony Setiadi

INTERNSHIP REPORT IN PT WIJAYA KARYA INDUSTRI ENERGI, BOGOR, INDONESIA

By

Widya Yudha Putri

ID No. 004201600042

Approved by

Ir. Hery Hamdi Azwir M.T.
Academic Advisor

Ir. Andira Taslim, MT.
Internship Coordinator

Ir. Andira Taslim, MT.
Program Head of Industrial Engineering

ABSTRACT

In the current era of globalization, competition between manufacturing companies specifically in the field of energy conversion is getting tougher. Strict competition requires each company to provide the best for its customers. Quality and product safety are the most important aspects that are considered by customers in choosing products. PT. Wijaya Karya Industri Energi is a company that moves rapidly in the field of energy-saving and renewable energy solutions. The company produces water heater and solar battery product. In production process, there are some defect products that can occurs. Assembly aluminum fin with riser pipe contributes the highest percentage of defect item which is 14.08%. This is what underlies the company to make continuous improvements, including those carried out by PT. Wijaya Karya Industri Energi. The method used to solve the problem is DMAIC. This method is chosen to improve the quality performance. The result of research shown that several corrective actions are needed to be taken, those are training the operator, scheduled a regular preventive maintenance, and socialized the SOP. After implementing the corrective actions, results shown that the sigma value of assembly process increased from 2,72 to 3,37.

Keywords: Quality, DMAIC, Six Sigma, Fish Bone, FMEA, Defect.

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Defect Per One Million Opportunity	:	The number of defect's forecast in order to calculate the possibility of defect in million.
Fishbone Diagram	:	Fishbone diagram or cause and effect diagram is a diagram used to identify the possible cause for a problem.
Lower Control Limit	:	Value that indicates the lowest level of quality acceptable for a product or service.
Six Sigma	:	The set of techniques and tools for improves business process that aim reduce defects.
Upper Specification Limit	:	Value that indicates the highest level of quality acceptable for a product or service.
DMAIC	:	Define Measure Analyze Improve and Control (DMAIC) is a method in six sigma, usually used in improvement of process and product.
Defect Per Unit	:	The number of defects in a sample divided by the number of units sampled.
Part per Million	:	Part Per Million is the number of defect in million.

CHAPTER I

INTRODUCTION

1.1. Problem Background

Element of production is a major factor that the company needs to be concerned about. The exact production performance measurement is the main factor of the successful of production process. Important factors that build reputation to an organization are quality, reliability, delivery and price. From those factors, the quality is the most important one. When a company keeps focusing on quality, there will be an escalation on reliability, delivery and price in line with the growth of quality.

PT. Wijaya Karya Industri Energi is a company that moves rapidly in the field of energy-saving and renewable energy solutions. In the current era of globalization which is increasingly competitive, competition between manufacturing companies, especially in the field of energy conversion is getting tougher. The tight competition requires each company to provide the best for its consumers. Quality, and product safety is one of the guarantees that must be given and fulfilled by the company to customers and also one of the important criteria that is considered by customers in choosing products.

A product that is running, does not always produce a perfect product (good unit). It is also likely to produce a damaged or defective product. This is what underlies the company to make continuous improvement efforts, including those carried out by PT. Wijaya Karya Industri Energi. The high number of defect in WIKA Solar WH during 4 months from May 2019 to August 2019 affects production from running well. Currently, Assembly aluminum fin with riser pipe process has been the number one contributors (14.08%) in making defect products. Since the number of defect keeps increasing, the number of scrap is increasing as well which resulted to the big loss of cost. This becomes one of company’s concern.

1.2. Problem Statement

The background of the problem leads into the statements below:

- What are the causes of defect in the whole production process of Solar Panel Water Heater?
- What are the improvements that can be implemented to reduce the number of defects of Solar Panel Water Heater?

1.3. Objectives

The main objectives of this report are:

- To determine the causes of defect in the whole production process of Solar Panel Water Heater.
- To create the improvements that can be used to reduce the number of defects of Solar Panel Water Heater.

1.4. Scope

Due to limited time and resources in doing this research, there will be some scope in the final project:

- The project is done in May 13th, 2019 – August 20th, 2019 in PT. Wijaya Karya Industri Energi.
- The main focus will be on the defect that contributes the most.

1.5. Assumption

Some assumptions that have to be made in order to run the improvement project properly are:

- The material used to produce the product does not change.

1.6. Research Outline

Chapter I **Introduction**

This chapter consists of the background of final project, problem identification, objective, scope and assumption of the research.

Chapter II **Literature Study**

This chapter delivers the previous study about quality and root cause analysis and other tools which support this project.

Chapter III **Research Methodology**

The flow of this final project is explained in this chapter.

Chapter IV **Company Profile and Project**

This chapter will give description of the company where the interns worked and the improvement project that the interns dealt.

Chapter V **Data Analysis**

The data observation is processed and analyzed in this chapter. This chapter consists of all the data gathered from observation. The researcher will explain more detailed analysis to support finding a solution.

Chapter VI **Conclusion and Recommendation**

This chapter will give the conclusion result of this final report, and also recommendation for future research.

CHAPTER II

LITERATURE STUDY

2.1. Quality

The definition of quality will be different for everyone and depends on the context. Quality is generally measured by the level of customer or customer satisfaction. How much satisfaction the customer gets depends on the level of suitability of the use of each customer. Thus, the definition of quality includes activities related to the achievement of user satisfaction of the item (Juran and Godfrey 1999)

The concept of quality itself is often regarded as a measure of the relative goodness of a product or service consisting of the quality of the design or design and the quality of suitability or compatibility. The quality of the design is a function of product specifications, while the quality of compatibility is how well the product is in accordance with the specifications and concessions implied by the design. There are many definitions of quality conveyed by experts, here is an understanding of quality in the opinion of experts:

- (Juran and Godfrey 1999) "quality is conformity with the purpose or benefits."
- (Crosby 1979) "quality is conformity with needs that include availability, delivery, reliability, maintainability, and cost effectiveness."
- (Deming, W.E. 1982) "Quality must aim at meeting customer needs now and in the future."
- (Feigenbaum, A.V. 1991) "quality is the overall characteristics of products and services that include marketing, engineering, manufacturing, and maintenance, in which products and services in its use will be in accordance with customer needs and expectations."
- (Scherkenbach 1991) "quality is determined by the customer; customers want products and services that meet their needs and expectations at a certain price level that shows the value of the product. "

2.2. Defect

A defect is any abnormal or abusive condition created by the crew. The American Society for Quality defines defect as a product's or service's nonfulfillment of an intended requirement or reasonable expectation for use, including safety considerations. There are four classes of defects: class 1, very serious, leads directly to severe injury or catastrophic economic loss; class 2, serious, leads directly to significant injury or significant economic loss; class 3, major, is related to major problems with respect to intended normal or reasonably foreseeable use; and class 4, minor, is related to minor problems with respect to intended normal or reasonably foreseeable use. Defective is a unit of product that contains one or more defects with respect to the quality characteristic(s) under consideration. Zero defect is an ideal condition that is desired by both producers and costumers. For manufacturing company, zero defects could suppress wastes

2.3. Six Sigma

Six Sigma is a disciplined, statistical-based, data-driven approach and continuous improvement methodology for eliminating defects in a product, process or service. Six Sigma as a disciplined and statistically based approach for improving product and process quality. On the other hand, six sigma is a management strategy that requires a culture change in the organization (Ismyrlis, V and Moschidis, O 2018).

Therefore, six sigma can be used as a target measurement of process industry about how well the product transaction process going between supplier and customer. The higher the sigma values achieved, the better the performance of industrial processes. Table 2.1 shows the sigma value that is measured based on the percentage of COPQ (Cost of Poor Quality) to sales value.

Table 2.1 Sigma Value

COPQ (Cost of Poor Quality)		
Sigma Value	**DPMO**	**COPQ as a Percentage of Sales Value**
1-sigma	691462 (very uncompetitive)	Cannot be calculated

COPQ (Cost of Poor Quality)		
Sigma Value	**DPMO**	**COPQ as a Percentage of Sales Value**
2-sigma	308,538 (average Indonesia's industries)	Cannot be calculated
3-sigma	66,807	25-40% from sales
4-sigma	6210 (average USA's industries)	15-25% from sales
5-sigma	233 (average Japan's industries)	5-15% from sales
6-sigma	3.4 (world class industries)	< 1% from sales

2.4. DMAIC Methodology

Six sigma as a set of methodologies and techniques used to improve quality and reduce cost utilizing a structured and disciplined methodology for solving business problems. A popular framework for implementing six sigma is DMAIC process. DMAIC, define, measure, analyze, improve and control, is a key process of standard framework for a six sigma project.

Figure 2.1 Framework of DMAIC

As can be seen on the figure 2.1, DMAIC consists of five main steps, which are:

1. **Define**: formally defines the target of process improvement consistent with the customer's demand or needs and company strategy. At this stage the proportion of defect that became the most significant cause of the damage as a source of production failure is determined by doing steps follows:
   A. Defining quality standard issues in producing a product that has been determined by company.
   B. Define action plan that should be done based on the results of observation and analysis of research.

C. Setting objectives of Six Sigma quality improvement based on observations.

2. **Measure**: measure the performance of the process at the present time to be compared with the target set. Do process mapping and collect data related to key performance indicators.
3. **Analyze**: analyze the causal relationships of various factors studied to determine the dominant factors that need to be controlled.

   A. Pareto Diagram

   Product will be analyzed by using a pareto diagram to be sorted based on the largest proportion of damage to the smallest. This pareto diagram will help to focus on more frequent product damage issues, which suggests which issues when handled will provide substantial benefits.

   B. Cause-effect diagram:

   The cause and effect diagram is used as a technical manual of the operational functions of the production process to maximize the success values of the quality of a company's products at a time when minimizing the risks of failure
4. **Improve**: optimizen the process using analyses such as Design of Experiment (DOE) to know and control the optimum conditions.
5. **Control:** controls the process continuously to improve process capability toward Six Sigma target.

2.5. Kaizen

Kaizen is related with quality management. Quality management is a way to have a continuous performance improvement in each operation level or process, in each functional area from an organiation, by using human resources and capital available (Gasperz 2001). Therefore, it can be stated that quality management is not only focusing on product but to the whole aspect in company that can be utilized. Kaizen is one of lean tools. Kaizen blits is an intensive and quick improvement process where team or department work hand by hand on a short term improvement project and not following traditional kaizen application which usually done half time (Evans and Lindsay 2007).

Improvement on kaizen is classified as small and continuous improvement. Process kaizen able to carry out the dramatical result follows the time. Kaizen implies because it does not cost high, ensures the continuous improvement for a long term (Imai 1986). There are three advantages of implementing kaizen compare to other methods, which are:

1. Time: time allocated for kaizen is scheduled. By having a schedule, participants of kaizen will be much more proactive on making improvements.
2. Workteam: during kaizen, participants would realize the comfortable of working in team that leads to the change of propensity to work alone.
3. As a proven: by looking to the kaizen result, people would understand that they need to control their working areas more than what they thought.

CHAPTER III

RESEARCH METHODOLOGY

This chapter contains the procedure and the phase of the entire process in completing the research. The flow process in this chapter will become a guidance to do the research so the objectives of this research are reached. Figure 3.1 shows the theoretical framework of the study.

Initial Observation	• Participate in project team of QSHE • Observe the whole production process • Identify the area that needs to be improved
Problem Identification	• Identify the current problem • Determine the objectives, scope & assumption • Performing direct observation & interview
Literature Study	• Quality & Defect • DMAIC • Kaizen
Data Collection	• General Process Mapping • Collect the number of defect items of all products • Collect the in process data of the highest defective product.
Data Analysis	• Define • Measure • Analyze • Improve • Control
Conclusion and Recommendation	• Conclusion of the problem & analysis • Recommendation for company and further research

Figure 3.1 Theoretical Framework

3.1. Initial Observation

The research first step is doing the initial observation. The research begins by participating the team project of Quality Health Safety and Environment Department (QHSE) in PT. WIKA Industri Energi (WINNER). By participating in the team project of QHSE, several activities that was conducted can be observed. The observed activities are the abnormalities or error that happened during the production process which will cause the defect items on panel.

3.2. Problem Identification

From the initial observation, the problem identification can be conducted. As the name implies, this step focuses in finding the problem to be tackled. In PT. WIKA Industri Energi, there are several defects occurs at panel production. This step also contains several sub-phases which are problem background, determining the problem statement, determining the research's objective, determining the research's scope and determining the research's assumption.

3.3. Literature Study

The literature study of the researh taken from journals and books. The literature study used as the resource to review the materials relevant with the study and as the supporting theories for the research. Theories can be used as a guidance during observation. Literature study give the essence of theoritical concept and knowledge for conducting this research. The important and necessary references are found to support the study and provide background knowledge on method and principles used in the study. Previous studies on the subject that may have any relation with the research are also gathered.

3.4. Data Collection

The data collected for the research take from the observation done in PT. WIKA Industri Energi for four months to analyze the problem related with quality performance. WIKA Solar WH has highest defect trend during observation time.

Assembly aluminum fin with riser pipe chosen as the cause of most defects being observed and analyzed so that improvement affected the quality performance can be made. The data collected are:

• General Mapping Process

• Defect data of WIKA Solar WH.

• Data result in process of absorber.

3.5. Data Analysis

After collecting the data, there will be an analysis to give the explanation what are the result of the calculating and what is the next step when the result is appropriate with the expectations. For doing the improvement also based on the result of analysis. DMAIC Method will be used when doing analysis until improvement of actual condition.

- **Define**: In this stage, the problem statement of the research is determined. This stage not using much statistical data and calculation. The defect data during May 2019 to August 2019 is shown. The data is calculated to identify which kind of defect that contributes more by using pareto diagram then the SIPOC diagram can be made. Those tools are used to identify the problem and specify the priority of problem.
- **Measure**: this stage is a stage of reformulating the problem and initiating a search for root causes with the stages of planning and retrieving data and calculating the current performance and identifying opportunities for improvement. Tools used in this stage are Minitab Data Analysis and calculation of sigma value.
- **Analyze**: this stage is a stage of searching and determining the root causes of problem by using pareto diagram that prioritize the problem which needs to be solved. Cause & effect diagram used to organize the information regarding the causes of problem that got from brainstorming and check the potential process failure and evaluate the priority of risk by using Failure Modes and Effect Analysis (FMEA).

- **Improve**: after root causes of problem have been identified, improvement needs to be taken by specifying the solution for the issues by using Action Planning for Failure Modes table for each failure mode based on priority rank.
- **Control**: this stage is a phase of controling the process performance to prevent the repetition of the same problem.

3.7. Conclusion and Recommendation

The final step of the research is to draw the conclusion from the data calculation and analysis result obtained to achieve the research's objectives. The recommendation from this research will be provided after the conclusion is presenting. The recommendation can be used by those who would like to conduct a research with similar topic in purpose to the betternment of the research in the future.

CHAPTER IV

COMPANY PROFILE AND PROJECT

4.1. Company Profile

Figure 4.1 PT. Wijaya Karya Industri Energi's Logo

With the company's spirit of "Spirit of Excellence" Idea, Creation and Innovation, WIKA Industri Energi moves rapidly in the field of energy-saving and renewable energy solutions. Like the sun that continues to emit bright light to the corners of the universe, all of this provides energy and enthusiasm to continue to advance and develop rapidly. The development of the Indonesian nation in all fields requires the fulfillment of electricity in every line. The energy fulfillment sector is the main thing to spur development in various sectors. But on the other hand the fulfillment of energy sourced from fossil fuels will be increasingly expensive and scarce.

The solar renewable energy industry continues to grow very rapidly in Indonesia, which consists of thousands of islands that are widespread. Solar energy is the right solution in fulfilling energy for development that is spread evenly across Indonesia. For this reason we are fully committed to innovating developing products based on energy savings and renewable energy.

WIKA Industri Energi innovates to develop various products based on solar energy and energy saving such as Solar Water Heater, Aircon Water Heater, Heat Pump Water Heater, Electric Water Heater, Solar Pool Heating and also various products based on Solar Panels such as Solar Home System, Solar Pumping System, Solar Street Light System, Solar Centralized Hybrid System, Solar Module / Panel and so on.

4.2. History of PT. Wijaya Karya Industri Energi

The impact of the energy & petroleum crisis in the 1980s which has been supported by top management of PT WIJAYA KARYA (WIKA) decided to move to the industry of energy-efficient products and utilizing renewable energy to support government programs to use and support fossil energy (oil and gas) which are increasingly scarce and increasingly expensive. It was agreed at that time that products that use renewable energy and are environmentally friendly will later become excellent needs and business in the future.

Discussing in 1987, the technical experts who were members of WIKA in the Industrial Equipment Division (DPI) worked with several technical experts from ITB and BPPT to successfully develop the concept and design of Solar Water Heater (PATS) / Solar Water Heater (SWH) products. in Indonesia, which is oriented to meeting the hot water needs of the household segment. Furthermore, this product was introduced and marketed to the public in 1988 under the WIKA SWH brand. The application of WIKA SWH for large capacity industrial segments has also been started since 1992.

WIKA Group's innovative work in producing energy-efficient products continues to roll, and in 1992 WIKA Aircon Water Heater (WIKA AWH) was launched, which is an energy-using water heater from an AC pump which uses its waste heat energy. . Two in One, AC will produce cold air for the room and at the same time heat the air without adding energy costs to household use. The WIKA AWH application for large capacity industrial segments has been started since 2003.

In the 1993 era WIKA Group developed its work in producing products that use renewable energy using WIKA Photovoltaic (WIKA PV) products, namely the technology of application of solar panels that utilize solar energy to be converted into electrical energy as home lighting power supplies, street lighting, pumps and other electrical equipment applications. In 1995, with the existence of WIKA PV products, PT. Wijaya Karya participated in the RNS project, which is a foreign assistance project that promotes electricity licensing and examiners nationally.

The achievements that have been achieved by WIKA's products based on renewable energy sources, energy saving and environmentally friendly, include:

1. General (All product)
    - 2010 - System Management Integration ISO 9001: 2008, ISO 14001: 2004, OHSAS 18001: 2007
    - 2011 - WIKA was awarded the "TOP BRAND 2011" product for the Water Heater category by the Marketing and Frontier Marketing Consulting Magazine
    - 2012 - WIKA was again awarded as the "2012 TOP BRAND" product for the Water Heater category by the Marketing and Frontier Marketing Consulting Magazine
    - 2017 - Integration of System Management ISO 9001: 2015, ISO 14001: 2015 & OHSAS 18001: 2007
    - 2017 - WIKA was awarded as the "2017 TOP BRAND" product for the Water Heater category by the Marketing and Frontier Marketing Consulting Magazine

2. WIKA Solar Water Heater (WIKA SWH)
    - 1997 - First export to Cyprus.
    - 2000 - Currently a Market Leader in the solar power water heating industry with 38.6% national market share.
    - 2005 - Scoping Export to Vietnam & United Arab Emirates (UAE)
    - 1988 until 2012 - It has been sold > 70,000 units and installed in 34 provinces in Indonesia and several export destinations.
    - 2011 - Investment Manufacturing Facilities Enamel Tank capacity of 30,000 tanks per year.

3. WIKA Aircon Water Heater (WIKA AWH)

- 1992 - Pioneer Aircon Water Heater products in Indonesia and the ASEAN region.
- 1992 - Currently the Market Leader in the water heater industry utilizes AC exhaust heat with market share (market share) of 46.6% nationally1992 - 2010> 20,000 units have been sold and installed in 18 provinces in Indonesia.

4. WIKA Photo Voltaic (WIKA PV)
    - 1993 - One of the pioneers in the application of Photo Voltaic products in Indonesia.
    - 1995 until 1997 - Incorporated in the RNS, the Government's first foreign aid project for Photovoltaic (Solar Home System) applications aimed at speeding up the spread and electricity extraction nationally.
    - 2003 - Currently active in Government projects within the Ministry of Energy of Human Resources (ESDM), Ministry of Development of Disadvantaged Villages (PDT), Ministry of Transmigration, Ministry of Home Affairs, BUMN, and Private CSR projects.
    - 2009 - Currently the development competence of a centralized and hybrid solar power plant (PLTS) system with various projects within the PLN that are spread across Indonesia.
    - 2011 - Present Construction of a photovoltaic module laminate line to enhance the TKDN value of solar panels.

4.3. Vision, Mission and Values of PT. Wijaya Karya Industri Energi

PT. WIKA Industri Energi has a vision & mission that represent the class of international class company. Thus, the Vision, Mission and Objectives of PT. WIKA Industri Energi are as follows

a. Vision

   "Becoming the Leading Company in Asean and Regional Indonesia in the Field of Renewable Energy through Energy Conversion and Conservation.”

b. Mission

- Full Range of Water Heater and Photovoltaic Products Through Quality and Competitive Products
- Has Productive Sales Network throughout ASEAN and Regional Indonesia
- Have a strong brand image
- Market Leader in the Water Heater and Photovoltaic Industry in Indonesia
- Building a strategic business for Thermoplastic pipes for Infrastructure and Superstructure needs
- Provider of solar power generation equipment (PLTS)

c. Values

- AGILITY: Passionate, Creativity, Future Oriented, Adaptable, High Mobility, Speed Of Change
- CARING: Care, People Oriented, Healthy, Safety, Trust, Respect, Individual
- EXCELLENT: Reliable, Performed Oriented, Market Driven, Customer Focus, Commitment, Deliver the Result, Faster

4.4. Organizational Chart

The organization chart is a diagram showing graphically the relation of one official to another, or others, of a company. It is also used to show the relation of one department to another, or others, or of one function of an organization to another, or others. This chart is valuable in that it enables one to visualize a complete organization, by means of the picture it presents. Every company has an organization which reflects to the structure of hierarchy in that company. This chart is used to control and monitor how company runs. Another benefit is to set the goals and to give a visual view of the position of the worker or employee. Figure 4.1 shows the organization structure of PT. WIKA Industri Energi.

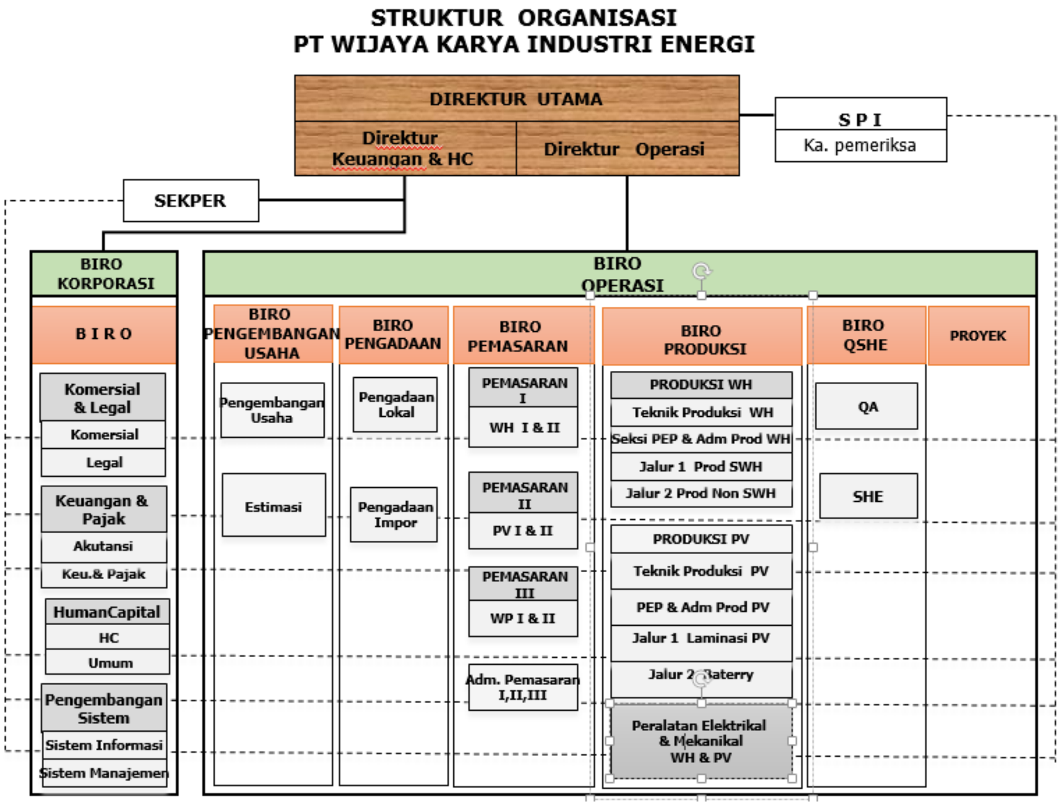

Figure 4.2 Organization Structure of PT. Wijaya Karya Industri Energi

4.5. Product & Services

PT. WIKA Industri Energi is located in Kompleks Industri WIKA, Jl. Raya Narogong No.Km. 26, Kembang Kuning, Kec. Klapanunggal, Bogor, West Java.

Figure 4.3 Kompleks Industri WIKA

PT. WIKA Industri Energi produces several kinds of products. Table 4.1 shows the product that produced in this company.

Table 4.1 List of Product Produced by PT. WIKA Industri Energi

PRODUCT	PICTURE
WIKA SOLAR WH	  

PRODUCT	PICTURE
WIKA AIRCON WH	 
WIKA ELECTRIC WH	

PRODUCT	PICTURE
WIKA HEATPUM WH	
WIKA PV	
SOLAR PV MODULES&COMPONENTS	
SOLAR STREET LIGHTS	

CHAPTER V

DATA COLLECTION AND DATA ANALYSIS

5.1. Overview

This chapter will be discussing about the data processing which covers the data collection, data calculation and analysis or the interpretation of the data. The method used is DMAIC. PT. Wijaya Karya Industri Energi is a company that moves rapidly in the field of energy-saving and renewable energy solutions. The high number of defect in WIKA Solar WH during 4 months from May 2019 to August 2019 affects production from running well. Currently, Assembly aluminum fin with riser pipe process has been the number one contributors in making defect products wihich is 14.08%. Since the number of defect keeps increasing, the number of scrap is increasing as well which resulted to the big loss of cost. This becomes one of company's concern. DMAIC method can be used to increase the process performance. DMAIC is commonly used to see the improvement of progress and control the improvement to be sustained. Therefore, DMAIC will be breakdown and explain furthermore.

5.2. Data Collection

In a study, data is the key to resolving the problems faced and data collection is very influential to get correct and accurate data. In this section, several data are collected in order to find the problem that contributes the highest number of defect item. Defective data for all products produced by the company is obtained based on data from May 2019 to August 2019. The defective data is illustrated in table 5.1 and figure 5.1.

Table 5.1 Defective Data for all Products from May-August 2019

Product	#Defect
WIKA Solar WH	2036
WIKA Aircon WH	760

Product	#Defect
WIKA Electric WH	310
WIKA PV	267
Solar PV Modules & Components	197
WIKA Heatpum WH	184
WIKA Energi Storage Li-ion Battery	106
Solar Street Light & Phone Charger	67

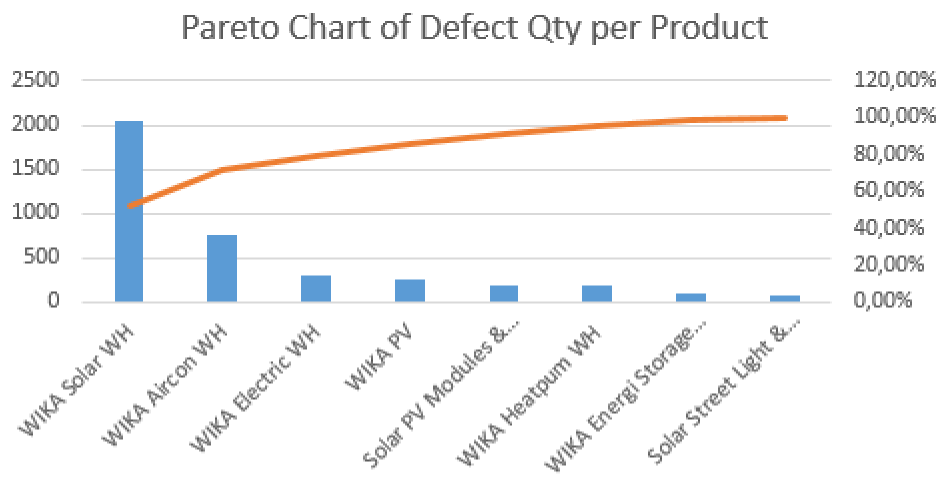

Figure 5.1 Defective Data for all Products from May-August 2019

PT. WIKA Industri Energi has 8 products in total. Table 5.1 and figure 5.1 shows the number of defect of each product from May-August 2019. As shown on the table and the figure above, WIKA Solar WH has the highest percentage of defect with the number of defect of 2036. Thus, the further data collection will be focused on WIKA Solar WH.

WIKA Solar WH consists of 2 major parts which are solar panel and tank. Defective data for each major part produced by the company is obtained based on data from May 2019 to August 2019. The defective data is illustrated in the table 5.2 and figure 5.2.

Table 5.2 Defective Data for each major part of WIKA Solar WH from May-August 2019

Product	Quantity Produced	#Defect	%Defect
Tank	16055	281	1,75%
Solar Panel	17292	635	3,67%

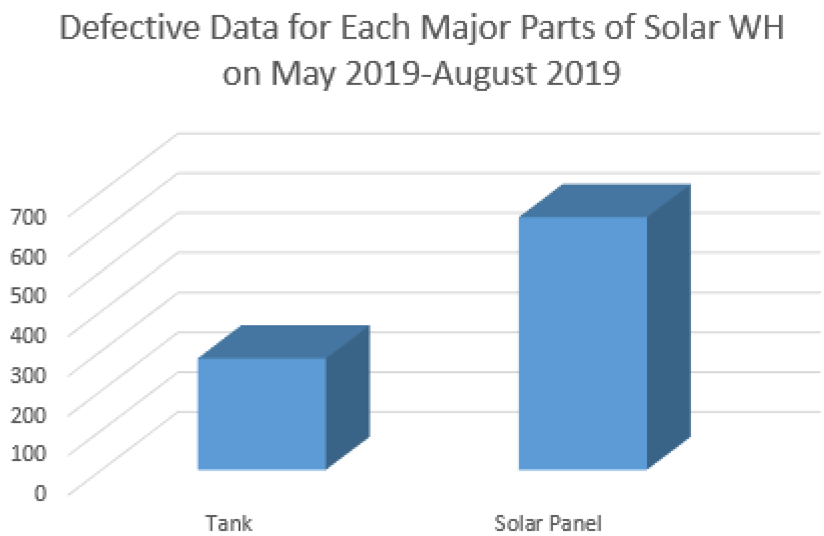

Figure 5.2 Defective Data for each major part of WIKA Solar WH from May-August 2019

Table 5.2 and figure 5.2 shows the defective data for each major part of WIKA Solar WH. Panel has the highest percentage of defect item than tank. Thus, the further data collection will be focused on solar panel.

Panel has 4 major parts which are absorber, frame, insulation, and cover. Defective data for each major part produced by the company is obtained based on data from May 2019 to August 2019. The defective data is illustrated in the table 5.3 and figure 5.3.

Table 5.3 Defective Data for each major part of Panel from May-August 2019

Product	Quantity Produced	#Defect	%Defect
Absorber	10450	679	6,10%
Frame	8970	379	4,05%
Insulation	9855	289	2,85%
Cover	7656	156	2,00%

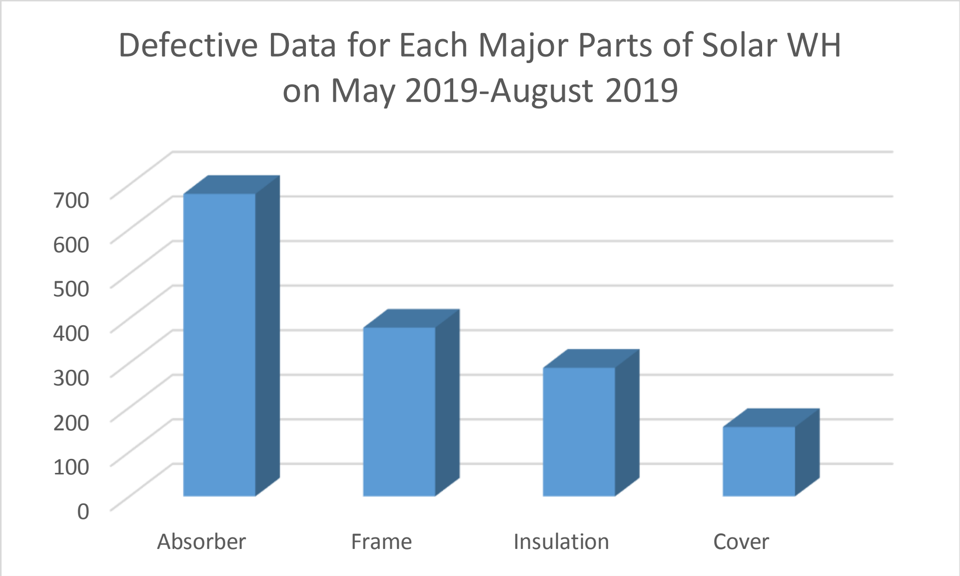

Figure 5.3 Defective Data for each major part of Panel from May-August 2019

Table 5.3 and figure 5.3 show the defective data for each major part of Panel. Absorber has the highest percentage of defect item than the other parts. It means that the company need to concern about the process of making it in order to reduce the number of defects.

5.3. Data Analysis

Based on the statement above, data has to be processed in order to determine highest defect percentage as the focus of this research. In this section, the data that have been collected will be analyzed using DMAIC approach.

5.3.1. Define

The first step to be taken in DMAIC method is Define. The purpose of "define" is to identify the problem that needs to be solved. Based on the data above, absorber has the highest defective percentage which is 6.10%. This number must be reduced in order to maintain the company's competitiveness. To analyze the causes of defects in absorber, it is important to know how to make it.

5.3.1.1. General Process of Absorber Production

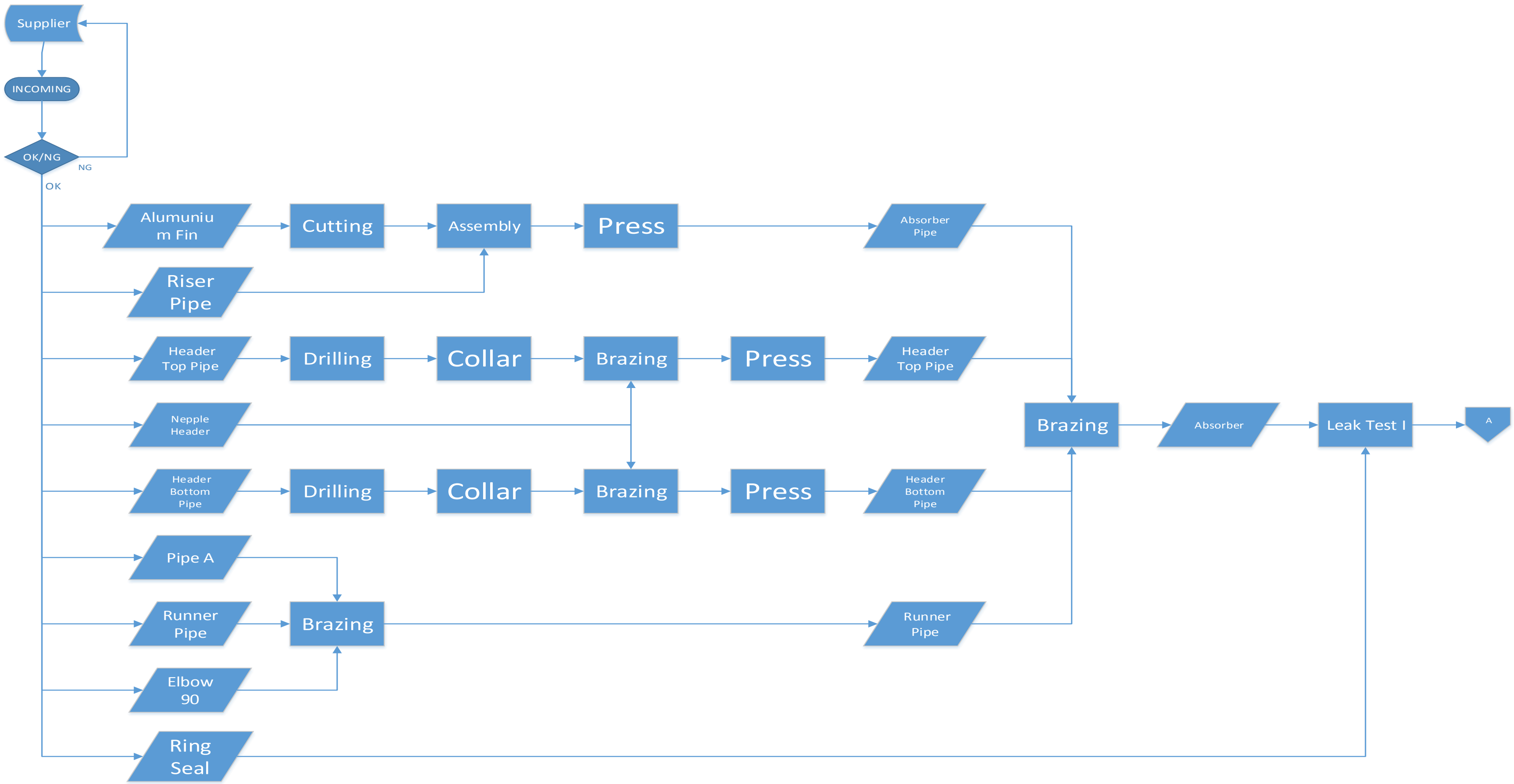

Figure 5.4 General Process of Absorber Production

Absorber is an important part to make a panel. To make an absorber, the company supplies all of the materials from the supplier. The inspection will be conducted in order to know whether the materials are in a good condition (OK) or in a bad condition (NG). If those materials are in a bad condition (NG,) the company will return it back to the supplier. If those materials are OK, those materials will be processed to the next step. As shown on the figure above, those materials are aluminum fin, riser pipe, header pipe, nepple header, pipe A, runner pipe, elbow 90, and ring seal. Each material will be processed and will be assembled as an absorber through the brazing process. After assembly process, the absorber will be tested in leak test. If the absorber passes the test, it will be assembled with other parts to make a panel.

5.3.1.2. Data Result In Process of Absorber

In order to analyze the data, data result in process of panel are needed. Table 5.4 and figure 5.4 show the defective data result in process of solar panel from May 2019 to August 2019.

Table 5.4 Defective Data In Process of Absorber from May – August 2019

Defective Data Process of Absorber from May – August 2019				
No	Process	Quantity Produced	#Defect	%Defect
1	Aluminum Cutting	13046	459	3,52%
2	Assemble Aluminum + Riser Pipe	10629	1497	14,08%
3	Drilling Header Top Pipe	6643	107	1,61%
4	Collaring Header Top Pipe	8599	219	2,55%
5	Drilling Header Bottom Pipe	7567	97	1,28%
6	Collaring Header Bottom Pipe	2469	125	5,06%
7	Brazing Nepple + Header Pipe	5507	194	3,52%
8	Press 100 ton	8225	198	2,41%
9	Press 80 ton	7650	349	4,56%
10	Brazing Pipe A +Runner Pipe + Elbow 90	9235	231	2,50%
11	Assemble Absorber	12553	175	1,39%
12	Leak Test	11641	69	0,59%
13	Assemble Panel	12759	107	0,84%

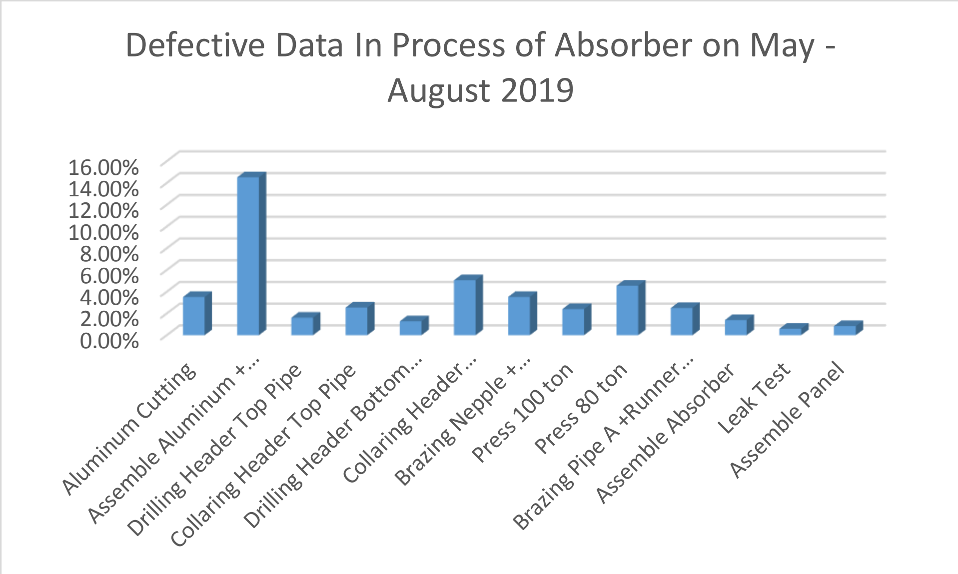

Figure 5.5 Defective Data In Process of Absorber from May – August 2019

Table and figure above show the defective data in process of absorber from May – August 2019. The highest percentage of defect item is on assembly aluminum with riser pipe process. Thus, the further data analysis will be focused on assembly aluminum with riser pipe process.

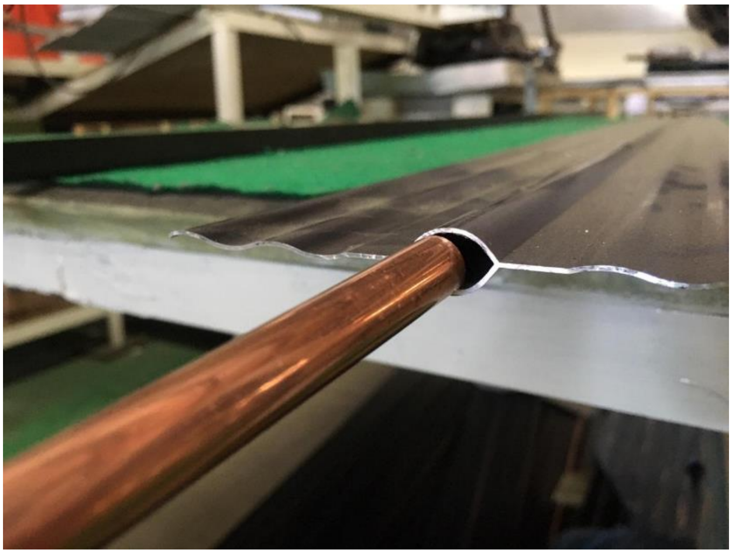

Figure 5.6 Defect Item of Assembly Aluminum Fin with Riser Pipe Process

Figure 5.6 shows the defect item of assembly aluminum fin with riser pipe process. As we can see from the figure, the riser pipe can't fit in with the aluminum fin because the diameter of the riser pipe doesn't meet the specification. If the riser pipe doesn't fit, both of the materials cannot be pressed.

5.3.1.3. SIPOC Diagram

SIPOC stands for supplier, input, process, output and customer. SIPOC diagram is made to make the process from supplier to customer be understood clearly. This diagram is really helpful in seeking a problem from process' perspective. Supplier is defined as a starting process and customer as a party that receive the products. Table 5.5 shows the SIPOC diagram of assembly aluminium fin with riser pipe.

Table 5.5 SIPOC DIagram

Supplier	Input	Process	Output	Customer
• Aluminium Fin • Riser Pipe	• Check • Spoilage	• Assembly	• Absorber Pipe	• Brazing

5.3.2. Measure

The aim of this step is to set the basis for enhancement objectively to current baselines. This is a phase of information collection with the aim of establishing baselines for process results. At the conclusion of the project, the performance metric baseline(s) from the Measure stage will be contrasted with the performance metric to determine objectively if important improvements have been made.

5.3.2.1 Statistical Process Control (SPC)

On SPC calculation, the data used is the data of the number of defective products (defects) that occur. The data obtained are attribute data that is qualitative data or unit that can be calculated type of defect and can be analyzed. This "P" map is made for the production of absorber. Defect data taken by subgroup based on month when the data collected, total produced and total defect. Table 5.6 shows the weekly defect data on May 2019 to August 2019.

Table 5.6 Weekly Defect Data in May 2019 – August 2019

Subgroup	Quantity Produced (ni)	Defect Quantity (di)	Defect Proportion (p)
1	598	78	0,1304
2	611	56	0,0917
3	590	48	0,0814
4	656	42	0,0640
5	619	27	0,0436
6	602	78	0,1296
7	579	55	0,0950
8	597	68	0,1139
9	701	295	0,4208
10	689	52	0,0755
11	665	35	0,0526
12	639	44	0,0689
13	651	36	0,0553
14	689	15	0,0218
15	721	53	0,0735
16	701	178	0,2539

Table above shows the various number of measurements so the UCL and LCL values need to be calculated by using "p" chart with "n" is not constant which can be known with the formula below:

- Center line

$$\hat{p} = \frac{Sum\ of\ Defect\ Quantity}{Sum\ of\ Quantity\ Produced}$$

- UCL and LCL

$$\text{UCL} = \hat{p} + 3\sqrt{\frac{\hat{p}(1-\hat{p})}{di}}$$

$$\text{LCL} = \hat{p} - 3\sqrt{\frac{\hat{p}(1-\hat{p})}{di}}$$

Where:

p̂ = Center Line

di = Defect Quantity

Table 5.7 shows the values of CL, UCL and LCL for each subgroup.

Table 5.7 CL, UCL, and LCL Calculation

Subgroup	Quantity Produced (ni)	Defect Quantity (di)	Defect Proportion (p)	CL	UCL	LCL
1	598	78	0,1304	0,1125	0,2199	-3,2204
2	611	56	0,0917	0,1125	0,2392	-3,9882
3	590	48	0,0814	0,1125	0,2494	-4,3012
4	656	42	0,0640	0,1125	0,2588	-4,9341
5	619	27	0,0436	0,1125	0,2950	-6,2557
6	602	78	0,1296	0,1125	0,2199	-3,2319
7	579	55	0,0950	0,1125	0,2404	-3,9189
8	597	68	0,1139	0,1125	0,2275	-3,4990
9	701	295	0,4208	0,1125	0,1677	-1,5601
10	689	52	0,0755	0,1125	0,2440	-4,4462
11	665	35	0,0526	0,1125	0,2728	-5,5515
12	639	44	0,0689	0,1125	0,2555	-4,7305
13	651	36	0,0553	0,1125	0,2705	-5,3968
14	689	15	0,0218	0,1125	0,3573	-9,3861
15	721	53	0,0735	0,1125	0,2428	-4,5014
16	701	178	0,2539	0,1125	0,1836	-2,1213

To test whether the data is valid or not which describe the actual process. The data used should be the data process within statistical control so that the data used to calculate index value is not showing any variations. Then control chart is made for attribute data which is p chart or fraction non conforming. This p chart is made by using Minitab 17 software.

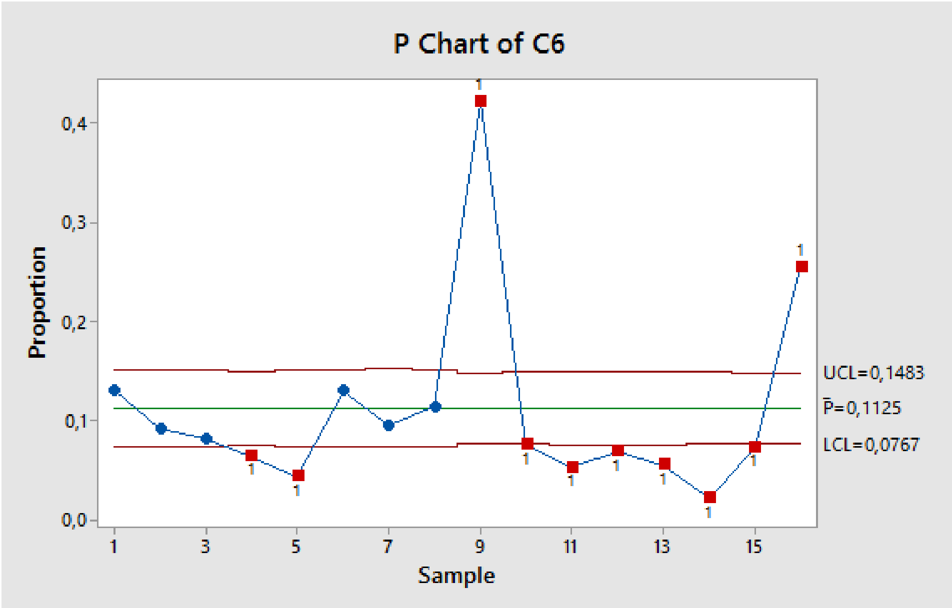

Figure 5.7 P- Chart for Defect Quantity

Figure 5.7 above shows the p-chart of defect quantity from data taken from. The p chart shows that from 16 data, there are 10 data outlier (above UCL or below LCL). The data outlier are subgroup 4, 5, 9, 10, 11, 12, 13, 14, 15, and 16. Since there are some outliers, it means that process still out of control and needs more improvement.

5.3.2.2. Calculation of Sigma Value

The next measurement step is measuring the level of Sigma and Defect Per Million Opportunities (DPMO). To measure the Sigma Level from the production of PT. WIKA Industri Energi can be done by way of Gaspersz (2007: 42) steps as follows:

- Defect Per Unit

$$DPU = \frac{Total\ Defect\ Quantity}{Total\ Quantity\ Produced}$$

- Defect Per Million Opportunities Calculation

$$DPMO = \frac{Total\ Defect\ Quantity}{Total\ Quantity\ Produced}\ x\ 1000000$$

Table 5.8 shows the calculation of DPO and DPMO.

Table 5.8 DPO and DPMO Calculation

Sub group	Quantity Produced (ni)	Defect Quantity (di)	Defect Proportion (p)	CL	UCL	LCL	DPO	DPMO
1	598	78	0,1304	0,1125	0,2199	-3,2204	0,1304	130435
2	611	56	0,0917	0,1125	0,2392	-3,9882	0,0917	91653
3	590	48	0,0814	0,1125	0,2494	-4,3012	0,0814	81356
4	656	42	0,0640	0,1125	0,2588	-4,9341	0,0640	64024
5	619	27	0,0436	0,1125	0,2950	-6,2557	0,0436	43619
6	602	78	0,1296	0,1125	0,2199	-3,2319	0,1296	129568
7	579	55	0,0950	0,1125	0,2404	-3,9189	0,0950	94991
8	597	68	0,1139	0,1125	0,2275	-3,4990	0,1139	113903
9	701	295	0,4208	0,1125	0,1677	-1,5601	0,4208	420827
10	689	52	0,0755	0,1125	0,2440	-4,4462	0,0755	75472
11	665	35	0,0526	0,1125	0,2728	-5,5515	0,0526	52632
12	639	44	0,0689	0,1125	0,2555	-4,7305	0,0689	68858
13	651	36	0,0553	0,1125	0,2705	-5,3968	0,0553	55300
14	689	15	0,0218	0,1125	0,3573	-9,3861	0,0218	21771
15	721	53	0,0735	0,1125	0,2428	-4,5014	0,0735	73509
16	701	178	0,2539	0,1125	0,1836	-2,1213	0,2539	253923
TOTAL	**10308**	**1160**	**1,7718397**	**1,801**	**3,944**	**-71,04**		
AVG	**644,25**	**72,5**	**0,11074**	**0,113**	**0,247**	**-4,44**	**0,1107**	**110740**

The DPMO value equals to 110740, this value between DPMO value of 115000 with sigma value equals to 2.7 and DPMO value of 96800 with sigma value equals to 2.8 (conversion table of sigma value is attached on the appendix), to calculate the sigma value, interpolation must be taken as follows:

$$\frac{115000 - 96800}{2.7 - 2.8} = \frac{115000 - 110740}{2.7 - x}$$

$$x = 2{,}723$$

The calculation above shows the sigma value of PT. WIKA Industri Energi. The sigma value of assembly aluminum fin with riser pipe process is equals to 2,723 with the total defect of 110740 per one million opportunities. Company that has sigma value equals to 2 is a non-competitive company. In consequence, improvements must be made to continuously achieve zero defect. If the problem is not dealth immediately, it will lead to the increasing number of defects which will result to waste on production cost. Further analysis and improvement are needed to be taken by company so that zero defect and six sigma's goal can be achieved.

5.3.3. Analyze

In data analysis, the data that have been collected will be analyzed further. Analyze stage aims to find the cause of quality problem by using proper tools data analysis. This is done to understand the whole process being observed and to define alternative solutions for solving problem. Identification which will be done not only covers root causes of a disability or failure analysis, but as well as the cause and effect relationship. Based on the data above, the highest percentage of defect item is on assembly aluminum fin with riser pipe. The defect item will cause the profit loss for the company. In order to find the cause of the defect, the data will be analyzed using fishbone diagram.

5.3.3.1. Cause and Effect Analysis using Fish Bone Diagram

The main objective of the company is to increase the company's marginal profit as well as better quality performance. To achieve that, improvements have to be done. Before doing improvements, further analysis must be done first. Brainstorming was done to know the causes of dominant defect that often happened. After doing observation in production line and brainstorming with relevant parties, defect caused by several factors which will be explained on the fishbone diagram on the next page. Using fishbone diagram will help to identify the problems related with high number defect in painting area. Factors caused defect divided into four categories which are man, machine, material and method. Figure 5.8 shows the fishbone diagram. Data used in fishbone diagram on the next page is identified as the causes of defect.

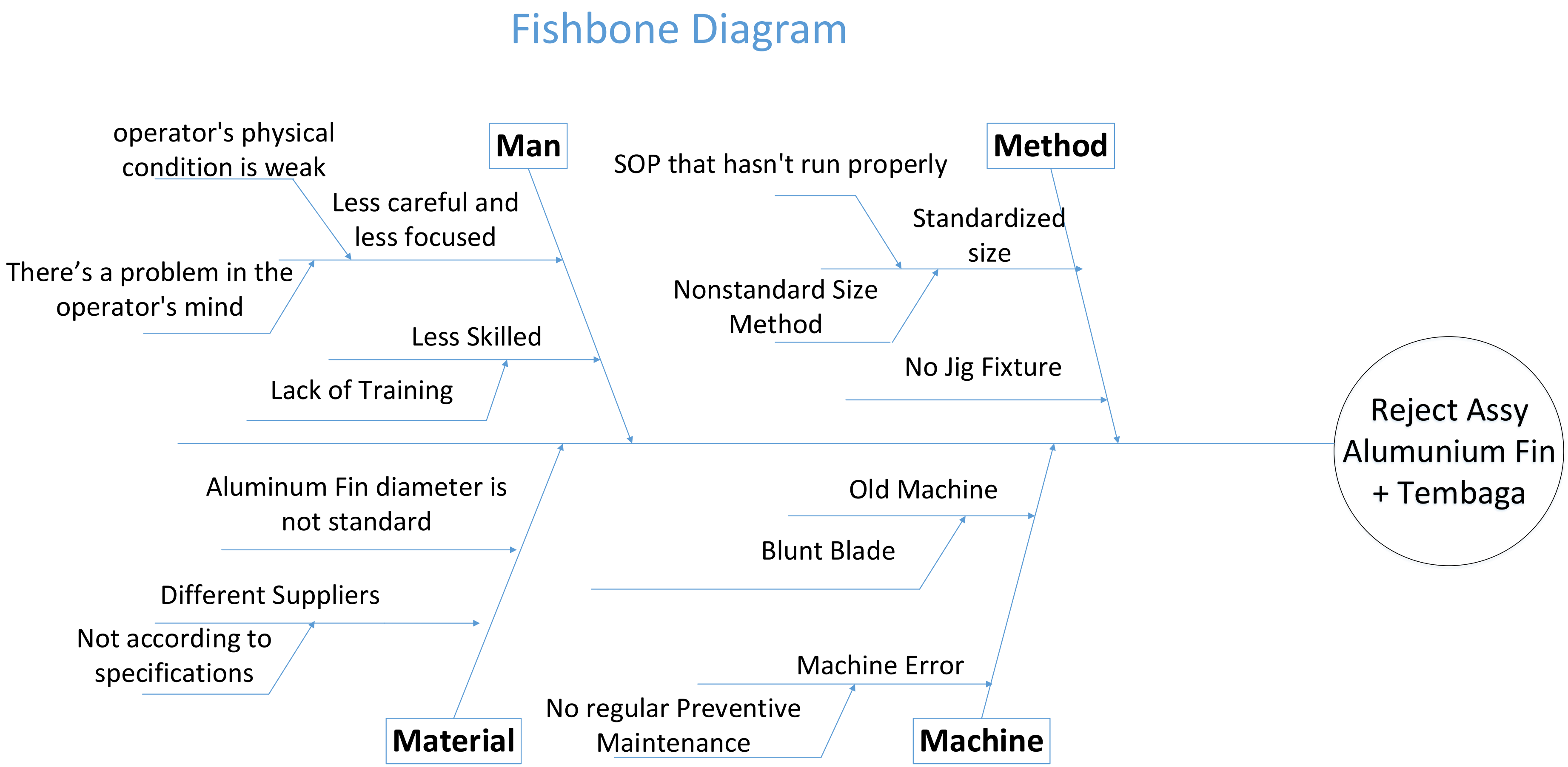

Figure 5.8 Fishbone Diagram of Reject Aluminum Fin + Riser Pipe

Figure 5.8 shows the fishbone diagram of assembly aluminum fin with riser pipe. The factors are categorized into four factors which are man, method, material, and machine. From the fishbone diagram it is known that there are several potential factors that can lead to the ineffectiveness of the running of the Panel production process:

1. Machine Factors.

   Ideally, operators must check the machine conditions to identify the abnormality so that it can be fixed and solved immediately. Regular checking of machine is the important aspect to do. By checking the machine condition, the cause of defect can be identified sooner, so the number of defects can be reduced. Regular checking machine has to be stated on the SOP so the number of defect caused by machine could be decreasing. Sometimes, several machines were not in standard. Place Machine factors are the main cause of this type of damage. This is caused by:

   a. The register changes position because the setting is less tight or too loose.
   b. The blade used for cutting is not sharp enough because it is not replaced by the operator in time. During the cutting process, the yield of the pieces becomes uneven and produces a size that is not ideal and the standard size is not standard.

2. Man Factors

   These factors can be the caused of defect because the process done in the area is not apart from the role of operator. Several operators are less skilled in doing machine settings and registers. They do not understand the quality standards, they assume that quality is not their responsibilities but it is QC's responsibility. The operators don't install the jigs properly because they are not focused. Lack of training and educating from leader possibly be the causes of the problem. Some operators which working in this area are high school graduates. They don't have much experiences and haven't been working previously. Currently, there is no proper training standard of new hire. New operators are trained by leaders or senior who have been working longer which lead to various knowledge and skill which are being taught. As a result, they not understand quality standards clearly.

3. Material Factors

   Material has the major factor related to the production process. Nonstandard diameter of aluminum fin causes the size of the fin hole to be unstable. It is not ideal for the assembling panel process. The nonstandard diameter of aluminum fin is caused by the supplier. The company often changes the supplier in a short period of time. Different supplier have a different specification as well. As result, the diameter of aluminum fin is not standard.

4. Method factor

   Everything related with production has been arranged and made by considering to the impacts. Method done by operators are listed in the SOP, but operators don't work in accordance with SOP. The SI (Standar Inspeksi) already exists but it is not in accordance with the requirements. The inspection needs a jig fixture in order to check whether the material is in a good condition or not.

5.3.3.2. Checking Potential Process Failure and Evaluating Risk Priority by using Failure Modes and Effect Analysis (FMEA)

Failure modes and effect analysis (FMEA) is a six-sigma tool that helps to plan quality improvement by identifying the crisis process factors. On FMEA table, frequency of occurrence value is filled, which represents how often it happens. Besides frequency of occurrence value, there is degree of severity which represents how big the effect of mode failure on defect dimension. The last one is chanel / probability of detection, which represents how big the probability of mode failure being detected and anticipated by existing supervision, in a scale of 1 to 10. If these three values are multiplied, the risk priority number (RPN) will be obtained. RPN defines risk value occured. The main improvement needs to be taken is improvement for solving mode failure with the highest RPN. Because of this, RPN will be sorted from largest to smallest. Table 5.9 shows the FMEA calculation.

Table 5.9 Failure Mode Effect Analysis Calculation

Process	Mode of Failure	Cause of Failure	Effect of Failure	Frequency of Occurrence (1 to 10)	Degree of Severity (1 to 10)	Change of Detection (1 to 10)	RPN
Zero defect in Assembly Aluminum Fin and Riser Pipe	Less skilled operator	Lack of Training	Operator don't understand the SOP clearly	8	6	7	336
	Invisible SOP placement	Operator don't understand the SOP	Unstandardized working method	6	5	6	180
	Machine Error	Machine is old	Unpressed Aluminum	3	4	5	60
	No regular machine checking	Lack of Preventive Maintenance	Machine error	6	7	7	294
	High 'NG' of Aluminum fin	Different suppliers and no jig fixtures	obstruction of the production process	2	3	5	30

Table above shows the diagram of failure modes and effect analysis (FMEA). From that table, RPN rank can be obtained. This research will be focused on the highest three of RPN value, which are:

- Rank 1, Less Skilled Operator (RPN: 336)
  The production process of making an absorber involved the operator. However, the operator in assembly aluminum fin with riser pipe is lacked of experience. They often do the operation without the standard operational procedure. They don't understand the SOP clearly. This problem can leads to the high number of defective item.

- Rank 2, No Regular Machine Checking (RPN: 294)
  When machine or tool is broken, it is easier to produce defect product because the machine or tool does not work properly based on standard. In order to assemble the aluminum fin with the riser pipe, pressed machine is needed. In production, it is often found that the machine or tool or jig does not work properly. It is caused by the lack of preventive maintenance. The

preventive maintenance is not carried out according to a predetermined schedule. It leads to the condition where the damage could not be identified earlier. After producing several outputs, it has finally known that there was an abnormality with the machine.

- Rank 3, Invisible SOP Placement (RPN: 180)
  SOP is made for operators so that the working performance and consistency can be maintained. But in actual, most operators didn't work by following SOP provided. It caused by the invisible SOP placement. The SOP is placed in a closed place and not easily accessible by the operator. Thus, the operator work with the wrong method which is leads to a high number of defect.

5.3.4. Improve

The next step of this research is Improve. This stage is related with defining and implementing solutions based on analysis result which done previously on analyze stage. In this research, activity done on improve stage is defining solutions or actions to be implemented in order to solve the problem. As stated before, it can be seen that the main root causes are less skilled operator, no regular machine checking, and invisible SOP. Below are the improvement that can be implemented to solve the problems.

- Training the Operator
  Training for operators should be done routinely to improve operator skills in the production process. The operator who receives the necessary training is more able to perform in their job. The training will give the operator a greater understanding of their responsibilities within their role, and in turn build their confidence. This confidence will enhance their overall performance and this can only benefit the company. The SOP should be made, so the operator will work based on the SOP.

- Scheduled a Regular Preventive Maintenance

Preventive maintenance is important. During this time, preventive maintenance is rarely done. The goal of a successful preventive maintenance program is to establish consistent practices designed to improve the performance and safety of the equipment at the company. By performing a regular preventive maintenance, the equipment remains to operate under safe conditions, both for the machine and the operators. Preventive maintenance can reduce the opportunities of machine errors. If the machine runs well, the number of defect can be reduced.

- Socialized the SOPs

  Standard operating procedures (SOPs) are step-by-step instructions that act as guidelines for employee work processes. Leaders have to explain and demonstrate the right method of working. The SOP must be placed in the area that can be seen by the operator. By socializing the SOP, all operators understand SOP clearly and working using the proper method listed on the SOP.

Solutions then can be implemented on six sigma implementation project. Corrective actions done based on those solutions are expected can improve sigma value of process that is used as a benchmark process quality to produce zero defect products. After solutions are implemented, on certain range time, metric value needs to be recalculated. If the value is increasing, then the analysis result done is not appropriate enough and further analysis must be taken.

5.3.5. Control

After the improvement, the last step is control. Control or monitoring is a phase aims to continuously evaluate the implementation result from improve stage. This stage has a purpose to ensure that conditions that have solved can be sustained in a long term. Control phase is maintaining the performance won’t be decreased again.

Control chart can be used by company for monitoring output of production process so that quick detection of abnormal variation can be done. Control chart will help to identify the existance of special cause variations which have to be eliminated. Controlling or monitoring is needed in order to have continous improvements. In this case, corresponding with data that will be taken which are variable data, so the most suitable control chart is p chart.

The improvements make much impact to the quality performance. Although it hasn't completely implemented, yet the progress of defect has been seen. The number of defect is decreasing significantly. Table 5.10 shows the data of weekly defect quantity after improvement from 19 August 2019 to 22 September 2019.

Table 5.10 Quantity Defect after Improvement

Sub group	Quantity Produced (ni)	Defect Quantity (di)	Defect Proportion (p)	CL	UCL	LCL
1	698	20	0,0287	0,0331	0,1531	-6,2291
2	718	25	0,0348	0,0331	0,1405	-5,4458
3	690	32	0,0464	0,0331	0,1280	-4,5260
4	707	23	0,0325	0,0331	0,1450	-5,7119
5	721	17	0,0236	0,0331	0,1633	-7,0582

The table above shows the total quantity produced, defect quantity, CL calculation, UCL and LCL calculation for each subgroup from 19 August 2019 to 30 September 2019. The statistical analysis of data after improvement then be tested to see whether the data is valid or not which describe the actual process. Control chart was made for attribute data is p chart or fraction non conforming. Figure 5.9 shows the p chart for defect quantity after improvement.

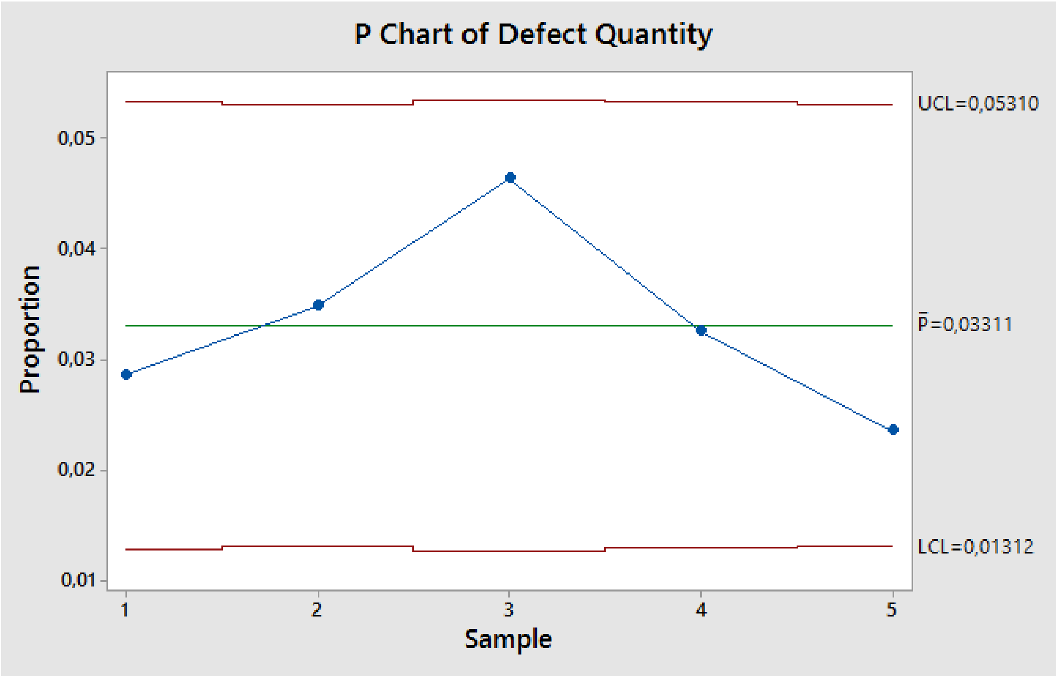

Figure 5.9 P-Chart of Defect Quantity (After Improvement)

The figure 5.9 shows the P-Chart of defect quantity after improvement. The data taken is from 19 August 2019 – 22 September 2019. The figure shows that there is no outlier data (above the UCL or below the LCL). It means that the data is statistically controlled.

The calculation of DPU and DPMO for each subgroup is the same as the example that is explained above. Table 5.11 shows the values of DPU and DPMO for each subgroup of the data after improvements.

Table 5.11 DPO and DPMO Calculation after Improvement

Sub group	Quantity Produced (ni)	Defect Quantity (di)	Defect Proportion (p)	CL	UCL	LCL	DPO	DPMO
1	698	20	0,0287	0,0331	0,153	-6,229	0,029	28653
2	718	25	0,0348	0,0331	0,140	-5,446	0,035	34819
3	690	32	0,0464	0,0331	0,128	-4,526	0,046	46377
4	707	23	0,0325	0,0331	0,145	-5,712	0,033	32532
5	721	17	0,0236	0,0331	0,163	-7,058	0,024	23578
TOTAL	**3534**	**117**	**0,1660**	**0,1655**	**0,730**	**-28,971**		
AVERAGE	**706,8**	**23,4**	**0,0332**	**0,0331**	**0,146**	**-5,794**	**0,033**	**33191**

The DPMO value equals to 33191, this value between DPMO value of 35900 with sigma value equals to 3.3 and DPMO value of 28700 with sigma value equals to 3.4 (conversion table of sigma value is attached on the appendix), to calculate the sigma value, interpolation must be taken as follows:

$$\frac{35900 - 28700}{3.3 - 3.4} = \frac{35900 - 33191}{3.3 - x}$$

$$x = 3.337$$

The calculation above shows the sigma value of PT. WIKA Industri Energi. The sigma value of assembly aluminum fin with riser pipe process is equals to 3.337 with the total defect of 33191 per one million opportunities.

5.4. Comparison Between Before and After Improvement

Table 5.12 shows the comparison between before the improvement and after the improvement.

Table 5.12 Comparison Before Improvement and After Improvement

Parameter	Before Improvement	After Improvement
DPMO	110740	33191
Sigma Value	2.723	3.337

Based on the table above, we can see that the value of DPMO decreased from 110740 per milion unit to 33191 per milion unit. The sigma value also increasing from 2.723 to 3.337. It means that the implementation of the improvements is working.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

By using DMAIC Methodology and tools such as DPMO, Fishbone Diagram, and DMAIC, the objectives from the research can be achieved.

6.1. Conclusion

The conclusions of this research are:

- Based on the observation and data taken from May 2019 to August 2019, assembly aluminum fin with riser pipe contributes the highest number of defects. This becomes the concern of company to improve the quality performance. The cause of defect has been previously stated in Chapter 5. From the FMEA calculation, the top 3 highest RPN rank are less skilled operator, no regular checking machine, and invisible SOP placement with RPN values of 336, 294, and 180 respectively. The operator in assembly aluminum fin with riser pipe is lacked of experience. They often do the operation without the standard operational procedure. Most operators didn't work by following SOP provided. It caused by the invisible SOP placement. The SOP is placed in a closed place and not easily accessible by the operator. Thus, the operator work with the wrong method which is leads to a high number of defect. Other than that, it is often found that the machine or tool or jig does not work properly. It is caused by the lack of preventive maintenance. The preventive maintenance is not carried out according to a predetermined schedule.
- The improvement that are implemented are traning the operator, scheduled a regular preventive maintenance, and socialized the SOP. Training for operators should be done routinely to improve operator skills in the production process. The SOP must be placed in the area that can be seen by the operator. By socializing the SOP, all operators understand SOP clearly and working using the proper method listed on the SOP. On the other hand, a regular preventive maintenance must be conducted, so the equipment

remains to operate under safe conditions, both for the machine and the operators. Preventive maintenance can reduce the opportunities of machine errors. If the machine runs well, the number of defects can be reduced.

6.2. Recommendations

Based on the results of the analysis and conclusions above, it is necessary to propose a number of suggestions as follows:

1. To improve the quality of production and reduce the reject, PT. Wijaya Karya Industri Energi should involve all employees in quality control issues.

2. Training for operators should be done routinely to improve operator skills in the production process.

3. It is better to do a briefing if any problems are found, especially in the process of assembly aluminum fin with riser pipe.

4. Preventive maintenance schedules must be carried out optimally so that there are no more damaged machines that cause disruption to the production rate.

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APPENDIX

Six Sigma Conversion Table

Yield	DPMO	Sigma	Yield	DPMO	Sigma	Yield	DPMO	Sigma
6.6%	934,000	0	69.2%	308,000	2	99.4%	6,210	4
8.0%	920,000	0.1	72.6%	274,000	2.1	99.5%	4,660	4.1
10.0%	900,000	0.2	75.8%	242,000	2.2	99.7%	3,460	4.2
12.0%	880,000	0.3	78.8%	212,000	2.3	99.75%	2,550	4.3
14.0%	860,000	0.4	81.6%	184,000	2.4	99.81%	1,860	4.4
16.0%	840,000	0.5	84.2%	158,000	2.5	99.87%	1,350	4.5
19.0%	810,000	0.6	86.5%	135,000	2.6	99.90%	960	4.6
22.0%	780,000	0.7	88.5%	115,000	2.7	99.93%	680	4.7
25.0%	750,000	0.8	90.3%	96,800	2.8	99.95%	480	4.8
28.0%	720,000	0.9	91.9%	80,800	2.9	99.97%	330	4.9
31.0%	690,000	1	93.3%	66,800	3	99.977%	230	5
35.0%	650,000	1.1	94.5%	54,800	3.1	99.985%	150	5.1
39.0%	610,000	1.2	95.5%	44,600	3.2	99.990%	100	5.2
43.0%	570,000	1.3	96.4%	35,900	3.3	99.993%	70	5.3
46.0%	540,000	1.4	97.1%	28,700	3.4	99.996%	40	5.4
50.0%	500,000	1.5	97.7%	22,700	3.5	99.997%	30	5.5
54.0%	460,000	1.6	98.2%	17,800	3.6	99.9980%	20	5.6
58.0%	420,000	1.7	98.6%	13,900	3.7	99.9990%	10	5.7
61.8%	382,000	1.8	98.9%	10,700	3.8	99.9992%	8	5.8
65.6%	344,000	1.9	99.2%	8,190	3.9	99.9995%	5	5.9
						99.99966%	3.4	6