



(Research/Review) Article

# The Collaboration of Statistical Process Control and Root Cause Analysis Method in Maintaining The Quality of Biometric Solution Products

Taufiq Agus Supriyanto<sup>1\*</sup>, Slamet Riyadi<sup>2</sup>, Fausta Ari Barata<sup>3</sup>

<sup>1</sup>. Universitas 17 Agustus 1945 Surabaya; email: [1262400031@surel.untag-sby.ac.id](mailto:1262400031@surel.untag-sby.ac.id)

<sup>2</sup>. Universitas 17 Agustus 1945 Surabaya; email: [slametriyadi10@untag-sby.ac.id](mailto:slametriyadi10@untag-sby.ac.id)

<sup>3</sup>. Universitas 17 Agustus 1945 Surabaya; email: [fausta@untag-sby.ac.id](mailto:fausta@untag-sby.ac.id)

\* Corresponding Author : Taufiq Agus Supriyanto

**Abstract:** The quality of biometric solution products needs special attention. This is based on complaints submitted by consumers. Following up on these complaints, research needs to be conducted to find out how consumers feel about biometric solution products, find the root of the problem that affects product quality, and also find solutions that can be done to maintain the quality of this biometric solution product. This study uses a qualitative research method with a case study approach at a biometric solution provider company. The research sample is a biometric solution product produced from July 2023 to March 2025. The collaborative application of the Statistical Process Control and Root Cause Analysis methods is used to determine whether product damage is still within control limits and also to determine the main causes of the decline in product quality. The results of the study showed that the reported product damage reached 23.6%, which exceeds the maximum product damage standard determined by management, which is 10%. Although the product damage exceeds the maximum standard, the results of calculations using the control chart show that the damage is still within normal control limits. However, several factors causing product quality problems are determined by human factors, materials, methods and measurements. The lack of technical capabilities and technical documentation from the Research and Development team shows a major influence on the problems that occur. Improvement steps can be taken through improving Research and Development procedures, completeness of technical documentation, and increasing the technical capabilities of the Research and Development team.

**Keywords:** biometric solution, Statistical Process Control, Root Cause Analysis, quality

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## 1. Introduction

In product manufacturing, quality control needs to be carried out. So, that the produced product has good quality. This quality control process requires in-depth analysis both in terms of the production process and the produced product. Good product quality will impact customer satisfaction and of course can increase company revenue. This applies to all manufacturing companies, including companies that produce biometric solution products. Biometric solution products are currently growing rapidly, this is because this product covers the basic needs of physical recognition to identify individuals, such as fingerprint scanning, face scanning, palm scanning, voice recognition and iris scanning.

One of the companies producing biometric solution products faced a problem where the products experienced problems that resulted in complaints from customers. This biometric solution product was first produced in July 2023. This product has gone through the Research and Development process, but it was found that the products had problems both during the quality control process and when the product had been used by customers. This damage occurred at varying times but was still within the 1-year warranty period.

Complaints from customers caused a bad impression on the image of the product and the company. So the company wanted a study to find out the root cause of the many product damages.

Product damage data shows that in 2023, product damage was around 24.5%. In 2024, product damage was recorded at 18.3% and in 2025, product damage was recorded at 42.4%. So that the average product damage compared to the amount of production is 23.6%. The percentage of product damage exceeds management's expectations, which is 10%. From this phenomenon, a study needs to be conducted to determine the cause of the quality problem that occurs. The problem-solving method that can be used in this process is to use the Statistical Process Control and Root Cause Analysis methods. Statistical Process Control is often used to identify what problems occur most often and whether these problems are still within the tolerance range. Root Cause Analysis is used to find the root of the problem that causes product damage.

Statistical Process Control and Root Cause Analysis methods has not been widely used in product quality assurance research. Most of these methods are used independently or combined with other methods. Several studies that have used a combination of the two methods where this method can identify a point that is outside the control limits and can be interpreted as a fact that quality control in the production process (injection) of PT XYZ is uncontrolled or still experiencing deviations and also found three critical processes that affect the failure of the process in shoe production in the PT XYZ case study (Fajrin & Sulistiyowati, 2018). In addition, the application of this collaborative method can also show exposed lining which is the most dominant type of defect and several factors that affect product defects in shoe products (Caesarriani, 2025).

From the research that has been conducted using the collaboration of Statistical Process Control and Root Cause Analysis methods, there has been no research on the use of both methods in maintaining the quality of biometric solution products. By conducting this research, it will be able to show how the application of both methods can be used to maintain product quality, especially in biometric solution products. From the collaboration of both methods, it is expected that the level of product damage can be reduced in the next production process. The percentage of product damage is expected to be lower than the damage tolerance determined by the company. By reducing the level of damage, customer satisfaction and company image can be improved. So that the company's income will increase.

## 2. Literature Review

### Quality

In making a product, it is necessary to pay attention to the quality produced. The purpose of higher quality is to provide greater customer satisfaction and is expected to increase revenue (Juran & Godfrey, 1998). Product quality can be defined as the ability of a product to carry out its functions including, durability, reliability, accuracy, ease of operation and repair, and other valuable attributes (Daga, 2017). (Assauri in Harjadi et al., 2021) states that there are factors that influence the quality of a product, including:

- 1.) The function of a product can be interpreted as what the product is used or intended for.
- 2.) External form, where the external form factor contained in a product is not only visible from its shape but also its color and packaging.
- 3.) The cost of the product is the cost of acquiring an item, for example the price of the item and the cost for the item to reach the buyer.

Product quality is inseparable from the production process. The better of the production process is carried out, it is expected to produce better quality products. To ensure that all processes can produce a quality products, the good of quality management is needed. Quality management can be described as a collection of activities such as planning quality, organizing quality, coordinating quality, controlling and evaluating quality carried out by each management function in the organization to improve performance in terms of work quality and work results (Chandra et al., 2020).

Several studies have shown that quality products have a positive impact on customer satisfaction and corporate image. Research on Masnun & Syabrus (2024), Nayra Cake Pekanbaru brownies customers shows that customer satisfaction levels increase along with product quality. In addition, product quality has also been shown to have a positive and significant effect on customer satisfaction at PT Airmas Perkasa (Khairul Hadi & Sulaeman, 2024). On the other hand, product quality has a positive but insignificant effect on repurchase interest with customer satisfaction as a mediating variable at Wizz Gelato Surabaya (Teressa et al., 2024).

With a quality products, it is expected that the level of product purchases will also increase. Product quality reflects all dimensions of product offerings that produce benefits for customers, product quality, whether in the form of goods or services, is determined through its dimensions. These dimensions include features, durability, serviceability, and aesthetics (Prasetyo & Priyambodo, 2025).

### **Biometric**

Biometric technology is increasingly widespread in all areas of people's lives. This shows that the use of this technology can provide good benefits. Biometrics is the science that studies how to determine a person's identity based on the physical, chemical, or behavioral characteristics of that person (Jain et al., 2019). Biometric data can be in the form of a face, fingerprints, palm, voice or irises. A biometric system is basically a pattern recognition system that operates by obtaining biometric data from an individual, extracting a set of features from the data obtained, and comparing this set of features with a set of templates in a database (Jain et al., 2004).

According to Datta et al. (2019) there are two models in the operation of biometric systems depending on the context of their application, namely:

#### 1. Verification Mode

In verification mode, the biometric system has already stored the usage template in the database. During the validation process, the system compares the collected information with the stored information, and if it matches, then the user is a valid user, otherwise, it is not.

#### 2. Identification Mode

In identification mode, the biometric system will recognize the user by comparing his/her data with all the templates stored in the database i.e., one-to-many comparison is performed to establish the identity of the individual.

Biometric systems work in several processes as (Hofstetter et al., 2024) follows:

#### 1. Enrollment

In the enrollment process, the original image of a trait is captured and transformed into a template that reflects the specific features extracted. A template is a configuration of data that cannot be reverse-engineered back to its original form.

#### 2. Identification

Identification is the process of determining who a subject is. The presented biometric information is cross-referenced to an existing database of registered individuals, to identify who the presenter is. This process is also called 1:N matching, where one person is compared to the entire database.

#### 3. Authentication

Authentication is the process of establishing a claimed identity, referred to as 1:1 matching. The presented biometrics are cross-referenced against pre-registered information of the claimed identity.

There are several types of biometrics as (Hofstetter et al., 2024) follows:

#### 1. Physique

Currently the physical biometric data that is widely discussed is fingerprints, irises, and faces. However, physical biometrics that are under development include palm prints, blood vessel recognition, and DNA forms.

## 2. Behavior

This type of biometric looks at how a person does something physically, such as:

- a.) The way they write – handwriting
- b.) The way they talk – voice recognition
- c.) The way they walk – gait
- d.) Eye movements – blinking
- e.) Facial movements – such as lip movements when speaking
- f.) How they type - keystrokes

In everyday life, biometrics are used in many ways. Several studies show how biometric data can be used to facilitate human identification. The use of biometric-based attendance at the Sukun Village Office, Malang City provides benefits in terms of convenience, accuracy of attendance hours, and also provides high-level security in maintaining representative information (Adiwidjaja et al., 2024). Biometric data can also be used in creating passwordless by simplifying the authentication process by eliminating the need for employees to remember or record passwords for each program or system, making the process safer and more convenient. This discovery also reduces the risk of cyber attacks and improves the user experience for employees (Gochez, 2023).

### Statistical Process Control

In maintaining product quality, a tool or strategy is needed to measure and ensure product quality. One method that can be used is Statistical Process Control . Statistical Process Control is a set of tools for managing processes, and determining and monitoring the quality of an organization's output. SPC is also a strategy to reduce variation in products, deliveries, processes, materials, attitudes, and equipment (Oakland, 2003).

Quality control measurements using the Statistical Process Control method can be carried out using the following tools:

1. Check Sheet is tool used to record the amount of production and damage that occurs.
2. Histogram, namely a bar graph that shows the comparative value of each product that is damaged.
3. Control chart, namely a graph that shows whether the damage condition is still within normal control limits.

Several studies have shown that the use of the Statistical Process Control method can help in determining problems that cause disruption to the quality of a product. The application of Statistical Process Control at the Karangpiang II IPAM showed statistically uncontrolled conditions in the pH parameters in the cleaning and filtering units (Hizni'am et al., 2019). The application of Statistical Process Control can also be used in the field of education such as in the analysis of the variability of the academic performance ratio so that more fundamental problems can be found so that they can help in decision making in the accreditation process (Gessa et al., 2022).

Research using the Statistical Process Control method can also produce Univen as the most dominant defect that occurred in March 2017 with a defect proportion of 39% and April 2017 with a defect proportion of 30% in the product quality control process at PT Toshiba Electronic Corporation (Purba & Arifin, 2022). In addition, there is also another study that shows that the results of the check sheet show that product defects are 10.38% per month. From the results of the Pareto diagram, it is known that the highest defect rate is scratched with a total of 104 units or 61.18%. And from the results of the control chart it can be seen that quality control is not controlled and does not comply with standards (Elyas & Handayani, 2020)

### Root Cause Analysis

After statistical data is created, it is necessary to analyze the root causes of the problem. By knowing the root causes, the solution steps to improve quality problems will be more measurable and focused. One method that can be used in determining the root cause is Root Cause Analysis . Root Cause Analysis is a structured investigation that aims to identify the true cause of a problem and the actions needed to eliminate it (Andersen &

Fagerhaug, 2006). Root Cause Analysis is also defined as a tool used to help groups or individuals identify potential root causes for a problem (Doggett, 2005).

In implementing the Root Cause Analysis method, there are five tools that can be used according to the release from Ease.io (2022) as follows:

1. Pareto Chart

A Pareto chart is a histogram or bar chart combined with a line chart that groups the frequency or cost of various problems to show their relative significance.

2. 5 whys

5 whys method is a method that uses a series of questions to explore layers of a problem sequentially.

3. Fishbone Diagram

Fishbone Diagrams are a visual method for root cause analysis that organizes cause-and-effect relationships into categories.

4. Scatter Plots

Scatter Plots are a quantitative method for determining whether two variables are correlated, such as testing potential causes identified in a Fishbone Diagram.

5. Failure Mode and Effects Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a method used during product or process design to explore potential defects or failures.

Several studies have used the Root Cause Analysis method to identify the root of the problems that occur. By using Root Cause Analysis, it was found that the factor that most influences the length of production waiting time in PT Kharisma SF shoe production is the human factor (Burhanuddin & Sulistiyowati, 2022). In other studies, it was found that the factors causing over sanding defects in the plywood manufacturing process were the human factor with the root cause of the lack of human resources and the method factor with the root cause of the lack of operator knowledge of sandpaper (Sidikiyah & Muhammad, 2022). The use of the Root Cause Analysis method was also used in user reviews of the Siminvest application where the results showed that there were five main categories of negative reviews identified, namely Features, Policies, Support, Performance, and UI/UX and the results of the analysis using the fishbone diagram can identify the root cause of the problem in each category, such as lack of information and limited features, burdensome policies, slow CS responses, problems with application speed and stability, and UI/UX design that is not user-friendly (Tamam et al., 2024).

### 3. Methodology

This study uses a qualitative approach. A qualitative research approach can be interpreted as an approach in conducting research that is oriented towards natural phenomena or symptoms (Abdussamad, 2021). The type of research used is a case study. A case study can be interpreted as a form of qualitative research that focuses on providing detailed data from several specific cases (Naamy, 2019). The research was conducted at one of the companies that produces biometric solution products. The informants involved in this study were customers who had purchased products as many as 5 customers, a research and development team of 2 people, a production team of 2 people, and a technical support team of 2 people. The research instrument used semi-structural interviews. Primary data was taken from interviews and observations of the production process. While secondary data was obtained from the history of product damage in the period July 2023-March 2025, production data in the period July 2023-March 2025, and archives of production procedures and research and development procedures.

### 4. Results and Discussion

#### Research and Development Process

In conducting research and development, there are several stages as follows:

1. Analysis of product specifications and requirements This stage aims to ensure that user and technical needs are clearly documented to be the basis for developing targeted products. In determining product specifications and needs, the Research and Development department collaborates with several other departments such as the

Marketing department which will provide input on market information and customer needs. In addition, it also collaborates with the production department to provide input related to production capacity and production cost calculations.

## 2. Design Planning and Making

This stage aims to create an initial to final design of the product that is adjusted to the specifications that have been set. In this case, the design is made based on the specifications in the Product Requirement Document (PRD). In addition, it is also necessary to conduct research on the technical equipment involved in product design.

## 3. Mockup Design and Creation

After the product design is successfully created, the next step is product design and manufacturing. This stage aims to change the approved and finalized product design into a physical mockup that can be used before mass production is carried out. The prototype form of the product created must be exactly the same as the product design. Each component must be made the same to ensure that the product produced has no shortcomings from the initial design.

## 4. Procurement of Materials, Products, and Prototypes

After the mockup is successfully created, it will be continued with the procurement process of components and materials that will be used for production. Before mass production is carried out, a product prototype will be made so that it can be ensured that the product made is technically and physically appropriate.

## 5. Product Testing

This product testing stage is very important to do. Because the results of this test will show how the product functions properly. In addition, it will be seen whether there is anything that needs to be fixed before mass production is carried out. So that it will reduce product errors and product quality can be guaranteed.

## 6. Product Launch

After a series of product tests are carried out and it is felt that the product made is in accordance with the requirements, then the final step of product development is the launch of the product itself. When the product has been launched, mass production will be carried out.

### **Production process**

The production process of this biometric solution product is initiated by the production team. In this production process, the production team works together with the warehouse team which is responsible for the provision and storage of goods. The production of this product is divided into several stages as follows:

#### 1. Suitcase assembly

At this stage, the production team assembles the suitcase components.

#### 2. Electricity assembly

At this stage, the electronic component assembly process is carried out including: Battery, Relay components and wiring, Switch, Power display, Adapter.

#### 3. QC In

At this stage, all biometric devices are checked physically and functionally.

#### 4. Assembly of all components

At this stage, all components are assembled according to their intended use.

#### 5. QC Out

To ensure that the biometric solution product produced is appropriate and can be used as a whole, the QC Out process is carried out. In this process, the production team will conduct a thorough check both in terms of physical and functional aspects of all components. If there is a discrepancy, the production team will conduct a check and repair.

### **After Sales Service and Device Repair**

In order to maintain good relations with consumers, the after-sales service team is tasked with ensuring that the process of receiving and handling customer complaints can be handled properly. Customers can contact after-sales services by contacting via Whatsapp, telephone, or email. Complaints submitted by consumers will be received by the Helpdesk staff who will then forward them to the technician.

In this after-sales service, it is not only focused on repairing the device, but also must provide input on product development. Where this can refer to damage or complaints submitted by customers and also with the results of the analysis of device damage obtained. Each customer complaint will be recorded on the ticket. From the ticket data, the details of the complaint and damage will be used as a report to the relevant parties to provide advice and views on the products owned.

### Consumer Experience

The product damage that occurs is certainly closely related to the consumer's experience. This product damage can reduce consumer confidence in the product and can give a bad impression and can also have an impact on future product sales. From this condition, a survey needs to be conducted to find out how consumers respond to the products they have.

#### 1. Intensity of use

Based on information from consumers, this biometric solution product is often used as its function. This is as conveyed by consumers as follows:

*"Used for a month at the exhibition ..... non-stop without holidays". (K1)*

*"Often used for mobile services". (K2)*

*"Until now we are still using the tool and its performance is still good, we have not experienced any problems or damage." (K3)*

*"We use it almost every day for the team except Friday, Saturday, and Sunday." (K4)*

From the statement conveyed, it shows that this product is indeed very necessary and in accordance with the existing market.

#### 2. Impressions about the product performance

At this point, the question was asked to find out in general how consumers' impressions were about the performance of the biometric solution products they had. Of the 5 consumers interviewed, 4 of them suggested that the performance of the product used was in accordance with what they needed. There was only 1 consumer who stated that it was sufficient because there was a problem with the battery capacity that did not match their expectations.

*"The performance is quite satisfactory but the battery is not as expected." (K4)*

#### 3. Product constraints

This question was asked to see what obstacles consumers experienced while using this biometric solution product. Some of the complaints expressed were about battery capacity, problems with Windows updates that caused the application to be unusable with biometric components, and the product was considered less flexible for recording sick people. This is as conveyed by consumers as follows:

*"Currently there is 1 unit of automatic Windows update to Windows 11 which causes the application not to function/run". (K4)*

*"Based on our experience in the field, we experienced problems with the cable being too short, the iris being too close so it was difficult to lift, and the battery running out quickly." (K5)*

### Statistical Process Control

The company determines that the tolerable product damage is 10%. When viewed in total, product damage that occurred from the beginning of production in July 2023 to March 2025 was recorded at 23.6%. This is certainly not in accordance with the tolerance limit determined by management. However, for further analysis, it is necessary to look at statistical calculations using the Control Chart. So that it can be seen whether the damage that occurs is still within the lower and upper limits or not.

Because the production samples obtained in each month are different, the formula used in this calculation is using a p-chart. In the p-chart there are several calculation sections as follows:

1. Calculation of damage proportion

$$P = \frac{np}{n}$$

P: proportion of defects per production sample

np: amount of damage

n: number of samples

2. Center line calculation.

This center line shows the average product damage from the entire sample and is obtained by the formula:

$$CL = \frac{\sum np}{\sum n}$$

CL: center line.

$\sum np$ : sum of all damages.

$\sum n$ : number of all samples.

3. Upper Control Limit (UCL) Calculation

Upper Control Limit shows the upper limit of variation that is still acceptable and is calculated using the formula:

$$UCL = \bar{p} + 3 \frac{\sqrt{\bar{p}(1 - \bar{p})}}{n}$$

4. Lower Control Limit (LCL) Calculation

The Lower Control Limit shows the lower limit of variation that is still acceptable and is calculated using the formula:

$$LCL = \bar{p} - 3 \frac{\sqrt{\bar{p}(1 - \bar{p})}}{n}$$

Calculations to determine the control map from damage and production sample data in the range of July 2023 to March 2025 produced the following results:

Table 1. Control Chart Calculation Results

Month	P	CL	UCL	LCL
Jul-23	0.29	0.24	0.72	-0.66
Aug-23	0.50	0.24	1.14	-1.04
Sep-23	1.00	0.24	1.51	-1.04
Oct-23	0.11	0.24	0.66	-1.04
Nov-23	0.50	0.24	0.69	-0.40
Dec-23	0.15	0.24	0.49	-0.40
Jan-24	0.27	0.24	0.56	-0.40
Feb-24	0.50	0.24	0.87	-0.66
Mar-24	0.08	0.24	0.59	-1.04
Apr-24	0.29	0.24	0.72	-0.66
May-24	0.14	0.24	0.72	-1.04
Jun-24	0.33	0.24	0.60	-0.40
Jul-24	0.06	0.24	0.55	-1.04
Aug-24	0.25	0.24	0.69	-0.66
Sep-24	0.17	0.24	0.76	-1.04
Oct-24	0.17	0.24	0.54	-0.50
Nov-24	0.11	0.24	0.66	-1.04
Dec-24	0.09	0.24	0.62	-1.04
Jan-25	0.33	0.24	0.97	-1.04
Feb-25	0.43	0.24	0.58	-0.28
Mar-25	0.44	0.24	0.55	-0.25

Source: Author's Calculations

From the calculation above, a control chart can be made to determine whether product damage compared to the amount of production is within the normal control limit. The following is a control chart from the resulting calculation:

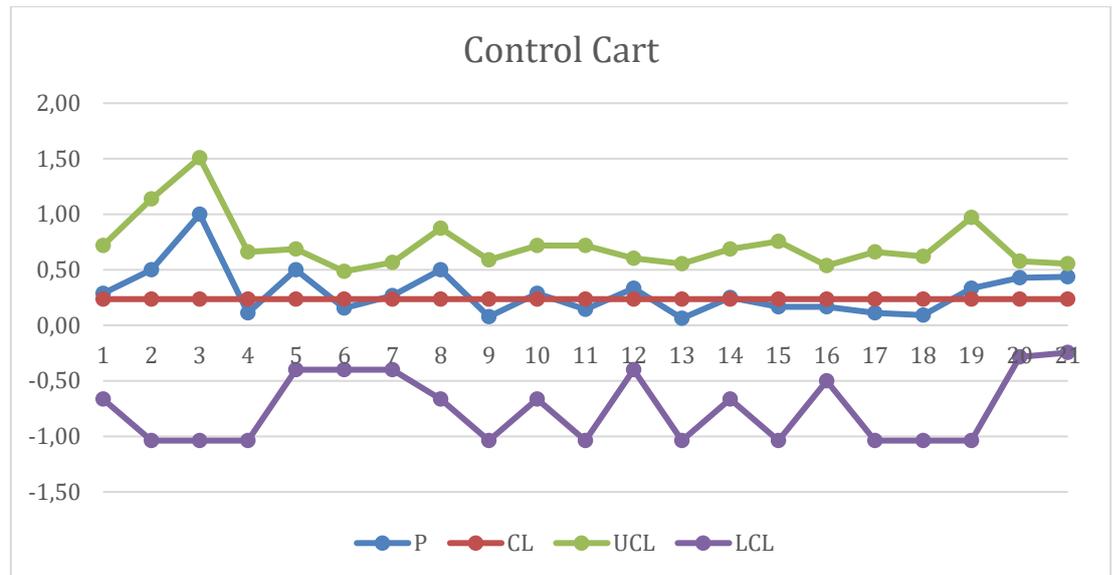


Figure 1. Control Chart

The calculation results and visual control maps of the damage and production data show that all samples presented are still within the upper and lower limits. Only the samples in February 2025 and March 2025 were close to the upper control limit. This shows something that must be watched out for and looked at more deeply why the damage occurred. So that a solution can be found for the problem.

### Root Cause Analysis

From the statistical data generated in the analysis using Statistical Process Control, it shows that the product damage that occurs is still within the upper and lower control limits. However, the percentage of product damage still exceeds the provisions given by the company management. For this reason, a more in-depth analysis is needed on the causes of product damage.

The Root Cause Analysis method approach was used. The tools used in this analysis are Fishbone Diagram and 5 whys. Data were collected from the observation and interview process conducted with predetermined informants.

#### 1. Fishbone Diagram

Fishbone diagram is widely used in problem analysis. In this diagram can show the relationship between factors that cause the problem to occur. According to (Kurniasih et al., 2021) there are several parts in the fishbone diagram, namely:

##### a. Fish Head Section

In this section, events that are influenced by the causes will be written, which will later be written in the fishbone section. Where the event is a problem whose cause will be sought.

##### b. Fish Bone Section

In this section there are categories that may have an impact on the problem that occurs. Some common categories are:

- a. Person
- b. Method
- c. Material
- d. Machine
- e. Measurement
- f. Environment

To find out the cause of the problems that occur, interviews and field observations were conducted. From the results of the study, it can be described as follows:

#### 1. Person

The interview results showed that from the human factor, several things were found that needed to be considered, such as:

- a. Lack of clarity of information from communication provided by the RnD team to the production team and Technical Support
- b. Slow handling of complaints submitted by the production team and Technical Support to the RnD team.
- c. Lack of knowledge about product life cycle by Research and Development team

#### 2. Method

From the results of observations and interviews, several conditions were obtained that could cause problems to occur, namely:

- a. Unclear documentation and work instructions.
- b. prototype testing process is not optimal. This is indicated by the presence of several parts of the product that are uncomfortable to use and quickly damaged.
- c. The training and knowledge transfer procedures from the RND team to the production and Technical Support teams are not yet structured.

#### 3. Material

From the observation results, component damage data and interviews with several informants showed that the component materials of the biometric solution product were less than ideal. Several things were conveyed regarding the materials as follows:

- a. Components wear out quickly.
- b. Components submitted for production do not conform to initial specifications.

#### 4. Machine

Analysis in this category will be able to describe whether the equipment used in the process of making this biometric solution product still has obstacles. From the interview results, it was found that the equipment needed was sufficient and in accordance with the needs.

#### 5. Measurement

From the results of observations and interviews, it was found that there was no standard for the final production results determined at the beginning. This made the production team not have an understanding of what kind of standards the Research and Development team wanted.

#### 6. Environment

In this category, it will be described whether the work environment in making this biometric solution product is appropriate or there are obstacles that are felt. From the interview results, it was found that the work environment was adequate and in accordance with the needs.

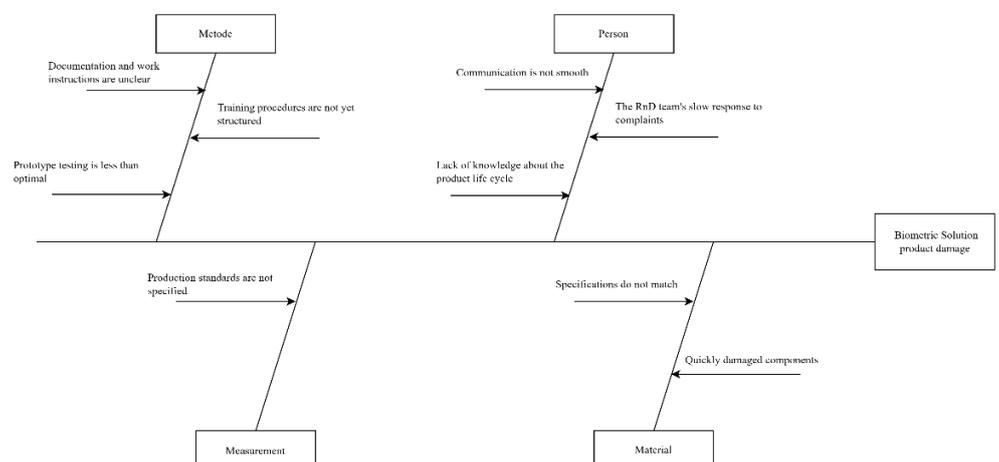


Figure 2. Fishbone Diagram

## 2. 5 whys

5 whys is often used in solving a problem, where a series of questions are asked to find out what causes each series of events. This method is considered effective for solving problems where it is easy to implement and can quickly find the root of the problem.

According to (Serrat, 2017) there are three key elements for using the 5 whys technique effectively, namely:

- a. Accurate and complete problem statement.
- b. Complete honesty in answering questions.
- c. Determination to find the root of the problem and solve it.

From the analysis using Fishbone Diagram, several important main problems were found and a deeper analysis will be carried out to determine the root of the actual problem using the 5 whys method. From the problems that are likely to be the cause, the problems that are considered important and need to be investigated in depth to find the root of the problem are selected as follows:

### 1. The slowness of the research and development team in responding to problems.

To find out the root cause of this problem, several questions were raised so that it was found that the root cause of this problem was the background and work experience between the production team, the Research and Development team and the Technical Support team were different. So that the Research and Development team had difficulty understanding the problem.

### 2. Component specifications do not match

The component specifications received by the production team were found several times to be inconsistent with the specifications specified in the technical documents. This resulted in poor production results. From the analysis results, it was found that the root cause of this problem was the lack of technical knowledge and experience of personnel for the creation of technical documents. The technical specifications written were less detailed and comprehensive, where each specification needed to be clearly described so that the purchasing team could find the appropriate vendor.

### 3. Quickly damaged components

Complaints submitted by consumers are more related to damaged components. From the analysis of this problem, the root cause is the absence of a QC In standard. This QC In standard contains procedures for initial component testing to vendor assessment. It is necessary to show in detail how the component testing process is carried out until the stress test. Thus, the results of which vendor components are in accordance with the desired standards will be obtained. In addition, assessments between vendors must also be made measurable in terms of technical components, stock of goods, and after sales support.

### 4. Prototype testing is less than optimal

Before the product is launched, testing needs to be done on the product prototype. Testing is not only done in terms of technical durability but also includes user experience. From the observation results, it was found that the prototype testing that was carried out was not optimal. This is evidenced by complaints from consumers both in terms of product durability and user experience that were not yet appropriate. The results of the analysis show that the testing of this prototype was not optimal because the sources were lacking. So the information obtained from the sales and Technical Support departments was inadequate. It needs to be noted that in determining the sources, a minimum limit needs to be made that covers various market conditions and consumer conditions, so that sufficient information is obtained and can be used as a test case when testing the prototype.

### 5. There is no standard for production results

Standard production results are very necessary in the process of making a product, where this can be a benchmark in the production process. When the standard production results are not determined, each individual production team will have their own preferences based only on technical documentation and verbal information from the Research and Development team. From the analysis results, the cause of this problem is because most members of the Research and Development team are still new and have no experience in making research documents.

## 5. Conclusions

### Conclusions

Based on the analysis of research results, the following conclusions can be as follow:

1. In general, the level of consumer satisfaction with biometric solution products is still quite good. This is based on consumer statements that the products can be used according to their function. There are only a few things that need to be improved for further product development such as battery capacity and flexibility of use.
2. The main factors causing damage to biometric solution products are due to human, material, measurement and method factors as follows:
  - a. Research and Development team in responding to complaints.
  - b. The component specifications received by the production team do not match the technical documents.
  - c. Component durability is poor.
  - d. Prototype testing is not optimal.
  - e. Production standards have not been established yet.
3. Based on the results of the study, it shows that the collaboration of the application of the Statistical Process Control and Root Cause Analysis methods can be used as a basis for finding solutions to maintain the quality of biometric solution products . Where the results of data processing using the Statistical Process Control method can be seen comprehensively to determine which components are often problematic and the results are also obtained that the reported product damage is still within normal control limits. Although, statistically the product damage is still within normal control limits, by applying the Root Cause Analysis method, the root of the problem that causes product damage exceeds management expectations can be found. So that suggestions for improvement can be given appropriately according to the problems found. Some solutions that can be used to improve the quality of biometric solution products are as follows:
  - a. Strengthening the technical capabilities of the Research and Development team .
  - b. Improvement of procedures and technical documentation for standardization of production results, component technical specification documents, and knowledge transfer procedures.
  - c. Research and Development team needs to learn about the product life cycle concept to increase their knowledge about product development.
  - d. Technical standardization of QC In needs to be made in detail, including the vendor selection procedure.
  - e. Prototype testing is maximized by looking for use cases in the field, either in the form of technical needs information, market conditions, or competitor products. Prototype testing also needs to see how the user experience is in using the product.

### Recommendations

Based on the conclusions above, several suggestions can be put forward as follows:

1. For companies to be able to apply the product life cycle concept and increase attention to Research and Development procedures in future product development.
2. For further researchers, they can use the Statistical Process Control and Root Cause Analysis methods to maintain the quality of products other than biometric solution products .

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