

Article

Analysis Quality Control of Creamer Product Packaging using DMAIC and RCA Methods

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Abstract: . This study aims to analyze the types of defects in the packaging process of creamer products and provide suggestions for improvements to the company based on the results of data processing that has been carried out with two methods to explain the material, energy, capital, and total losses. The method used involves calculating the sigma index with several tools such as pareto diagrams, fish bone diagrams to see the extent of the cause and effect, and failure tree diagrams to find out the root of the problem and in analyzing the root of the problem also involves the 5Whys method. The results of the analysis show that productivity is able to survive and be stable by needing to evaluate several factors that produce a high percentage in the analysis of product packaging process defects. Improvement proposals are addressed to the company for improvement and optimization of the results of the company.

Keywords: Six sigma; RCA; DMAIC; Fishbone; FTA

1. Introduction

PT. XYZ is a company engaged in the manufacturing of food and beverages (plant-based creamers), as an additional ingredient for food and beverages. Plant-based creamer comes in powder form, made from vegetable fats and other food additives. Creamer is also referred to as a milk substitute because it has a taste characteristic similar to milk, so the creamers produced by this company are categorized as plant-based or non-dairy creamers because their main raw material is hydrogenated vegetable oil, which is added with glucose syrup and other food additives. The product is packaged in a bag made of two types of materials: the inner part uses PET plastic in accordance with food standards, and the end is sealed with a heat sealing process. The outer part consists of a paper bag made from recycled paper and is sewing as the outer seal of the product.

Through the utilization of a product quality control system, a business has the potential to increase its product output. This is due to the fact that each product will meet the predetermined quality criteria, resulting in a reduction in the number of defective items produced during the manufacturing process [1]. To ensure the successful implementation of all companies according to the predetermined plan, it is very important to establish a strong Quality Control (QC) system [2]. At its core, the goal of this quality control is to carry out all operations to prevent or eliminate defective goods.

Quality improvement is a task carried out with the aim of enhancing overall quality. The process for quality improvement is related to enhancing the effectiveness and proficiency of procedures with the aim of increasing customer satisfaction. Quality assurance is a vital effort aimed at instilling confidence in customers that the products they receive align with their specific requirements. As a result, many tools are essential in the process of ensuring quality, including compliance with process standards, procedural

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manuals (which outline operational standards), work instructions, and other related documents concerning quality [3].

From the production side, in the last 6 months, 17,600 bags were produced, with each bag weighing 25kg. When calculated in kilograms, the total produced is 440,000 kg. In the last 6 months, with that level of production, there have been product defects amounting to 371 bags per month, equivalent to 9,275 kg, categorized by failure type with percentages of filling 20%, sealing 26%, sewing 30%, and coding 23% over the past six months. In analyzing the problem well in identifying defects, this study chose to apply the DMAIC concept from the Six Sigma method.

The method used to achieve continuous improvement to meet the objectives. DMAIC is executed systematically, relying on scientific principles and factual evidence [4]. The five stages in DMAIC are the fundamental approach of the Six Sigma method [3]. This method is a roadmap used for continuous improvement. DMAIC consists of define, measure, analyze, improve, and control [5]. And in this study, the Root Cause Analysis (RCA) method is also used as a quality control method for processes that can be well-controlled, because by using this method, it is possible to determine the number of defective products according to their types statistically and to identify the root causes of these defects [6].

Root Cause Analysis (RCA) is a method for problem-solving, aimed at identifying the root causes of an issue or an unexpected event. This method is used to help answer the questions of what happened on the packaging production line in the company, how it could happen, and why it could happen. The main objective is to identify factors expressed in terms of form, magnitude, location, and time due to certain habits, actions, and conditions that need to be changed to avoid unnecessary mistakes [7]. In this research case, this method is used to ensure that problems occurring at the initial stage are identified. The goal is to determine the source of the problem by using a series of appropriate actions, accompanied by suitable methods, to ensure the root cause of the problem [8].

Several previous studies referenced to support this research include Supriyadi's study [9], which discusses ways to improve productivity in flexible packaging production and reduce product defects using the Six Sigma method. Research by Ramadhan [10] discusses improvement proposals to minimize defects in the packaging of cement sacks by applying the Six Sigma method. Research by Sirine [11] on quality control in companies to reduce product defects ranging from 0.34% to 1%, where the company has to incur higher production costs and suffer losses by implementing DMAIC from the Six Sigma method. Research by Wibowo [7] on the root cause analysis of leftover material costs in construction projects, which range from 12.40% to 14.50%, using the Root Cause Analysis and Fault Tree Analysis methods.

In this study, there is a difference from previous research, namely by using two methods: the DMAIC concept from Six Sigma, which is used to analyze the causes of defects, and the RCA method with the Fault Tree Analysis (FTA) and 5 Whys concepts, which are used to find the root cause of the problem and provide improvement suggestions. It is hoped that this research can provide the company with an overview to reduce the product defects that occur. Previous research explains the theories used in the study, including definitions and formulas that will be used in the calculations of the Six Sigma and RCA methods. Previous research explains the theories used in the study, including definitions and formulas that will be used in the calculations of the Six Sigma and RCA methods.

Quality control is carried out to analyze whether the product meets expectations, taking corrective actions in the production process if there are discrepancies to ensure the best quality standards are maintained [3]. Quality becomes the main aspect that consumers highly consider when making the right decision to buy or not buy a product. With all their efforts, business actors strive to meet consumer needs by providing quality products [4]. Product quality is very important for every company to maintain its quality in order to compete in a tight business environment. Quality products are a key objective for any

business to maintain products that meet customer expectations, therefore companies need to engage in very intensive quality control activities [3]. Quality is one of the main parameters in a company to survive amidst the intense competition in the industry. The term quality carries many meanings and interpretations. Different individuals will interpret it differently. Not a few interpret that quality means the holistic characteristics and attributes of a product or service whose capabilities can satisfy needs, both explicitly stated and implied [5].

Defect is defined as a product that does not meet the company's specifications and can no longer proceed to the next stage. However, by incurring costs, time, and effort in the repair process, the product can be reprocessed through repair or refurbishment [6]. Research Objective: (1) To identify the causes of packaging defects in cream products at PT.XYZ (2) Provide improvement suggestions and identify the root causes of issues in the packaging process to minimize product defects.

2. Materials and Methods

This research activity was conducted for six months and implemented at PT XYZ. This research method uses an observation method where observations, records, and directly identifies research objects in order to obtain the required data, namely from the packaging process, inspection and defect data in the process and collecting data directly by analyzing worker behavior, tools and observing defective products and conducting direct interviews by means of verbal questions and answers with production supervisors, production staff, quality control staff, engineering, production operators and involving experts from outside the company, namely from CV. RGB with the resource person being the factory head assistant. This study refers to the application of the Six Sigma (DMAIC) and Root Cause Analysis (RCA) methods using problem-solving techniques with the Fault Tree Analysis (FTA) and 5Whys concepts.

1. Six Sigma (DMAIC)

Six Sigma is a comprehensive and adaptable framework that facilitates the achievement, assistance, and optimization of company operations [12]. Six Sigma has five stages, which are used to improve business performance. These stages include: goal setting (define), performance measurement (measure), data analysis (analyze), improvement (improve), and process control (control). During this process, it is important to verify and update problems or opportunities, processes, and customer needs at each step [13]. Define is the initial step that aims to identify and formulate existing problems. At this stage, the goals to be achieved are also determined. Aspects such as costs, benefits, and impacts on customers are important considerations in this stage. Some tools that are often used include Pareto charts, SIPOC diagrams (Suppliers, Input, Process, Output, and Customer), and relationship diagrams [14]. Measure is the second step in improving the quality of Six Sigma. There are three things that need to be done at this stage, namely: determining quality characteristics or also called CTQ (Control to Quality) which are directly related to the specific needs of consumers of a product, then developing a plan in collecting data through measurements in the output/outcome process, and finally measuring current performance to establish a basis for the starting point of implementing this method [4]. Analyze at this stage is done to find the root cause of the problem that occurs. The search for the root cause is done by analyzing the Pareto diagram to find out defects that must immediately receive special action and brainstorming together with related parties [15]. The improve stage is the fourth step in the DMAIC cycle, where creative ideas and solutions are developed and evaluated. After the problem is identified, measured, and analyzed, various potential solutions can be generated to overcome the problem. And the control stage is the last phase in the DMAIC method, where after the solutions are implemented, measurement steps continue to be taken to ensure the stability of improvement and predictability of the process [16]. In the Six Sigma methodology, the

evaluation of the performance of a process in a company is measured by the sigma level. When the sigma value is closer to six, the process performance is considered very good. The calculation of the sigma level is based on the use of Defects Per Million Opportunities (DPMO) for attribute data. The calculation of DPMO and sigma level for attribute data can be done by following the calculation steps below [16]:

- a. *Defect Per Unit (DPU)*

$$DPU = \frac{D}{U} \quad (1)$$

Source [16]

Where:

D = Number of defects or defects that occur in the production process

U = Number of units inspected

- b. *Defect Per Opportunity (DPO)*

$$DPO = \frac{D}{U \times OP} \quad (2)$$

Sumber [16]

Where:

OP (Opportunity) = Characteristics that have the potential to become defects.

- c. *Defect Per Million Opportunity (DPMO)*

$$DPMO = DPO \times 1.000.000 \quad (3)$$

Source [16] [17]

- d. Sigma level using Microsoft Excel assistance

$$= \text{NORMSINV} (1 - DPMO / 1.000.000) + 1,5 \quad (4)$$

Source [16]

- e. Classification based on sigma level

Table 1. *Level Sigma*

<i>Level Sigma</i>	<i>Defect Per Million Opportunity (DPMO)</i>	<i>Category</i>
6	3,4	<i>World Class</i>
5	233	
4	6.210	<i>Industry Average</i>
3	66.807	
2	308.538	<i>Not Competitive</i>
1	691.642	<i>Very Not Competitive</i>

Source [4]

In table 1 it can be observed that the higher the sigma level achieved, the better the performance of an industry's production. A value of 6 sigma is better than 4 sigma or 3 sigma. Six sigma is a tool used in quality control based on high discipline statistics and comprehensively by eliminating the main source of a problem through the (DMAIC) approach [18].

2. Control Chart

The P control chart, or better known as the P-Chart, is a tool used to control attributes in a process. This attribute is related to the properties of goods that are assessed based on the proportion of a certain number of events, for example goods are accepted or rejected in the production process [16]. After the data is collected at the define and measure stages, this third stage is to identify the root cause of quality problems. To do this, a P-Chart is often used to help determine whether or not a product exceeds the control limits [19]. The steps in compiling a P control chart (proportion of defective units) are as follows [20]:

- a. Calculating for each subgroup of the unit proportion value to determine the average percentage of defects, namely with the formula:

$$\bar{P} = \frac{np}{n} \quad (5)$$

Source [20]

Description:

np : Number of failures in subgroup

n : Number of checks in subgroup

b. Next, finding the center line can be done using the equation

$$CL = \bar{P} = \frac{\sum np}{\sum n} \quad (6)$$

Source [20]

Menghitung batas kendali atas atau *Upper Control Limit* (UCL)

Description:

\bar{P} = Average percentage of product damage

$\sum np$ = Total number of defective products

$\sum n$ = Total number of product inspections

c. Then calculate the upper control limit (UCL) and the lower control limit (LCL), as a reference for the limits of the graph line of the proportion that will be displayed on the P diagram.

Calculating the upper control limit (UCL)

$$UCL = \bar{P} + 3 \sqrt{\frac{\bar{P}(1-\bar{P})}{n}} \quad (7)$$

Source [20]

Description:

\bar{P} = Average percentage of product damage

n = Number of products

Calculating the lower control limit (LCL)

$$LCL = \bar{P} - 3 \sqrt{\frac{\bar{P}(1-\bar{P})}{n}} \quad (8)$$

Source [20]

Description:

\bar{P} = Average percentage of product damage

n = Number of products

3. Root Cause Analysis (RCA)

In problem solving, it is necessary to trace the root cause of the problem that causes a process flow to be hampered, so by applying the Root Cause Analysis (RCA) method. Root cause analysis, or RCA, is a structured investigation process to identify the true sources of problems in an event. The purpose of this analysis is to find out the root cause of the underlying problem. RCA is a method used to identify and fix root causes with the intention of designing and implementing solutions that can prevent recurring problems [6]. RCA is used in analysis to identify the main cause of a problem by focusing on identifying the most common or visible aspects, which are then linked to the root cause [7]. In this study, the use of this method was to ensure the problem occurred at an early stage. The goal is to determine the source of the problem by using a series of appropriate actions, accompanied by appropriate methods, to ensure the root cause of the problem [8]. The RCA technique in the problem solving process helps the team to recognize the cause-and-effect relationship of failure to eliminate or reduce the potential for future recurrence. One method that complements the RCA process is Fault Tree Analysis (FTA) which is often used for reliability analysis in critical systems [21]. A widely used technique for conducting deductive investigations of embedded facts. FTA is a precise systematic technique for assessing the probability of failure of various systems in a visual diagram called a fault tree, which allows for quantitative and qualitative assessment projects [22]. A fault tree [23]. Fault tree (FT) is a deductive graphical method used to identify potential causes of undesirable events, often referred to as top events (TE). The graphical representation of FTA is based on Boolean logic, which shows the logical relationship between various faults and their causes. Top events usually represent system failures that can result in safety hazards or economic losses. As a deductive method, the development of a fault tree begins by considering TE as the root of the tree and then, building the tree

down until the basic events (BEs) that cause the top event are known [23]. The entire process in this research can be seen from the research flow diagram in Figure 1 below:

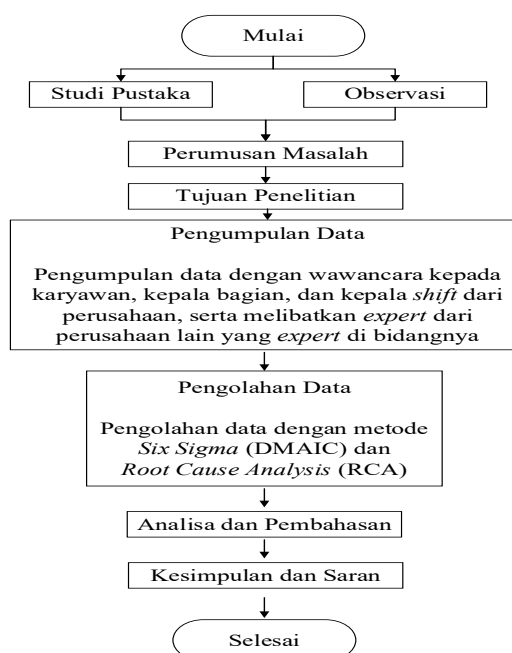


Figure 1: Research Flowchart

From Figure 1, it can be seen that this research was conducted directly in the field to be able to formulate problems and collect the necessary data, which was then processed using the Six Sigma method in the DMAIC concept by determining the CL, UCL and LCL values, then continued by finding the DPU, DPO and DPMO values by processing the data using Microsoft Excel to obtain results from the company's sigma level, which was then continued with the Root Cause Analysis (RCA) method to obtain an improvement plan to reduce defects that occur and finally draw conclusions from all the objectives of the research conducted.

3. Results

From the data that has been obtained, it is processed using the Six Sigma and Root Cause Analysis (RCA) methods as a method to analyze the sigma level and root causes of defects in the creamer product packaging process. Various defects that occur in packaged products.

1. Define Stage

PT. XYZ is a manufacturing industry company in the field of additional food that produces creamer from vegetable types or better known as non-dairy creamer. The creamer manufacturing process goes through several stages, including packaging. In this stage, several categories were found that refer to product defects, including filling that is less or more than the standard net weight of the product (filling), plastic packaging seals that are not completely closed (sealing), sewing results that are not in accordance (seawing), and print results of production codes that are unreadable or faded (coding).

1. Determining the CTQ (Critical to Quality) value

Table 2. CTQ (Critical to Quality)

No.	CTQ	Description	Impact
1.	Filling	The product is filled into the packaging beyond capacity or less than the standard net weight of the product.	1. The product does not pass the quality checker and is categorized as Not-Good Product (NGP).

2.	<i>Sealing</i>	The heat sealing is leaking, and is not completely closed.	2.	The product cannot be distributed to the market and consumers in general.
3.	<i>Seawing</i>	The condition of the stitching on the end of the product packaging is not neat and not in the correct position.	3.	3. Products that accidentally pass and go out to the consumer market have a 96% chance of being returned.
4.	<i>Coding</i>	The condition of the printed production code and product description is unreadable and faded.	4.	The company experiences a loss of time and material because it has to repeat the production process from the beginning, and the packaging materials used increase because the materials used cannot be reused.
			5.	Decreased production quality due to less than optimal process capabilities.

In the research conducted, the preparation of CTQ described in table 2 is based on the results of interviews and observations with the head of production, shift head, and packaging machine operator. In addition to internal parties, interviews were also conducted with sources from CV. RBG where the company is also engaged in the food sector and the company is also a consumer of one of the products similar to that produced by. The interview was conducted with the assistant head of production CV. RGB.

2. Table of product packaging defect data for the period July - December 2023

From table 3 product defect data, it can be seen that the product defects are as follows:

Table 3. Types and Number of Defects in the Packaging Process

Period	Product Defect Types			
	<i>Filling</i>	<i>Sealing</i>	<i>Seawing</i>	<i>Coding</i>
<i>July</i>	56	140	225	110
<i>August</i>	45	141	235	120
<i>September</i>	45	141	222	120
<i>October</i>	45	141	214	120
<i>November</i>	45	141	235	120
<i>December</i>	40	131	225	115
TOTAL	276	835	1.356	705

In table 3 above explains the product defect data, it can be seen that product defects in the form of seawing occupy the first position as the largest contributor of defects with a total of 1,356 bags, then product defects in the form of sealing occupy the second position as the largest contributor of defects with a total of 835 bags, then coding defects as many as 705 bags, and filling defects as many as 276 bags. From the total product defects of 3,172 bags in the data collection period of July - December 2023.

3. Create a Pareto diagram to describe product packaging defect data as an indication of the problem topic.

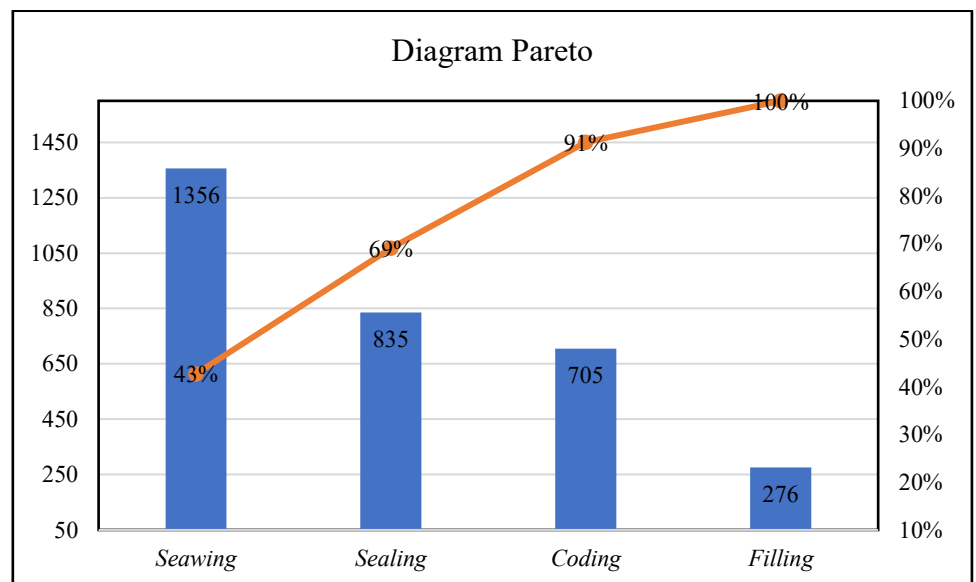


Figure 2. Pareto Diagram of Product Defects

In Figure 2, it can be identified that the cause of the problem can be solved by making improvements to the category of product defect types that have a percentage in the range approaching 80% [24]. In the Pareto diagram in Figure 2, it is known that of the 4 categories of product defect types, there are 3 categories that dominate, namely seawing, sealing, and coding defects, so that it is prioritized to immediately carry out a repair plan.

2. Measure Stage

The measure stage is carried out to determine the sigma level. Measurements are made on defect data from the packaging process for 6 months with a total of 184,708 bags of production units and 5,888 bags of defects were found. Then calculations are made to determine the number of defects per month (np) and the proportion of defects that occur by calculating the data obtained from the following equation:

1. Calculating the proportion of the average percentage of defects

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

The following is an example of calculating the average percentage of defects in the period of July:

$$\bar{P} = \frac{\text{Number of defects in July}}{\text{Number of production in July}}$$

$$\bar{P} = \frac{531 \text{ bag}}{32.000 \text{ bag}}$$

$$\bar{P} = 0,0166$$

2. Calculating the value of the center line or Center Line (CL)

The following is an example of calculating the center line in July with the known

$$\sum np = 186.000 \text{ and the total number of product defects } \sum n = 3.172$$

$$CL = \bar{P} = \frac{3.172}{186.000}$$

$$\bar{P} = 0,0171$$

3. Calculating the upper control limit or Upper Control Limit (UCL)

The following is an example of calculating the upper control limit (UCL) in July:

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

$$UCL = 0,0171 + 3 \sqrt{\frac{0,0171(1-0,0171)}{32.000}}$$

$$UCL = 0,0192$$

4. Calculating the Lower Control Limit (LCL)

The following is an example of calculating the lower control limit (LCL) for July:

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

$$LCL = 0,0171 - 3 \sqrt{\frac{0,0171(1-0,0171)}{32.000}}$$

$$LCL = 0,0149$$

To find out the calculation of the P, CL, UCL and LCL values during July to December, see the following table 4:

Table 4. Results of Measurement of P, CL, UCL and LCL Values

Month	Production Amount	Defect Amount	Proportion	UCL	CL	LCL
July	32.000	531	0,0166	0,0192	0,0171	0,0149
August	31.000	541	0,0175	0,0193	0,0171	0,0148
September	30.000	528	0,0176	0,0193	0,0171	0,0148
October	30.000	520	0,0173	0,0193	0,0171	0,0148
November	33.000	541	0,0164	0,0192	0,0171	0,0149
December	30.000	511	0,0170	0,0193	0,0171	0,0148
Total	186.000	3.172				

After the calculation in table 4, it can be seen that the average P value is 0.0171, the average CL value is 0.0171, the average UCL value is 0.0180 and the average LCL value is 0.0162. Based on data processing, a P control chart is then created, which can be seen in the following figure:

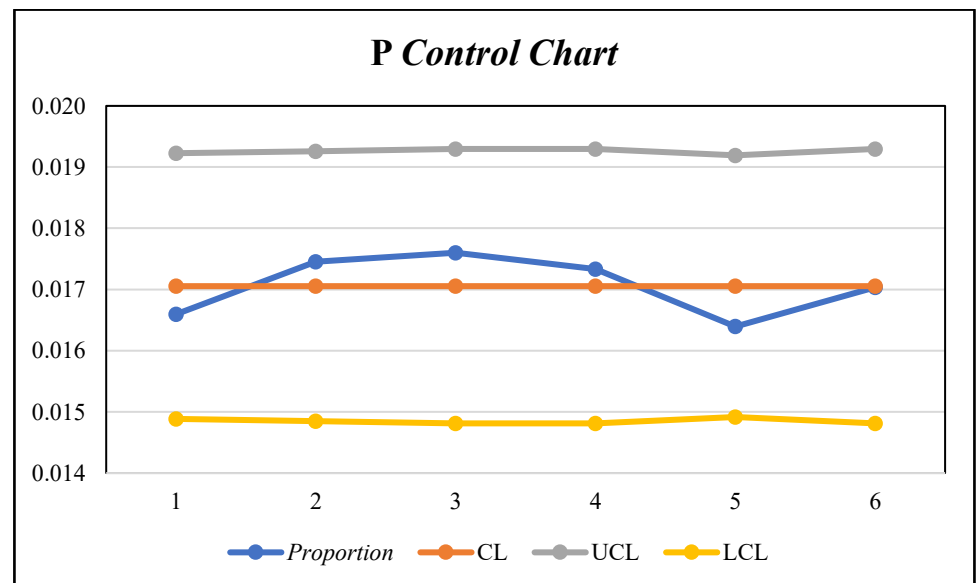


Figure 3. P Control Chart Graphic of Packaging Process

In Figure 3, the P control chart graphic of the packaging process can be said that to emphasize zero defects, improvements are needed to obtain production optimization. By emphasizing the priority of zero defects, the company will be able to achieve the target of increasing the sigma level for improvement. With this improvement, it is expected that the company's performance will increase and every line in the company will feel a good positive impact.

5. Calculation of DPU value

Table 5. Results of Calculation of DPU Packaging Process

Period	Production Unit	Defect	Opportunities	DPU
July	32.000	531	4	0,0166
August	31.000	541	4	0,0175
September	30.000	528	4	0,0176
October	30.000	520	4	0,0173
November	33.000	541	4	0,0164
December	30.000	511	4	0,0170

As seen in table 5, it provides the results of the calculation of the Defect Per Unit (DPU) value after the equation is carried out, the largest DPU value is found in September with a DPU value of 0.0176, while the lowest DPU value is found in November with a value of 0.0164.

6. Calculating Defect Per Opportunities (DPO)

To find out the DPO value during July to December, see the following table 6:

Table 6. Results of Calculating DPO Packaging Process

Period	Production Unit	Defect	Opportunities	DPU	DPO
July	32.000	531	4	0,0166	0,00415
August	31.000	541	4	0,0175	0,00436
September	30.000	528	4	0,0176	0,00440
October	30.000	520	4	0,0173	0,00433
November	33.000	541	4	0,0164	0,00410
December	30.000	511	4	0,0170	0,00426
Jumlah	186.000	3.172			

Table 6 shows the results of the calculation of the DPO value in the packaging process with the highest DPO value of 0.00440 in September with a production volume of 30,000 bags and a number of defects of 528 bags, while the smallest DPO value of 0.00410 was in November with a production volume of 33,000 bags and a number of defects of 541 bags.

7. Calculation of DPMO and Six Sigma Level

The DPMO value is converted into a sigma value using Microsoft Excel with the conversion calculation formula $DPMO \text{ Value} = \text{NORMSINV} ((1,000,000 - DPMO)/1,000,000) + 1.5$ [13]. Table 7 shows the calculation of the DPMO value and sigma level in the packaging process from July to December

Table 7. Results of Calculation of DPMO and Sigma Level of the Packaging Process

Period	Production Unit	Defect	Opportunities	DPU	DPO	DPMO	Level Sigma
July	32.000	531	4	0,0166	0,00415	4148,438	4,14
August	31.000	541	4	0,0175	0,00436	4362,903	4,12
September	30.000	528	4	0,0176	0,00440	4400,000	4,12
October	30.000	520	4	0,0173	0,00433	4333,333	4,12
November	33.000	541	4	0,0164	0,00410	4098,485	4,14
December	30.000	511	4	0,0170	0,00426	4258,333	4,13
Jumlah	186.000	3.172					

Based on the calculation of DPMO value and sigma level in table 7 of packaging quality control at PT XYZ in the report data from July to December, the production volume was 186,000 bags, then 3,172 bags of products were found to have defects. After obtaining the number of production results and defects in packaging for 6 periods, the DPMO calculation was carried out with an average DPMO value of 4266.915, which means that there are 4266.915 products that experience defects during the packaging process in one million production with an average sigma value of 4, then quality control can be said to be still not good because it is still far from the 6 sigma value which has a criterion of 3.4 DPMO. Because it is still far from the 6 sigma value, improvements to reduce the number of defects are needed so that the company is able to compete with world-class companies.

3. Analyze Stage

The problem analysis stage can be carried out after finding facts and data. By analyzing the main problem, analyzing the solutions that will be provided and analyzing the existing process capabilities [25]. The steps taken are pareto diagram analysis and fishbone diagram. Fishbone diagram cause-effect analysis of problems in product defects produced is carried out to help facilitate grouping causes and provide alternative solutions as improvement plans that can be carried out by applying the fishbone diagram as follows:

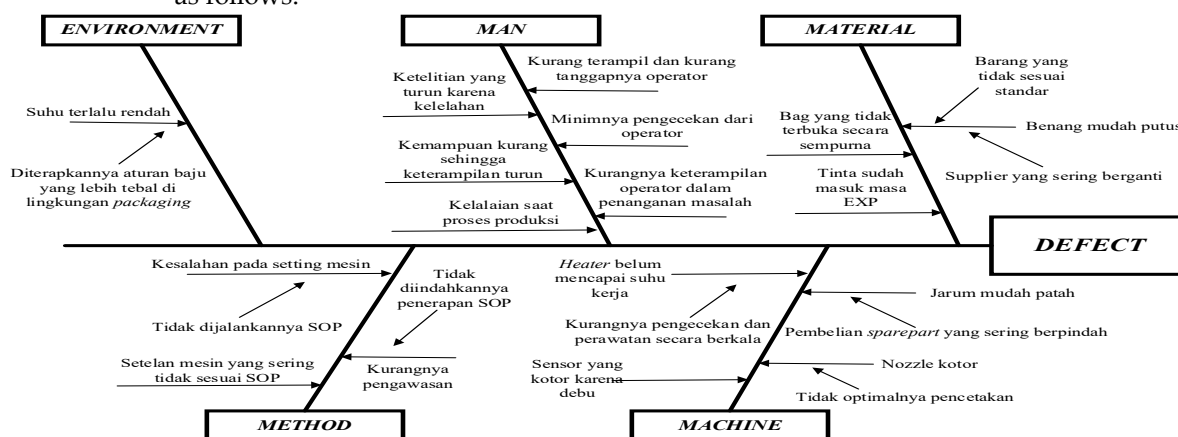


Figure 4. Fishbone Diagram of Product Packaging Defects

From Figure 4, the fishbone diagram of product sealing defects can be analyzed that the causes of defects are influenced by 5 main factors, namely material, machine, man, method, and environment. The material factor occurs because the thread is easily broken which is influenced by goods that do not meet standards, and suppliers who often change. Then there is a bag factor that does not open perfectly, and ink that has expired. In the machine factor, there is a dirty nozzle that affects the optimal coding print results. Then there is a needle that breaks easily because it does not meet standards. The heater that has not reached the working temperature, causing sealing failure, is influenced by low preventive maintenance. The sensor is dirty because of dust from the product which also affects the machine.

In the man factor, it is generally influenced by operator negligence and minimal supervision, this is because operators who have gone through training have considered standards trivial because of the lack of awareness of employee personnel, and the company must emphasize the company's commitment to rules and standards for the progress of the company. In the method factor, there is an error in the machine settings and in general, the company's standards are not respected by employees and the lack of punishment is applied.

4. Improve Stage

This stage is a stage carried out to provide improvement suggestions to reduce failures in the creamer product packaging process at PT. XYZ after the factors causing the problem are known through analysis using the Six Sigma method with the highest

percentage of defect types obtained, then using root cause analysis using the FTA method to find out what factors have the most influence on the defect.

5. Improve Stage

This stage is a stage carried out to provide improvement suggestions to reduce failures in the creamer product packaging process at PT. XYZ after the factors causing the problem are known through analysis using the Six Sigma method with the highest percentage of defect types obtained, then using root cause analysis using the FTA method to find out what factors have the most influence on the defect.

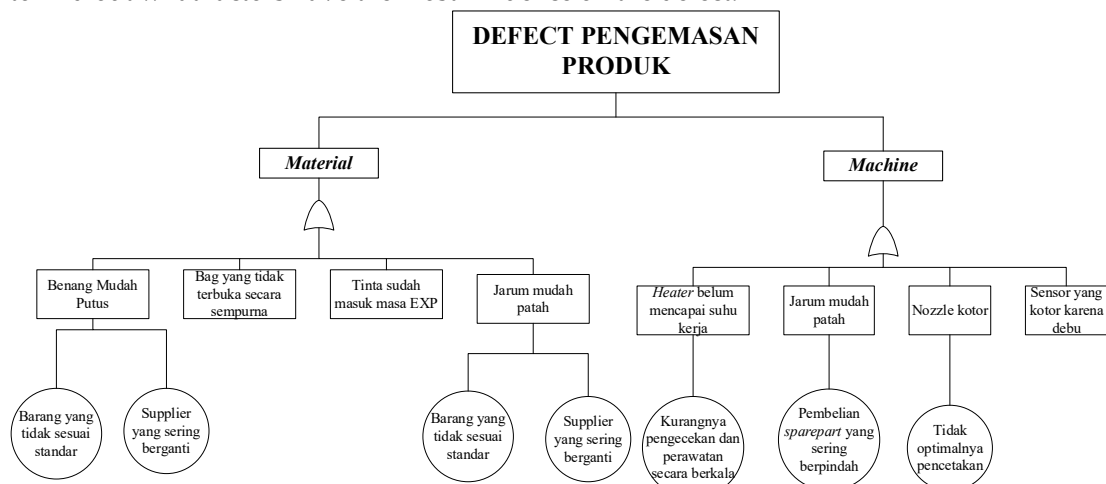


Figure 5: Fault Tree Analysis Diagram of Product Packaging Defects Machine Factors

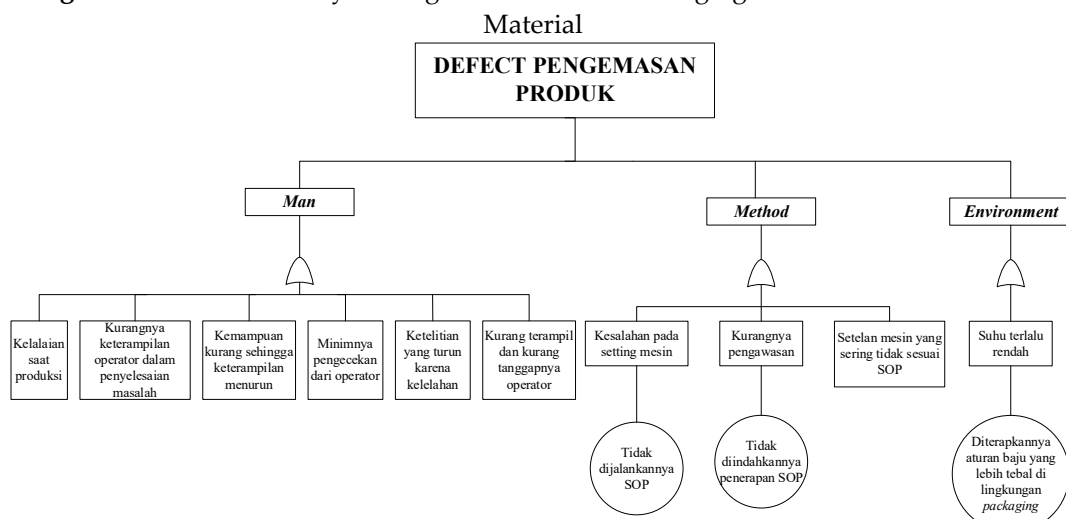


Figure 6: Fault Tree Analysis Diagram of Product Packaging Defects Man Method Environment Factors

Based on the fault tree analysis diagram in Figure 5 and Figure 6, it can be concluded that the proposed quality control plan in following up on the problem is considered quite necessary. The highest factor that causes the product to fail in the problem tree analysis above is the machine and material factor where periodic machine maintenance is the main point and procurement of materials through quality suppliers is also the main point, and there are three other factors that cause failure in the process including human labor does not understand the standards when operating the machine, methods that are not applied, and an environment that has a low temperature.

Table 8. 5 Why's Method Packaging Process

<i>Defect</i>	<i>Why 1</i>	<i>Why 2</i>	<i>Why 3</i>	<i>Why 4</i>	<i>Why 5</i>
<i>Man</i>	Operator is not careful	Rushing to work	Decreased focus due to fatigue	Focus on target results not quality	Operator power limitations
	Continue the process on products that are indicated as defective	Not paying attention to the condition of the product, whether it is good or bad	Not comparing with previous shift results	Lack of self-checking	No checks are done every 15 minutes
	Operator capabilities are still lacking	Insufficient operator experience	No improvement from the operator	Results of training that was not implemented	Ignoring standards because they feel they have completed training
	Heat sealer is not hot enough	No regular maintenance is performed	Maintenance schedule not yet available	Maintenance using vendors	Treatment is not from the company
<i>Machine</i>	<i>Setting after shift break is often constrained</i>	Needle holder that often shifts	<i>Needle materials are often different due to differences in suppliers of goods during procurement.</i>	<i>Needle brands that often change</i>	Broken needles slow down the process
	Use of ink that has expired	Lack of maintenance for coding	<i>Nozzle often gets stuck due to dried ink blockage</i>	Sensor covered in dust	Periodic replacement of spare parts for coding
<i>Environment</i>	Always low temperature	Low temperatures make workers more reluctant to move	Room temperature conditions for workers	Control room temperature and humidity that often changes	The thickness of clothing at work affects performance
<i>Method</i>	The application of production process methods has not been carried out in the field	Treatment in each division is different	Lack of understanding of the importance of standards	Lack of strict punishment for mistakes	Socialization is no longer carried out after the training period
<i>Material</i>	The quality of packaging materials often varies	<i>Suppliers of goods often change</i>	Items that arrive often do not meet standards	Supplier selection is tightened	Purchase and procurement of materials must refer to standards

Based on table 8 RCA using the 5 Why's method, the causes of defects in the creamer product packaging process are influenced by 5 factors, namely man, machine, method,

material and environment. The most dominant factor that occurs in human factors is because the machine operator is not careful, does not pay attention to the good and bad of the product, and checks the product periodically every 15 minutes to ensure the results are appropriate.

6. Control Stage

At the control stage in this study, only suggestions are provided for immediate corrective measures to be taken on the causes of defects. At this stage, all strategic steps are prepared and then implemented to reduce the level of defects. This improvement aims to provide high-quality output, a plan for improving the results of the causes of defects based on direct interviews with the head of production, production staff and quality control, and literature reviews from previous studies. The following improvement proposal plans were obtained:

1. Human Factors

- a. Provision of regular training, and providing continuous direction [9].
- b. Checking each process so that the results are always in accordance with company standards [10].
- c. Scheduling work hours with work shifts or adding break times to twice a day, in order to improve employee concentration and accuracy in working [10].

2. Machine Factors

- a. Periodic checks on all machines after use of production activities, recording in daily machine performance and making minutes [10].
- b. Improvement Providing a catalog related to machine specifications and how to operate each machine.
- c. Carrying out routine machine maintenance, not only when the machine is damaged (preventive maintenance) [15].

3. Method factors

Checks and preparation of minutes and notes are carried out on each taking of goods, maintenance, and purchases. In order to maintain control of each existing item and avoid the accumulation of expired goods [15].

4. Material factors

- a. Selection of suppliers with quality submissions must be a priority for the company. Because the influence of material quality affects the product.
- b. Coordination between departments for communication and similarity of perceptions regarding the quality that must be met for better performance of all department lines. [9]

5. Environmental factors

- a. Arrangement of air circulation in the bag material storage area so that it is not too humid, with a standard of 20o C and humidity of 35% - 60% to prevent damage to the material [10].
- b. Always remind and emphasize every time a briefing is carried out and equipped with posters as a reminder.
- c. Giving punishment to workers who are not responsible for following standards.

4. Discussion

The analysis of the defect in the packaging process at PT XYZ revealed several critical factors contributing to the product quality issues. The primary defects identified were related to filling, sealing, seaming, and coding. Each of these defects not only affects the product's physical appearance but also significantly impacts customer satisfaction and the company's overall reputation. The results from the Pareto diagram indicate that seaming defects are the most prevalent, followed by sealing and coding issues. These findings suggest that immediate corrective actions should focus on these three areas to minimize defects and improve overall product quality.

The application of Six Sigma methodology, including the calculation of DPU (Defects Per Unit), DPO (Defects Per Opportunity), DPMO (Defects Per Million Opportunities), and sigma levels, provided valuable insights into the process's current state. The sigma level of approximately 4 indicates that while the process is functioning, it is still far from

the ideal level of 6 sigma, which corresponds to only 3.4 defects per million opportunities. This highlights a substantial opportunity for improvement, particularly in optimizing the production process and reducing defects.

A closer examination using the Fishbone diagram revealed that the root causes of defects stemmed from multiple factors, including human error, machinery inefficiencies, material quality, and operational methods. The human factor, such as operator negligence and lack of awareness, was found to be the most significant contributor to defects. The machine factor, including inadequate maintenance and inconsistent settings, also played a key role in causing defects, particularly in sealing and coding processes. Furthermore, the quality of materials, especially packaging components and ink, was found to be inconsistent, adding to the defects encountered in production.

To address these issues, several improvement measures have been suggested. These include enhancing employee training programs to ensure operators are aware of the quality standards, implementing regular maintenance schedules for machinery, and strengthening supplier selection processes to ensure high-quality materials. Additionally, introducing stricter monitoring and control mechanisms at each stage of production will help in detecting defects early and reducing the chances of faulty products reaching the market.

Overall, the implementation of these improvements will not only enhance the company's sigma level but also improve customer satisfaction by reducing the frequency of product defects. Achieving a higher sigma level, closer to 6 sigma, will allow PT XYZ to meet international standards, reduce waste, and strengthen its competitive position in the market. Therefore, the focus should be on continuous improvement, monitoring, and adapting to changes in both internal processes and external factors such as material quality and workforce efficiency.

5. Conclusion

The results of the quality control data processing using the Six Sigma and RCA methods on the packaging process of cream products conducted at PT XYZ from July to December revealed at least four types of defects occurring in the packaging of cream products, namely sewing, sealing, coding, and filling defects, caused by five factors. Where the material and machine factors are the dominant causes of product packaging defects. In terms of material factors, it is due to the low quality of the thread, which easily breaks during the sewing process, caused by the frequent changes in material suppliers with varying quality. From the machine factor, where the heating process of the sealer machine is not optimal, causing frequent leaks during the sealing process. And the lack of preventive maintenance, which causes the packaging machine to operate sub optimally. On the human factor side, the main cause is the lack of employee awareness in applying standards and training outcomes. From the environmental factors and the low implementation of punishment and supervision methods, the answer lies in the consistently poor air circulation in the work environment, which causes employees to become quickly fatigued, leading to a tendency to be lazy and choose to leave the production room and not supervise.

With the provision of improvement proposals based on the root cause identification results in this research, it is hoped that they can serve as a reference for the company in the initial steps of the improvement process. In this study, it is identified that there are factors causing defects in product packaging, with the dominant factors originating from materials and machinery. To minimize the occurrence of repeated failures, the causes of these dominant factors can be addressed as soon as possible. In this study, there are still many shortcomings, such as insufficient observation between shifts because the research was conducted from morning to evening, while the night shift conditions have not been optimally addressed. The involvement of policymakers was minimal, so the sources of information were solely from the production side without any involvement from management. The limited access to primary data is restricted, so in this research, only field data can be accessed, and the company's information is closed off.

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