

# **Analysis Of Quality Control in Clothing Products Using the Six Sigma Method**

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## **Abstract**

This research is focused on collared and T-shirt products in the garment industry with various types of clothing, especially for the upper middle market segment. High-quality products that meet consumer needs are highly expected in today's competitive era. The results of observations of the products in this company found that there were many defects. Types of defects include dirty defects, holed, cut, and oblique defects. The method used to reduce defects is the Six Sigma method with fishbone diagram analysis, why-why analysis, and FMEA to improve product quality with the research objective of identifying the largest types of defects that occur in the production process, identifying factors that influence the biggest defects in the production process, providing suggestions for improvements using the application of six sigma with the DMAIC (Define, Measure, Analyze, Improve, Control) stages which aims to reduce defects in the production process. The DPMO value obtained was 13619.5 for collared shirts and 15376.3 for T-shirts with a sigma level value of 3.71 for collared shirts and 3.66 for T-shirts, which is still far from what was expected. Suggestions for improving quality are making Check sheets, providing training to operators, scheduling machine maintenance, and replacing equipment with more appropriate equipment.

## **Keywords**

Six Sigma, Fishbone Diagram, FMEA, Why-Why Analysis

## **1. Introduction**

The high volume of production demand often causes a company to ignore the quality of its products. With increasingly tight competition and high consumer demand, business actors must think more about and improve the quality of their products, starting from the initial manufacturing process until the goods are in the hands of consumers. The company is engaged in the garment industry with a variety of clothing models, especially for the upper middle market segment facilitated by automatic factory machines and supported by well-known textile suppliers with superior quality fabric quality. This company produces clothes for well-known brands. By collaborating with large companies, companies must provide the best quality products that have passed and passed the quality control process so that the quality of the products produced is always guaranteed and customers can feel satisfied.

Based on observations that have been made, in the clothing production process several types of product defects were found which were quite high, namely collared shirts at 5.4% of total production, and T-shirts at 4.6% of total production. Therefore, it is necessary to research to analyze the types of defects in the production process and the factors that cause these defects so that efforts can be made to reduce the number of defects during production. For this purpose, this research carried out an analysis of these defects with the aim of the research, namely identifying the largest types of defects that occur in the production process, identifying factors that influence the largest defects in the production process, providing suggestions for improvements that can be made to improve quality in the production process. The production process uses the application of Six Sigma with the DMAIC (Define, Measure, Analyze, Improve, Control) stages which aims to reduce defects in the production process.

## **2. Literature Review**

This study aims to reduce the total of defects, and increase the quality of the product with the Six Sigma method which uses a fishbone diagram, why-why analysis, and failure mode and effect analysis.

### **2.1 Six Sigma Method**

Six Sigma is a methodology used to enhance the quality of a product. It is a widely embraced and innovative approach in the realm of quality management, serving as an alternative in quality control principles. The Six Sigma method, also known as DMAIC, is an acronym for Define, Measure, Analyze, Improve, and Control.

## **2.2 Fishbone Diagram**

The fishbone diagram, also known as the Ishikawa diagram, is a tool utilized to identify the root causes of a problem by examining its various symptoms. It is part of the seven basic tools of quality and illustrates the cause-and-effect relationship of potential issues. The main problem is depicted at the head of the fishbone, with its causes branching off into sub-categories such as environment, workers, machines, and management. In the context of this research, the fishbone diagram will be employed to identify the primary causes of defects.

## **2.3 Why-why Analysis**

Why-Why analysis is a problem-solving technique that involves iteratively asking "why" to delve into the fundamental causes of an issue. While specific literature reviews on Why-Why analysis were not found, it is a commonly utilized tool in quality management and problem-solving methodologies such as Six Sigma. The process of conducting a literature review entails scrutinizing existing research to pinpoint knowledge gaps and establish a theoretical basis for one's work. Critical analysis is pivotal in comprehending research evidence, involving an assessment of its validity and relevance. Literature reviews can take various forms, each with its distinct purpose and methodology, such as narrative reviews, scoping reviews, or systematic reviews. The primary objective of a literature review is to ascertain the extent to which a body of knowledge reveals discernible trends or aggregates empirical findings related to a specific research question, thereby supporting evidence-based decision-making.

## **2.4 Failure Mode and Effect Analysis**

Failure Mode and Effect Analysis (FMEA) is a systematic model utilized to identify and prevent problems within a system. It involves discussions across different divisions in a company to analyze the causes of failure for components and subsystems in a process or product. FMEA employs criteria such as occurrence, detection, and severity to determine risk priority numbers (RPN) and risk score values (RSV), which are then used to determine actions for prioritized risks.

## **3. Methods**

Research was carried out with the aim of identifying the types and causes of defects in products. The research process begins with field and literature studies, then identifying problems that occur and then formulating the problem. Then collect data and analyse it in the Define stage, which involves creating a project charter, SIPOC diagram, and Critical To Quality. The next step is the Measure stage, which includes calculating the P control chart, process capability, and DPMO value. After that, it is analyzed at the Analyse stage using a fishbone diagram, why-why analysis method, and failure mode and effect analysis, then recommendations for improvements related to the causes of the problems that have been identified are proposed.

## **4. Data Collection**

Production data and product defects used in this research are data from March 2023 to August 2023 with two clothing models, namely T-shirts and collared shirts. Based on the data obtained, for the collared shirt model, it is known that the production quantity from March 2023 to August 2023 for the collared shirt product type is 40,420 pcs with a total product defect of 2,202 pcs or 5.4% of the total production. It is known that there are 551 dirty defects, 603 holed defects, 541 cut defects, and 507 oblique defects. Meanwhile, for the T-shirt model, it is known that the number of production from March 2023 to August 2023 for the T-shirt product type is 32,344 pcs with a total product defect of 1,492 pcs or 4.6% of the total production. It is known that there are 485 dirty defects, 508 holed defects, and 499 cut defects.

## **5. Results and Discussion**

On T-shirts, the defects that exist are dirty, holed and cut, while on collared shirts there are defects in dirty, holed, cut and oblique. The following is a table of accumulated defect data for collared shirts and T-shirt products which can be seen in Table 1 and Table 2 below.

Table 1. Accumulated Defect Data for Collared Shirt Products

No.	Defect Type	Number of Defects	Percentage (%)	Cumulative Percentage (%)
1	Holed	603	27.4	27.4
2	Dirty	551	25	52.4
3	Cuttetd	541	24.6	77
4	Oblique	507	23	100
	Total	2,202		

Based on the accumulation table above, the Pareto diagram for defects in collared shirts and T-shirts can be seen in Figure 1 and Figure 2 below.

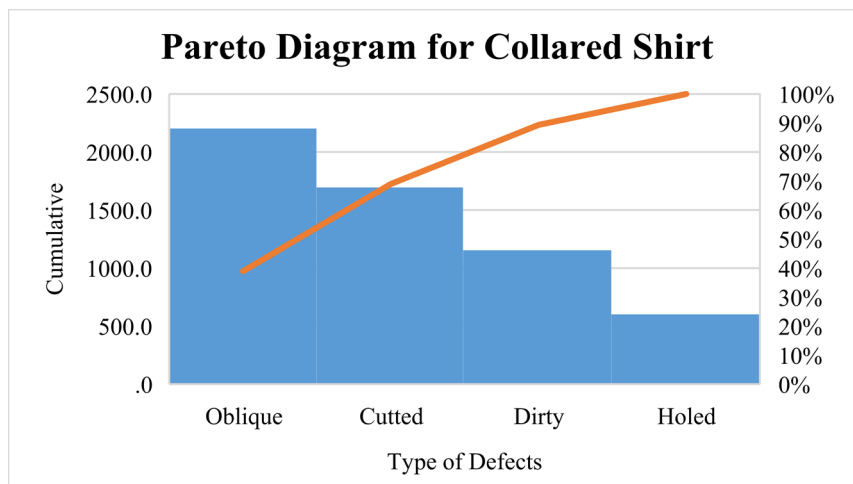


Figure 1. Pareto Defect Diagram for Collared Shirt Products

Table 2. Accumulated Defect Data for Oblong Clothing Products

No.	Defect Type	Number of Defects	Percentage (%)	Cumulative Percentage (%)
1	Holed	508	34	34
2	Cuttetd	499	33.4	100
3	Dirty	485	32.5	66.6
	Total	1,492		

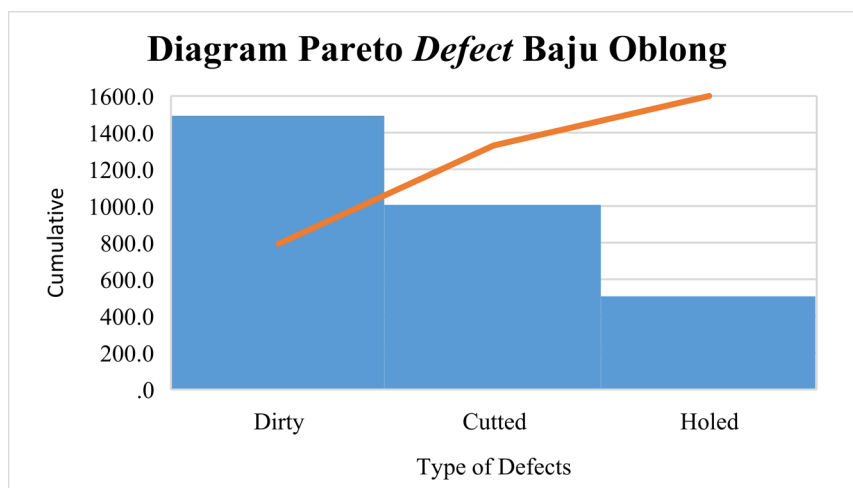


Figure 2. Pareto Defect Diagram for Oblong Clothing Products

### 5.1 Define Stage

The Define stage is the beginning of processing defect data in the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) method. In this step, product identification and production processes will be carried out. The "Define" will describe defect problems in the Project Charter, SIPOC diagram (Supplier, Input, Process Output, and Customer), and Critical to Quality (CTQ).

#### 5.1.1 Project Charter

*Project charters* are documents issued by the project initiator or sponsor that officially approve the continuation of the project and authorize the project manager to allocate resources to project activities. In the project charter, there is information such as the title of the project being worked on, the background behind the implementation of the project, a description of the project, the goals to be achieved, the scope of the project, the parties involved, the estimated duration of implementation, and so on. The following is Table 3 of project charters.

Table 3. Project Charter

<b>PROJECT CHARTER</b>					
<b>1. Business Case</b>	<b>3. Constraints &amp; Assumptions</b>		<b>4. Project Scope</b>		
This company produces T-shirts and collared shirts, where in the production process there are several factors that produce defects in the product. Defects from March to August 2023 reached 2,202 pcs on collared shirt products, and 1,492 pcs on T-shirt products. Therefore, analysis was carried out using the Six Sigma method to improve quality and reduce the number of defects.	<b>3.1 Constraints</b>		This research was conducted in the production division at This company located in North Jakarta. This company is a garment company that produces clothes. Researchers took collared shirts and T-shirts because these products were the most widely produced. The data studied is production data and defect data for six months from March-August 2023.		
	The limitation for students is that the data provided is data for six months with collared shirts and T-shirts.				
<b>2. Project Statement</b>	<b>3.2 Assumptions</b>		<b>5. Preliminary Plan</b>		
<b>2.1 Problem Statement</b>	The assumption of the research carried out is that the number of defects can be reduced.		Timeline	Start Date	End Date
There are defective products in the production process of collared shirts and T-shirts, such as dirty cloth, holey cloth, cut cloth, and slanted plackets. The total production of collared shirts was 40,420 pcs with defects of 2,202 pcs, and the total production of T-shirts was 32,344 pcs with defects of 1,492 pcs.			<i>Define</i>	29-09-2023	06-10-2023
<b>2.2 Opportunity Statement</b>	Make efforts to reduce the number of product defects using the Six Sigma method with the hope of reducing the number of defects.		<i>Measure</i>	09-10-2023	20-10-2023
			<i>Analyze</i>	23-10-2023	27-10-2023
			<i>Improve</i>	30-10-2023	10-11-2023
			<i>Controls</i>	13-11-2023	08-12-2023
			<b>6. Benefits</b>		
			This research can be useful for the company for improvements so that they can be applied to the company and it is hoped that it can reduce the number of product defects.		

PROJECT CHARTER			
2.3 Goal Statement	Signature		
The target of this research is reducing defects in products.	Leader	Production	Director
	Tharisyia	Niko	Jerome

### 5.1.2 SIPOC diagram

The SIPOC diagram describes information about Suppliers, Input, Processes, Output, and Customers involved in the production process can be seen in Figure 3 below.

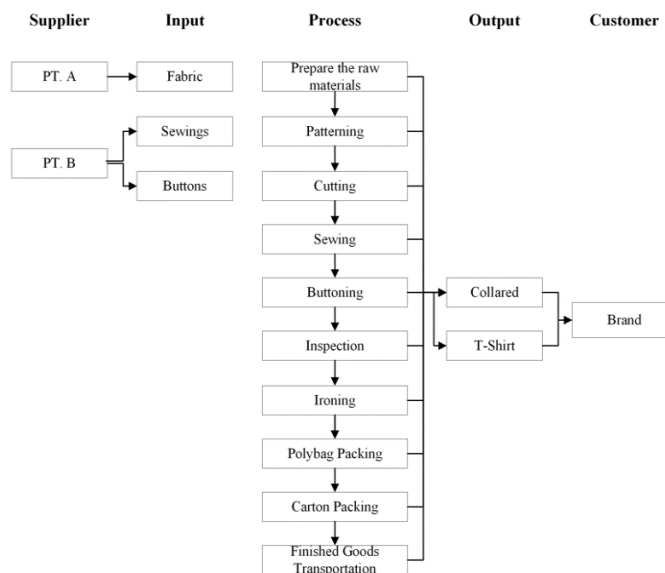


Figure 3. SIPOC diagram

### 5.1.3 Critical To Quality

*Critical to Quality* is the next step used to determine whether a process or product complies with standard specifications in order to meet consumer needs and demands. This step is used to determine the types of defects found in the production of collared shirts and T-shirts. *Critical to Quality* can be seen in Table 4 below.

Table 4. Critical to Quality (CTQ)

Factor	Voice of Customer	CTQ Description		CTQ Measurement	
		Standard	Items	Standard	Measuring instrument
Visual	There are no product defects	The condition of collared shirts and T-shirts is free from physical defects	Physical collared shirts and T-shirts	The condition of collared shirts and T-shirts is free from physical defects	Visual check
Design	Appropriate product design, clothing sizes and raw materials	Design, size and raw materials for clothes according to consumer demand	Physical collared shirts and T-shirts	Selection of fabric for raw materials and measurements in the patterning process	Visual check

### 5.2 Measure Stage

The next stage is measuring. The data that has been obtained at the defined stage is then measured to determine the process capability to take corrective action that can be implemented using several tools, namely P control charts, DPMO, and process capabilities can be seen in Figure 4 and Figure 5 below.

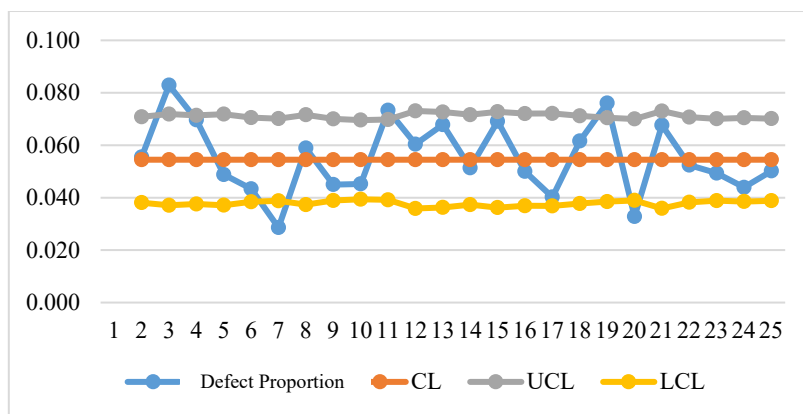


Figure 4. Control Map P for Collared Third

Based on the control chart p above, it can be concluded that there is still data that is outside the control limits or is still not good, namely on March 17 2023, April 14 2023, May 12 2023, July 14 2023, July 21 2023. This means that the number of defects in production still needs to be there are improvements to improve the quality.

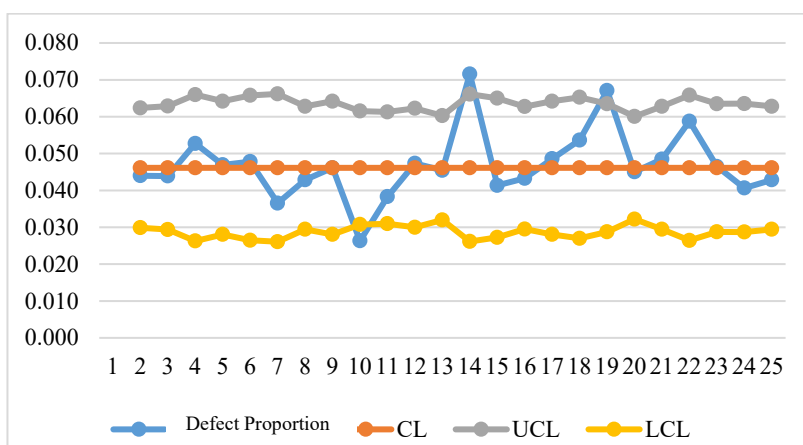


Figure 5. P Control Map for T-Shirt

Based on the p control chart above, it can be concluded that there is still data that is outside the control limits or is still not good, namely on May 5 2023, June 9 2023, July 14 2023. This means that the number of defects in production still needs improvement to improve quality.

Next, we obtained a calculation of the defect proportion capability, resulting in the production of collared shirts with a Cp of 1.21 and a Cpk of 0.53. Meanwhile, in the production of T-shirts, the Cp is 1.20 and the Cpk is 0.56, so both products still need improvement proposals to increase quality because they do not meet the good Cp values, namely  $<1.33$  and  $Cpk < 1$ . Next, the DPMO and Sigma values will be calculated. Based on the calculations that have been carried out, the DPMO value obtained for collared shirts is 13619.5 or it can be said that there are 13619.5 defects in 1,000,000 possibilities. Next, the DPMO value is converted into a sigma value, namely 3.71. For T-shirts, based on the calculations that have been carried out, the DPMO value obtained is 11532.3 or it can be said that there are 11532.3 defects in 1,000,000 possibilities. Next, the DPMO value is converted into a sigma value, namely 3.77.

### 5.3 Analyze Stage

After the measurement stage, the next stage is the analysis stage. At this stage, the aim is to detect problems by determining how to close the performance gap between the current system or process and the expected results. At this stage, an analysis will be carried out to explore the factors that cause defects. This is done using fishbone diagrams and FMEA (Failure Mode and Effect Analysis).

### 5.3.1 Fishbone Diagram

A fishbone diagram is a tool used to identify root causes or factors that contribute to a particular problem or effect. There are factors in this diagram, namely 6M or People, Machines, Methods, Materials, Measurements, and Environment for further analysis to be carried out to analyze the impact and relationship between these factors. The following is a fishbone diagram for collared shirt products in the table below based on discussions with the head of production. Fishbone diagram of collared and T-shirt can be seen in Figure 6 below.

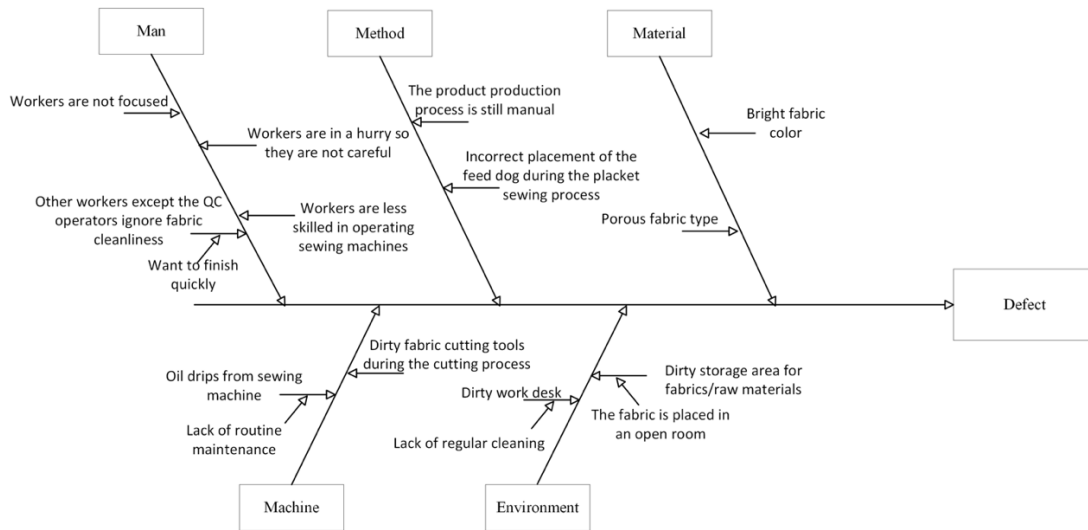


Figure 6. Fishbone diagram of collared and T-shirt types

### 5.3.2 Why-Why Analysis

Why-Why Analysis is a simple investigative method used to identify the root cause of a problem or undesirable event. The focus is to continually ask "why" sequentially until reaching the fundamental root cause. The following is a why-why analysis of collared shirt products in the table below based on discussions with the head of production. Why-Why Analysis can be seen in Table 5 below.

Table 5. Why-Why Analysis

No.	Defect	Why 1	Why 2	Why 3	Why 4
1	Dirty	The number of dirty fabric defects in the form of dust stains during the inspection process	Defects are not realized during the receipt and preparation of raw materials, or during the production process	Lack of quality inspections when receiving fabric raw materials and lack of cleanliness of the production environment during the production process	Fabric checks during the process of receiving and preparing raw materials are only carried out randomly or not thoroughly and for the cleanliness of the production environment we only rely on three cleaning staff for three floors of the building.
2	Holed	The foot pressure on the sewing machine is too strong	Employees who operate sewing machines are less skilled	Employees do not understand sewing machine features	Employees are not given training regarding the use and features of sewing machines
3	Cutted	The fabric was cut by employees when finishing the sewing process	The scissors provided cannot reach small parts of the seams and remnants of material that need to be cut	Scissors are too big	The type of scissors used are large fabric scissors
4	Oblique	The fabric cannot be moved or is stuck due to improper placement of the feed dog	There is damage to the sewing machine feed dog	Lack of routine sewing machine maintenance	There is no scheduling of sewing machine maintenance

### 5.3.3 Failure Mode and Effect Analysis

FMEA (Failure Mode and Effect Analysis) is a systematic function that functions to identify the failure mode when a failure occurs. Assessments are carried out on the level of damage (severity), possibility of occurrence, and detection. The following is a why-why analysis of collared shirt products in the table below based on discussions with the director, head of production, and production employees. FMEA Analysis can be seen in Table 6 and Table 7 below.



Table 6. FMEA Analysis of Collared Shirt Products

No.	Potential Failure Mode	Potential Failure Effect	S	Potential Failure Cause	O	Current Process Control	D	RPN	Rank	Action Recommended
1	Dirty	There are stains on the fabric	5	Lack of quality inspection upon receipt of fabric raw materials	7	Random fabric checking upon receipt of fabric raw materials	8	280	2	Increased inspections upon receipt of fabric, fabric is checked thoroughly and recorded using a check sheet
				Lack of cleanliness of the production environment	7	Cleaning dirty production environments	5	175	3	Improve the cleanliness of the production environment by establishing written regulations regarding the cleanliness of the production environment
2	Holed	There are holes in the fabric	7	The pressure of the sewing machine foot is too strong	9	Sewing operators are taught how to use sewing machines by follow operators	5	315	1	Provide training on the use of sewing machines
3	Cutted	There is a tear defect in the fabric	7	The scissors used to cut the remaining material are too big	6	Carefully cut off the remaining ingredients	4	168	4	Replace large fabric scissors with claw thread scissors to make cutting easier in harder to reach areas
4	Oblique	The stitching in the middle of the shirt is not precise	4	Incorrect placement of the feed dog due to the feed dog getting stuck	4	Checking the sewing machine and changing the oil	6	96	5	Make a sewing machine maintenance schedule every 25 dozen.

Table 7. FMEA analysis of T-shirt products

No.	Potential Failure Mode	Potential Failure Effect	S	Potential Failure Cause	O	Current Process Control	D	RPN	Rank	Action Recommended
1	Dirty	There are stains on the fabric	5	Lack of quality inspection upon receipt of fabric raw materials	7	Random fabric checking upon receipt of fabric raw materials	8	280	2	Increased inspections upon receipt of fabric, fabric is checked thoroughly and recorded using a check sheet
				Lack of cleanliness of the production environment	7	Cleaning dirty production environments	5	175	3	Improve the cleanliness of the production environment by establishing written regulations regarding the cleanliness of the production environment
2	Holed	There are holes in the fabric	7	The pressure of the sewing machine foot is too strong	9	Sewing operators are taught how to use sewing machines by fellow operators	5	315	1	Provide training on the use of sewing machines
3	Cutted	There is a tear defect in the fabric	7	The scissors used to cut the remaining material are too big	6	Carefully cut off the remaining ingredients	4	168	4	Replace large fabric scissors with claw thread scissors to make cutting easier in harder to reach areas
4	Oblique	The stitching in the middle of the shirt is not precise	4	Incorrect placement of the feed dog due to the feed dog getting stuck	4	Checking the sewing machine and changing the oil	6	96	5	Make a sewing machine maintenance schedule every 25 dozen.

Based on the results of analysis using the FMEA method, it is known that defects in the fabric with holes for both clothing models have the highest level. Next, recommendations for improvement are given regarding each defect at the improve stage.

### 5.4 Improve Stages

The improvement stage is carried out to provide solutions to problems that cause defects in the product. In this research, the proposed improvements are proposed by considering the results of the fishbone diagram, why-why analysis, and FMEA, namely as follows:

1. Creation of check sheets for follow-up inspections.
2. Provide training on the use of sewing machines.
3. Schedule sewing machine maintenance every 25 dozen.
4. Create new regulations in writing regarding the cleanliness of the production environment.
5. Adding large fabric scissors with claw thread scissors to make it easier to cut parts that are more difficult to reach during the sewing process.

With this recommendation, it is hoped that the company can improve quality control and reduce the number of defects.

### 5.5 Control Stages

The control stage is the final stage in the Six Sigma method. At this stage, a double check is carried out regarding the proposals that have been given to the company by comparing the results of observations on product defects before and after implementing the proposed improvements. The comparisons made were on control charts, DPMO calculations, and the company's sigma value after implementation for 4 weeks. Based on production data and product defects for collared shirts and T-shirts after implementation, a control chart was obtained. The P control chart can be seen in Figure 7 and Figure 8.

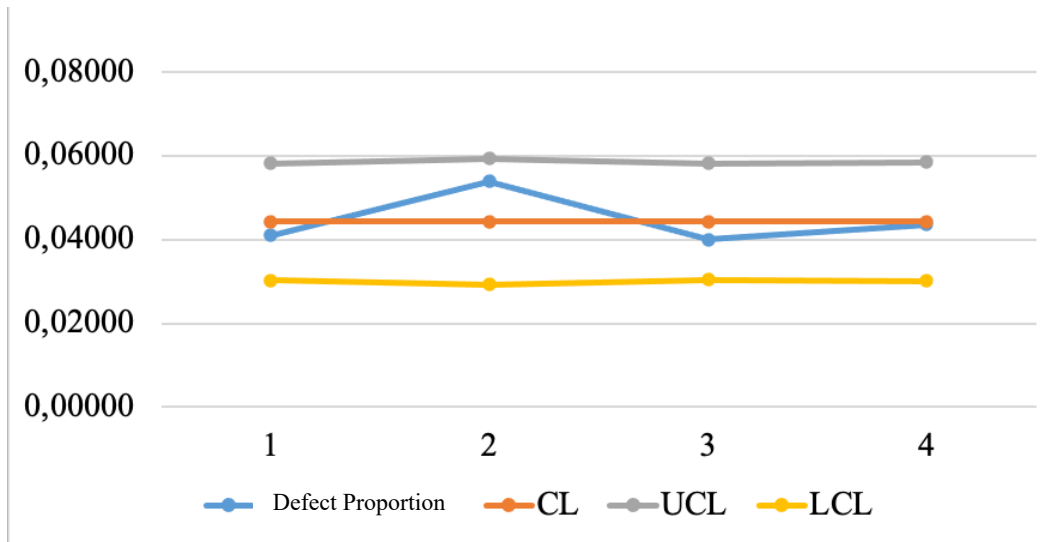


Figure 7. P Control Map for Collared Shirts After Implementation

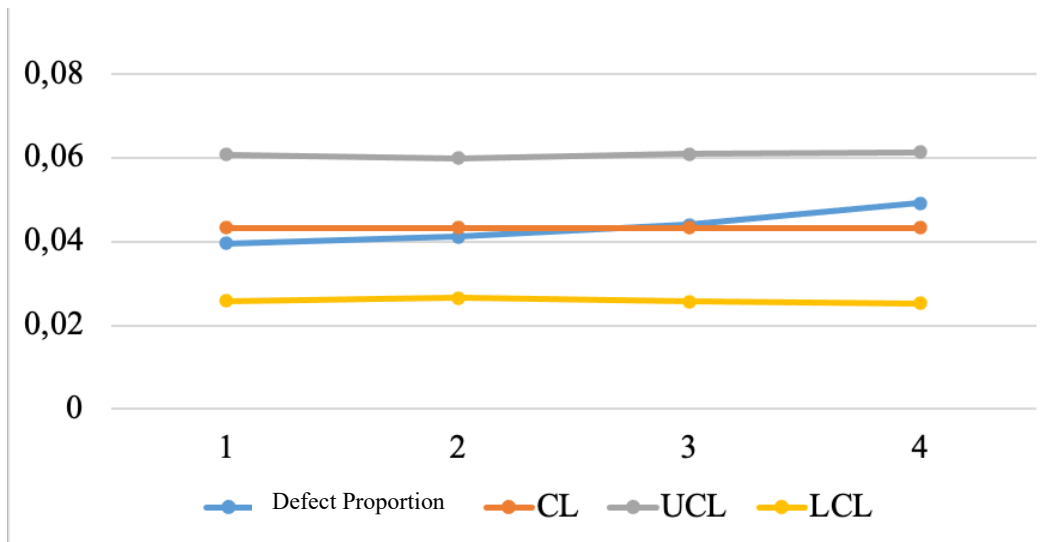


Figure 8. P Control Map for T-Shirts After Implementation

This is a comparison between the percentage of defects, DPMO value, process capability, and sigma level, before and after implementation which can be seen in Table 8 and 9 below.

Table 8. Comparison of Process Performance Levels Before and After Implementation of Collared Shirt Products

Criteria	Before Implementation	After Implementation
Percentage	5.4%	5.1%
Cp	1.21	1.22
Cpk	0.534	0.545
DPMO	13619	12965
Sigma Levels	3.71	3.73

Table 9. Comparison of Process Performance Levels Before and After Implementation of T-shirt Products

Criteria	Before Implementation	After Implementation
Percentage	4.6%	4.3%
Cp	1.20	1.21
Cpk	0.561	0.572
DPMO	15376	14368
Sigma Levels	3.66	3.69

## 6. Conclusion

Based on the results of the research that has been carried out, several conclusions can be drawn as follows:

1. Processed research data, it can be seen that the types of defects found in the production of collared shirts are dirty fabric, holey fabric, cut fabric and slanted plackets. Meanwhile, in the production of T-shirts, namely dirty cloth, holey cloth, cut cloth
2. Holed defect in collared shirts and T-shirts is the type of defect with the highest RPN value.
3. Corrective action plan to reduce *defects* in production, namely making check sheets for follow-up inspections, providing training on the use of sewing machines with people who are experts in the field, scheduling sewing machine maintenance every 25 dozens of productions, making written regulations regarding the cleanliness of the production environment, adding large fabric scissors with thread scissors claws to make it easier to cut parts that are more difficult to reach during the sewing process.
4. The percentage of defects in collared shirt products decreased from 5.4% to 5.1%. Meanwhile, T-shirt products fell from 4.6% to 4.3%.
5. The sigma level for collared shirt defects increased from 3.71 to 3.73. Meanwhile, T-shirt defects increased from 3.66 to 3.69.

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## Biography

**Tharisya Sanrio Putri** is a student of Tarumanagara University's industrial engineering study program, she was born in Jakarta on June 2002. She was active in student organization activities for two periods at faculty level, in the first

year she served as a member of research and development commission, and in the second period she served as chairman of research and development commission. The work programs she chaired include Comparative Studies with Indonesian University, Social event for charity events to orphanages, and also activities to welcome new members to the organization. He was also active as a writer for a community service journal with lecturers for one year.

**Ahmad** born in West Nusa Tenggara, November 1, 1970, is a student in the Transportation Management Doctoral program. He is also currently a lecturer in the Industrial Engineering Study program at Tarumanagara University. He teaches the areas of expertise in Operation Research, Factory Design and Industrial Modeling & Simulation. This 11th of 12 children is a postgraduate graduate of Masters in Product Design, University of Indonesia. He spent his undergraduate degree in the student city of Jogjakarta. Apart from being a Permanent Lecturer, he is also on the Board of Trustees of a foundation, Member of the Central ISTMI Management (Industrial Management Engineering Association), and Member of PEI (Indonesian Ergonomics Association). He is also active in research and provides product design and entrepreneurship training workshops. He also writes for journals or research proceedings and services in journals including ISIEM, TICATI, SNMI, SNTS, SERINA, Bhaktimas, and JITI.

**Mohammad Agung Saryatmo** is a full-time lecturer at Universitas Tarumanagara's Department of Industrial Engineering. He holds a Bachelor of Engineering in Industrial Engineering from Universitas Gadjah Mada in Indonesia and a Master of Management from Universitas Diponegoro in Indonesia. He also holds a PhD from Asian Institute of Technology, Thailand. His research interests are in the areas of digital supply chain management, quality management, strategic human resources management and service quality.