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Application of Lean Six Sigma, FMEA and Fuzzy to Improve Garment Product Quality (Case Study: Jhono Garment, West Jakarta)

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Abstrak

Jhono Garment memproduksi berbagai jenis pakaian, termasuk kaos, polo, pakaian tidur, pakaian anak, pakaian olahraga, dan lain-lain dengan sistem made by order (produksi berdasarkan pesanan). Permasalahan yang sering terjadi dalam proses produksinya adalah masih ditemukannya cacat pada produk, yang menimbulkan kerugian biaya dan waktu. Penelitian ini bertujuan untuk mengetahui tingkat cacat dan nilai sigma dari produk Jhono Garment, mengidentifikasi faktor pemborosan yang harus dieliminasi terlebih dahulu, menemukan faktor penyebab cacat produk, serta memberikan rekomendasi perbaikan terhadap penyebab cacat tersebut. Pengumpulan data dilakukan dengan menggunakan data primer dan sekunder, yaitu data produksi periode November 2022 hingga April 2023 serta data proses produksi. Metode yang digunakan dalam penelitian ini adalah Lean Six Sigma, FMEA, dan fuzzy. Hasil penelitian menunjukkan bahwa produk kaos Jhono Garment memiliki nilai sigma sebesar 4,006. Faktor pemborosan yang harus dieliminasi terlebih dahulu adalah cacat produk. Faktor penyebab cacat di Jhono Garment terdiri atas lima aspek, yaitu manusia, mesin, material, metode, dan lingkungan. Rekomendasi perbaikan untuk mengurangi pemborosan akibat cacat adalah dengan membuat cetakan lipatan pada proses pelipatan produk.

Kata kunci: *fuzzy, FMEA, Lean Six Sigma, rekayasa kualitas*

Abstract

Jhono Garment produces various kinds of clothing including t-shirts, polo, nightwear, children's clothes, sportswear, and others with a made by order system. The problem that is often experienced by this Garment is that there are still defects or defects in the product in the production process that cause cost and time losses. This study aims to determine the level of defects and sigma values of products produced by Jhono Garment, find out what waste factors must be eliminated first, find out the factors that cause product defects in Jhono Garment, provide recommendations for improvements to the causes of defects in Jhono Garment products. Data collection in this study is using primary and secondary data, namely production data from November 2022 to April 2023 and production process data. The methods used are lean six sigma, FMEA and fuzzy. The results showed that the sigma value of the Jhono Garment product is a T-shirt clothing product with a sigma value of 4.006. The waste factor that must be eliminated first is waste defects. The factors causing defects in Jhono Garment consist of 5 factors, namely humans, machines, materials, methods, and the environment. The recommendation for improvement of waste defects is to make folding molds in the product folding process.

Keywords*: fuzzy, FMEA, Lean Six Sigma, quality engineering*

1. Introduction

Fashion is valued not only as a clothing industry which is a basic human need. More than that, fashion shows a person's lifestyle in appearance and becomes part of self-identity and group (Mustikarani &; Irwansyah, 2019). The fashion industry is determined by consumer purchasing power (consumer spending) which is strongly influenced by the brand of the product (Hadijah, 2014). For this reason, every fashion or clothing industry business actor must have good quality to be the choice of consumers and be able to compete with competitors.

Competition in the fashion industry in Indonesia itself is quite tight, plus the rise of second-hand clothing (thrift) coming in from abroad. According to the Minister of Cooperatives and SMEs, Teten Masduki, in a joint press conference with the Ministry of Trade, he revealed that importing used clothing could disrupt the local market because it is certain that local products cannot compete (Kemendag, 2023). This imported clothing thrifting will also harm textile SME producers, 80% of clothing manufacturers in Indonesia are dominated by small and micro industries, while second-hand clothing imports have so far cut their market share by 12-15% (Wahyudi, 2023).

Likewise, data from the DataIndustri Research shows that the growth of the fashion industry shows an

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upward trend from 2015-2019 the growth of the apparel industry continued to grow, in 2020 it decreased due to the Covid-19 pandemic (DataIndustri Research, 2023). The years 2021-2022 have increased again along with the end of the pandemic and are predicted to continue to increase in the following years. Therefore, every apparel industry in Indonesia must be prepared to face this increase which will make competition tighter. One of the things that can be prepared to face this competition is by improving the quality and quality of clothing products made (Nasution &; Azhar, 2020).

Quality is one of the important criteria considered by consumers in the selection of a product. A product is said to have high quality if it can meet the specifications desired by consumers without the slightest defect (Putri &; Alfareza, 2019). One way to minimize defects in these products is by means of quality control. Quality control is an effort that helps companies to produce products that are in accordance with the quality standards set by the company (Haryono & Sumiati, 2023). This quality control is expected to prevent and minimize the number of defective products so as not to cause losses to the company. With quality control, companies can find out what is hampering the production process and immediately make improvements so that the company's performance continues to improve. Thus, quality control must be carried out by every company to maintain the quality of the product itself and also maintain the company's reputation (Andriani et al., 2019).

One method that can be used by companies in quality control efforts is lean six sigma which is a combination of lean manufacturing methods and six sigma methods. Lean manufacturing is a systematic approach by making continuous efforts to eliminate waste and increase value added from products where these products are in the form of goods or services that aim to provide value to customers (Hasibuan & Desrianty, 2022). Meanwhile, six sigma is a structured methodology to improve processes focused on reducing process variations (process variants) while reducing defects (products/services that do not match specifications) by using statistics and intensive problem-solving tools (Ikhsan &; Yuniati, 2022).The way lean six sigma works is to use the stages of define, measure, analyze and improve (Hasibuan & Desrianty, 2022), then both methods are integrated with the fuzzy method to get better priority of corrective actions.

The fuzzy method is a precise way to define an input space into an output space (Ellianto et al., 2017). Fuzzy logic is a logic that has a vagueness or vagueness value between right or wrong. In fuzzy logic theory a value can be true or false simultaneously. But how much truth and error depends on the weight of the membership it has (Admirani, 2018).

Literature review states that six sigma contributes to offering new measurement methods in achieving satisfaction and quality for textile and textile product industries (Kurnia et al., 2021). Implementation of six sigma in the textile product or garment industry has been carried out quite frequently in recent years. There are six sigma implementation for jersey production quality control (Jasmine et al., 2024) and six sigma implementation to control weaving fabric production defects (Nugraha et al., 2024). However, this implementation has not considered waste elimination steps with lean six sigma (Fibriani et al., 2024) and combined with application of Fuzzy FMEA to obtain better priority recommendations (Basuki et al., 2023). These studies have limitations where the recommendations produced cannot be fully implemented until the control stage. Therefore, this study aims to implement lean sigma and Fuzzy FMEA until the control stage.

2. Research Methods

2.1. Define Phase

The determination of what processes to evaluate is determined at this stage. Process considerations to be evaluated are significant process stages or Critical to Quality (CTQ) that affect profit creation for the company, but in that process many product failures and defects are found that will affect the next stage of the process.

Furthermore, make an Operational Process Chart (OPC), which is a work map arranged based on the sequence of production process activities. The time and process in which each activity occurs are known.

2.2. Measure Phase

At this stage, the 3 types of products studied are measured at the level or level of production defects for each product. The first stage is to look at the control chart of the three types of products to see whether some are out of control limits or not, then identify seven wastes to find out the most dominant types of waste and to find out when value added and non-value added are used value stream mapping. The next stage is the calculation of the sigma value of the selected product with the following formula:

$$DPMO = \frac{Number\ of\ Defective\ Products}{(Number\ of\ Products\ InspectedxCTQ)} \times 1{,}000{,}000 \quad (1)$$

$$Sigma\ Score = NORMSINV\left(\frac{1000000 - Total\ DPMO}{1000000}\right) + 1.5 \quad (2)$$

2.3. Analyze Phase

This stage will analyze the cause of the error using several tools including Fishbone Diagram or fishbone diagram is a QC tool used to identify and show the

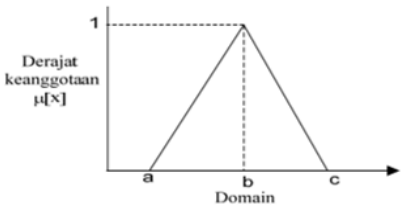
relationship between cause and effect in order to find the root cause of a problem, often called a cause and effect diagram that shows cause and effect factors on quality (Hermawan & Safariyani, 2024).

It further uses FMEA's Failure Mode Effect Analysis to assist businesses in identifying and eliminating weak points by reviewing the causes and effects of components, assemblies, and subsystems. It helps Six sigma practitioners detect and fix problems before they happen, resulting in improved quality of their processes, services, and products (Haq et al., 2021) at this stage, the FMEA process will be carried out, there are 3 main stages, including severity, occurrence, and detection.

The next step, using Fuzzy, is a good way to map an input space into an output space. Traditional systems are designed to control a single output coming from several unrelated inputs. Because of this independence, the addition of new inputs complicates the control process and requires a recalculation of all functions.

In contrast, the addition of new inputs to fuzzy systems, i.e. systems that work based on fuzzy logic principles, only requires the addition of new membership functions and the rules associated with them (Shega et al., 2012). At this stage the values of FMEA, namely severity, occurrence, detection will be processed using the fuzzy method by determining the degree of membership. The degree of membership of a variable x is denoted by the symbol μ(x) (Widianti & Firdaus, 2016). Commonly used functions include:

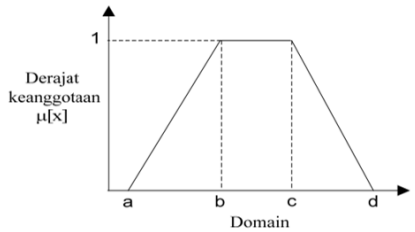
1. Triangular curve-shaped function



Membership functions:

$$[x] = \begin{cases} 0; & x \le a \text{ and } x \ge c \\ \dfrac{x-a}{b-a}; & a \le x \le b \\ \dfrac{c-x}{c-b}; & b \le x \le c \end{cases} \quad (3)$$

2. Trapezoidal Curve Function



Membership functions:

$$\mu[x] = \begin{cases} 0; & x \le a \text{ and } x \ge c \\ \dfrac{x-a}{b-a}; & a \le x \le b \\ \dfrac{c-x}{c-b}; & b \le x \le c \\ \dfrac{d-x}{d-c}; & c \le x \le d \end{cases} \quad (4)$$

2.4. Improve Phase

Identify and describe actions or improvement activities recommendations Share problem solving at the process stage so that ways to improve quality are obtained. At this stage using the 5W1H tool.

2.5. Control Phase

Monitor all repair activities to remain stable and in accordance with the specification limits desired by the customer and then make life cycle improvements from the production process.

3. Results and Discussion

3.1. Define Phase

1. Operational Process Chart

Jhono Garment has three products, namely T-shirts, polo shirts, and sleepwear. Based on the three OPC Jhono Garment products, almost all production lines of the three products are the same, there is only a slight difference in polo production, namely the addition of buttons. Figure 1 shows the OPC T-Shirts.

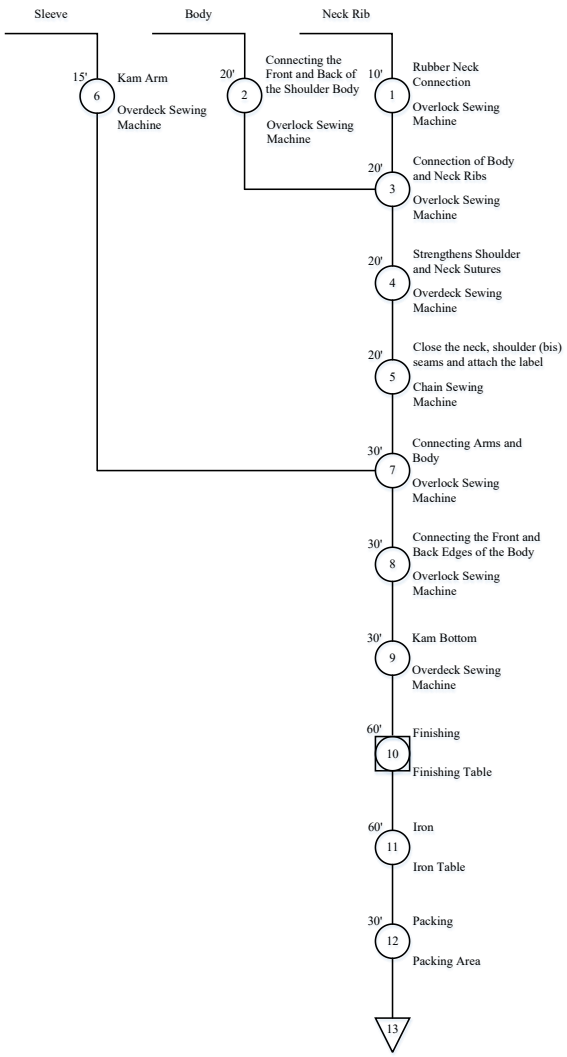


Figure 1. OPC T-Shirt

2. Determination of Critical to Quality

Based on the results of an interview with the owner of Jhono Garment, the Critical to Quality obtained based on customers and the provisions of Jhono Garment are 4, namely, Visual, Size, Stitching, and Neatness. Figure 2 shows the CTQ Tree.

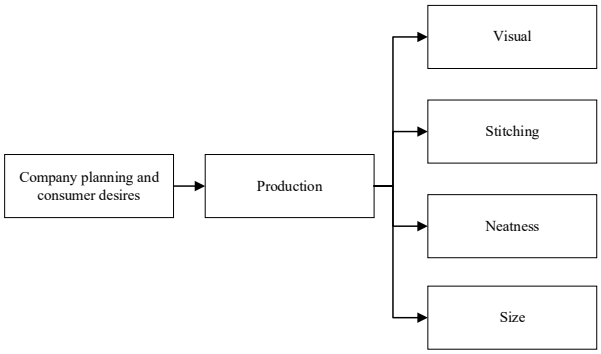


Figure 2. CTQ Tree

3.2. Measure Phase

1. Control Chart

In this research using Minitab 18 software for making control charts. P Chart are shown in Figure 3-5.

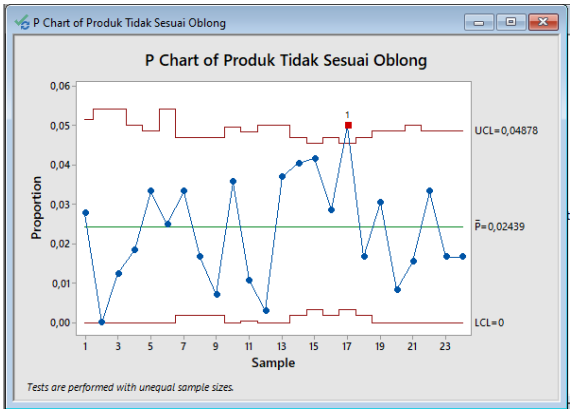


Figure 3. Control Chart T-Shirts

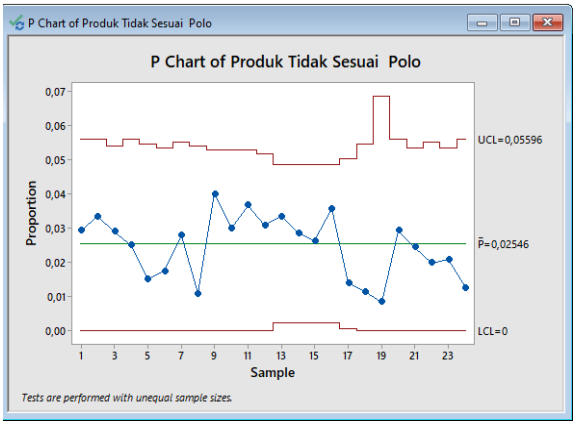


Figure 4. Control Chart Polo

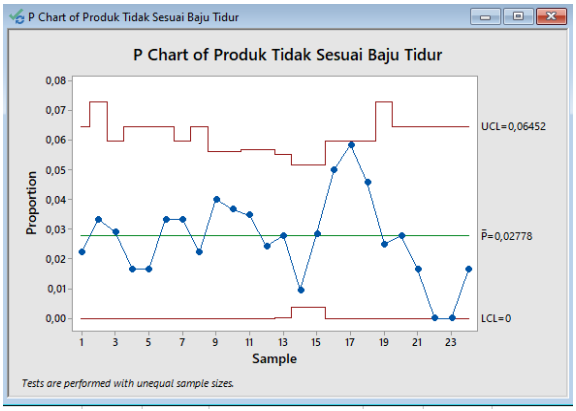


Figure 5. Nightdress Chart Control

Figure 3 shows that only T-shirts are outside the control limits, so this research will be more focused on T-Shirts type products.

2. Identify Seven Waste

Based on the OPC type of T-Shirts product, a description of the production process can be seen in Table 1.

Table 1. Process Chart T-Shirts

Distance (m)	Time (s)	Symbol	Process Description	Category
5	60	○ ⇨ □ D ▽	Transfer of raw materials from warehouse to work station	NVA
	10	○ ⇨ □ D ▽	Neck rubber connection	VA
	20	○ ⇨ □ D ▽	Front and back body shoulder connection	VA
	20	○ ⇨ □ D ▽	Connection of body and neck ribs	VA
	20	○ ⇨ □ D ▽	Reinforce shoulder and neck seams	VA
	20	○ ⇨ □ D ▽	Close the shoulder and neck seams and attach the label.	VA
	15	○ ⇨ □ D ▽	Kam Arm	VA
	15	○ ⇨ □ D ▽	Connecting hands and body	VA
	30	○ ⇨ □ D ▽	Connecting the body parts at the edges	VA
	30	○ ⇨ □ D ▽	Bottom of Kam	VA
5	60	○ ⇨ □ D ▽	Waste thread disposal and QC	VA
2	60	○ ⇨ □ D ▽	Ironing	VA
	30	○ ⇨ □ D ▽	Packing	VA
5	60	○ ⇨ □ D ▽	Storage in finished goods warehouse	NVA
17	450	11	1	1		1	Total	

The following is the result of calculating value stream mapping:

$$VAR = \frac{value\ added\ time}{non\ value\ added\ time} \times 100\% \quad (5)$$

$$VAR = \frac{330}{450} \times 100\% = 73\% \quad (6)$$

Identification is carried out by observing and interviewing the owners and workers of the production department obtained that there is waste. Table 2 shows the seven wastes.

Table 2. Identify Seven Waste

No	Waste	Explanation
1	Overproducing	Not found
2	Inventory	Not found
3	Defects	Found
4	Transportation	Found
5	Motion	Not found
6	Waiting	Not found
7	Overprocessing	Found

a. Overproducing

Overproducing or overproduction in Jhono Convection according to the owner is said to be almost non-existent because Jhono Convection always produces its products based on the number of customer requests or made by order so that the production process is always calculated well without any excess production.

b. Inventory

Inventory or storage at Jhono Convection has never experienced a shortage of raw materials or accumulation of finished goods due to the made by order system. When production has reached the target, the product will be immediately taken by the customer and the customer will receive raw materials for further production on. Therefore, the inventory at Jhono Convection can be said to be balanced.

c. Defects

Defects are still common in Jhono Convection. Defects are caused by various factors in the production process and defects of customers when providing raw materials. There are two types of defects, namely irreparable defects, and irreparable defects. Defect repair in 1 product costs Rp 5,000 to Rp 10,000 with a repair time of 10 to 30 minutes depending on the type of defect. Therefore, this defect is one of the most dominant wastes in Jhono Convection

d. Transportation

In the Jhono Convection transportation process, there is a slight obstacle, namely the distance between the warehouse and the workstation is too far, which is 5 meters. Therefore, it takes a long time for the process of moving goods and increases the time for non-value added.

e. Motion

Based on waste inventory analysis, overproduction and transportation do not have a significant correlation, so they do not cause waste motion. Jhono convection in the production system is considered quite good because there is no excessive movement or is not needed during the production process.

f. Waiting

Waiting or waiting time in the production process at Jhono Convection is almost non-existent. This is because the production system uses a push production system or parallel thrust so that there is no waiting time in each process at each workstation.

g. Overprocessing

Overprocessing or unnecessary processing in Jhono Convection is almost non-existent. This is because this convection has been experienced in the world of convection for 15 years. Unnecessary processes have been eliminated with experiential research.

3. Sigma Value Calculation

The sigma value calculation is carried out as part of the measure stage. The result is shown in Table 3.

Table 3. DPMO calculation

Period	Product Type	Production Quantity	Number of Defects	CTQ	DPU	DPMO	Sigma Value
Nov23 – Apr 22	T-Shirts	8652	211	4	0,00610	6097	4,006

Example of calculating the sigma value of T-Shirts products:

$$DPU = \frac{211}{8652 \times 4} = 0.00610 \quad (7)$$

$$DPMO = \frac{211}{8652 \times 4} \times 1000000 = 6.097 \quad (8)$$

In the calculation results above, the DPU value in the T-Shirts is 0.00610 while the DPMO is 6,097 and the sigma value of this T-Shirts type of product is 4.006 which means it is in a sigma 4 condition with the possibility of damage occurring of 6,097 for 1,000,000 productions. If calculated based on DPMO, the number of defects per month is 61 pieces of products from 10,000 clothing production.

3.3. Analyze Phase

At this stage, identification of defects that occur in the three types of products produced by Jhono Convection is carried out. The tools used are fishbone diagram, FMEA and Fuzzy. The following are defects that occur in T-Shirts type products in Jhono Convection which can be seen in Table 4.

Table 4. Defect that occurs

No	Types of defects
1	Messy stitching
2	Torn
3	Dirty
4	Messy packaging

4. Fishbone Diagram

Clothing products at Jhono Garment have five types of defects, namely messy stitching, torn, dirty and messy packing. Here is the cause-and-effect diagram shown in Figure 6-9.

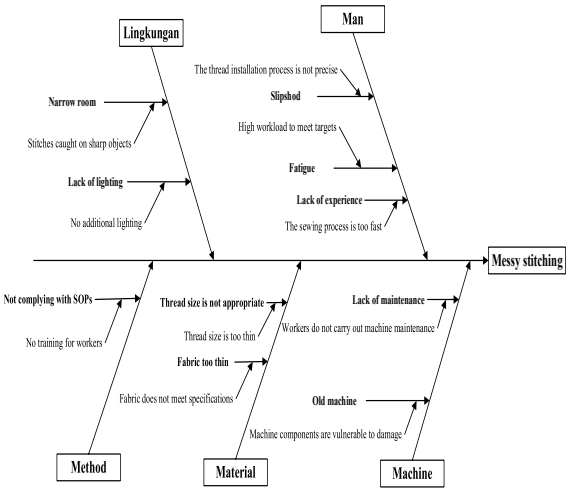


Figure 6. Fishbone Diagram Messy Stitching

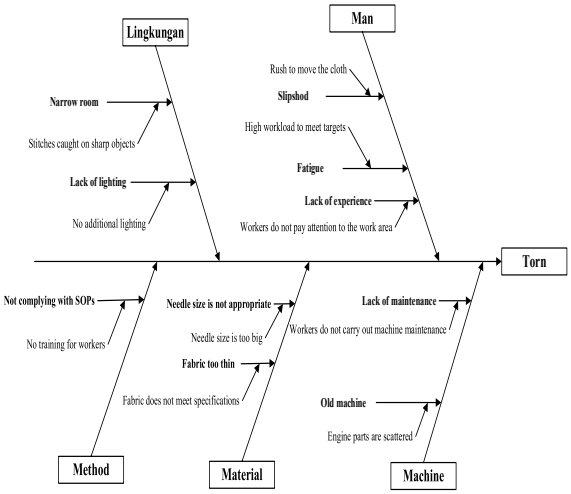


Figure 7. Fishbone Diagram Torn

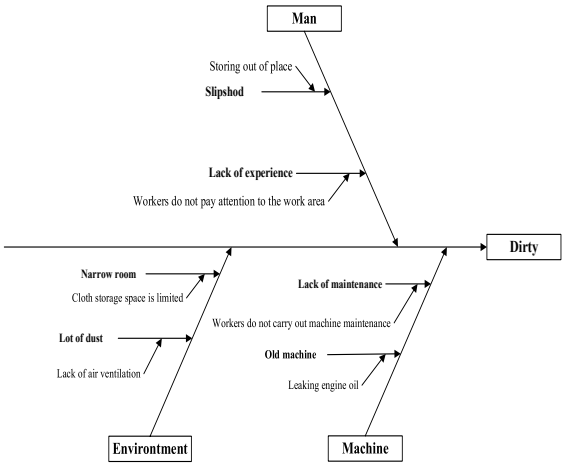


Figure 8. Fishbone Diagram Dirty

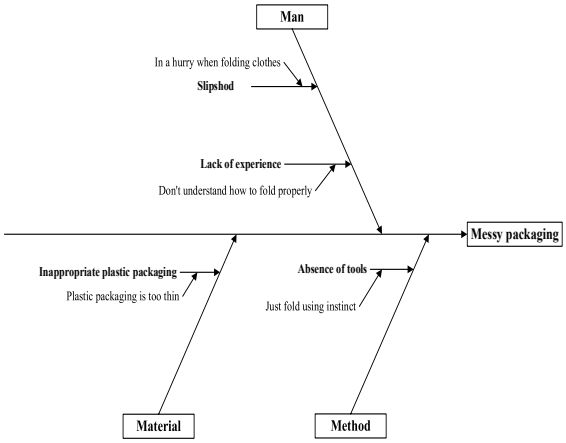


Figure 9. Fishbone Diagram Messy Packaging

4. Failure Mode and Effect Analysis (FMEA)

Based on the results of the cause-and-effect diagram that illustrates the factors causing the defect of the untidy seam, then a FMEA table is made by giving a score to the results of the identification of the cause-and-effect diagram.

Assessment of severity, occurrence and detection based on potential failure effects, causes of failure and Risk Priority Number (RPN) with the formula:

RPN = severity × occurrence × detection.

5. Fuzzy

This fuzzy stage serves to evaluate the risk of failure or defect based on the results of FMEA. The next stage is to determine the category of SOD values based on the results of FMEA. Table 5 shows the SOD Category.

Table 5. SOD Category

Score			Category
S	O	D	
1	1	1	VL
2,3	2,3	2,3	L
4,5,6	4,5,6	4,5,6	M
7,8	7,8	7,8	H
9,10	9,10	9,10	VH

Note: S (Severity); O (Occurrence); D (Detection)

The next step is to find the membership value of each SOD value with calculations based on the membership curve of the SOD input value The Fuzzy Risk Priority Number (FRPN) is then determined according to the rules established by experts in the fuzzy method. The provisions for the fuzzy input membership curve and fuzzy membership rules are presented in Table 6.

Table 6. Category Input Fuzzy

Category	Curve Type	Parameter
VL	Trapezoid	[0 0 1 2.5]
L	Triangle	[1 2.5 4.5]
M	Trapezoid	[2.5 4.5 5.5 7.5]
H	Triangle	[5.5 7.5 9]
VH	Trapezoid	[7.5 9 10 10]

Note: VL (Very Low); L (Low); M (Moderate); H (High); VH (Very High)

Based on the table above, the value of membership degrees based on the fuzzification SOD results is obtained in Table 7.

Table 7. Input Fuzzy

Failures Type	Severity		Occurrence		Detection	
	Membership Value	Category	Membership Value	Category	Membership Value	Category
A1	1.00	M	1.00	M	0.75	L
A2	1.00	M	0.75	H	0.75	M
A3	0.67	H	0.75	M	0.75	L
A4	0.75	M	1.00	M	0.75	L
A5	1.00	VH	0.75	M	0.75	L
A6	1.00	M	0.75	H	0.75	L
B1	0.75	H	0.75	H	0.75	M
B2	0.75	H	0.75	H	0.75	M
B3	1.00	M	1.00	M	0.75	L
B4	0.75	M	1.00	M	0.67	L
B5	0.75	H	1.00	M	0.67	L
B6	1.00	M	1.00	M	0.75	L
C1	0.75	H	0.67	H	1.00	M
C2	0.75	H	0.67	H	1.00	M
C3	0.75	M	1.00	M	0.67	L
C4	1.00	M	1.00	M	0.75	L
D1	1.00	VH	1.00	VH	0.75	L
D2	1.00	VH	1.00	VH	1.00	M
D3	1.00	VH	1.00	VH	1.00	M
D4	1.00	VH	0.67	H	0.75	L

An example calculation for the variety of failure of the A1 severity variable with category M is as follows:

$$[x] = \begin{cases} 0; & x \le a \; and \; x \ge d \\ \dfrac{x-a}{b-a}; & a \le x \le b \\ 1; & b \le x \le c \\ \dfrac{d-x}{d-c}; & c \le x \le d \end{cases} \quad (9)$$

For the variety of failures of A1 the severity variable does not need to be calculated because the severity value for A1 is 5 categories M, the number 5 is between b and c means 1 because b ≤ 5 ≤ c for more details can be seen in the following figure:

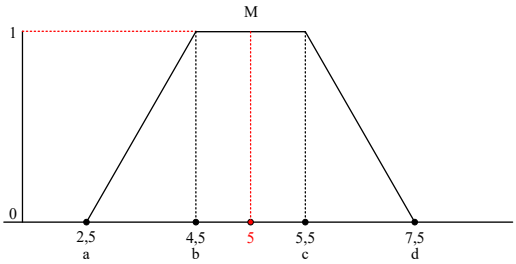


Figure 10. Calculation for A1

The next calculation example for the variety of failure A2 variable Occurrence which is valued at 7 with category H then obtained the following formula:

$$[x] = \begin{cases} 0; & x \leq a \text{ and } x \geq c \\ \dfrac{x-a}{b-a}; & a \leq x \leq b \\ \dfrac{c-x}{c-b}; & b \leq x \leq c \end{cases} \quad (10)$$

$$\mu x = \frac{(7-5.5)}{(7.5-5.5)} = 0.75 \quad (11)$$

For more details can be seen in the following picture:

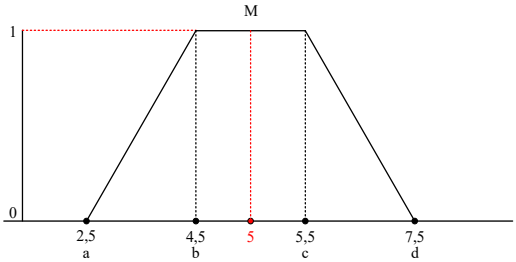


Figure 11. Calculation for A2

This stage is an adjustment between the value of the SOD variable and the existing rules for the fuzzy method to get the fuzzy risk priority number value. Based on the rule above, the values of α and FRPN are obtained in table 8.

Table 8. Alpha and FRPN

Failure Type	α	FRPN
A1	0.75	375
A2	0.75	550
A3	0.67	633
A4	0.75	375
A5	0.75	775
A6	0.75	550
B1	0.75	550
B2	0.75	775
B3	0.75	375
B4	0.67	367
B5	0.67	633
B6	0.75	375
C1	0.67	767
C2	0.67	767
C3	0.67	367
C4	0.75	375
D1	0.75	775
D2	0.75	775
D3	1.00	800
D4	0.67	767

An example calculation for α A1 is as follows:

$$\alpha = \mu S(x) \cap \mu O(x) \cap \mu D(x) \quad (12)$$

$$\alpha = \min((\mu S(5) \cap \mu O(5) \cap \mu D(3))$$

$$\alpha = \min(1; 1; 0; 7.5)$$

$$\alpha = 0.75$$

The α value is obtained based on the smallest value of the degree of membership of the SOD variable because based on the fuzzy membership rule number 62 “if severity M and occurrence M and detection L then FRPN is MH" there is a description cap or and then the smallest value is used. To perform FRPN calculations, fuzzy FRPN output provisions are used in table 9.

Table 9. Category Input Fuzzy

Category	Curve Type	Parameter
VL	Trapezoid	[0 0 25 75]
VL-L	Triangle	[25 75 125]
L	Triangle	[75 125 200]
L-M	Triangle	[125 200 300]
M	Triangle	[200 300 400]
M-H	Triangle	[300 400 500]
H	Triangle	[400 500 700]
H-VH	Triangle	[500 700 900]
VH	Trapezoid	[700 900 1000 1000]

An example of FRPN calculation for A1 is as follows:

In FRPN A1, the fuzzy membership rule number 62 is used "if severity M (5) and occurrence M (5) and detection L (3) then FRPN is MH" then the value is on the MH category curve (triangle) using the calculation of indigo α (0.75)

Then the following formula is obtained:

$$[x] = \begin{cases} 0; & x \leq 300 \\ \dfrac{x-300}{400-300}; & 300 \leq x \leq 500 \\ 1; & x \geq 500 \end{cases} \quad (13)$$

$$0.75 = \frac{x-300}{100}$$

$$x = 375$$

For more details can be seen in the following picture:

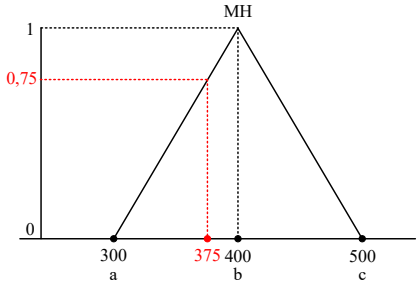


Figure 11: Calculation FRPN A1

For further calculations carried out in the same way but according to the curve possessed by each fuzzy rule that exists. From the calculation above, a comparison between FMEA RPN and Fuzzy RPN can be seen in table 10.

Table 10. Fuzzy FMEA Comparation

Failures Type	Severity	Occurrence	Detection	RPN	Rank	FRPN	Rank
A1	5	5	3	75	12	375	7
A2	5	7	4	140	7	550	6
A3	8	4	3	96	10	633	5
A4	6	5	3	90	11	375	7
A5	9	4	3	108	8	775	2
A6	5	7	3	105	9	550	6
B1	7	7	4	196	6	550	6
B2	7	7	4	196	6	775	2
B3	5	5	3	75	12	375	7
B4	6	5	2	60	14	367	9
B5	7	5	2	70	13	633	4
B6	5	5	3	75	12	375	7
C1	7	8	5	280	3	767	3
C2	7	8	5	280	3	767	3
C3	6	5	2	60	19	367	8
C4	5	5	3	75	12	375	7
D1	9	9	3	243	5	775	2
D2	9	9	5	405	2	775	2
D3	9	10	5	450	1	800	1
D4	9	8	3	216	4	767	3

Based on the results of the comparison of RPN and FRPN, different priority scale ratings are obtained, but there are also similarities. As in rank 1 between RPN and FRPN has the same rank 1 on the variety of D3 failures, namely untidy packing defects with no tools for folding clothes, so it has been obtained for priority repair in Jhono Garment.

3.4. Improve Phase

This stage is to make suggestions for improvements to the defect analysis that occurs in the product under study. The tool used for analysis is 5W1H. In this analysis process there are several questions to determine the factors that cause defects in T-Shirts products with the questions What, Who, Where, When, Why and How. Table 11 shows the result of 5W1H analysis.

Table 11. 5W1H

Defect Type (What)	Source of Waste (Where)	Person in Charge (Who)	Time of Event (When)	Reason (Why)	Solutions (How)
Messy packaging	Packaging Workstation	Operator	Folding clothes for packing	D1. Packaging workers rush while folding clothes. D2. The worker entered the wrong clothing size and plastic size. D3. Workers only use instinct to fold clothes to make them look neat. D4. High workloads result in workers being negligent in fulfilling clothes folding procedure.	D1. Supervise the folding process. D2. Separate the plastic sizes and put size labels on the plastic. D3. Make folding molds so that clothes are neat and consistent. D4. Increase the number of workers in the folding section.

3.5. Control Phase

This control stage is the latest approach from DMAIC in the Six Sigma method. At this stage, control measures are taken against the stages that have previously been carried out. In particular, the improvement proposal is based on the priority rating of the results of the Fuzzy RPN analysis that has been carried out. Based on table 10, the highest FRPN value is in the variety of D3 failures in untidy packing defects due to the absence of tools for folding clothes. Researchers propose improvements by making folding molding tools for clothes so that untidy packing defects can be minimized.

This study conducted a comparison experiment when not using a folding mold and when using a folding mold during one production period, which is one week, can be seen in table 12.

Table 12: Folding mold experiment

Production Period	Production Amount	Total Defect Messy Packaging
29 May 2023 - 2 June 2023	360	8
5 June 2023 - 9 June 2023	360	0

It was shown that before using folding molds, the production defects of packing were not neat in the production period of May 29 – June 2, there were 8 defects. Meanwhile, at the time of use of folding molds, namely the production period of June 5 – June 9, there were no defects. Therefore, it can be concluded that this folding mold is very effective for reducing untidy packing defects in Jhono Garment.

3.6. Discussion

The results of the study showed that the most dominant waste found in the garment industry is defects. These results are in line with (Basuki et al., 2023; Fibriani et al., 2024), although (Jasmine et al., 2024; Nugraha et al., 2024) did not apply lean six sigma, defects remain the main problem. The defects found were also similar, namely stitching, neatness, and cleanliness (Basuki et al., 2023; Fibriani et al., 2024). However, it is slightly different for (Jasmine et al., 2024) where the product is a jersey with a white spot defect and (Nugraha et al., 2024) with woven fabric with a warp feed are sparse defects. Most stated that the main cause of defects is human problems with the recommended solution implementing the establishment of SOPs and work instructions (Basuki et al., 2023; Fibriani et al., 2024; Jasmine et al., 2024; Nugraha et al., 2024). While this study shows that the main cause is the method where Fuzzy FMEA gives better recommendation priority, namely the need to improve the folding method. The results of other studies are also difficult to confirm because there is no application of solution recommendations at the control stage (Basuki et al., 2023; Fibriani et al., 2024; Jasmine et al., 2024) other than (Nugraha et al., 2024) who has shown improvements in the form of sigma values as in this study.

4. Conclusion

The sigma value of Jhono Garment products is selected based on a control chart that exceeds the UCL or LCL limit, namely T-shirt clothing products showing the possibility of damage reaching 6,097 for 1,000,000 productions with a sigma value of 4,006. The waste factor that must be eliminated first is waste defect because this waste is the most dominant or most often occurs in Jhono Garment with defect repair in 1 product costing IDR 5,000 to IDR 10,000 with a repair duration of 10 to 30 minutes depending on the type of defect.

The recommendation for improvement of waste defects is to make folding molds in the product folding process. The application of this folding mold can reduce untidy packing defects by 100% in a one-period production trial. The trial is considered effective in reducing the level of untidy packing defects in Jhono Garment.

This study has not conducted a comprehensive waste analysis so that waste elimination has not been maximized. Waste Assessment Model (WMA) can be used in further research so that waste can be identified properly. This is because WAS is accompanied by tools in the form of Waste Relationship Matrix (WRM) and Waste Assessment Questionnaire (WAQ). In addition, the Fuzzy FMEA calculation in this study is still done manually. Therefore, for further research to obtain comparative results, Matlab software can be used.

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