Evaluation of Production Risks Using The Six Sigma Method and Failure Mode and Effect Analysis (FMEA) in Quality Control at PT Busana Indah Global

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Abstract. This research aims to evaluate production risk at PT Busana Indah Global using the Six Sigma method and Failure Mode and Effect Analysis (FMEA) as a quality control tool. The aim of this research is to improve product quality, reduce defects, and optimize the production process. The Six Sigma method is used to identify and reduce the risk of defects in the production process. This method includes collecting and analyzing quality data, identifying the causes of major defects, and designing improvements to improve product quality. FMEA is used to identify potential failures in production systems and processes. This method includes identifying the causes of potential failures, assessing their impact on product quality, and determining severity, occurrence level, and detection capability. By using FMEA, companies can identify and overcome production risks that can cause defects in products.

Keywords: Production Risk Evaluation, Six Sigma Method, Failure Mode and Effect Analysis (FMEA), Quality Control.

1 Introduction

In the era of globalization and competitive markets, companies are faced with pressure to produce high quality products. In the manufacturing industry, companies often face challenges in maintaining consistent quality of their products, identifying and controlling risks that may occur during the production process due to various risks that can affect product performance and quality. Quality control is an important aspect to ensure that the products produced meet the specified standards. According to Dr. W. Edwards Deming, a statistician and management consultant who contributed greatly to the development of quality control and quality management, one of the key components in quality control is production risk evaluation. Deming how important it is to improve quality (Aditama R.A, 2020).

Production risk evaluation focuses on identifying, analyzing and managing risks related to the production process in order to improve product quality. Production risk

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evaluation aims to identify these risks and develop effective control strategies. Production risk evaluation includes steps such as risk analysis, impact assessment, and risk level determination. To overcome this problem, the approach that can be used is to apply the Six Sigma and FMEA (Failure Mode and Effect Analysis) methods.

Six Sigma is a quality management approach that aims to reduce variability in the production process. By using the Six Sigma method, companies can improve their production processes and reduce the number of defects produced. Meanwhile, FMEA (Failure Mode and Effect Analysis) is a method used to analyze and identify potential failures in the production process. FMEA helps in identifying risks that may occur during the production process, so that they can take effective preventive measures.

PT Busana Indah Global is a company operating in the apparel industry. Most of the products produced by PT Busana Indah Global are Carter's clothes. In the production process, PT Busana Indah Global experienced various problems, such as the large number of defects in the products it produced. Based on the data obtained, there were 3889 defective products out of 40765 pcs produced in the period January - August 2023, with an average percentage of defective products reaching 9 out of 10%. So, this problem must be addressed immediately to reduce the risk of defective products so that product quality is maintained.

2 Literature Review

2.1 Quality

Quality is a measure or level of excellence or perfection of a product, service or process. The term "quality" can refer to various contexts, such as physical products, services, performance, or business processes. In general, quality refers to the degree to which a product or service meets or exceeds established expectations or requirements. Goetsch and Davis (2005) define quality as a dynamic condition related to products, services, people, processes and environments that meet or exceed expectations. Quality reflects the level of excellence or perfection of an entity. According to Suyadi (2002:16) product quality is determined by several factors such as the planned form of a good or service (design), the raw materials used (raw materials), the method or process of making it, how to send it to consumers including how to package it, technological developments and way of service.

The concept of quality in the manufacturing industry refers to the level of excellence and customer satisfaction with the products produced. This concept includes product quality, process quality, service quality, supplier quality, consistency quality, cost quality, and innovation quality. To achieve this, quality management is needed in the implementation process. Quality management is the process of planning, controlling and improving the quality of products or services in an organization. Quality management aims to increase customer satisfaction and the performance of organizations that provide quality products and services, through participation and collaboration of all stakeholders, work teams, customer orientation, continuous improvement, and process performance with the application of quality management techniques and tools (Mosadeghrad, 2014).

2.2 Quality Control

According to Bonar & Lutfhi (2018:221), quality control is a technique and planned activity or action carried out to achieve, maintain and improve the quality of a product and service so that it conforms to predetermined standards and can meet consumer satisfaction. The goal of quality control is to identify and resolve defects or nonconformities in products or services before they reach the final consumer. Quality control includes a series of steps and activities carried out in each stage of production or service provision. Several aspects that are generally considered in quality control are quality planning, process control, product inspection, statistical process control, and corrective action.

2.3 Six Sigma

Six Sigma is a methodology used to reduce variability and improve quality in business processes. According to Pande et al. (2002) Six Sigma is uniquely driven by a strong understanding of facts, data, and statistical analysis, as well as careful attention to managing, improving, and embedding business processes. The main goal of Six Sigma is to achieve very low or almost zero error rates in business processes. This methodology focuses on measuring, analyzing, improving, and controlling business processes involving the use of statistical and analytical tools to identify the root causes of problems and reduce variability in processes.

The core concept of Six Sigma is the use of standard deviation as a measure of variability in business processes. Sigma level (σ) describes how close a business process is to the desired end goal. The higher the Sigma level, the fewer errors or defects generated by the business process. For example, if a process reaches the Six Sigma level, it means it produces only 3.4 defects per million opportunities (DPMO), which means a very low error rate. The Six Sigma methodology involves a DMAIC (Define, Measure, Analyze, Improve, Control) approach to solving problems and improving quality.

2.4 FMEA (Failure Mode and Effect Analysis)

FMEA (Failure Mode and Effect Analysis) or which can be translated as Failure Mode and Impact Analysis. FMEA is a systematic method used to identify, analyze and reduce potential risks in a product, process or system. Chrysler (in Puspitasari, Rachmadi & Setiawan 2018) defines FMEA as an analysis methodology used to ensure potential problems with products and processes are considered and addressed thoroughly. According to McDermott et al. (2008) FMEA focuses on preventing defects, improving safety, and increasing customer satisfaction. Ideally, FMEA is carried out during the product development stage. However, despite this, FMEA can also produce substantial treatment benefits.

3 Research Methods

This research was conducted at PT Busana Indah Global which is located on Jl. Cireundeu No. 10, Jl. Pabuaran RT 01 RW 01, Ciheulang Tongoh, Cibadak District, Sukabumi. The research was conducted in March - October 2023. This type of research is descriptive research, namely research that describes a research object by collecting data through interviews and company data. The object of this research is the production quality of Carter's clothing products which is carried out in the QC Finishing section. The data processing method used in this research is the six sigma method with DMAIC stages (Define, Measure, Analyze, Improve and Control) but without Control.

Quantitative data is then analyzed and identified using a Pareto diagram to then measure the level of defects using sigma calculations which include Defect per Unit (DPU) analysis, Defect per Million Opportunities (DPMO) analysis, and sigma size. Furthermore, using control charts as a statistical tool to monitor and control production or operational processes provides a visual depiction of the performance of a process by plotting measurement or observation data from the process over time.

Meanwhile, qualitative data was analyzed using the SIPOC diagram. SIPOC diagrams are tools used in quality management and process management to depict and structure the key elements of a process. SIPOC is an abbreviation for Supplier, Input, Process, Output, and Customer, which represents the main components in a process. In the context of Six Sigma or quality management, Critical To Quality (CTQ) is used to identify and prioritize critical attributes that must be met by a process or product. CTQ helps quality or improvement teams to focus their efforts on the most meaningful and important aspects of meeting customer needs. Next, a cause-and-effect diagram is used which is also known as an Ishikawa diagram or Fishbone Diagram to analyze and visualize the cause-and-effect relationship between various factors that influence a particular problem or situation. The categories used in cause-and-effect diagrams are:

- Man: Factors related to an individual's skills, training, motivation, or actions that influence the problem.
- Machine: Factors related to the equipment, machines, or tools used in the process.
- Method: Factors related to procedures, work methods, or instructions used in carrying out the process.
- Materials: Factors related to raw materials or materials used in the process.
- Measurement: Factors related to the measurement, control, or evaluation methods used in the process.
- Environment: Factors related to environmental conditions, such as temperature, humidity, or other external factors.

Once these factors have been drawn out as “fishbones,” the next step is to identify and drill down to the specific factors that are contributing to the problem or undesirable outcome. Within each category, these factors can be further analyzed using tools such as 5M (Man, Machine, Method, Material, Measurement). The data is then processed using Failure Mode and Effect Analysis (FMEA), which is a systematic method used to identify, analyze and reduce the risk of failure in processes, products or systems. FMEA involves identifying failure modes, analyzing the effects of failure, and determining the level of risk associated with each failure mode. This method allows teams to prioritize improvement efforts and develop appropriate prevention or mitigation actions.

4 Results and Discussion

4.1 Define Stage

At this stage, the SIPOC diagram (Supplier, Input, Process, Output, Customer) is used to understand the entire interconnected process and define the critical characteristics that must be met (CTQ).

1) SIPOC Diagram

SIPOC diagrams are tools used in quality management and process management to depict and structure the key elements of a process. The following is the SIPOC diagram of PT Busana Indah Global.

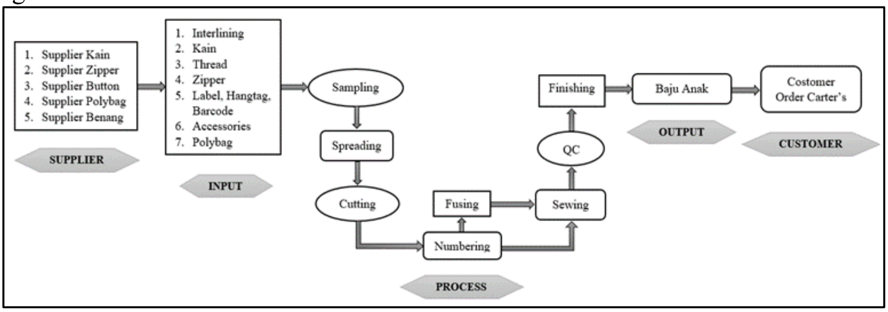

Fig. 1. SIPOC Diagram of PT Busana Indah Global

- Suppliers
  PT Busana Indah Global has different suppliers, this is done because it considers the main raw materials used in the production process, such as fabrics, yarns, accessories, printing, and others. Fabric suppliers are Kim Hing Piece Work Limited, yarn from PT Marathon, accessories from PT Paxar, and printing from PT Happy and Mamoru.
- Input
  At the input stage, the raw materials used by PT Busana Indah Global are fabric, accessories such as HTL, care label, main label, snap, button, zipper, and printing (if any).
- Process
  Before the production process is carried out the fabric must be 100% insfect in the warehouse and rilexs for 1x24 hours. After that, continue to the spreading and cutting process, then after finishing loading into the sewing and run according to production SOPs, continue iron and checking 100% finishing after rubbing and entering packing through the metal detector then shipping.
- Output

Output produced by PT Busana Indah Global is in the form of children's clothes with a charter's brand, with the amount of output produced in accordance with orders from consumers. Because in the production process PT Busana Indah Global applies a make to order system, meaning that the production process is carried out in accordance with the demand originating from consumers.

- Customers
  Most of PT Busana Indah Global's products are sent to Mexico, China, US and Canada. This is because there has been collaboration carried out by PT Busana Indah Global with related parties. So the delivery of finished products will be arranged in accordance with the agreement between PT Busana Indah Global and consumers.

2) Critical to Quality (QTC)
   CTQ refers to the characteristics or critical factors that must be met or controlled in order for a product or service to meet customer expectations and established quality standards. In this case, the data used is product defect data in January – August 2023 at PT Busana Indah Global.

Table 1. Types of Product Defects for the Period January – August 2023

Bulan	Jenis Cacat															Jumlah Cacat (Unit)	Jumlah Produksi	Persentase Cacat
	Untrimming Thread	Broken Stitched	Skip Stitched	Oil Stain/ Dirty	Pleated	Open Seam	Hi-Low	Over Lap	Puckring	Fabric Defect	Sheding	Wavy	Univen Seam	Hole	Wrong Size			
Januari	73	68	45	45	17	22	5	30	4	0	3	13	34	0	0	359	4650	7,72%
Februari	77	61	70	50	26	29	26	34	2	1	0	0	13	3	4	396	4491	8,82%
Maret	125	67	87	64	78	56	2	18	20	0	18	2	9	13	31	590	8460	6,97%
April	202	131	97	28	16	26	24	14	8	0	1	0	45	1	5	598	6597	9,06%
Mei	97	67	39	22	18	58	2	34	30	0	1	11	32	1	3	415	4567	9,09%
Juni	66	43	42	90	30	8	16	2	2	0	0	35	0	0	0	334	2842	11,75%
Juli	170	100	93	61	60	34	9	32	11	11	0	39	26	0	1	647	4807	13,46%
Agustus	171	72	51	21	90	23	2	60	5	0	0	19	32	4	0	550	4351	12,64%
Jumlah	981	609	524	381	335	256	86	224	82	12	23	119	191	22	44	3889	40765	9,54%

Source: PT Busana Indah Global Defect Product Data for January – August 2023

From the table above, it can be seen that during the period January – August 2023 there were 15 types of production defects with a total number of defects (units) of 3,889 out of a total production of 40,765 units.

4.2 Measure Stage

At this stage, things that are done to determine the company's sigma level are:

- Determining Critical to Quality (CTQ)

Table 2. Percentage of Total Defective Products

No	Reject Item	Frequency	Percentage From Total
1	Untrimming Thread	981	25,22%
2	Broken Stitched	609	15,66%
3	Skip Stitched	524	13,47%
4	Oil Stain / Dirty	381	9,80%
5	Pleated	335	8,61%
6	Open Seam	256	6,58%
7	Over Lap	224	5,76%
8	Univen Seam	191	4,91%
9	Wavy	119	3,06%
10	Hi-Low	86	2,21%
11	Puckring	82	2,11%
12	Wrong Size	44	1,13%
13	Sheding	23	0,59%
14	Hole	22	0,57%
15	Fabric Defect	12	0,31%
Total		3889	100,00%

Table 3. Accumulated Percentage of Total Defective Products

No	Reject Item	Frequency	Accumulation Frequency	Percentage From Total	Accumulation Percentage
1	Untrimming Thread	981	981	25,22%	25,22%
2	Broken Stitched	609	1590	15,66%	40,88%
3	Skip Stitched	524	2114	13,47%	54,36%
4	Oil Stain / Dirty	381	2495	9,80%	64,16%
5	Pleated	335	2830	8,61%	72,77%
6	Open Seam	256	3086	6,58%	79,35%
7	Over Lap	224	3310	5,76%	85,11%
8	Univen Seam	191	3501	4,91%	90,02%
9	Wavy	119	3620	3,06%	93,08%
10	Hi-Low	86	3706	2,21%	95,29%
11	Puckring	82	3788	2,11%	97,40%
12	Wrong Size	44	3832	1,13%	98,53%
13	Sheding	23	3855	0,59%	99,13%
14	Hole	22	3877	0,57%	99,69%
15	Fabric Defect	12	3889	0,31%	100,00%
Total		3889		100,00%	

Source: Defective Product Data, processed (2023)

- Performance baseline measurement
  When measuring baseline performance, DPMO (Defects Per Million Opportunities) is used to determine the sigma level. The steps that can be taken in calculating DPMO are as follows:
  1) Units (U)
     How many products are checked or measured. The following is the number of products examined during the research period.

Table 4. Total Production of PT Busana Indah Global for the Period January – August 2023

Bulan	Jumlah Produksi
Januari	4650
Februari	4491
Maret	8460
April	6597
Mei	4567
Juni	2842
Juli	4807
Agustus	4351
Jumlah	40765

Source: PT Busana Indah Global Production Data for the Period January – August 2023

3) Opportunities (O)
Characteristics or indicators that have the potential to become a defect. There are 15 types of characteristics or indicators selected, as in the following table.

Table 5. Types of defective products at PT Busana Indah Global

No	Reject Item
1	Untrimming Thread
2	Broken Stitched
3	Skip Stitched
4	Oil Stain / Dirty
5	Pleated
6	Open Seam
7	Over Lap
8	Univen Seam
9	Wavy
10	Hi-Low
11	Puckring
12	Wrong Size
13	Sheding
14	Hole
15	Fabric Defect

Source: PT Busana Indah Global Defect Product Data for January – August 2023

4) Defect (D)
D is the number of defects that occur during production. The following is the number of disabilities that occurred during the research period.

Table 6. Number of Defective Products

Bulan	Jumlah Cacat
Januari	359
Februari	396
Maret	590
April	598
Mei	415
Juni	334
Juli	647
Agustus	550
Jumlah	3889

Source: PT Busana Indah Global Defect Product Data for January – August 2023

5) Defects Per Unit (DPU)
DPU is the defect proportion value obtained from the number of defects in the total sample divided by the total sample.

Table 7. Calculation of defects per unit for PT Busana Indah Global for the period January – August 2023

Bulan	Jumlah Produksi	Jumlah Cacat	DPU
Januari	4.650	359	0,077
Februari	4.491	396	0,088
Maret	8.460	590	0,070
April	6.597	598	0,091
Mei	4.567	415	0,091
Juni	2.842	334	0,118
Juli	4.807	647	0,135
Agustus	4.351	550	0,126
Jumlah	40.765	3.889	0,795

Source: Defective Product Data, processed (2023)

An example of the DPU calculation from the January period is as follows.

$$\text{DPU} = \frac{\text{D}}{\text{U}} = \frac{359}{4.650} = 0{,}077$$

6) Total Opportunity (TOP)
TOP is the number of opportunities that occur, and the types of defects that are included in the critical characteristics for quality (CTQ) of all products produced.

Table 8. Calculation of PT Busana Indah Global's Total Opportunity for the Period January – August

Bulan	Jumlah Produksi	TOP
Januari	4.650	69.750
Februari	4.491	67.365
Maret	8.460	126.900
April	6.597	98.955
Mei	4.567	68.505
Juni	2.842	42.630
Juli	4.807	72.105
Agustus	4.351	65.265
Jumlah	40.765	611.475

Source: Defective Product Data, processed (2023)

The following is an example of TOP calculation for the January 2023 period.
TOP = U x OP = 4,650 x 15 = 69,750

7) Defects per Opportunities (DPO)
DPO is the opportunity for product defects to occur with critical characteristics for quality (CTQ).

Table 9. Defects per Opportunities PT Busana Indah Global Period January – August 2023

Bulan	Jumlah Cacat	TOP	DPO
Januari	359	69.750	0,005
Februari	396	67.365	0,006
Maret	590	126.900	0,005
April	598	98.955	0,006
Mei	415	68.505	0,006
Juni	334	42.630	0,008
Juli	647	72.105	0,009
Agustus	550	65.265	0,008
Jumlah	3.889	611.475	0,053

Source: Defective Product Data, processed (2023)

An example of calculating Defects per Opportunities for the January 2023 period is as follows.

$$DPO = \frac{D}{TOP} = \frac{359}{69.750} = 0,005$$

8) Defects per Million Opportunities (DPMO)
DPMO is the chance of a product defect occurring against critical characteristics for quality (CTQ) in 1 million opportunities.

$$DPMO = DPO \times 1000000$$

Table 10. Defects per Million Opportunities PT Busana Indah Global Period January – August 2023

Bulan	DPO	DPMO
Januari	0,005	5.146,953
Februari	0,006	5.878,424
Maret	0,005	4.649,330
April	0,006	6.043,151
Mei	0,006	6.057,952
Juni	0,008	7.834,858
Juli	0,009	8.973,025
Agustus	0,008	8.427,181
Jumlah	0,053	53.010,875

Source: Defective Product Data, processed (2023)

The following is an example of DPMO calculation for the January 2023 period.
DPMO = DPO x 1000000 = 0.005x 1000000 = 5,146,953

8) Sigma Level Determination
To measure the sigma level, you can use tools in the form of a sigma conversion table or by using Microsoft Excel by entering the formula:

= normsinv((1000000-DPMO)/1000000)+1.5

Table 11. Sigma Level Calculation

Bulan	DPMO	Sigma
Januari	5.146,953	4,07
Februari	5.878,424	4,02
Maret	4.649,330	4,10
April	6.043,151	4,01
Mei	6.057,952	4,01
Juni	7.834,858	3,92
Juli	8.973,025	3,87
Agustus	8.427,181	3,89
Jumlah	53.010,875	31,88
Rata-rata	6.626,359	3,98

Source: Defective Product Data, processed (2023)

The following is an example of determining the sigma level for the January 2023 period.
= normsinv((1000000-DPMO)/1000000)+1.5
= normsinv((1000000-5,146.953)/1000000)+1.5
=4.07
From these calculations, the control chart can be obtained as follows.

Table 12. P-Chart Calculation Data Table

Bulan	jumlah produksi	jumlah produk cacat	proporsi produk cacat	CL	UCL	LCL
January	4560	359	0.079	0.096	0.10	0.091
february	4491	396	0.088	0.096	0.10	0.092
maret	8460	590	0.070	0.096	0.10	0.092
april	6597	598	0.091	0.096	0.10	0.092
mei	4567	415	0.091	0.096	0.10	0.092
juni	2842	334	0.118	0.096	0.10	0.092
juli	4807	647	0.135	0.096	0.10	0.092
agustus	4351	550	0.126	0.096	0.10	0.092
total	40675	3889				

Source : Defective Product Data , processed (2023)

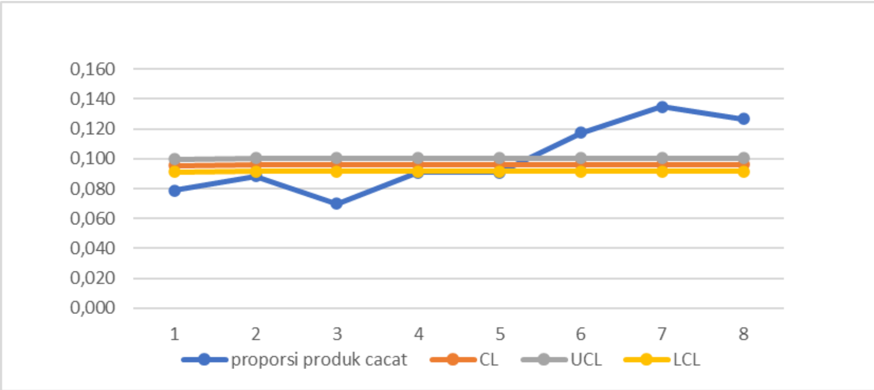

Fig. 2. Control chart graph

Source: Defective Product Data, processed (2023)

From the diagram above, it can be seen that the production process has improved even though in the 3rd month there was a decline, but in the following months it increased further. In the data above, namely in the 3rd month period, the level of defect proportion in that period is out of control, but the data for that period has a smaller defect rate compared to other periods. However, the inconsistency of the graph shows that the production process has not been carried out properly. Companies must carry out better quality control to reduce the number of product defects every month. This can be caused by various things such as materials, labor, machines, environment etc.

4.3 Analyze Stage

At the analysis stage, cause and effect diagrams and Pareto diagrams are used to analyze the reasons that cause defective products. Aspects that cause defective products are human factors, machines, methods, materials, environment and measurements.

- Pareto Chart

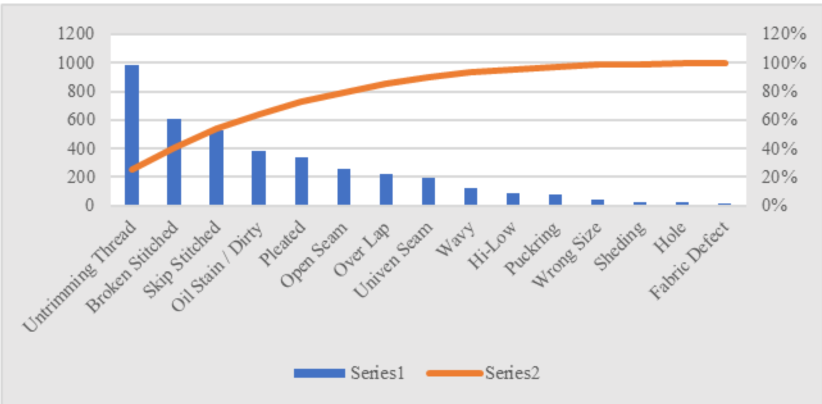

Fig. 3. Pareto Diagram

Source: Defective Product Data, processed (2023)

Based on the Pareto diagram above, it can be seen that the highest percentage of defects is untrimming thread with a percentage of 25.22% with a number of defects of 981 units. - Next is broken stitched with a percentage of 16.55% with a number of defects of 609 units, skip stitched at 13.47% with a number of defects of 524 units, oil stain/dirty of 9.80% with a number of defects of 381 units, pleated of 8.61% with a number of defects of 336 units, opem seam of 6.58% with a number of defects of 256 units, over lap of 5 .76% with a number of defects of 224 units, Univen seam of 4.91% with a number of defects of 191 units, wavy of 3.06% with a number of defects of 119 units, Hi-Low of 2.21% with a number of defects of 86 units, puckring of 2.11% with a number of defects of 82 units, wrong size of 1.13% with a number of defects of 44 units, shedding of 0.59% with a number of defects of 23 units, Holes of 0.57% with a number of defects of 22 units and finally fabric defects amounted to 0.31% with a total of 12 defective units.

- Cause – Effect Diagram

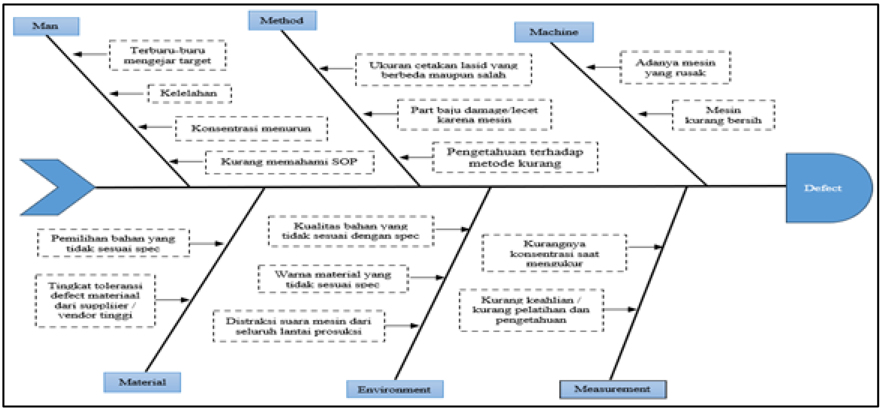

Fig. 4. Cause and Effect Diagram

Source: Processed (2023)

From the cause and effect diagram above, it can be seen that the occurrence of production defects is caused by 6 factors, namely:

1) Man. This factor is caused by rushing to pursue targets, fatigue, decreased concentration, and lack of understanding of SOPs.
2) Machine. Defects caused by mechanical factors are caused by damaged machines and the machines used being less than clean.
3) Method. This is caused by the size of the lacid mold being different or incorrect.
4) Material. This factor is caused by the selection of inappropriate materials.
5) Environment. This is caused by the distraction of machine noise from the entire production floor.
6) Measurement. Disability by this factor is caused by a lack of skills and knowledge.

- FMEA (Failure Mode and Effect Analysis)
  Failure Mode and Effect Analysis (FMEA) is a technique used to find, identify and eliminate potential failures, problems or errors that occur in systems, designs and processes before they reach consumers (Stamatis, 1995). This method can be used to analyze the risk of failure, to analyze failures and the effects of products or processes that have the potential to occur in the future.

The following is a table of company defect data for the period January – August 2023

Table 13. Analysis of causes of defects

Factor	Due to process failure	S	Cause of failure	O	Controls carried out	D
Man	- The operator does not work according to the standard of ability, this is due to the operator's lack of skills - The operator is not aware that after sewing he does not cut the thread short and clean	3 4	-Less skilled operator - Operator is not focused	2 4	- recruiting employees with sewing experience - supervisor and chief carry out checks in the line area	2 2
Machine	- automatic machine settings are unstable - The machine's tension is not stable so the stitches are not tight enough	2 3	- the engine mechanic does not control -The operator is not careful	2 2	- Checking so that the machine is repaired - mechanic info so the engine can be reset	2 2
Method	- late arrival of material components - not in accordance with the implementation of the schedule	4 2	- Unexpected obstacles - The operator did	2 2	- implement a bundle system, to be as effective as possible - instructed the production administration to prioritize styles that	3 2

	line so that the shigment date is left behind		not double check		will be exported in the near future	
Material	- Low thread quality, so the thread gets tangled easily - discovery of dirty raw materials	2 3	- The material is difficult to sew or produce - less sterile	2 1	- Checking raw materials so that they are in good condition when they arrive used - Use of appropriate PPE such as gloves on the process	4 2
Environment	-The temperature of the production floor tends to be hot due to the large number of lights used and lack of ventilation -The operator's work area is dirty, this shows that Awareness of cleanliness is still lacking	3 4	- Hot air - Lots of dust and dirt	3 3	- increase air ventilation by installing windows or using a blower - every 10 and 15 o'clock, carry out a clean-up in the factory area by playing sambalado music so that operators can refresh their work while cleaning.	2 1
measurements	- buyer's specs do not match the final specs -The pattern and sample staff does not provide information on reducing or adding patterns so that many aspects do not match the work sheet	1 1	- lack of concentration and thoroughness - miss communication	2 1	- Before production starts the final spec and buyer's spec must be the same first - improve communication between staff and operators	2 2

The table above is the result of analyzing the causes of untriming threads using the FMEA method, there are several assessments, namely severity, occurrence and detection. Severity is used to analyze how much impact will affect the output produced during the process. From the FMEA analysis, the greatest severity level is 4 for human, method and environmental factors. This is because these factors can result in defects and also work accidents for operators such as stitches or needle pricks and others.

Occurrence is an assessment of the probability that something will happen and result in a form of failure. Based on this table, the largest occurrence value is 4 for human factors. This is because operators are negligent and lack concentration while working. Meanwhile, detection is the ability to control failures that occur. The highest detection value is 4 in the method factor. Because the control problem is still considered quite low in detecting failure.

From this table, the RPN score results are obtained as follows.

Table 14. RPN Score Results

Factor	Due to process failure	RPN	Amount	Rank
Man	- The operator does not work according to the standard of ability, this is due to the operator's lack of skills - The operator is not aware that after sewing he does not cut the thread short and clean	12 32	44	1
Machine	- automatic machine settings are unstable - The machine's tention is not stable so the stitches are not tight enough	8 12	20	5
Method	- late arrival of material components - not in accordance with the implementation of the schedule line so that the shigment date is left behind	24 8	32	2
Material	- Low thread quality, so the thread gets tangled easily - discovery of dirty raw materials	16 6	22	4
Environment	- The production floor temperature	18 12	30	3

	tends to be hot because too many lights are used and there is not enough ventilation - The operator's work area is dirty, this shows that awareness of cleanliness is still lacking			
measurements	- buyer's specs do not match the final specs -The pattern and sample staff does not provide information on reducing or adding patterns so that many aspects do not match the work sheet	4 2	6	6

The RPN value is obtained from multiplying the severity, occurrence and detection values. Then rank the RPN values, based on table 2, the highest RPN value is the human factor of 44, the second is the method factor with an RPN value of 32, the third is the environmental factor with a value of 30, and the fourth is the material factor with a value of 22, the fifth is the machine factor with a value of 20, the six measurement factors with a value of 6. So that the company can take appropriate action based on the RPN value.

4.4 Improve Stage

Based on the FMEA results and analysis of failures caused by untriming threads, there are several suggestions for improvements from the author regarding this matter, namely:

- Companies can rotate operators so that operators do not get bored with their work
- Companies can provide training carried out in stages, namely 2 times a month. This training is carried out to improve the quality and work skills of operators
- Companies can provide retraining to provide operators with the skills needed to face changing work demands and also in accordance with the wishes of buyers. In this training, employees are given explanations and direction about machine operation, making basic patterns, knowledge about QC, sewing training, about K3 in the garment industry and also motivation so that the turnover rate is not high

- Providing PPE and instilling the importance of using PPE when carrying out work. Using PPE can eliminate existing dangers, so operators can concentrate on their respective jobs. Apart from that, the company also assesses whether the training is effective or not
- Companies should provide adequate air ventilation and also add blowers so that operators do not overheat. Temperatures that are too high are not good for operators / because operators will easily get tired when doing their work. A good air temperature is around 18-28 C, while the temperature at PT Busana Indah Global is 30 C. So ventilation is required at least 15% of the floor area.

5 Conclusions and Recommendations

5.1 Conclusion

Based on the results of the research that has been carried out, the following conclusions are obtained:

1. The DPMO value and sigma value with the largest percentage of defects at PT Busana Indah Global are untriming thread defects with a DPMO value of 6,626.359 and a sigma value of 3.98. Based on the Pareto diagram above, it can be seen that the highest percentage of defects is untrimming thread with a percentage of 25.22% with a total of 981 defects.
2. Defects in untriming thread at PT Busana Indah Global are caused by 6 factors, namely (1) human factors, this occurs because the operator does not work according to the standard of ability, this is due to the operator's lack of skill and the operator's lack of awareness after sewing, not cutting the thread short and clean. . (2) material factor, occurs because the raw materials are dirty and the quality of the thread is low, so that the thread easily becomes entangled. (3) method factors occur due to late arrival of material components and not complying with the implementation of the schedule line so that the shift date is left behind. (4) machine factors occur because the machine settings are automatic and the machine tention is not stable so the stitches are not tight enough. (5) environmental factors, this occurs because the temperature of the production floor tends to be hot due to the large number of lights used, lack of ventilation, and dirty operator work areas. This shows that awareness of cleanliness is still lacking. (6) measurement factor, this occurs because the buyer's spec does not match the final spec for the pattern staff and the sample does not contain information on reducing or adding patterns so that many specs do not match the work sheet.

5.2 Recommendations

Recommendations that can be given to PT Busana Indah Global are as follows:

1. Continuous Monitor and Evaluate: Implement effective quality control and continuously monitor results. Ensure that corrective action is taken if there are deviations from quality targets.

2. Training and Awareness: Ensure that all operators involved in production understand the importance of SOPs. Provide appropriate training.
3. Communication and Collaboration: Ensure there is effective communication and collaboration between different departments, including production and QC/QA to ensure that understanding of production risks and quality control efforts is maintained.
4. Periodic Evaluation: Carry out regular evaluations of the production process in quality control.
5. Compliance with Standards: Ensure that all production practices comply with applicable quality standards, including applicable industry standards and regulations.

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