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Research Article

Analysis of Waste Production by Applying the Lean Six Sigma Method to Reduce Effects on Micro, Small, and Medium Enterprises (MSMEs) of Convection in Kudus

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Abstract.
This descriptive research was conducted with a qualitative approach. The study included three MSMEs of convection in Kudus because Muslimah clothing convection in Kudus is increasing. However, in the production process, several defective products are still found. The existence of these defects indicates the presence of waste in the production process. Therefore, the purpose of this research was to find out the causes of defects in the production process and take corrective steps to reduce defects. Based on the waste identification that has been done, the most critical waste defects are selected using the AHP questionnaire. Then the DPMO calculation was carried out, which showed the sigma level value for the three MSMEs, namely 3.75, 3.57, and 3.64. Next, the root causes of waste was analyzed using fishbone diagrams and FMEA tables. Recommendations for improvements are given to reduce the occurrence of these root causes. If the recommendations for improvement are implemented, there will be an increase in the sigma level for the three MSMEs, namely 4.02, 4.19, and 3.97.

Keywords: convection, lean six sigma, defect, waste

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1. Introduction

Micro, Small, and Medium Enterprises (MSMEs) are productive enterprises owned by individuals or corporate entities that have met the criteria of MSME. As stipulated in the regulations of legislation No. 07 of 2001, according to the understanding of MSME, criteria of MSME can be seen in the Table 1.1 below.

TABLE 1: Criteria of MSME.

Criteria	Asset	Omzet
Micro	Maximum 1 billion	Maximum 2 billions
Small	1 – 5 billions	2 – 15 billions
Medium	5 – 10 billions	15 – 50 billions

The current industry has developed rapidly, one of the industries that currently is convection because clothing is a necessity. As clothing products advance, demand for them rises. There are also new styles of clothing. So, there is rivalry in the convection sector because more people are creating it. Therefore, the quality of a product is crucial to satisfy client needs given the competitiveness in the convection sector. Good quality products will have more value on the product. Kudus is also one of the districts in Central Java that can grow rapidly through the development of MSME. However, there are still no industrial centers in the Kudus. Whereas the industrial center area can enhance micro, small, and medium enterprise activities. The MSMEs that develop in the Kudus are very diverse, such as the cigarette industry, garment industry, processed food, spare parts of vehicles, and others.

The potential industry in the Kudus besides the cigarette industry, is the garment industry which has become a standing industry known for its diverse products. Kudus is a city of Santri, and there are many Islamic boarding schools in Kudus. Kudus communities have a high spirituality and a majority of Islam. Kudus communities are famous for their religiosity. In Kudus community life, people hold religious activities such as pilgrimage, recitation, carnival of Santri days, etc. So, in their day-to-day life they often wear Muslimah clothes like a robe, skirt, and head scarf. As a result, the convection of Muslimah clothes in the Kudus is increasing.

This research is going to use a sample of 3 MSMEs of convection based on the explanation above and based on the MSME criteria of micro, small, and medium. So this research can represent a cluster convection of Muslimah clothes in the Kudus. There is Faza Collection as a micro MSME. It is located in the village of Pedawang. Faza Collection is produced in the form of a variety of children's Muslimah clothes. Then, Nida Collection is a small MSME. It is located in the village of Singocandi, the City's capital. Nida Collection is produced in the form of Muslim and Muslimah clothes. And Halwa Apparel is a medium MSME. It is located in the village of Gedangsewu, Bae. Halwa Apparel is produced in the fashion of Muslimah. The quality of the products the convection above is one of the problems that exist. That one has seen a defect in the production process, as shown in the Table 1.2 below.

Table 2: The Percentage of Defects on March 2023.

Convection Name	Total Production	Total Defect	The Percentage of Defects
Faza Collection	468	14	2,99 %
Nida Collection	2.800	96	3,42 %
Halwa Apparel	4.783	147	3,07 %

Sources: processed data, 2023

The quality of the products the convection above is one of the problems that exist. the defect indicates the existence of waste during the production process. Womack & Jones (1997) define waste as all work activities that use resources but do not generate value. All types of waste must be eliminated to increase the value of products (goods or services) and further increase customer value. One method that can be used to reduce is the Lean Six Sigma method. Six Sigma helps identify waste and hidden costs, eliminate defects, increase profit margins, increase customer satisfaction, commitment, and employee satisfaction, and expand business. (Purba & Siti Aisyah, 2017).

This research was conducted on the basis of previous research. The difference from previous research is the location of the research and the use of the sample. Research conducted by Teja et al (2022) shows that the sigma level increases after the implementation of improvement by applying the lean six sigma but this research doesn't carry out waste analysis to determine the overall condition of the production process. Based on the various research findings above, further research needs to be carried out by conducting a seven-waste analysis to find out the causes of critical waste and overcome the causes.

2. Method

The data processing in this research is carried out about the production process, the amount of production, and the number of defects. The data is then processed using the following analytical tools below :

a. SIPOC Diagram

b. Fishbone Diagram

c. FMEA Table

d. Poka Yoke

2.1. SIPOC Diagram

SIPOC stands for Supplier, Input, Process, Output and Customer. SIPOC is a diagram used to present workflow. SIPOC must be present at the start of the project to be sure that everyone will see the process in the same light. According to Pande & Neuman (2002), the SIPOC diagram is a high-level process map that identifies the main elements of a process that contains a list of processes, people, organizations, sources of materials, and information used in a process.

2.2. Fishbone Diagram

The fishbone diagram often called the Cause and Effect diagram can show the cause and effect of a problem (Bank, 1992). The factors that are the main causes that affect quality in the fishbone diagram consist of 5M + 1E namely machine, man, method, material (production materials), measurement, and environment. These factors are useful for grouping types of root causes into a category.

2.3. Failure Mode Effect Analysis (FMEA) Table

The US Armed Forces introduced the FMEA to the military community in the late 1940s. Before a product or service is accepted by customers, FMEA is a technique used in engineering, is used to define, and identify, faults, errors, and so forth from the system, design, process, and/or service (Hendy Tannady, 2015).

The FMEA process there are 3 main variables. Namely severity, occurrence, and detection. Severity is a rating or a level that refers to the seriousness of the impact of something's potential failure mode. The impact of the rating starts to scale from 1 to 10, where a scale of 1 is the lightest impact while 10 is the worst impact and determination to ratings. Occurrence is a rating that refers to 10 at some frequency of the occurrence of defects in the product. Mark the frequency of failure indicates the frequency of problems that occur due to potential causes. Detection is a process control that will specifically detect the roots cause of failure. Detection is a measurement to control failures that may occur (Hendy Tannady, 2015).

2.4. Poka Yoke

Here are the steps in preparing the Poka Yoke method:

a. Describe the damage or potential damage to be resolved.

b. Ratio or percentage of damage.

c. Identify the process by which the damage occurs.

d. Write clearly and in detail the steps of the process to be analyzed.

e. Look carefully at the process to see if there is any difference from what has been detailed.

f. Identify work steps or conditions that can cause damage or work errors, such as the environment, measuring instruments, and work equipment.

g. Use the 5 whys method to solve the problem.

h. Identify the Poka Yoke equipment that will be used to solve the problem.

i. Repeat the evaluation after applying Poka Yoke equipment.

3. Result and Discussion

3.1. Result

3.1.1. Sipoc Diagram

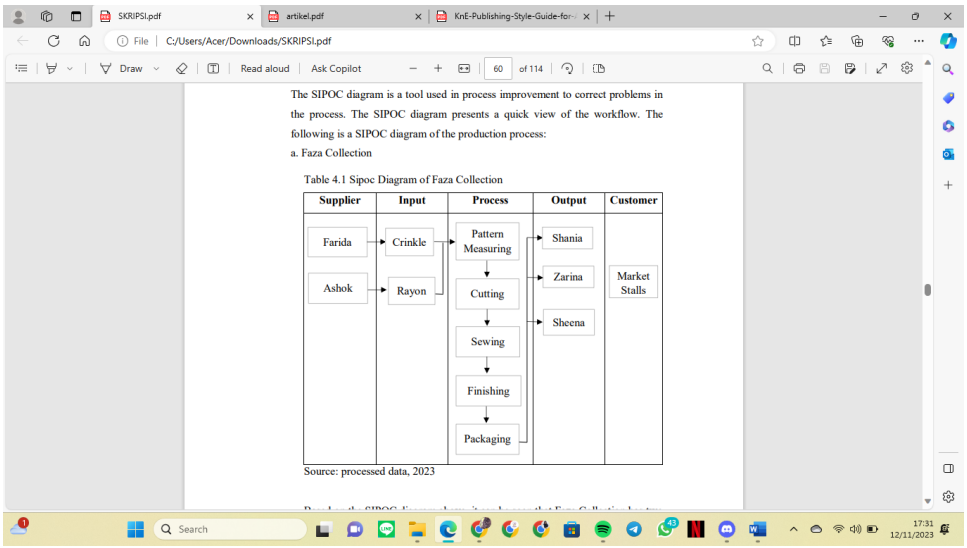

Figure 1: SIPOC Diagram of Faza Collection.

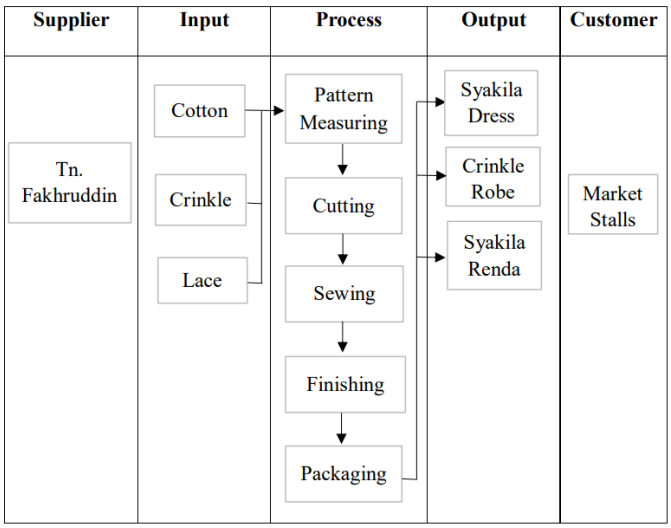

Figure 2: SIPOC Diagram of Nida Collection.

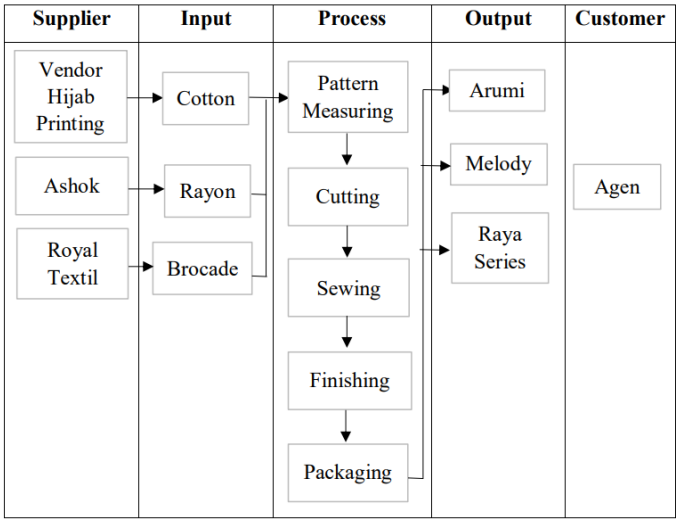

Figure 3: SIPOC Diagram of Halwa Apparel.

3.1.2. Waste Identification

1. **Transportation**

No	Start	Destination	Types of Goods	Conveyance
1.	Floor	Cutting Part	Raw Material	Human
2.	Cutting Part	Sewing Part	WIP	Human
3.	Sewing Part	Finish Seam Part	WIP	Human
4.	Finish Seam Part	Ironing Part	WIP	Human
5.	Ironing Part	Packaging Part	Raw Material	Container Box
6.	Packaging Part	Finished Goods Warehouse	Finished Good	Container Box

Figure 4: Transfer Data of Faza Collection.

No	Start	Destination	Types of Goods	Conveyance
1.	Floor	Cutting Part	Raw Material	Human
2.	Cutting Part	Sewing Part	WIP	Container Box
3.	Sewing Part	Finish Seam Part	WIP	Human
4.	Finish Seam Part	Ironing Part	WIP	Container Box
5.	Ironing Part	Packaging Part	Raw Material	Human
6.	Packaging Part	Finished Goods Warehouse	Finished Good	Car

Figure 5: Transfer Data of Nida Collection.

No	Start	Destination	Types of Goods	Conveyance
1.	Floor	Cutting Part	Raw Material	Human
2.	Cutting Part	Sewing Part	WIP	Human
3.	Sewing Part	Finish Seam Part	WIP	Container Box
4.	Finish Seam Part	Ironing Part	WIP	Container Box
5.	Ironing Part	Packaging Part	Raw Material	Container Box
6.	Packaging Part	Finished Goods Warehouse	Finished good	Van

Figure 6: Transfer Data of Halwa Apparel.

2. **Waiting**

Machine	The Quantity of Machine	Frequency Breakdown	Wasted Time (Day)
Sewing Machine	1	1	1

Figure 7: Machine Breakdown Data of April 2023 on Nida Collection.

Machine	The Quantity of Machine	Frequency Breakdown	Wasted Time (Day)
Steam Iron	1	3	3

Figure 8: Machine Breakdown Data of April 2023 on Halwa Apparel.

3. **Defect**

Convection	Total Production	Total Defect	The Percentage of Defects
Faza Collection	850	58	3,65 %
Nida Collection	4.559	266	5,83 %
Halwa Apparel	7.862	377	4,80 %

Figure 9: Total Defect.

4. **Excess Processing**

	Activity
1.	Packaging of non-standard fabrics into sacks
2.	Sold at a low price
3.	Trash

Figure 10: Non Value Added Activity.

3.1.3. Critical Waste

Waste	Point	Priority Waste	Matriks x Priority	Consistency
Defect	3,41	0,49	2,77	5,69
Overproduction	0,47	0,07	2,77	41,31
Waiting	0,46	0,07	2,77	42,21
Transportation	0,51	0,07	2,77	38,07
Inventory	0,87	0,12	2,77	22,32
Motion	0,73	0,10	2,77	26,60
Excess Processing	0,55	0,08	2,77	35,31

Figure 11: Waste Weighing on Faza Collection.

Waste	Point	Priority Waste	Matriks x Priority	Consistency
Defect	2,22	0,32	2,49	7,86
Overproduction	0,49	0,07	2,49	35,33
Waiting	1,36	0,19	2,49	12,82
Transportation	0,61	0,09	2,49	28,78
Inventory	0,79	0,11	2,49	21,95
Motion	0,99	0,14	2,49	17,66
Excess Processing	0,54	0,08	2,49	32,44

Figure 12: Waste Weighing on Nida Collection.

Waste	Point	Priority Waste	Matriks x Priority	Consistency
Defect	2,12	0,30	3,41	11,29
Overproduction	0,39	0,06	3,41	60,76
Waiting	1,12	0,16	3,41	21,25
Transportation	0,65	0,09	3,41	36,48
Inventory	0,89	0,13	3,41	26,75
Motion	1,04	0,15	3,41	23,03
Excess Processing	0,78	0,11	3,41	30,63

Figure 13: Waste Weighing on Halwa Apparel.

3.1.4. Pareto Diagram

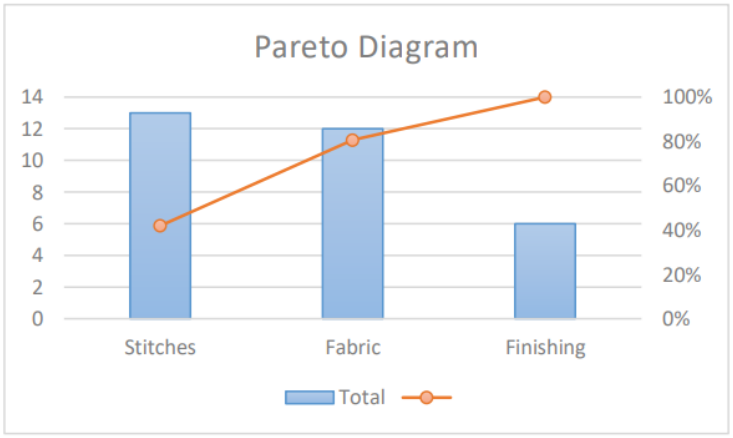

Figure 14: Pareto Diagram of Faza Collection.

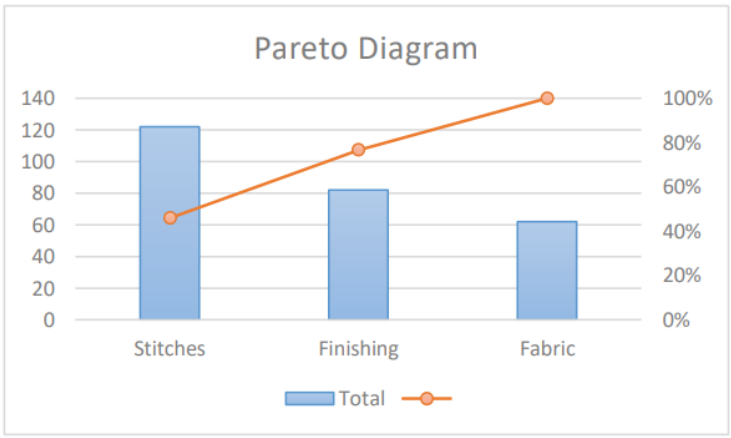

Figure 15: Pareto Diagram of Nida Collection.

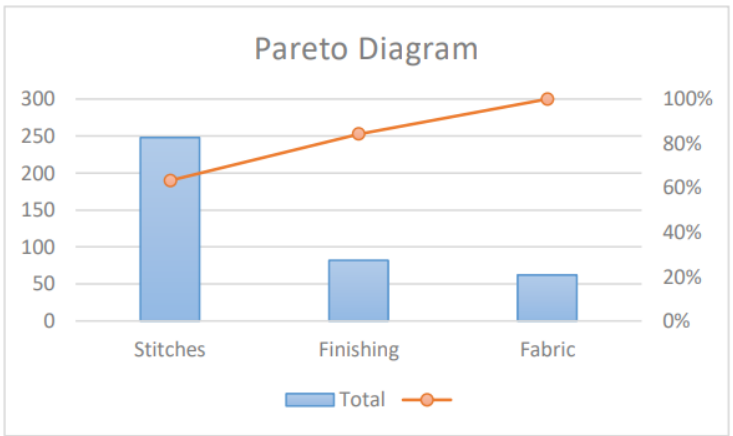

Figure 16: Pareto Diagram of Halwa Apparel.

3.1.5. Calculate DPMO and Sigma Level

Convection	DPMO	Level Sigma
Faza Collection	12.156,90	3,75
Nida Collection	19.488,70	3,57
Halwa Apparel	15.984,10	3,64

Figure 17: Sigma Level.

3.1.6. Fishbone Diagram

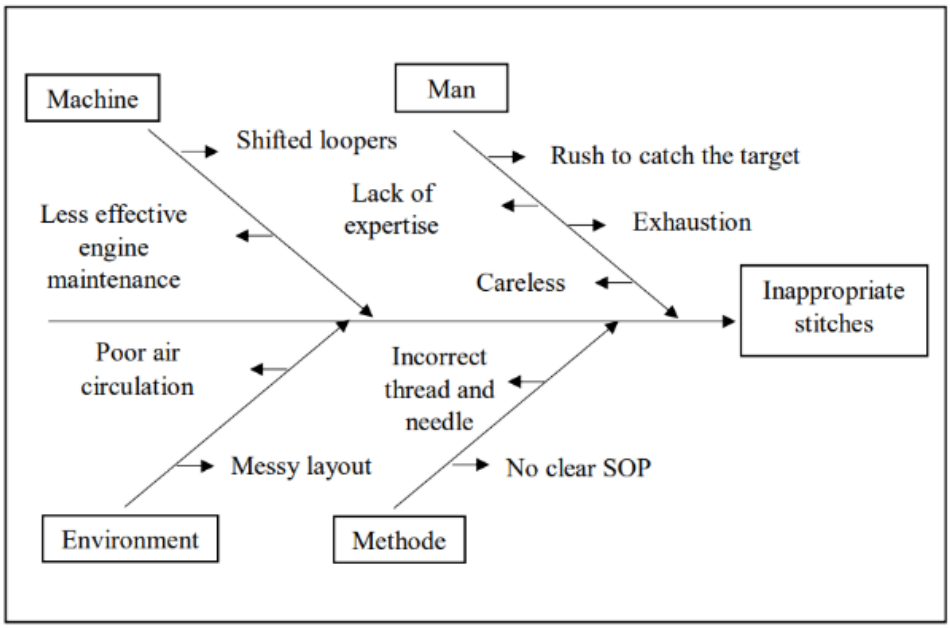

Figure 18: Fishbone Diagram of Seawing Part.

3.1.7. FMEA Table

FMEA	Convection's Name	Faza Collection				
	Researcher's Name	Eka Fahma Apriani				
	Filler Name & PIC	Mu'izzatul Latifah				
Modes of Failure	**Effect of Failure**	**Cause of Failure**	**S (1)**	**O (2)**	**D (3)**	**RPN (1x2x3)**
Inappropriate stitches	Untidy stitches	Rush to catch the target	7	4	1	28
	No holes in the buttons	Lack of expertise	7	4	4	112
	The shape does not match the pattern	Exhaustion	7	4	4	112
		Careless	7	4	4	112
		Shifted loopers	7	3	3	63
		Less effective engine maintenance	7	3	3	63
		No clear SOP	7	7	5	245
		Incorrect thread and needle	6	4	5	120
		Poor air circulation	6	4	1	24
		Messy layout	6	4	1	24

Figure 19: FMEA Table of Faza Collection.

FMEA	Convection's Name	Nida Collection				
	Researcher's Name	Eka Fahma Apriani				
	Filler Name & PIC	Maulida Fitriya				
Modes of Failure	**Effect of Failure**	**Cause of Failure**	**S (1)**	**O (2)**	**D (3)**	**RPN (1x2x3)**
Inappropriate stitches	Untidy stitches	Rush to catch the target	8	4	1	32
	No holes in the buttons	Lack of expertise	6	3	6	108
	The shape does not match the pattern	Exhaustion	6	3	6	108
		Careless	6	3	6	108
		Shifted loopers	4	3	1	12
		Less effective engine maintenance	4	1	1	4
		No clear SOP	6	4	7	168
		Incorrect thread and needle	4	7	4	112
		Poor air circulation	4	1	1	4
		Messy layout	4	3	1	12

Figure 20: FMEA Table of Nida Collection.

FMEA	Convection's Name	Halwa Apparel				
	Researcher's Name	Eka Fahma Apriani				
	Filler Name & PIC	Fatimatush Sholikhah				
Modes of Failure	**Effect of Failure**	**Cause of Failure**	**S (1)**	**O (2)**	**D (3)**	**RPN (1x2x3)**
Improper accessory attachment	Untidy stitches	Rush to catch the target	10	7	1	70
	No holes in the buttons	Lack of expertise	4	4	4	64
	The shape does not match the pattern	Exhaustion	4	4	4	64
		Careless	4	4	4	64
		Shifted loopers	4	7	1	28
		Less effective engine maintenance	4	1	1	4
		No clear SOP	7	7	4	196
		Incorrect thread and needle	7	3	4	84
		Poor air circulation	4	4	1	16
		Messy layout	4	4	1	16

Figure 21: FMEA Table of Halwa Apparel.

3.1.8. Poka Yoke Method

Causative Factor	Preventive Measure
Rush to catch the target	- Manage orders and production schedules - Ensure equipment and tools are ready during the production process
Lack of expertise	- Conduct selection according to the field in the recruitment process
Exhaustion	- Provide a safe and comfortable work environment - Pay attention to the health condition of workers before work
Careless	- Implementing a good control system during the production process
Shifted loopers	- Adjustment and checking of sewing machines
Less effective engine maintenance	- Routine checking of production machines
No clear SOP	- Preparation of SOP in accordance with the needs of production and employees - Running and supervising SOP in the production process so that they are implemented as they should
Incorrect thread and needle	- Grouping the type of thread on the type of fabric to be used
Poor air circulation	- Adding fan facilities or widening the area
Messy layout	- Layout arrangement according to the flow of the production process

Figure 22: Preventive Measure.

3.1.9. Control

Description	Convection	The Percentage of Defects		DPMO		Level Sigma	
		Before	After	Before	After	Before	After
Minimizing defective product	Faza Collection	2.99 %	1.77 %	12.156,90	5.910,17	3,75	4,02
	Nida Collection	3.42 %	1.06 %	19.488,70	3.526,56	3,57	4,19
	Halwa Apparel	3.07 %	2.05 %	15.984,10	6.832,54	3,64	3,97

Figure 23: Comparison of the Value of Defect.

3.2. Discussion

1. Based on the SIPOC diagram can presents a quick view of the workflow. We can see the supplier material, process, and customer of each MSME.

2. The analysis of seven wastes in the production process, the three MSMEs identified four wastes namely waiting, defects, movement, and excess processing. After weighting, the critical waste is defect.

1. Based on the Pareto Diagram in the figure above, it shows that the three MSMEs have the same type of defect, which is a priority improvement in the next analysis process, namely the type of seam defect. so that improvement is needed to reduce the level of defects in the product.

2. Based on the calculation of the DPMO value, the sigma level shows that of the three MSMEs above, it is at level 3. This sigma value indicates that the company is still at a bad level, so it needs to make some improvements in the production process.

3. After analysis by Fishbone Diagram of the causes of defects in the sewing process, an FMEA table is made, which is shown in Table 4.19, to determine the priority of improvements that can be made by looking at the RPN. The value of the RPN indicates this problem; the greater the RPN value, the more it indicates problematic and requires more attention.

4. The priority repair or improvement is only done for factors with the highest RPN values. Based on the table above, the three MSME have the highest RPN, namely the absence of a clear Standard Operating Procedure (SOP). So, the corrective

step that must be taken is to make a new SOP in accordance with the production process and employees in order to reduce production process errors.

5. The poka-yoke is based on preventative actions that identify and eliminate mistakes and the causes of variations and defects in the production process.

4. Conclusion

The purpose of this research is to find out about waste during the production process and the causes of defects. Based on the waste identification that has been done, the most critical waste defects are selected using the AHP questionnaire. Then, analyze the root causes of waste by using fishbone diagrams and FMEA tables. After making improvements, the percentage of total defects from the total production of the three MSMEs shows a decrease in the percentage rate from last month. In addition, the sigma level in May 2023 of the three MSMEs was on average at level 4, which also shows that the sigma level has increased from last month which was at level 3.

Acknowledgements

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