IMPLEMENTATION OF THE DMAIC APPROACH FOR QUALITY IMPROVEMENT AT THE ELASTIC TAPE INDUSTRY

Hibarkah Kurnia*[1], Choesnul Jaqin[2], Hasiholan Manurung[1]

[1]Master of Industrial Engineering Program, Mercu Buana University,
[2]Master of Industrial Engineering Department, Mercu Buana University,
Gedung Tedja Buana, Jl. Menteng Raya No.29 - Jakarta, Indonesia 10340

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Abstract

The scope of this research is in one of the textile industries with elastic tape produced on the weaving machine, which has decreased production due to production defects that do not meet the target. This research aims to determine the leading causes of dominant defects, increase the sigma level with Six Sigma methods, and propose improvements to be included in the Key Performance Indicators (KPI) method. The results of this study that the dominant factor causing the defect is the curved elastic tape defect, which consists of the machine factor, and the method. Factors driving the machine include the hook like a side thread lock that is often bent and the difference in the thickness of the tape between the left, middle and right. The causative factor of this method is checking the thickness of the elastic band only in the center position. The results of corrective actions impact increasing the sigma level by 10% from 3.3339 to 3.6832. In contrast, repair defects can reduce defects before repair by 18.92% and after repair by 9.23%. It is proposed to be included in the KPI so that the weaving department can control and be enthusiastic about continuous improvement.

Keywords*: DMAIC; Elastic Tape; Six Sigma; Textile; Quality Improvement*

1. Introduction

The elastic band production process in Indonesia must increase production and reduce manufacturing defects to compete well in the global market. This study discusses how elastic band products can increase production and reduce defects on target. The elastic band production defect data for 2019 was 53.2% (attached in **Figure 2**). This is the management's concern to be able to fix the problem of increasing defects because the company will experience high costs if it is not immediately repaired. The implementation of Six Sigma with the Define Measure Analyze Improve Control (DMAIC) approach has often been used in various industrial sectors, including the elastic band weaving industry.

Therefore, the background of the research problem is to analyze the main factors causing dominant defects in elastic bands, how to fix the main weaknesses in the stock, and how the DMAIC approach can measure the magnitude of the sigma level. Six Sigma focuses on continuous improvement and aids in process optimization by identifying the source of the defect (Sundaramali et al., 2021) (Kurnia, Jaqin, et al., 2021). The contribution of this research is to serve as a scientific work that can answer the improvement of the quality of the elastic tape, and practice can be used as literature material in similar research. Value Stream Mapping (VSM) helps define key process stages to improve each stage's problems (Mukhlis et al., 2021). The Six Sigma method effectively identifies and analyzes product failures and can improve the capability/level to get better quality products (Saryanto et al., 2020). Six Sigma has been successfully applied at one of the Indian small-scale units to improve the rejection/ rework rate in manufacturing products by the pressure die casting process (Malek & Desai, 2015).

The Six Sigma-DMAIC methodologies will be applied to solve the problem. Therefore, the collection center will no longer have economic losses due to impurity discounts (Herrera et al., 2019). Using Six Sigma and the DMAIC methodology in this home appliances company has reduced the number of defective aluminum parts, significantly affecting customer satisfaction and cost savings (Ahmed et al., 2018). It is expected that we can boost the performance of the traditional boat building industry by implementing Six Sigma (Praharsi et al., 2020).

Continuous quality improvement can be achieved by implementing Failure Models Effects Analyze (FMEA) in automotive SMEs. Then the identified improvement points and their effects were different for individual case companies, but all showed continuous quality improvement. Six Sigma is a customer-driven approach representing the systematic implementation of various statistical methods, tools, and techniques for quality improvement and customer satisfaction (Ravichandran, 2016). The product studied in this paper is solvent-based paints and a multivariate technique based on SEM is applied to optimize the

quality to improve the success rate of sales (Khodami et al., 2021).

Identify and analyze the quality control process to determine the main factors causing the occurrence of defective products. The method used is Six Sigma and FMEA, then the research results, the Defect value per Million Opportunity (DPMO) obtained is 181.67, and the sigma value is 5.07 (Fithri, 2019). The interactions between elements can be identified using the Design of Experiment (DoE) method in the textile (Yame & Ali, 2019). They are improving product quality with the technique used in Six Sigma and Fishbone Diagram. With the results of his research, a new set of optimal combinations is applied to the lay carriage to increase the sigma level from 0.7 to 2 and Capability (Cp) from 0.2 to 1.47 (Abbes et al., 2018). The research results can supplement the sigma level from 3.74 and reduce contamination in the third row resulting in a sigma level of 4.32 (Adikorley et al., 2017). Statistical Process Control (SPC) is a well-established technique in a context that has recently been used in software production (Kurnia, Setiawan, et al., 2021).

The DMAIC approach and the DoE method can reduce non-conforming polyester bypass fibers in Indonesia (Syafwiratama et al., 2017). The measurement results obtained that the average sigma level is 3.32, and the sigma level included in Sigma three will cause a 25-40% (Shafira & Mansur, 2018a). The waste weight of defective products is 26.25%, the waiting time for waste is 16.02%, the DPMO value is 2,150, and the sigma value is 4.36 (Nurprihatin et al., 2017). The results of the research input from the average index value of productivity, material (98.85%), and energy (95.11%) %) (Bakar et al., 2017). Raw material quality control and process quality control hurt the number of defective products and quality (Cost of Quality). In contrast, the quantity of faulty products positively affects production costs (Sihombing & Sumartini, 2017). The DMAIC phase effectively controls and improves product quality levels in the automotive industry (Setiawan & Setiawan, 2020).

Cost of Poor Quality (COPQ) is known as the cost of quality, meaning how much cost is incurred due to failure of quality; COPQ also means the cost or price the company must pay when it is not perfect or the costs incurred as a result of wrong or product failure that does not meet customer standards (Saxena & Srinivas Rao, 2019). Lean Six Sigma (LSS) approach is a structured and systematic methodology for improving a process focused on reducing process variance as much as possible, minimizing defects (products/services that fall outside of specifications) by using statistics and problem-solving tools intensively (Kurnia & Hardi Purba, 2021).

The analysis in this study is with research conducted in the same garment industry but with different products including. Reducing production costs while improving quality in the garment industry, using the DMAIC approach in the sewing section, with the methods used are SIPOC, Six Sigma, Pareto Diagrams, and SOPs with research results before the sigma level improvement is 2.69. After repairs, it increases to 2.80 (Zaman & Zerin, 2017). in this study, the same use the DMAIC approach with a six sigma method, Pareto diagrams, and fishbone diagrams. the difference is at the defined stage of this research using CTQ, at the analysis stage using FMEA to measure how much the main cause affects the potential risk generated, at the control stage this research uses the KPI method as a renewable one in controlling problems in management's monthly reports no longer through SOPs.

Furthermore, it reduces the number of perforated defects in prayer rug products in the garment industry with the method used in Six Sigma with the sigma value after implementing improvements of 3.31 (Wardana et al., 2015). In this study, the method used is not only six sigma before improvement and after improvement. before calculating six sigma after improvement, this study uses the 5W+2H method in planning and taking corrective actions so that the expected result is to increase the sigma level. The implementation of Six Sigma has also begun in textile factories that produce raw fabrics, with the DMAIC stage which uses several quality tools including CTQ, P control charts, Fishbone diagrams, FMEA, Five M checklists, and six sigma level calculations (Fithri, 2019). The difference with this study is that the quality improvement tool is more complete with the addition of six sigma level calculations before and after repair, the use of 5W+1H, and FMEA through FGD. The existence of the Kaizen Method at the time of repair and control using KPIs that are included in the company's targets can be a challenge in the future in terms of improvement or profit.

The new approach of this research is that the FGD method can determine the value of the FMEA RPN and priority for improvement because it is carried out with several experts in their field and consistency of control can always be done by including sigma level targets in the departmental KPIs so that it will be a new challenge in terms of supervision and implementation of Six Sigma. in the manufacturing industry in the field of elastic bands.

This study discusses the stages of DMAIC by measuring the sigma level and using several quality improvement tools. This study aims to determine the main cause of the dominant defect, increase the level of sigma with the Six Sigma method, and propose improvements to be included in the Key Performance Indicators (KPI) method to become a new challenge for the elastic band industry in Indonesia.

2. Methods

A. Data Information

The technique needed to collect data used in this study is observation because the data type is primary data. The type of attribute defect is the failure of the elastic tape production process, so the data obtained is in the form of quantitative data. For secondary data, the data collection technique is document study or monthly production report documents. At the same time, qualitative data is obtained from analyzing the causal factors or root cause analysis through focus groups during a meeting with leaders.

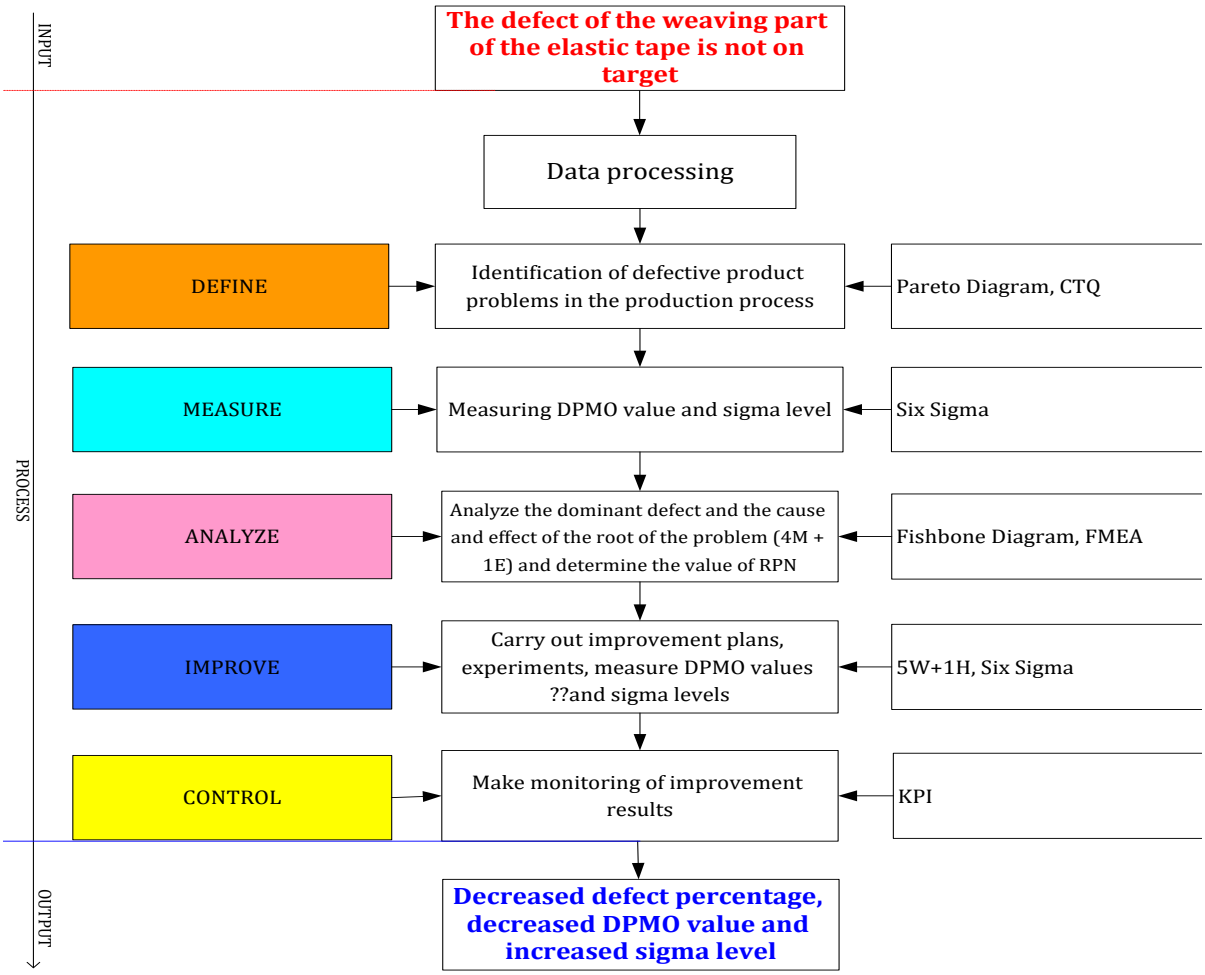


Figure 1. Application Framework

The secondary data population obtained in this study is production data and defect data for a certain period in one of the elastic tape industries in Indonesia. One of these industries already represents the other elastic tape industry because machines and making elastic tape are almost identical. The sample in this study is a sample of elastic tape checked by a QC operator, and the results of the inspection results are recorded in a production check sheet and defects. To make a sample of elastic tape, the material is from several color threads consisting of a composition of yarn composed of 50% polyester, 40% spandex, and 10% nylon.

In this study, the import is carried out using the DMAIC approach with Six Sigma: Pareto Diagram, Critical to Quality (CTQ), Fishbone Diagram, FMEA, 5W+1H, Six Sigma, and KPI method. This research aims to determine the leading causes of dominant defects with the FMEA method, increase the sigma level with Six Sigma methods, and propose improvements in the KPI method. This research was conducted on elastic tape at the Weaving machine. This research is at PT YKK Zipper Indonesia in the Cibitung area, Bekasi, West Java, Indonesia.

B. Research Method

This research method consists of three phases so that this research is more focused and well structured. The first phase is called the input phase where this phase explains the phenomena of problems that have occurred due to many defects that occur so that the company must be able to determine the direction or purpose of this research. The second phase is the process phase where this phase describes and describes data collection and improvement methods both before and after improvement and using several quality improvement tools in each stage. the last phase is the output phase where this phase is expected to confirm answers to problems and act consistently in monitoring and monitoring improvements so that company goals can be achieved properly. The article understudy was developed according to the stages of the DMAIC methodology **Figure 1**.

Quality variations exist in product specifications, losses/ defects are in the form of unsatisfactory products, poor quality repair problems, sizes too tiny, sizes too large, or other issues (Summers, 2016), in his book quoting back about losses/ defects Taguchi. Quality improvement is when the company identifies the problem, creates a repair team, analyses the root cause, and eliminates it (Saxena & Srinivas Rao, 2019).

It is the book, the Kaizen process of implementation and quality improvement redistributes Hitoshi Yamada. The success of Six Sigma depends upon the selection of different tools and techniques at

Table 1. CTQ Research Method

No Column	Month–Year	Production (kg) A	Total defect (kg) B	Defect (%) C
1	Jan-20	production	defect	$\frac{B}{A+B} x100\%$
..	..	..	..	..
6	Jun-20	..	..	..
Grand Total		Total Production	Total Defect	Average Defect

each stage. Furthermore, the tools and techniques selection depends on the type of problem (Patel, 2017).

The Six Sigma program has a five-phase cycle, namely DMAIC for process improvement, becoming increasingly popular in Six Sigma organizations (Saxena & Srinivas Rao, 2019). The DMAIC stage is just a workflow used to determine what the customer wants (Carroll, 2013). The best Pareto solution was compared with the schedule used in the hospitals (Hamid et al., 2018).

Define Stage

Pareto Diagram is a bar graph that shows problems based on the order of the number of events. The order starts from the number of the issues that occur the most to those that occur the least (Ginn & Varner, 2004). The data analysis methods in this study are to take a data report on the check sheet for defects and types of defects filled in by the inspector for 40 lots, then input them into the computer in Microsoft Excel. Next, perform the addition of defects according to the type of defects. Finally, input defect data and kind of defect into Minitab-19 software, then a Pareto Diagram graph will be formed.

CTQ is a defect problem that significantly affects production (Abbes et al., 2018). As for the steps to determine CTQ, collect production data reports (kg) and defects (kg) from January 2020~June 2020 on weaving machines and input them into Microsoft Excel, as shown in **Table 1**.

To find out the CTQ of the types of defects that often appear for six months, the next step is to break down the number of defects according to the kind of defect. Furthermore, the types of defects that often appear or critical qualities will be identified in this study.

Measure Stage

To determine the sigma level, the research method takes production report data and defects on an elastic tape weaving machine for 40 lots before improvement and then inputs it into Microsoft Excel. Determining the sigma level can use the help of Microsoft Excel and calculation of Defects Per Unit (DPU), Defects Per Opportunity (DPO), and Defect Per Million Opportunities (DPMO) with the formula:

- ✓ $\text{DPU} = \frac{\text{Amount Defect}}{\text{Amount Unit}}$ (1)
- ✓ $\text{DPO} = \frac{\text{DPU}}{\text{CTQ}}$ (2)
- ✓ $\text{DPMO} = \text{DPO} \times 1{,}000{,}000$ (3)
- ✓ Level Sigma = $\text{NORM.S.INV}\left(\frac{(1{,}000{,}000-\text{DPMO})}{1{,}000{,}000}\right) + 1{,}5$ (4)

Four block diagram is a description of a process and states improvement direction that leads to two sides of improvement, namely technology and control which is a description of the ability of the process (Z) of an ongoing process. The Zshif and Zbench. lt calculations in the four-block diagram are as follows:

$$Zst = Zbench.lt + 1.5 \quad (5)$$

$$Zshift = Zbench.st - Zbench.lt \quad (6)$$

Analyze Stage

Fishbone Diagram is an analysis carried out by starting from the consequences or problems that arise and then in a structured way looking for possible causes. In general, six factors can cause deviations in business processes, namely 4M (Material, Method, Machine, Man) and 1E (Environment).

This study's FMEA data analysis method is to make a Focus Group Discussion (FGD) at the meeting and determine the failure factors included in the FMEA table. Then, it is continued by assessing the risk priority number (RPN) value of the potential failure mode. Each of the three risk factors is usually assigned a deal on a numerical scale ranging from 1 to 10. After there is a Risk Priority Number (RPN) value with the formula RPN = OxSxD, where Occurrence (O) is the probability, Severity (S) is the seriousness of the failure, and Detection (D) is the ability to detect failure before the impact of the failure effect manifests. The next step is to prioritize the RPN value that has been determined (rating scale). After FMEA analysis, further in-depth research is carried out using why-why analysis.

Improve Stage

5W+1H is a structured method to generate ideas using a series of questions related to the problems or goals set (Saxena & Srinivas Rao, 2019). In this study, the data analysis method was obtained during the Focus Group Discussion in a meeting where the content of the meeting discussion determined 5W+2H with the results of mutual agreement.

To determine the sigma level, the research method takes production report data and defects on an elastic tape weaving machine for 40 lots after improvement and inputs it into Microsoft Excel. The steps to get the sigma level are the same as before at 3.2.2.

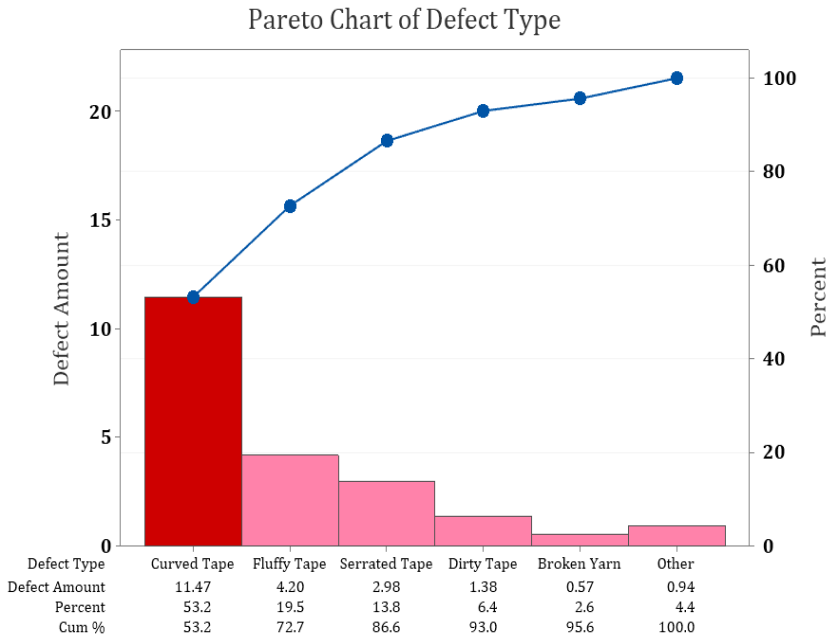


Figure 2. Pareto Diagram of Elastic Tape Defect Before Improvement

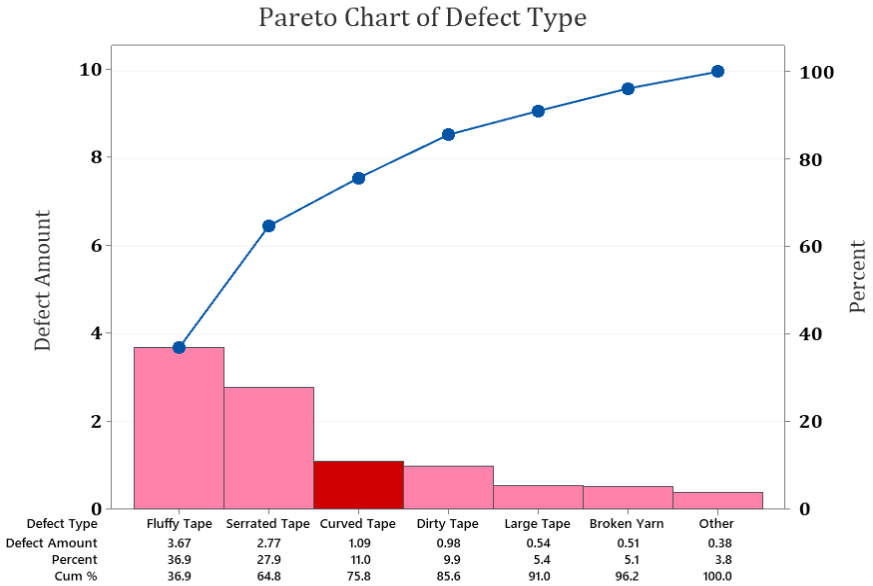


Figure 3. Pareto Diagram of Elastic Tape Defect After Improvement

Control Stage

The research methods in this KPI report at PT YKK have been running since 2019 with item parameter cost, delivery, quantity, and no quality-related to a sigma level. Make it propose it serves to control the results of daily quality improvements. The quality factor will be included in the monthly KPI targets to monitor the production team's quality improvement projects. Submit sigma level items/ parameters, especially in the elastic tape weaving machine, to the KPI coordinator with the person's approval in charge of the KPI. This makes it a new target for this section to keep motivating the continuous improvement routine.

3. Result and Discussion

Define Stage

The results of the Pareto Diagram before the repair can be seen in **Figure 2**. It means that the data on the defect of the elastic tape before taking corrective action is the initial data. After improvement, the Pareto diagram can be seen in **Figure 3**, which means that the elastic tape defect data after improvement.

Based on **Figure 2**, the most Pareto or dominant defects (red block color) are curved tape defects of 53.2%. Therefore, these perforated defects must be followed up immediately for improvement.

In **Figure 3**, it can be seen that the dominant defect before improvement, namely the curved tape defect in the red beam, becomes the 3rd position after the fluffy tape and serrated tape defect. Disability after repair decreased by 11.0% which means decreased by 79.3%. To get a CTQ, the data needed is a production report document and a six-month defect report. When determining the type of defect that often appears, testing is more accurate because elastic tape defects vary widely in types of defects. The report data documents can be seen in **Table 2**.

Table 2. Production Report and Defects of Elastic Tape

No	Month-Year	Production (kg)	Defect (kg)	Defect (%)
1	Jan-20	560	132	19.09
2	Feb-20	535	125	18.94
3	Mar-20	587	136	18.81
4	Apr-20	495	118	19.25
5	May-20	436	98	18.35
6	Jun-20	328	89	21.34
	Total	2,941	698	19.18

Table 3. Production Report and Defects of Elastic Tape

No	Defect Type	Total Defect (kg)
1	Curved Tape	372
2	Fluffy Tape	136
3	Serrated Tape	97
4	Small Size	12
5	Dirty Tape	45
6	Large Tape	19
7	Broken Yarn	19
	Total	698

Table 4. Sigma Level Before Improvement

Parameter	Unit	Before Improvement	Remark
Total Production	kg	973	
Total Defect	kg	227	
Defect	%	18.92	Target 10%
DPU	unit	0.2333	
DPO	opportunity	0.0333	
DPMO	PPM	33,333	
Level Sigma	sigma	3.3339	

Table 2 shows that the sample taken from January 2020 to June 2020 for 6 months resulted in a total of 698 defects with a defect percentage of 19.18%. After getting the total defects, still in the form of quantity defects and the types of elastic tape defects that have not been seen, the next step is to break down the fundamental weaknesses into types of defects. So it will be seen the kinds of imperfections that often appear or are called CTQ. For more details, see **Table 3**.

Based on **Table 3**, it can be concluded that the CTQ in this study amounted to 7 types of defects that often appear. The most dominant CTQ is a hole in the elastic tape because the weaving QC inspector will see this defect during a visual inspection of the elastic tape that has just come out of the machine.

Measure Stage

Before and after repairing the elastic tape defect, the sigma level can be determined by entering all production data and defects in Microsoft Excel software and using formulas 1 to 4 in section 3.2.2. The results of data processing for Six Sigma can be seen in **Table 4**. **Table 4** shows that the defect (%) before improvement is 18.92% while the target is 10%. The DPMO results are 33,333 and the sigma level is very low 3.3339. Four block diagram describes a process and states improvement direction that leads to two sides of improvement, namely technology and control, which represents the ability of the process (Z) of an ongoing process. Based on Sigma Level 3.33 (before improvement), it can be calculated Zshif value as a reflection of control ability and Zst value which reflects the knowledge of technology and then plots it in Four block diagrams that show the capability of the ongoing process (Z). The Zshif and Zbench. The calculations in the four-block diagram are as follows:

Zst = Zbench.lt + 1.5
3.33 = Zbench.lt + 1.5
Zbench.lt = 3.33 – 1.5 = 1.83
Zshif = Zbench.st – Zbench.lt = 3.33– 1.83 = 1.50

The next step is after knowing the value of Zshif (control ability) and Zst (sigma level) then it can be done by making four block diagrams to illustrate the current process condition (current condition), as for the Four block diagrams referred as in **Figure 4**.

Analyze Stage

Based on the results of meetings with operators and leaders using brainstorming and why-why analysis, the main factors causing the problem were obtained. The next step from the results of the Fishbone Diagram is to use Microsoft Visio software, and it will look like **Figure 5**.

Figure 5 shows the main causes of perforated defects in machines, methods, man, and materials. While the root causes consist of: the different thicknesses of the surface tape, only check the thickness of the tape in the middle, bent hook part, control tensor, and QC operators don't understand. The report of the five main causes was obtained from brainstorming with

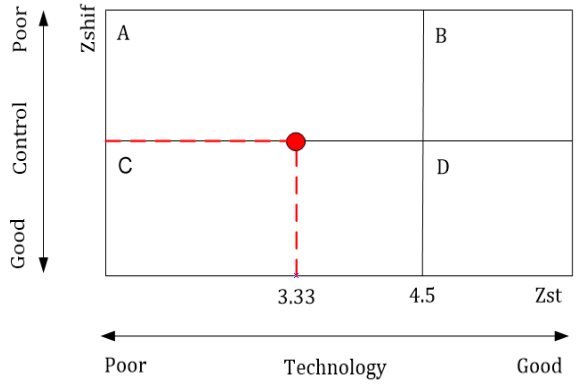


Figure 4. Four Block Diagram Product Failure (Defect) Before Improvement

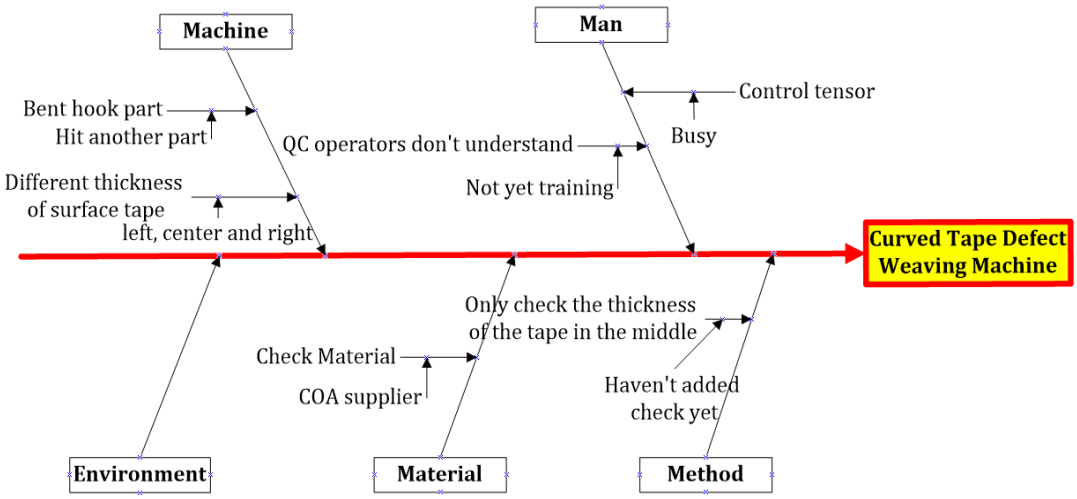


Figure 5. Fishbone Diagram Result

Table 5. FMEA Analysis of Curved Tape Defects

Potential Failure Mode	Sev	Potential Failure Effects	Occ	Potential Cause of Failure	Det	RPN	Rank
Different thickness of surface tape	8	Loss production	7	left, center, and right	7	392	2
Only check the thickness of the tape in the middle	6	Many defects	7	Haven't added check yet	7	294	3
Bent hook part	9	Machine stop	7	Hit another part	7	441	1
Control tensor	6	Downtime loss	5	Operator busy	4	120	4
QC operators don't understand	4	Speed loss	4	Not yet training	5	80	5

a single machine operator. B ased on the meeting results in the Focus Group Discussion (FGD) activity, nine members from the leader level to the president director had the capacity as an expert judgment in determining FMEA scores. The results can be seen in **Table 5**.

The results of the FMEA show that four main causative factors result in dominant defects. Therefore, the organization may decide that any RPN above 200 creates an unacceptable risk. In this study, FMEA analysis by an experienced repair team during FGD.

Improved Stage

The proposed improvements using the 5W+1H method were carried out during the FGD meeting attended by nine expert judgments from the leader level to the president director. The results of 5W+1H will be submitted for improvement plans, and the results can be seen in **Table 6**. **Table 6** shows that four factors cause perforated defects in the proposal to repair perforated defects, namely a curved tape in the weaving machine.

For the next step, each person in charge of repairs takes corrective actions with the team that has been formed. The repair team takes disciplinary actions according to the repair plan made to not clash with other work. The Method of Improvement curved tape defect on weaving machines can be seen in **Table 7**.

In examining the elastic band sample to find out the results of the sample curve using a curvature paper tool, more details can be seen in **Figure 6**. The results of checking the quality of the elastic band for each condition can be seen in **Figure 7**.

Table 6. Determine 5W+1H for Planning Improvement

No	What	Why	How	Who	When	Where
	What is the problem?	**Why should it be dealt with?**	**How to deal with it?**	**Who is in charge?**	**When will it be implemented?**	**Where is it carried out?**
1	Bent hook part	Hit another part	Substitution part for making trial	Mardian	September 22, 2020	Weaving machine area
2	Different thickness of surface tape	No changes to the specifications of the webbing	Trial changes To the specifications of the webbing on the feeling carrier	Budiono	October 23, 2020	Weaving machine area
3	Only check the thickness of the tape in the middle	There is no inspection of the left and right of the ribbon	Three-position check after out of production	Yudi S	November 5, 2020	Inspection product area

Table 7. Improvement of Curved Tape Defects

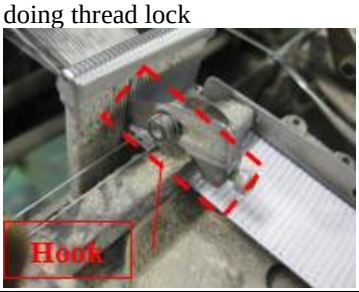
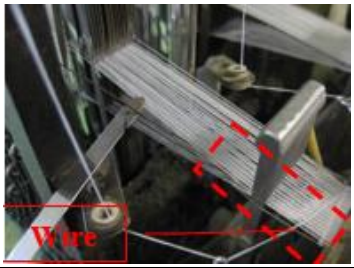
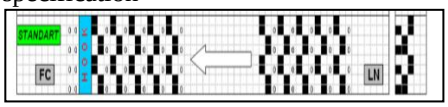
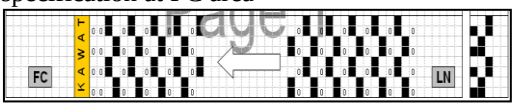
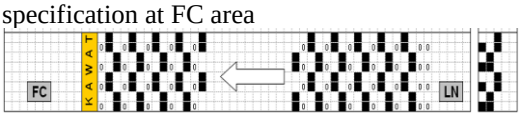
No	Factor	Before Improvement	After Improvement
1	Machine (Substitution part)	Current condition use hook part for doing thread lock 	Trial condition change to wire part 
2	Machine FC = Feeling Carrier, LN = Lach Needle, ◨ = Yarn, ○ = Spandex	Current condition of elastic tape specification  The specification is FC, Spandex, Spandex, Hook, Yarn, and Yarn	**Test 1** condition change to elastic tape specification at FC area  The specification is FC, Kawat/ Wire, Spandex, Spandex, Yarn, and Yarn **Test 2** condition change to elastic tape specification at FC area  The specification is FC, Kawat/ Wire, Spandex, Yarn, Spandex, and Yarn
3	Method	Checking the Thickness of the Feeling Carrier (left) and Latch Needle (right) sections is not only done in the center section PIC: Inspector line and QC Operator	Thickness checking is carried out at 3 points, namely: Latch Needle, Center and Feeling Carrier PIC: Inspector line, QC Operator, and Technician

Figure 6 is a tool for measuring band bias that has been registered in the internal standardization. These tools are manufactured in mm units and are often used by QC and production operators in tape quality checks. The results of the examination of the sample band can be seen in **Figure 7**. If you look at **Figure 7**, it can be seen that the condition of test 2 has better band quality than the condition of test 1 and the current condition. So it can be concluded that test condition two will be applied to mass production conditions.

After all the machine conditions have been changed to test 2, the results of the sigma level can also be known in **Table 8**, namely by collecting data from 40 lots in one machine. **Table 8** shows that the defect (%) before improvement is 18.92% and after improvement is 9.23% while the target is 10% so that the defect is decreased by 48.7% and has reached the target. The DPMO results decreased by 56.3% so the sigma level increased by 10.4%.

Four block diagram describes a process and states improvement direction that leads to two sides of improvement, namely technology and control, which represents the ability of the process (Z) of an ongoing process. Based on Sigma Level 3.68 (after improvement), it can be calculated Zshif value as a reflection of control ability and Zst value which reflects

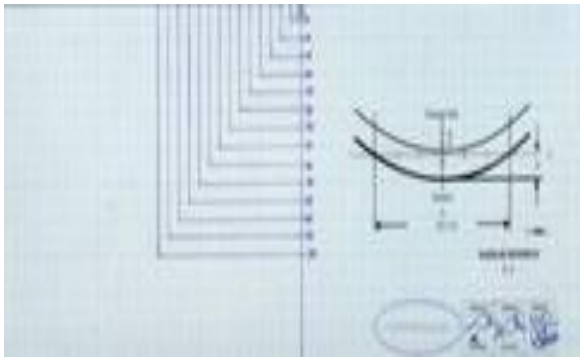


Figure 6. Tool of Curvature Tape Checking

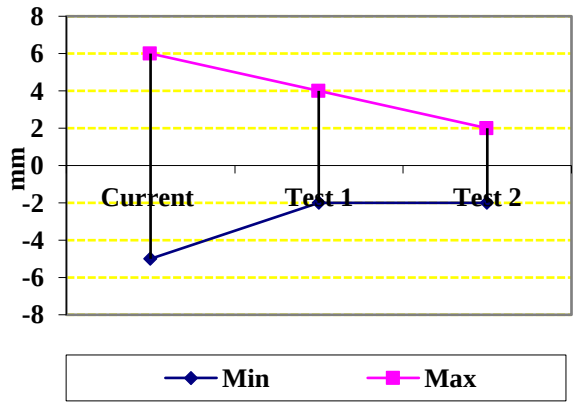


Figure 7. Elastic Tape Curvature Quality Inspection Results

Table 8. Calculation Sigma Level After Improvement

Parameter	Unit	After Improvement	Remark
Total Production	kg	1,032	
Total Defect	kg	105	
Defect	%	9.23	Target 10%
DPU	unit	0.1018	
DPO	opportunity	0.0145	
DPMO	PPM	14,549	
Level Sigma	sigma	3.6832	

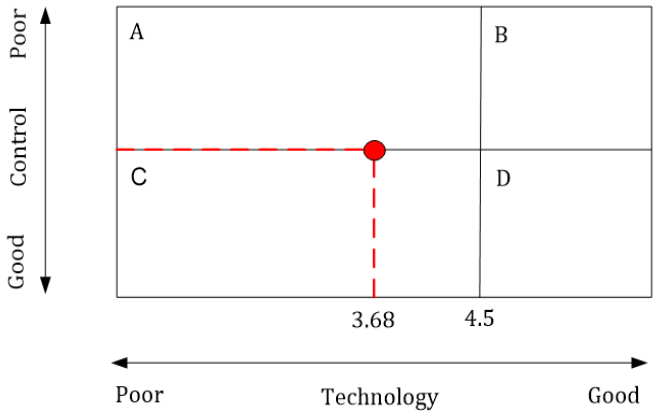


Figure 8. Four Block Diagram Product Failure (Defect) After Improvement

the knowledge of technology and then plots it in Four block diagrams that show the capability of the ongoing process (Z). The Zshif and Zbench. The calculations in the four-block diagram are as follows:

Zst = Zbench.lt + 1.5
3.68 = Zbench.lt + 1.5
Zbench.lt = 3.68 – 1.5 = 2.18

Zshif = Zbench.st – Zbench.lt = 3.33– 2.18 = 1.50

The next step is after knowing the value of Zshif (control ability) and Zst (sigma level) then it can be done by making four block diagrams to illustrate the current process condition (current condition), as for the Four block diagrams referred as in **Figure 8**.

Table 9. Key Performance Indicators Weaving Department

Core Program	No	Descriptions	Unit	Point (%)	Target	Record 2019	Record 2020	Target 2021	Record 2021 to June
Quality	1	Loss Production/Defect	%	15.0	52%	25.3	20.6	10.0	9.55
	2	Sigma Level Elastic Tape (Special Weaving Machine)	Sigma	10.0	108%	N/A	3.1017	3.3600	3.6870
Quantity	3	Production Result	Kg	20.0	117%	443.8	256.5	300.0	284.1
	4	Consume Needle Part	n/kg	12.5	92%	0.6321	0.0542	0.0498	0.0486
Delivery	5	First Production Test Report (Average)	Hour	7.5	75%	24.5	16.0	12.0	11.7
	6	Change Item Production Report (Average)	Hour	7.5	71%	8.0	7.0	5.0	5.4
Cost	7	Cost Complain	USD	7.5	83%	1,230	1,351	1,128	986
Safety	8	Total Incidence (Light, Moderate, Severe)	Time	10.0	100%	1	0	0	0
Improvement	9	Idea Realization/ Suggestion System	Times /Year	10.0	108%	10	13	14	9
		Total		100					

Control Stage

The results of the KPI report in this study function to control the effects of quality improvements, where quality factors will be included in the monthly KPI targets so that management can monitor quality improvement projects carried out by the production team as validation. The results of the KPI Knitting Department can be seen in **Table 9**.

Discussion With Previous Research

Previous literature reviews can be discussed due to the similarities with this study. Six Sigma is a method for reducing product variance and increasing productivity (Shafira & Mansur, 2018b). This DMAIC method is a manufacturing business process strategy that can be used by various companies, one of which is to increase customer satisfaction (Syafwiratama et al., 2017). This method can also identify complex problems. In general, the implementation of six sigma is carried out in the DMAIC stage (Zaman & Zerin, 2017), (Setyaningrum et al., 2020), and (Kurnia, Jaqin, et al., 2021).

This study aims to determine the factors that cause dominant defects, namely the Pareto diagram, fishbone diagram, and CTQ method. This method is also almost the same used by other researchers before knowing the level of sigma in determining Six Sigma (Wardana et al., 2015), (Nurprihatin et al., 2017), and (Fithri, 2019). This research is more directed so that the research is more conceptualized in the implementation of improvements, so it is necessary to know before repairs first, in determining the priority of improvement using the FMEA method to be more measurable, in controlling actions using KPI as a management control tool in improvement efforts carried out by each department in an organization.

Quality Improvement Recommendation

After making improvements by implementing Six Sigma in the DMAIC approach, the recommendations that will be carried out so that the quality of elastic tape can be maintained and even can be improved are:

- The use of wire in the left band position, which is near the FC will give a strong effect in that position so that the elastic band will be formed straight or not wavy which will reduce defects.
- Experimental test 2, namely FC, Wire, Spandex, Yarn, Spandex, and Yarn positions is a new specification with better bias checking results than test 1. Therefore, this specification needs to be standardized and applied to all machines with the same item and type.
- Inspection of the elastic band for the quality of the thickness of the tape must be carried out in 3 positions, namely the LN, center, and FC positions. This treatment is to obtain an even thickness of the tape at the time of checking the quality of the elastic band.
- The elastic tape output from the Weaving machine is very important, there is an automatic inspection of the tape on the inspection machine before the packing process. The author recommends to the management to plan the installation of this machine so that each exit of the elastic band can be directly detected by the machine sensor or digitizing the band inspection so that the elastic band defects can be suppressed and reduced according to the company's goals.

4. Conclusion and Future Research

The conclusions that can be put forward in this study include: The dominant factor causing the defect is the curved elastic band defect, which consists of the machine factor, and the method. Factors causing the machine include the hook like a side thread lock that is often bent and the difference in the thickness of the tape between the left, middle and right. The causative factor of this method is checking the thickness of the elastic band only in the middle position.

The results of corrective actions impact increasing the sigma level by 10% from 3.3339 to 3.6832. In contrast, repair defects can reduce defects before repair by 18.92% and after repair by 9.23%. To control the sigma level, it is proposed to be included in the KPI so that the knitting department can control and be enthusiastic about continuous improvement. Therefore, further research is recommended to improve the production process by integrating lean methods effectively and efficiently.

For future research, researchers are interested in writing an article on the integration relationship between Lean Six Sigma (LSS) and the application of Industry 4.0 to increase productivity in the elastic tape industry in Indonesia.

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