Quality Control Analysis Using the Six Sigma Approach and Failure Mode and Effect Analysis (Fmea) As an Effort To Reduction Product Defects At CV. Hikmah Jaya Convection

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Abstract

CV. Hikmah Jaya Konveksi is a company operating in the convection sector that serves companies, offices, campuses and schools, both private and government. CV. Hikmah Jaya Konveksi as a company operating in the convection sector was founded on January 26 2011. CV. Hikmah Jaya Konveksi is at the address Griya Kebraon Utara VIII No. 27 Surabaya. The aim of this research is to identify types of product defects, find out the sigma level value for defective products produced and analyze the causes of product defects to provide recommendations for existing problems in the company so that it can reduce the level of defects in products. The method used for this research is Six Sigma with the Define, Measure, Analyze, Improve, Control (DMAIC) stages by calculating the company's sigma value and Failure Mode And Effect Analysis (FMEA) for recommendations for improvements to the problem. Based on the results of data processing and data analysis, 3 defects were obtained in the product, including skipped seams, wrinkled seams and slanted seams with an average sigma value of 4.08. Based on the FMEA analysis, the proposed improvements given to minimize defective products are providing training related to sewing SOPs and conducting evaluations. Leaders and Supervisors are responsible for defective products in their respective areas, conducting briefings for each line before production to clarify duties and responsibilities. respectively, providing lubricating oil to machine parts that have the potential to cause friction which causes noise, carried out periodically every 3 weeks, increasing supervision of all workers so that workers can focus when producing uniforms, checking machine maintenance, making maintenance scheduling regularly periodically every month 3 times.

Keywords : *Defective products;DMAIC; FMEA*

1. Introduction

Currently, the world is increasingly competitive in meeting the needs of diverse consumers, companies must take strategic steps in managing their business. Product quality has a significant effect on a company's performance. Quality products are products that can meet buyers' needs [1] . Therefore, currently many companies are competing to innovate to attract consumer attention. Innovation is important for consumers because it creates differences between one product and another [2] . However, the next most important thing is quality. Quality products are the most important key to achieving excellence in market competition and will ultimately increase consumer satisfaction. Each product definitely has superior quality and advantages compared to other products [3] . According to [4] Product quality is the product's ability to produce results that meet or exceed consumer expectations. Part of consumers consider product quality as the main factor in their purchasing decisions. Product quality degradation often occurs during the production process, which can have a negative impact on the final product quality. According to [5] To reduce product damage, the right strategy is needed so that product quality is maintained . Therefore, a process called quality control is needed. From the problems above, researchers carried out quality control at CV. Wisdom Jaya Konveksi uses the Six Sigma method and Failure Mode and Effect Analysis (FMEA).

According to [6] Six Sigma is a quality control method that is often used, which is defined as an approach to improving quality and customer service which aims to achieve customer satisfaction. The Six Sigma concept is carried out according to DMAIC (Define, Measure, Improve and Control). The advantage of the Six Sigma method is its focus on financial results that can be measured at the

organizational level. This method helps analyze the root causes of product defects and presents suggestions for improvements in quality control. [7] . According to [8] FMEA is a methodology used to evaluate failures occurring in a system, design, process, or service . Potential failure identification is carried out by assigning a value or score to each failure mode based on the occurrence level, severity level and detection level . These three factors are used to calculate the Risk Priority Number (RPN) value which helps determine priorities for corrective action plans. Failure Mode and Effect Analysis (FMEA) analysis is carried out at the Improve stage of the Six Sigma methodology. The application of the FMEA concept at the Improve stage aims to produce structured improvement recommendations in the quality improvement plan, especially for dealing with defective products [9] .

2. Method

According to [10], in Six Sigma there is a Define, Measure, Analyze, Improve, Control (DMAIC) stage , which is a stage used to measure the implementation of Six Sigma and aims to improve continuously so as to achieve the Six Sigma target . DMAIC starts from the Define (Identification), Measure (Measurement), Analyze (Analysis), Improve (Improvement), Control (Control) stages. The following are the stages of DMAIC, namely:

a. Define Stage
   The first step in the Six Sigma approach , namely Define , focuses on identifying critical problems at the ongoing stage. This stage also determines what is called Critical To Quality (CTQ) and makes observations on the production flow from the Supplier, Input, Process, Output, Customer (SIPOC) diagram.

b. Measure Stage
   The aim of this stage is to prove the problem from existing data. To measure the problem, the Defects Per Million Opportunities (DPMO) calculation stage can be carried out to evaluate the company's current performance. Calculating the DPMO and sigma value is carried out according to the Critical To Quality (CTQ) determination .

c. Analyze Stage
   Has the function of providing priority input on efforts to overcome the root causes of problems, showing the impact of failed processes and final products to consumers, as well as explaining the causes of process failures to the root causes of problems and providing input for improvisation efforts.

d. Improve Stage
   Make various efforts to eliminate all causes of product defects and process failures.

e. Control Stage
   Has the function to supervise the implementation of improvement plans that have been created and planned .

According to [11] Failure Mode And Effect Analysis (FMEA) is a structured procedure for identifying and preventing as many failure modes as possible, known as failure mode and effect analysis. Following are several steps for completing Failure Mode And Effect Analysis (FMEA), namely:

a. Identify products and processes
b. Make notes about possible problems that arise, their impact, and the factors that cause them
c. Assess the level of severity (Severity), probability of occurrence (Occurrence), and detection capabilities (Detection)
d. Calculate the Risk Priority Number (RPN), from the formula of multiplying the Severity, Occurrence and Detection values . FMEA is used to analyze services before they reach customers. To calculate the RPN (Risk Priority Number) value for a process, initial knowledge of the value is required Severity, Occurrence, and Detection first.

3. Results and Discussion

3.1. Define Stage

In the uniform production process, results will be obtained from the process which will later influence the number of rejections that arise from several defects in the production process. Determination of CTQ in uniform production will focus on the production process. Data collected to create CTQ (Critical To Quality) obtained through interviews with management and information from customers . The following is the CTQ created and summarized by CV. Wisdom of Jaya Konveksi, see Table 1:

Table 1 CTQ from the uniform production process

No.	CTQ Uniforms
1	Jump Stitch
2	Creasing Seams
3	Oblique Stitching

a) Jump Stitch

Skipping stitches occur because the operator is not careful, lacks focus, is tired and sleepy. See Figure 1.

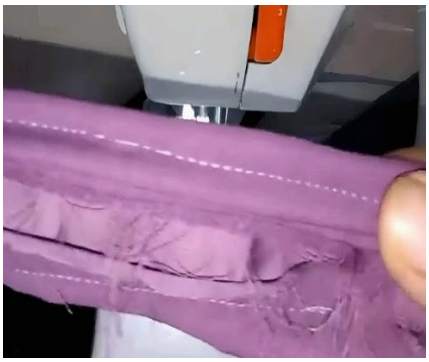

Figure 1 Skip-stitched uniforms

b) Creasing Seams

Shrinking stitches can occur due to lack of machine maintenance (sewing machine performance is less than optimal, the machine stalls or dies). See Figure 2.

Figure 2 Puckered Seam Uniform Clothing

c) Oblique Stitching

Slanted stitches are usually caused by cutting material that does not match the pattern provided. See Figure 3.

Figure 3 Oblique Seam Uniform

3.2. Measure Stage

The measure stage is one of the operational steps in improving quality using the Six Sigma method . In the measure stage , control chart analysis will be carried out as well as calculations of DPMO and sigma values. See Figure 4.

a) P- Chart

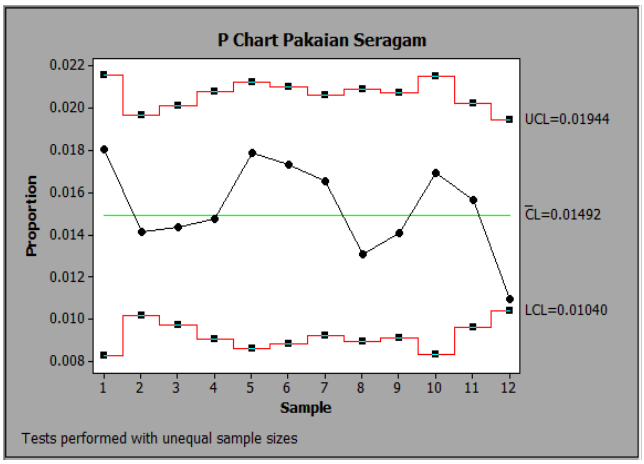

Figure 4 Uniform Production Control Map

Based on the calculated P- Chart results , it can be seen that the data obtained from the CL, UCL and LCL calculations is proven to have no data that exceeds the upper and lower limits. So it can be concluded that the data is in accordance with the control limits.

b) Defects Per Million Opportunities (DPMO)

Table 2 Calculation of DPMO and Sigma Level

No.	Month	Production Quantity (pcs)	Number of CTQs	Number of Defects (pcs)	DPU	DPO	DPMO	Sigma
1.	March 2023	2,991	3	54	0.018	0.006018	6018.0	4.02
2.	April 2023	5,862	3	83	0.014	0.004719	4719.3	4.10
3.	May 2023	4,870	3	70	0.014	0.004791	4791.5	4.09
4.	June 2023	3,798	3	56	0.015	0.004914	4914.0	4.09

5.	July 2023	3,301	3	59	0.018	0.005957	5957.5	4.02
6.	August 2023	3,524	3	61	0.017	0.005769	5769.2	4.03
7.	September 2023	4,051	3	67	0.017	0.005513	5531.1	4.05
8.	October 2023	3,677	3	48	0.013	0.004351	4351.3	4.12
9.	November 2023	3,901	3	55	0.014	0.004699	4699.0	4.10
10.	December 2023	3.011	3	51	0.017	0.005645	5645.4	4.04
11.	January 2024	4,663	3	73	0.016	0.005218	5218.6	4.07
12.	February 2024	6,477	3	71	0.011	0.003653	3653.1	4.19
Average		4,177	3	62.33	0.01533	0.005106	5106	4.08

Based on the Table 2 calculating the DPMO value and sigma level of uniform production during the period March 2023 to February 2024, the Defect Per Million Opportunities (DPMO) value was obtained at 5106.0 and then converted to the sigma table to 4.08. It can be explained that the probability of damage is 5106 .0 for a million production. This shows that the DPMO pattern and sigma achievement are not yet consistent, which shows that the production pattern has not been managed properly and still needs improvement

a.

3.3. Analyze Stage

At this analysis stage , each source of the problem will be explored to find a solution down to the root. Therefore, analysis is needed to produce appropriate alternative solutions in accordance with the goals set by Six Sigma . In completing this analysis stage , Pareto and fishbone diagrams are used .

a) Pareto Chart

The analysis carried out is to find out the biggest potential CTQ that influences the level of product defects. To find out this, you can use the Pareto diagram.

Table 3 Pareto Diagram Analysis Results

No.	Type of Defect	Number of Defects(Units)	Defect Percentage (%)	Cumulative Percentage (%)
1.	Skip Stitches	326	43.59%	43.59%
2.	Creasing Seams	214	29.21%	72.8%
3.	Oblique Stitching	202	27.20%	100.00%
Total		748	100	

From the Table 3, it will then be applied in the form of a Pareto diagram as follows:

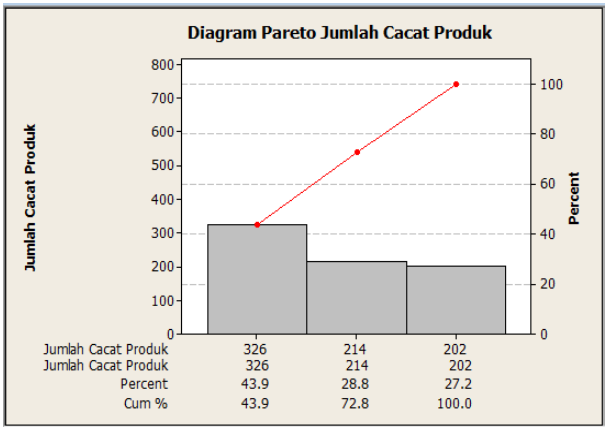

Figure 5 Pareto Diagram for Uniform Clothing Products

Based on Figure 5 the Pareto diagram, it can be seen that of the three levels of product defects in uniforms, the highest is product defects in skip stitching.

b) Fishbone Diagrams

The following is a bone diagram that researchers will present regarding the three types of defects in uniform products: skipped stitches, puckered stitches, and slanted stitches. This diagram will help to identify the cause of the defect in the product, making it easier to find the best solution.

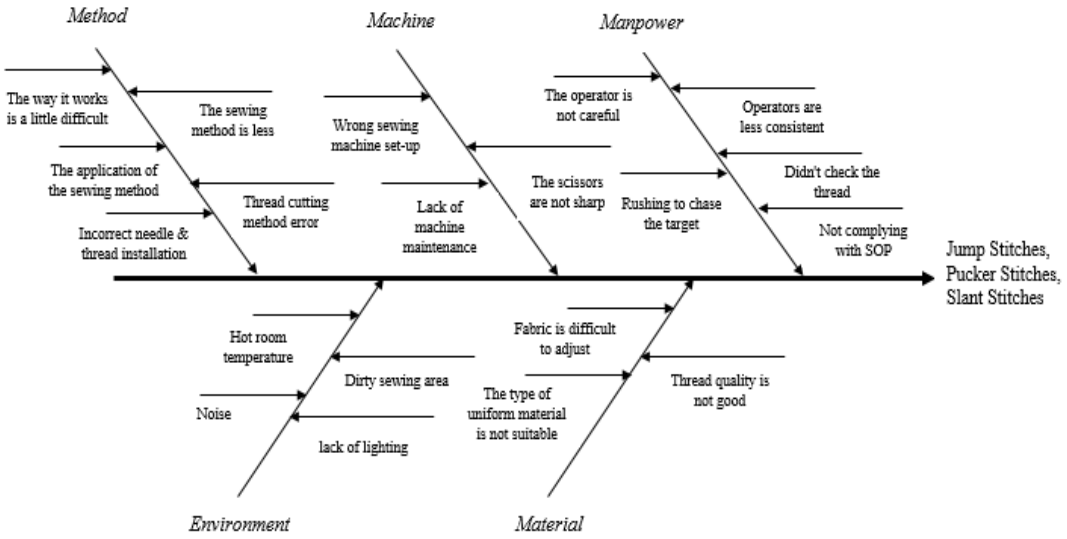

Figure 6 Fishbone Diagram of Uniform Defects

Figure 6 is fishbone diagram, there are 20 root problems consisting of manpower, there are 5 root problems in it, namely the operator is not careful, is in a hurry to catch the target, the operator is not consistent, does not check the thread, does not fulfill the SOP (Standard Operating Procedure), then on the machine there are 3 root problems in it, namely wrong sewing machine set-up , lack of machine maintenance, scissors are not sharp enough, then in the method there are 5 root problems in it, namely the method of work is a little difficult to do, the sewing method is not precise, the needle and thread are not installed correctly. , the sewing method is not optimal, the thread cutting method is wrong, next in the material there are 3 root problems in it, namely the fabric material is difficult to adjust, the type of uniform material is not suitable, the quality of the thread is not good, for the last one in the environment there are 4 root problems in it, namely temperature hot room, noise and dirty sewing area, lack of lighting.

3.4. Improve level

At the improve stage , improvement proposals are made to minimize defects that occur in each process using the FMEA (Failure Mode And Effect Analysis) method. FMEA is used to improve product and process quality performance. In the FMEA table, a value or score is assigned to each failure mode based on the occurrence level , severity level and detection level . From the results of scoring, the Risk Priority Number (RPN) will be known which is produced by multiplying the occurrence, severity and detection levels for each cause . The following are the results of improvement using the FMEA method, see Table 4:

Table 4 Failure Mode and Effect Analysis

Process Name: Stitching									
Factor	**Potential Failure Modes**	**Potential Failure Effects**	**S**	**O**	**Potential Causes of Failure**	**D**	**RPN**	**Recommendation**	**Rank**
Man	1. Operators are less careful, less focused, tired and sleepy	Jump stitch, pucker stitch, Oblique seam	4	3	Operator fatigue	3	36	Give yourself a few minutes for stretching or relaxation	13
	2. Operators are less consistent	Oblique seam	7	6	Operator is not focused.	6	252	Provide regular training to operators	1
	3. Rush after the target	Jump stitch	7	6	achieve production targets	5	210	Provide enthusiasm and motivation to operators	2
	4. Didn't check the thread	Seams puckered	7	5	Not complying with the thread inspection SOP	5	175	Increase supervision in each production line and provide regular SOP explanations	3
	5. Not complying with SOPs	Jump stitch, pucker stitch, Oblique seam	6	6	Lack of supervision	4	144	Provide regular explanations of SOPs	4
Machine	1. Lack of machine maintenance (sewing machine performance is less than optimal, the machine stalls or dies)	puckered seams, Oblique seam	5	5	Lack of regular maintenance	5	125	Schedule maintenance periodically 3 times a month	5
	2. Wrong sewing machine set-up	Jump stitch, pucker stitch, Oblique seam	4	5	Lack of training	5	100	Provide sewing machine setting SOP training to mechanics	6
	3. Scissors are neither sharp nor blunt	Seams puckered	5	5	Lack of supervision and maintenance	3	75	Check sewing equipment before use	8
Material	1. Fabric is difficult to flatten, fabric is difficult to arrange	Seams puckered	5	3	Fabric is too slippery or stiff	5	75	Operators must be thorough and careful when sewing	8
	2. Inappropriate type of material	puckered seams, Oblique seam	5	4	Lack of supervision	4	80	checking raw materials before ordering and purchasing	7
	3. Thread quality is not good	Seams puckered	4	4	Lack of understanding	4	64	thread check	9

Method	1. Sewing method is less than optimal	Jump stitch, pucker stitch, Oblique seam	4	3	Operators lack training	5	60	Provide sewing SOP training to sewing operators and conduct evaluations once a month	10
	2. The way it works is a little difficult to do	Jump stitch, pucker stitch, Oblique seam	4	3	Lack of skills and lack of understanding of how things work	4	48	Provide training and sewing skills tests to sewing operators	11
	3. Needle and thread sizes do not match	Seams puckered	5	3	Lack of understanding regarding the use of needle and thread	3	45	Provide training on SOPs for using needles and threads	12
	4. The application of the sewing method is not appropriate	Jump stitch, pucker stitch, Oblique seam	3	3	Lack of understanding of SOPs	3	27	Provide sewing SOP training to sewing operators once a month	14
	5. Thread cutting method error	Oblique seam	2	3	Not complying with the thread cutting SOP	3	18	Provide training on thread cutting SOPs	15
Environment	1. Hot room temperature	Jump stitch, pucker stitch, Oblique seam	4	2	Lack of air ventilation, no fan or anything like that	2	16	Add air ventilation	16
	2. Dirty sewing area	Jump stitch, pucker stitch, Oblique seam	3	3	Local workers do not pay attention to the cleanliness of the surrounding environment	2	18	Always remind workers to clean their respective work environments before and after work	15
	3. Noise	Jump stitch, pucker stitch, Oblique seam	3	2	Sewing machines, music, and other tools make noise	2	12	Provide lubricating oil to engine parts that have the potential to cause friction periodically and install sound dampeners	17
	4. lack of lighting	Jump stitch, pucker stitch, Oblique seam	2	4	Workers do not pay attention to workplaces that are poorly lit.	2	16	provide additional lighting in the workplace	16

Based on the FMEA table above, there are 20 failure modes, but there are 6 failure modes that have the highest RPN values, namely the operator is not focused with an RPN value of 252, pursuing production targets. RPN value 210 , Failure to comply with thread inspection SOPs RPN value 175, lack of supervision RPN value 144 Lack of regular maintenance RPN 125, Lack of training RPN value 100.

3.5. Control Stage

Control is the final stage in the DMAIC stage of the six sigma method . At this stage, control and supervision is carried out to improve production quality and minimize defects through proposed improvements that have been provided. The following are things that need to be done at the control stage .

a) Providing training related to sewing SOPs and conducting evaluations to operators once or twice a month. An example of a sewing SOP is checking and preparing sewing equipment starting from needles, thread, scissors, and others according to the material to be sewn.
b) Leaders and Supervisors are responsible for defective products in their respective areas and are responsible for motivating employees to increase awareness of the work being done.
c) Conduct briefings for each line before production to clarify their respective duties and responsibilities and always focus on work to minimize product defects.
d) Providing lubricating oil to machine parts that have the potential to cause friction that causes noise, carried out regularly every 3 weeks and installing sound dampeners to reduce noise.
e) Increase supervision of all workers so that workers can focus while uniform production is underway.
f) periodic maintenance scheduling is carried out every 3 times a month to minimize damage to the sewing machine.

4. Conclussion

Based on the previous discussion, it can be concluded that Critical To Quality determination stage, there are 3 types of product defects in uniforms, namely skip stitches caused by operators who are not careful and tired, wrinkled stitches caused by lack of machine maintenance (sewing machine performance is less than optimal, the machine stumbles or dies) , skewed seams caused by inappropriate cutting of raw materials. Based on data processing using the Pareto diagram, it can be seen that the most dominant level of defects in uniform clothing products is defects in skip stitching. Proposed quality control and improvement based on implementation tools from FMEA (Failure Mode and Effect Analysis) as follows :

a) Providing training related to sewing SOPs and conducting evaluations to operators once or twice a month. An example of a sewing SOP is checking and preparing sewing equipment starting from (needle, thread, scissors) according to the material to be sewn.
b) Leaders and supervisors are responsible for defective products in their respective areas and are responsible for motivating employees to increase awareness of the work being done.
c) Conduct briefings for each line before production to clarify their respective duties and responsibilities and always focus on work to minimize product defects.
d) Providing lubricating oil to machine parts that have the potential to cause friction that causes noise, carried out regularly every 3 weeks and installing sound dampeners to reduce noise.
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f) periodic maintenance scheduling is carried out every 3 times a month to minimize damage to the sewing machine.

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