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# The Analysis of Product Quality Improvement at Garment 3 of PT. XYZ Using Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) Method to Reduce the Number of Product Defects

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## Abstract

Quality is one of things considered by consumers in selecting products. Therefore, each company definitely has quality control department having job to make sure that resulted products have met desired quality standard. One of the companies is PT XYZ which is engaged in the textile industry. Quality control of PT XYZ always tries to maintain good quality of shirts and trousers as the company's product. However, many defects are still found in the production process. Up to now, quality control carried out by the company is considered not yet optimal in controlling number of defects produced. Hence, this research aims to analyze potential causes of failure or defect in apparel production of PT Sri Rejeki Isman Tbk and offer suggestions regarding kinds of improvement and investment that need to be taken by the company, also find out whether the investment costs incurred can be returned for investment or not. Thus, the company can minimize the occurrence of defects Moreover, Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA), and Feasibility Study method were used in this research to identify and analyze the occurrence of defects. Based on the research findings, the highest Risk Priority Number (RPN) value obtained was Run Off Stitch defect with number of 210. Besides, the highest RPN value is priority which requires immediate corrective action. FTA is used to find out root cause of occurrence defect.

## Keywords
Product Defect, Garment, FMEA, FTA, Feasibility Study

## 1. Introduction
The growth of textile and garment industry continues increasing. Based on the statistic data from Ministry of Industry of Indonesia (KEMENPERIN), it records the highest growth in the third quarter of 2019 for 15.08%. The achievement surpasses the economic growth for 5.02% in the same period. It can lead to fierce competition in the textile and garment industry. The competition in this industry manages to get the companies try to provide some satisfactions for the customers. Quality becomes an important factor in determining the customers' satisfaction to the product, because good product quality can fulfill consumers' wish and need. Furthermore, good quality products with low price will attract consumers' interest to keep using and purchasing the products. Quality control is needed to produce good quality products. In addition, quality control is engineering and management activities measuring product quality,

comparing the product to specification or condition, and taking appropriate corrective action if there is a difference between actual performance and the standard (Siregar dan Setiawannie, 2022). Defective product is often found in companies or factories, either during the production process or outside the production process, such as delivery process. The defective products will bring down the companies' reputation.

PT XYZ is a company engaged in garment and textile sector. The quality produced by PT XYZ has been acknowledged by the world. According to the data obtained from Quality Assurance department of PT XYZ, it is recorded in the production result of Comtex brand trousers products that there are 1,536 defective products which did not pass quality control and need rework. Based on the existing problems within PT XYZ, this company still requires a better and more precise quality control. The method which can be applied to control the product quality is *Failure Mode and Effect Analysis* (FMEA), focusing on defect prevention and increase the customers' safety and satisfaction (McDermott dkk, 2009), and *Fault Tree Analysis* (FTA) which is used to detect symptoms so the root of the problems can be identified. Then, feasibility study method serves to find out the suggestions and investments which should be made to identify the feasibility of the product. These three methods are expected to improve product quality of PT XYZ by carrying out correction and evaluation of defective products and Company's investment.

### 1.1 Objectives

This research aims to identify the causes of defect in the production process at Garment 3 PT XYZ using Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) method. Besides, this research also creates strategies to reduce the occurrence of defects.

## 2. Literature Review

### 2.1 Failure Mode and Effect Analysis

FMEA is a method used to identify all potential failures which may occur in the production plan and/or process until the product is produced and to analysis the effect of each failure (Musfiroh & Hisprastin, 2021). There are three types of assessment in Failure Mode and Effect Analysis (FMEA); they are severity, occurrence, and detection.

- Severence is a score of 1-5 which corresponds to the serious effects of the existing failure mode; the bigger the effect, the bigger the score. Severity (S) is an assessment of level of influence felt by customers (Firdaus & Widianti, 2015). Severity score is rated on a scale of 1 to 10 (Table 1).

Table 1. Severity Rating

| Score | | The Effects Caused |
|---|---|---|
| 1 – 2 | Minor | Do not have expectation that trivial nature from this fault can cause signufucant effect to the product and or service. The consumers may not realize the fault. |
| 3 – 4 | Low | Damage at a low level is caused by nature. Based on this fault, it will only cause a bit of nuisance towards consumers. The consumers will notice a slight decrease in product and or service quality, there is a little inconvenience in the next process, or a little rework is needed. |
| 5 – 6 | Moderate | Moderate or fair order occurs because this fault causes some dissatisfaction. Consumers will be uncomfortable or even disturbed by the fault. This fault needs unscheduled correction and or damage to equipment |
| 7 – 8 | High | High level consumers dissatisfaction is caused by the nature of this fault, such as unusable product or unsatisfactory service. Not paying attention to security issues and government regulations can lead to disturbance on the sustainable process and or service. |
| 9 – 10 | Very High | The higgest level of fault occurs when the fault affects the consumers safety and involves violation of government regulations |

- Occurrence (O) is a score indicating how often a problem occurs which caused by potential cause (Table 2). Besides, occurrence score can also be used as analysis benchmark of failure chances occurring on a scale of 1 to 10. Occurrence is the level of likelihood of a risk event occurring (Ridho et al. 2020).

Table 2. Occurrence Rating

| Score | Possible Event | The Level of Risk Occurrence |
|---|---|---|
| 1 | <1 of 1.500.000 | Almost never happen |
| 2 | 1 of 150.000 | Very rarely |
| 3 | 1 of 15.000 | Quite rarely |
| 4 | 1 of 2.000 | A bit rare |
| 5 | 1 of 400 | Rarely |
| 6 | 1 of 80 | Sometimes |
| 7 | 1 of 20 | Quite often |
| 8 | 1 of 8 | Often |
| 9 | 1 of 3 | Very often |
| 10 | >1 of 2 | Almost always happen |

- Detection (D) is a score to find out cause of failure mode. D is given on scale of 1 to 10, in which detection score is inversely proportional to reliability level to detect cause of failure mode (Table 3).

Table 3. Detection Rating

| Score | Level of Seriousness | Detection Criteria |
|---|---|---|
| 1 | Almost Certain | The control can definitely prevent risks |
| 2 | Very Easy | The likelihood that the risk can be prevented is very high |
| 3 | Easy | The likelihood that the risk can be prevented is high |
| 4 | Quite Easy | The risk may be able to be prevented |
| 5 | So-So | The risk has a good chance of being prevented |
| 6 | A bit difficult | It is unlikely that the risk can be prevented |
| 7 | Quite Difficult | It is quite unlikely that the risk can be prevented |
| 8 | Difficult | There is a slim chance that the risk can be prevented |
| 9 | Very Difficult | There is a very slim chance that the risk can be prevented |
| 10 | Almost Impossible | The control cannot prevent the risks |

## 2.2 Risk Priority Number (RPN)

Risk Priority Number (RPN) is a measure used to assess risks to identify critical failure modes related to design or process (Gatot Basuki, 2018). The range of RPN score is from 1 (absolute best) to 1000 (absolute worst). RPN FMEA is used to determine improvement priority scale; which one should be improved first. The following is a formula for calculating RPN.

$$RPN = S \times O \times D$$

## 2.3 Fault Tree Analysis (FTA)

FTA (Fault Tree Analysis) is a method of quantitative risk analysis with logic and graphic model displaying possible combination of event, namely bad or good, everything occurred within the system, an application which can cover a

system, equipment and as an analysis (Ariwibowo & Nur, 2018). Therefore, factors and combination of causes which leads to accidents can be identified by using this analysis.

### 2.4 Feasibility Calculation

Data analysis which is used to analyze financial aspect is quantitative analysis with analysis of ability in fulfilling capital requirements and analysis of investment feasibility, such as Payback Period (PP), Net Present Value (NPV), Profitability Index (PI), Internal Rate of Return (IRR), Average Rate of Return (ARR) dan Benefit Cost Ratio (BCR). The feasibility criterion of ability in fulfilling capital requirements is comparing the size of capital requirements with the ability to provide the capital. A business idea is claimed feasible if income is higher than capital expenditure (Nugroho & Astuti, 2021).

## 3. Methods

The methods used to solve this defect problems are as follows:

a. The first stage is data collection and processing. The data collection stage is a stage to gather the data required in this research. Techniques of collecting data used in this research are direct observation and literature study.
b. Data processing stage is started by determining the highest failure type with Pareto diagram. Then, the causes of the highest failure are determined by FMEA method. After that, creating root cause tree or FTA based on FMEA data processing result. The last, making calculation of investment feasibility analysis using feasibility test.
c. Conducting required data analysis.

## 4. Data Collection

Data were gathered from observation and historical data of company. The observation was conducted by interviewing garment supervisor (Table 4).

Table 4. Data Defect

| DEFECT | The Amount of Defect | Percentage | Cumulative Percentage |
|---|---|---|---|
| Hi-Low | 237 | 15,43% | 15,43% |
| Run Off Stitch | 201 | 13,09% | 28,52% |
| Trimming | 144 | 9,38% | 37,89% |
| Uneven Stitch | 124 | 8,07% | 45,96% |
| Slented | 121 | 7,88% | 53,84% |
| Puckering | 92 | 5,99% | 59,83% |
| Skip Stitch | 86 | 5,60% | 65,43% |
| Stain | 82 | 5,34% | 70,77% |
| Open Seam | 77 | 5,01% | 75,78% |
| Shading Color | 62 | 4,04% | 79,82% |
| Bad Shape | 58 | 3,78% | 83,59% |
| Unbalance | 45 | 2,93% | 86,52% |
| Melet | 38 | 2,47% | 89,00% |
| Twisted | 34 | 2,21% | 91,21% |
| Bubbling | 34 | 2,21% | 93,42% |
| Pleated | 30 | 1,95% | 95,38% |
| Waves | 18 | 1,17% | 96,55% |
| CK | 17 | 1,11% | 97,66% |
| Not Same Width | 16 | 1,04% | 98,70% |
| Broken | 10 | 0,65% | 99,35% |
| Loose Stitch | 10 | 0,65% | 100,00% |
| **TOTAL** | **1536** | **100,00%** | |

## 5. Results and Discussion

a. Calculation of Risk Priority Number (RPN)
   This calculation is used to find out the causal factors having the greatest risk. It causes high score of resulted RPN (Table 5).

Table 5. Risk Priority Number

| **Failure Mode** | **Results of Potential Failure** | S | O | **Causes of Potential Failure** | D | RPN |
|---|---|---|---|---|---|---|
| Lack of expertise in working process | Hi-Low | 7 | 6 | Inappropriate handling by operator | 4 | 168 |
| Lack of accuracy in working process | Run Off Stitch | 7 | 6 | The operator complete their job in a rash | 5 | 210 |
| Lack of accuracy in working process | Trimming | 4 | 6 | Disorderly thread cutting by the operator | 2 | 48 |
| Lack of attention to provision or SOP in working process | Uneven Stitch | 6 | 6 | The operator is negligent by pulling the fabric while the sewing process is in progress | 2 | 72 |
| Lack of attention to provision or SOP in working process | Slented | 3 | 6 | The operator is negligent in marking the fabric | 4 | 72 |
| Lack of attention to provision or SOP in working process | Puckering | 5 | 6 | Setting thread tension in the machine is too high | 2 | 60 |

The higher the RPN score obtained, the greater the resulted risk. Based on the calculation of Risk Priority Number (RPN) score, it is found that Run Off Stitch is the most risky type of defect.

b. Calculation of Defect Presentage and The Making Of Pareto Diagram (Figure 1)

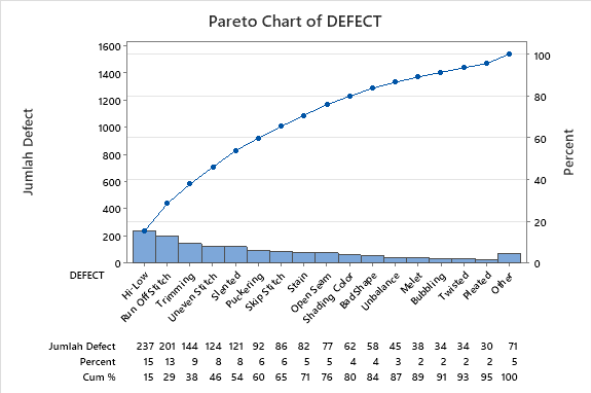


Figure 1. Defect Presentage

Based on the above pareto diagram, the most and urgently improved defect is defect that has 80% percentage, while based on the order of hi-low defect is the defect that mostly has percentage of 15,43%.

c. Improvement Suggestions Using Fault Tree Analysis (FTA) on Product Defect
This method has tree diagram shape. It shows the relationship between problems and its causes. At the top, it contains information concerning problems which is occurred. Next, below the top part, it contains causative factors of the problems. The last one is the bottom part, it contains roots of the problems and its solution must be found. The following is Fault Tree Analysis (FTA) of factors that has critical RPN score. It includes in cumulative

percentage area of 80%, and the defects that have RPN score of more than 100 are Run Off Stitch dan Hi-Low (Figure 2, 3).

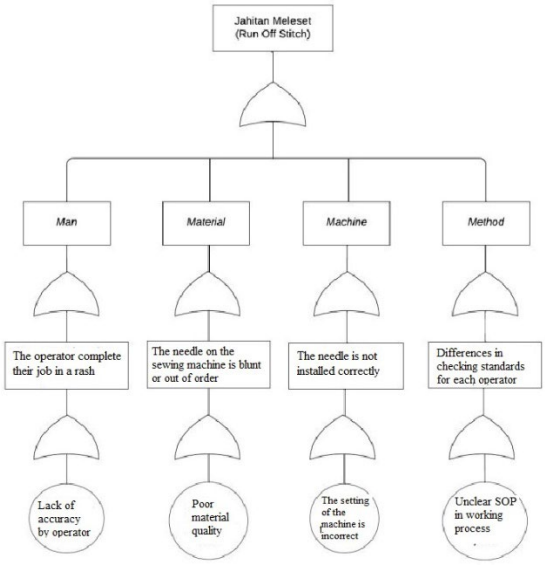


Figure 2. Fault Tree Analysis Defect Run Off Stitch

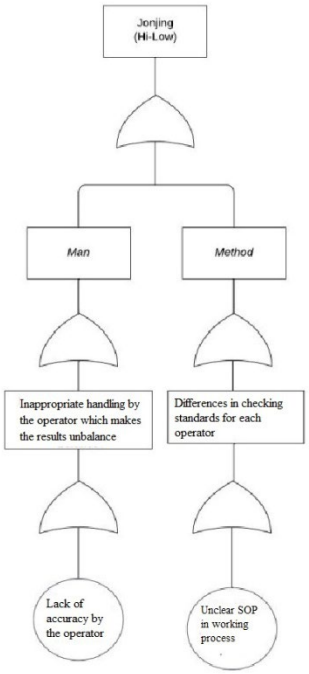


Figure 3. Fault Tree Analysis Defect Hi-Low

d. Improvement Suggestions Using 5W+1H Analysis (Table 6)

Table 6. 5W+1H Analysis

| Number | Faktor | What | Why | When | Who | Where | How |
|---|---|---|---|---|---|---|---|
| 1 | Man | There are sewing products that are run off stitch | Lack of accuracy of the operator | During the production process | Quality control supported by supervisor and sewing operator | Sewing Department | Give enough break time & create enjoyable work environment. |
| 2 | | There are sewing products that are not linier | Operator handling is not accurate | During the production process | Quality control supported by supervisor and sewing operator | Sewing Department | Increase supervision on production line & give some training |
| 3 | Machine | There are sewing products that are run off stitch | Machine setting its not approriate | Before the production process | Quality control supported by supervisor, sewing operator, and maintenance operator | Sewing Department | Do checking sewing machine routinly |
| 4 | Material | There are sewing products that are run off stitch | The niddle of the sewing machine is dull and broken | Before the production process | Quality control supported by staff or purchasing management | Purchasing Department | Buy material that has good quality & routinly change the material |
| 5 | Method | There are sewing products that are run off stitch | The uncleared SOP | Before the production process | Quality control supported by *supervisor* and sewing operator | Sewing Department | stick to the SOP applied & research about the SOP applied. |
| 6 | | There are sewing products that are not linier | The uncleared SOP | Before the production process | *Quality control* supported by *supervisor* and sewing operator | Sewing Department | stick to the SOP applied & research about the SOP applied. |

e. The Calculation of Feasibility Test
The following is the cash flow result based on investment calculation (Table 7, Figure 4).


Figure 4. Cash Flow of Investment Calculation

Table 7. Calculation of NPV, IRR

**CALCULATION OF NPV, IRR**

| | | |
|---|---|---|
| **MARR =** | | **4,75%** |
| **AOC (Annual Operating Cost) =** | Rp | 128.294.820 |
| **Creation of New SOPs =** | Rp | 77.500.000 |
| **Employee Training =** | Rp | 122.800.000 |
| **Tools** | | |
| IC (Initial Cost) = | Rp | 348.480.000 |
| SV (Salvage Value) = | Rp | - |
| K (Life, years) = | | 1 Years |
| **Annual Benefit =** | Rp | 1.531.800.000 |

| **EOY** | | **Income** | | **Cashflow** | | **Tools Depreciation** | | **Cashflow** | | **NPV** |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Rp | - | -Rp | 200.300.000 | Rp | - | -Rp | 200.300.000 | -Rp | 200.300.000 |
| 1 | Rp | 1.531.800.000 | Rp | 1.055.025.180 | Rp | - | Rp | 1.055.025.180 | Rp | 1.055.025.180 |
| 2 | Rp | 1.531.800.000 | Rp | 1.055.025.180 | Rp | - | Rp | 1.055.025.180 | Rp | 1.055.025.180 |
| 3 | Rp | 1.531.800.000 | Rp | 1.055.025.180 | Rp | - | Rp | 1.055.025.180 | Rp | 1.055.025.180 |
| 4 | Rp | 1.531.800.000 | Rp | 1.055.025.180 | Rp | - | Rp | 1.055.025.180 | Rp | 1.055.025.180 |
| 5 | Rp | 1.531.800.000 | Rp | 1.055.025.180 | Rp | - | Rp | 1.055.025.180 | Rp | 1.055.025.180 |
| **PW** | | | Rp | 5.074.825.900 | | | Rp | 5.074.825.900 | **Rp** | **4.399.146.524** |
| | | | | | | | | | **IRR** | **527%** |

NPV value obtained is Rp 4,399,146,524.00. It categorizes as a positive value, so it shows that the investment is feasible to be taken. Besides, it can provide benefits for the company (Table 8).

Table 8. Calculation of BCR

| CALCULATION OF BCR | | | | | |
|---|---|---|---|---|---|
| **Investment Period** | | 5 | | | |
| **MARR** | | 4,75% | | | |
| **AOC (Annual Operating Cost) =** | Rp | 128.294.820 | **Initial Investment** | Rp | 200.300.000 |
| **Creation of New SOPs =** | Rp | 77.500.000 | **Annual Operating Cost** | Rp | 348.480.000 |
| **Employee Training =** | Rp | 122.800.000 | **Annual Benefit** | Rp | 1.531.800.000 |
| **Tools** | | | | | |
| IC (Initial Cost) = | Rp | 348.480.000 | **Benefit** | | Rp6.677.975.387,66 |
| SV (Salvage Value) = | Rp | - | **Total Investment Costs** | Rp | 1.363.443.100 |
| K (Life, years) = | | 1 | **B/C Ratio** | | 4,89787611 |
| **Annual Benefit =** | Rp | 1.531.800.000 | | | |

BCR value here has value of 4.89, in which the value is >1. It shows that the investment is feasible to be taken and it can provide benefits for the company (Table 9).

Table 9. Calculation of PBP

| CALCULATION OF PBP | | |
|---|---|---|
| **Initial Investment** | Rp | 200.300.000 |
| **Annual Operating Cost** | Rp | 348.480.000 |
| **Annual Benefit** | Rp | 1.531.800.000 |
| **Total Investment Costs** | Rp | 200.300.000 |
| **Total Benefits per Year** | Rp | 1.183.320.000 |
| **Payback Period** | | 0,17 Year<br>2,03 Months |

The result of PBP value here is 0.17 year, in which it is 0.17<n (5 years). Therefore, it can be concluded that the payback period is feasible. It shows that the investment is feasible to be undertaken and it can provide benefits for the company.

## 6. Conclusion

Based on the analysis result, there are 21 types of defect. The most dominant types of defect which become focus of improvement on the Comtex brand based on Pareto diagram is hi-low with cumulative percentage of 15.43% and run off stitch defect with cumulative percentage of 28.52%. Furthermore, based on the calculation of RPN, the greatest value obtained is on run off the stitch and hi-low defect. Run Off Stitch defect is caused by lack of precision from the operators because they complete their job in a rash. Then, Hi-Low defect is the effect of lack of accuracy done by the operators resulting inappropriate handling, so it makes the results unbalance. The improvements carried on to overcome defect problems in the production process at Garment 3 of PT XYZ are providing sufficient rest time, creating comfortable work environment, and reaffirming and reviewing the applicable SOPs. Improvement proposals in term of routinely maintenance of sewing machine and improving the quality of sewing needles are worthy to be carried on. It is due to the calculation of obtained NVP value, with amount Rp 52,208,979,714.9; it means that the investment made is feasible to be carried out. Moreover, based on the calculation of BCR value, it obtains 28.90 which means the investment made is feasible to be carried out. Then, the PBP value obtains 0.146 year, it means the investment made is also feasible to be carried out.

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