The use of FMEA for the Quality Control Analysis of Greige Fabrics (case study in the Weaving Department of PT. Unitex, Tbk)

P Fithri\textsuperscript{1,2}, D Jovie Andra\textsuperscript{1,3}, E Wirdianto\textsuperscript{4}, and Taufik\textsuperscript{5}

\textsuperscript{1}Industrial Engineering Department, Engineering Faculty, Universitas Andalas, Kampus Unand Limau Manis Pauh Padang, Sumatera Barat, Indonesia
\textsuperscript{2}primafithri@eng.unand.ac.id, \textsuperscript{3}dedejovieandra@gmail.com,
\textsuperscript{4}e.wirdianto@gmail.com, \textsuperscript{5}taufik@ft.unand.ac.id

Abstract. PT Unitex, Tbk, is a textile company in Bogor. The problem that is found in this company is the number of defects that occur in the weaving section, namely reaching. If conditions like this are allowed, it will cause losses to the company. With these conditions, PT Unitex wants to reduce the number of defects to a minimum. For this reason, the main problem raised in this study is how to control the quality of defective fabrics produced by PT Unitex, Tbk, to support and evaluate the quality control policies implemented by PT Unitex, Tbk by using Pareto diagram tools, and fishbone diagrams later in analysis using the Failure Mode And Effect Analysis (FMEA) method. The results of this research are obtained: In the period July - December 2018, 5 types of fabric defects were most dominant, namely OSA TOSHI, NIHON DOSHI, USUDAN, TATE GIRE, and ATSUDAN. Analysis of Failure Mode and Effect Analysis of the causes of failure obtained from the fishbone diagram obtained the highest severity value for human factors, the highest occurrence value for less precision and control, and the highest detection value for engine maintenance.

Keywords: Textile company, Defects, Weaving section, Failure Mode And Effect Analysis (FMEA) method

1. Introduction

Increased consumer demand for personal needs, such as clothing, makes the level of competition in the textile industry more stringent. Quality is a very powerful tool in maintaining a company's business [1]. It can compete with other products; therefore, every company must improve its efficiency and minimize product defects that occur in every product production process [2], [3]. In Indonesia, demand for clothing products is increasing every year and can be seen in Figure 1.

Based on Figure 1, the demand for clothing products in Indonesia has increased from 2011-2018. With the demand for clothing products in 2018 amounting to 20036 (in millions of USD). Based on these data, each industry must improve the quality of its products to be accepted by consumers and be able to compete with other industries to get consumers. Quality control has an important role in the company. One of them is by showing the quality of its products and not ignoring product failures or product defects. Product quality is the main focus of the company. So that with increasing demand for a product will have an impact on increased sales results. According to Irwan and Haryono (2015), PT. Unitex, Tbk, which is engaged in the textile industry, is a company that manufactures fabrics...
consisting of several processes. In general, the fabric production process at PT. Unitex, Tbk consists of spinning, weaving, and dyeing processes.

Figure 1. Demand for clothing products in Indonesia According to the Economic Intelligence Unit

The Spinning section is processed by cotton or polyester yarn and blended with polyester. In this Weaving section, the fabric is processed from yarn or blended yarns with other materials such as yarn weaving with a process of weaving the yarn so that it becomes a raw cloth (Greige Cloth). Fabric defects occur in the weaving process; this is because several causes make the fabric defective. The weaving process uses Shokki machines; there are seven types of shokki machines, including New DB, AJL DB, DB 810, DB 813, Old AJL 30, Old AJL H4, and New AJL. Based on previous research conducted by Tejaskumar S. Parsana and Mihir T. Patel in 2014 stated that FMEA was used to identify and analyze all failure modes from various parts of the system, the effects of these failure modes on the system and how to avoid failures or moderate the effects from the failure system [4]. Jigor Doshi conducted other research and Darshak Desai in 2016, Failure Mode and Effect Analysis (FMEA) is a quality tool used to identify potential failures and related effects on processes and products, so that continuous improvement in quality can be achieved by reducing it [5]. FMEA also can be used for analysed the risk priority [6]–[8]. With so many defects that occur in a process will cause harm to a company. Therefore, research on the FMEA method as a means system for quality control for shokki machines in the Weaving department at PT. Unitex, Tbk needs to be reviewed and efforts made in creating continuous and better product quality improvements going forward. Based on the background description in the previous sub-chapter, the following problem can be summarized: how to control the quality of the product defects in the greige fabric in the Weaving department at PT. Unitex, Tbk by using the Failure Mode and Effect Analysis method to reduce the defect level of the greige fabric products and their causes?

The objectives that can be expected to be achieved in this study are: 1. Identify possible causes of product defects. 2. Analyzing the Causes of product defects to reduce the level of fabric product defects in the Weaving department at PT. Unitex, Tbk. 3. Provide recommendations for improvement of the causes of fabric defects.

2. Method

The initial stage of the research carried out in the form of direct observation to the field to see the process that is taking place. The purpose of the observations made is to find out the condition of the company’s real production. Observations were made generally about the quality control system used by the company. Collecting complete information related to all processes and conditions that occur obtained directly through the field supervisor and employees. Based on this information, a picture of the problems associated with quality control is found in the company.
A literature study is a stage of preparing the theoretical foundation that can support research originating from various sources that are considered relevant. So, we get supporting theories that will be used to solve the problems in this study. Literature sources used include those from books, journals, and research from other parties that are considered relevant. The literature used can provide an overview related to the basic theories of quality control using the Failure Mode and Effect Analysis (FMEA) method as well as other supporting theories that help in conducting discussions to resolve this problem.

At this stage, identification of the problems that occur in the company. One of the main problems that occur is the quality of fabric production. The quality of the fabric produced from the production process carried out shows that there are still fabrics that are in grade C due to defects found in the fabric. So that effort is needed to improve the quality control of fabrics.

Sources of data used in this study are primary data and secondary data. Primary data were obtained from direct observations in the field and interviews of the authors with related parties, including the head of the weaving division, field supervisors, and operators who were directly involved in handling the system or process that was taking place while the secondary data obtained by the author from sources that have been collected are production data and the number of defects, production processes and product quality characteristics.

The data processing that will be carried out in this study is based on the stages contained in the Failure Mode and Effect Analysis method which consists of the following steps: Identification of the type of failure that occurred, identification of the cause of the failure, determination of rating severity, occurrence, and detection, Calculation and ranking RPN values, analysis of causes of defects, proposed improvements and controls. Before doing data processing, it is necessary to recapitulate production data, which includes production data of both grade A and grade C products for each type of fabric. Then, the data is processed using the Failure Mode and Effect Analysis (FMEA) method following the stages.

1. Identify the types of failures that occur an initial step in the FMEA method is to look for any possible fabric failures or defects that occur in the system as a whole. Seeing the type of failure that can occur from data obtained from the company or can also be direct observation.
2. Identify the Cause of failure next step is to identify the cause of the failure that has been obtained from the initial step. The tool used in identifying problems using fishbone diagrams and Pareto diagrams.
3. Determination of Rating Severity, Occurrence, and detection The next step is weighing the severity, occurrence, and detection of several factors obtained from the fishbone diagram. Then to get the RPN value, it is done severity, occurrence, and detection multiplication.
4. Failure Mode and Effect Analysis (FMEA) AnalysisAfter identifying the consequences of fabric defects, the next step is to create an Analysis of Failure Mode and Effect Analysis, where the severity, occurrence, and detection values are first searched.

Then the next step is to multiply the rating value to get the RPN value which is then performed an analysis of the severity value due to process failure, an analysis of the occurrence value of the cause of failure, an analysis of the detection value of the control carried out, and an analysis of the RPN value of the failure factor that happened. The last stage of the research conducted is to draw conclusions from the results of practical work research and provide suggestions regarding improvements that can be made by others in future research.

3. Result and discussion
Data collection was carried out by collecting data on the amount of production of greige cloth combined two types of fabric, namely yarn dyed and piece dyed. Data on the type of fabric defects with grade C for each type of machine used. The data comes from the production report data and defects in the Weaving section in the December 2018 period. The defect product data collected consists of the number of defects produced, the percentage of defects produced from each fabric produced, and the machine used, and the types of defects that occur. The defect product data collected
is defect product data in the period July - December 2018 obtained from the archive of the Weaving section which can be seen in Table 1.

**Table 1. Production Results of Defective Fabrics by Type of Fabric Type and Machine Type for the Period July - December 2018**

| Month   | Type of Fabric | NEW DB | DB 810 | DB 813 | AJL 30 | AJL DB | AJL H4 | NEW AJL |
|---------|----------------|--------|--------|--------|--------|--------|--------|---------|
| July    | Yarn Dyed      | 6355.55| 4276.745| 9863.16| 5484.45| 0      | 0      | 10296.1 |
|         | Piece Dyed     | 0      | 0      | 328.9  | 329.5  | 3874.27| 730.57 | 0       |
| August  | Yarn Dyed      | 7137.96| 5303.49| 5603.49| 973.075| 6356.13| 429.5  | 2881.975|
|         | Piece Dyed     | 0      | 0      | 973.075| 429.5  | 2881.975| 1041.47| 0       |
| September | Yarn Dyed   | 8759.04| 6870.3  | 8684.83| 8271.33| 3874.27| 730.57 | 13620.27|
|          | Piece Dyed     | 0      | 8759.04| 0      | 6870.3  | 631.995| 8854.83| 0       |
| October | Yarn Dyed      | 13135.68| 9859.11| 11926.03| 10871.55| 0      | 0      | 0       |
|          | Piece Dyed     | 0      | 0      | 3256.725| 403    | 6476.235| 5740.45| 0       |
| November | Yarn Dyed    | 12489.6145| 7274.3 | 9595.94 | 9001.96 | 332.5  | 0      | 0       |
|         | Piece Dyed     | 0      | 0      | 857.79  | 312    | 5300.45 | 1913.49| 0       |

Based on data on the types of defects that occur in each machine, ranking is obtained based on the type of fabric defects that often occur that will be identified the cause of the defects can be seen in Table 2.

**Table 2. Ranking of types of fabric defects that often occur**

| Type of Fabric Defect | July | August | September | October | November | December | Average | Percentage | Cumulative Percentage |
|-----------------------|------|--------|-----------|---------|----------|----------|---------|------------|-----------------------|
| OSATOSHI              | 8302.49 | 9342.16 | 10502.14 | 12276.97 | 11939.47 | 10496.80 | 29.89   | 29.89      |                      |
| NIHONDOSHI            | 4367.4 | 4955.07 | 5727.4    | 6791.27 | 5756.77  | 6840.19  | 5739.68 | 16.35      | 46.24                 |
| USUDAN                | 2721.295 | 3129.905 | 3583.62  | 4156.42  | 3474.71  | 4009.21  | 3512.51 | 10.00      | 56.24                 |
| TATE GIRE             | 2564.75 | 2952.825 | 3467.745 | 4366.025 | 3207.525 | 3916.605 | 3412.58 | 9.72       | 65.96                 |
| ATSUDAN               | 2171.57 | 2616.735 | 3041.39  | 3757.63  | 2885.72  | 3480.47  | 2992.25 | 8.52       | 74.48                 |
| TATE HIKE             | 1285.33 | 1250.93 | 1451.18  | 3404.3   | 2829.6   | 3134.22  | 2225.93 | 6.34       | 80.82                 |
| SHORT PICK            | 1702.045 | 1877.83 | 2373.26  | 2789.09  | 1774.89  | 3104.505 | 2270.27 | 6.47       | 87.29                 |
| MURAITO               | 1000.31 | 1174.83 | 1690.235 | 2178.885 | 1469.585 | 2537.665 | 1675.25 | 4.77       | 92.06                 |
| ITOKOZU               | 989.02 | 1122.565 | 1316.065 | 2269.075 | 852.355  | 1859.025 | 1401.35 | 3.99       | 96.05                 |
| NOZZLE                | 5100.99 | 301.33 | 473.66   | 1162.96  | 521.66   | 756.91   | 1387.75 | 3.95       | 100.00                |
| Total                 | 30214.2 | 28724.18 | 33626.695| 43152.63 | 33390.385| 41578.27 | 35114.39 |           |                      |

The use of Pareto diagrams in identifying the causes of fabric defects to show the problem is based on the order of the many types of fabric defects that occur. The sequence starts with the number of problems that occur the most until the least occur. The graph is indicated by the highest bar graph (far left) to the lowest graph. Pareto diagram of the average fabric defects in the period July - December 2018 can be seen in Figure 2.
Based on Figure 2, it can be seen that ten types of fabric defects dominate in PT. Unitex, Tbk. OSA TOSHI is the most dominant type of fabric defect that is OSA TOSHI along 10496.80 meters, with a cumulative frequency of 29.75%. Then followed by NIHON DOSHI along 5739.68 meters with a cumulative frequency of 46.02%, and so with other fabric defects.

Based on the causes of fabric defects of each type of fabric defects that occur, there are several potential causes of defective products, including human, machine, method, material, and environmental factors. The following is a description of the potential causes of the problem for each factor that affects product defects:

1. **Human Factors**
   The human factor is one of the factors causing the dominant type of defect in PT. Unitex, Tbk. This is because one operator supervises many machines, so the operator feels tired while working, which results in decreased accuracy. Then the lack of supervision of the machine that results in negligence of workers, causing the machine to be uncontrolled, and workers make mistakes when setting the machine.

2. **Engine Factor**
   Machine factors also affect the fabric defects, this is caused by damage to the engine shokki such as wear and tear on the machine, setting the wrong machine, the machine is less sensitive so that when the thread breaks the machine does not die, there is some damage to the machine that makes the thread break, and also possible due to lack of maintenance of these machines.

3. **Material Factors**
   The material used to produce greige fabric is obtained from spinning. Material from spinning often does not comply with the standards that should be. Because the average fabric defect occurs because the thread is broken when weaving. And some threads have different thicknesses.

4. **Environmental Factors**
   Environmental factors also affect the production process of greige cloth. This is because, at the time of the production process, there is dust around the machine, which causes the dust to accumulate in the middle so that it is also woven, which results in the fabric being grade C or defective.

5. **Method Factors**
   The method factor is also one of the causes of the many fabric defects that occur in PT. Unitex, Tbk. Fabric defects are also caused by improper machine setting procedures such as incorrectly setting the speed of the machine which makes the machine not work effectively. Then the fabric defects also often occur because the operator does not do routine checking when woven in the
shokki unit. Then the production control in the sizing unit lacks this is because, during the sizing process, many threads break up in the size box.

After identifying the consequences of fabric defects, the next step is to make a Failure Mode and Effect Analysis Analysis, where the severity, occurrence, and detection values are first searched. Then the next step is to multiply the rating value to get the RPN value which is then performed an analysis of the severity value due to process failure, an analysis of the occurrence value of the cause of failure, an analysis of the detection value of the control carried out, and an analysis of the RPN value of the failure factor that happened. Following is the Analysis of Failure Mode and Effect Analysis, which can be seen in Table 3.

| No | Factor     | Due to process failure | Severity | Cause of failure | Occurrence | Control carried out | Detection | RPN | Total RPN per Factor | Rank |
|----|------------|------------------------|----------|------------------|------------|---------------------|-----------|-----|---------------------|------|
| 1  | Human      | Defects occur          | 8        | Not carefull     | 8          | Operators are given a reprimand | 4         | 256 | 512                 | 2    |
| 2  | Human      | Defects occur          | 8        | Less control     | 8          | Operators are given a reprimand | 4         | 256 |                     |      |
| 3  | Machine    | The production process is interrupted | 4        | Engine failure   | 7          | Perform periodic engine maintenance | 7         | 196 |                     |      |
| 4  | Machine    | The production process is interrupted | 4        | Incorrect engine settings | 6          | Perform periodic engine maintenance | 7         | 168 | 460                 | 3    |
| 5  | Material   | The production process is interrupted | 4        | Less sensitive engine | 4          | Checking the machine and looking for causes related to the machine are less sensitive | 6         | 96  |                     |      |
| 6  | Material   | Defects in production result | 7        | Low yarn strength | 8          | For longer payroll and process improvement | 4         | 224 |                     |      |
| 7  | Environmental | Defects in production result | 7        | Thread does not meet specifications | 7          | Control the material to be used whether it is according to specifications or not | 6         | 294 | 518                 | 1    |
| 8  | Environmental | Defects in production result | 7        | Cotton dust scattered | 6          | Checking around the machine | 5         | 210 | 210                 | 5    |
| 9  | Method     | Defects occur          | 5        | Incorrect engine setting procedure | 6          | Conducted training for operators | 6         | 180 |                     |      |
| 10 | Method     | Defects occur          | 5        | Free weft remains on the fabric | 6          | Operators are given a reprimand | 4         | 120 |                     |      |

There are several kinds of assessments in the FMEA method, namely, severity, occurrence, and detection. From Table 4., it can be seen that the greatest severity points are found in the human factor which is worth eight. This is because human factors are the cause of fabric defects. With the inaccuracy of the operator makes the control of the machine becomes less.

Based on Table 4, it can be seen that the highest Occurrence value of the writer is given, namely on human and material factors. With a very low level of detail and control will cause the operator to make mistakes that cause damage to the fabric. And also, the low quality of the yarn can cause fabric defects to occur so that when the thread breaks, the operator does not realize that there will be a fabric defect that will cause the fabric to be grade C.
The highest weighting Detection value is given to maintenance with a weight value of 7. The author gives a value of 7 because these factors need to be done because of the many damages to the machine that results in disruption of the production process.

After weighting has been done, then the RPN value will be obtained from the multiplication of severity, occurrence, and detection. Then after that, the RPN score from the largest to the lowest. Based on Table 4, it can be seen that material factors get the first rank. Therefore material factors are a priority to be repaired first because material factors are the biggest contributing factors for fabric defects.

Recommendations for improvement that can be given are related to the problem factors that occur, namely, first making a good SOP that aims to make it easier for each operator to operate the machine correctly and prevent errors in the use of the machine that will later affect the fabric production process. Secondly, making machine control forms. Making this form is intended so that the state of the machine can be controlled easily both by the maintenance. This is one way to reduce the possibility of damage that occurs in the engine, such as worn machines. The controlled maintenance of the machine is expected to reduce fabric defects that occur due to damage to the machine.

Third, the procurement of training for operators. The purpose of this training provision is expected for each operator to prioritize operating the machine by specified standards. Training can be done by outsiders and insiders as needed. It is also hoped that the material in training can change the way of thinking that operators not only carry out tasks by their respective responsibilities but also pay attention to the damage and quality of products produced. Fourth, for material factors. The step that must be done is to communicate the problem to the spinning department. It could also be suggested that the spinning department is done for a long time.

4. Conclusion
The results of this research are obtained: In the period July - December 2018, 5 types of fabric defects were most dominant, namely OSA TOSHI, NIHON Doshi, USUDAN, TATE GIRE, and ATSUDAN which would serve as samples and priority handling. Identification of the causes of fabric defects is made using a fishbone diagram with the causes of defects found including from human factors, materials, machinery, environment, and methods. Analysis of Failure Mode and Effect Analysis of the causes of failure obtained from the fishbone diagram obtained the highest severity value for human factors, the highest occurrence value for less precision and control, and the highest detection value for engine maintenance. Proposed improvements that can be given to the problems above, namely making a good SOP and sticking to each machine, making a form to control the state of the machine components, providing training to the operator, and communicating the problem to the Spinning section.

Acknowledgment
Authors would like to thank the Industrial Engineering of Engineering Faculty of Universitas Andalas for providing publication grant FY 2019.

5. References
[1] D. Bauer, Thomas; Fiedler, Lars; Jacobs, Jeff; Spillecke, 2017. “The secret to great marketing analytics? Connecting with decision makers,” McKinsey Co.
[2] G. Akrani, 2013. “What is Product Quality? Definition Meaning Importance,” Kalyan City Life Blog.
[3] M. R. Suryoputro, M. Sugarindra, and H. Erfaisal Syah, 2017. “Quality Control System using Simple Implementation of Seven Tools for Batik Textile Manufacturing,” in IOP Conference Series: Materials Science and Engineering, doi: 10.1088/1757-899X/215/1/012028.
[4] T. S. Parsana and M. T. Patel, 2014. “A Case Study: A Process FMEA Tool to Enhance Quality and Efficiency of Manufacturing Industry,” Bonfring Int. J. Ind. Eng. Manag. Sci., doi: 10.9756/bijiems.10350.
[5] J. Doshi and D. Desai, 2017. “Application of failure mode & effect analysis (FMEA) for continuous quality improvement - multiple case studies in automobile SMEs,” *Int. J. Qual. Res.*, doi: 10.18421/IJQR11.02-07.

[6] D. M. Barends, M. T. Oldenhof, M. J. Vredenbregt, and M. J. Nauta, 2012. “Risk analysis of analytical validations by probabilistic modification of FMEA,” *J. Pharm. Biomed. Anal.*, doi: 10.1016/j.jpba.2012.02.009.

[7] W. Wang, X. Liu, Y. Qin, and Y. Fu, 2018. “A risk evaluation and prioritization method for FMEA with prospect theory and Choquet integral,” *Saf. Sci.*, doi: 10.1016/j.ssci.2018.08.009.

[8] P. Fithri, N. A. Riva, L. Susanti, and B. Yuliandra, 2018. “Safety analysis at weaving department of PT. X Bogor using Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA),” in *2018 5th International Conference on Industrial Engineering and Applications, ICIEA 2018*, pp. 382–385, doi: 10.1109/IEA.2018.8387129.