Analysis Of Production Processes On Heat Resistant Products Using FMEA & FTA Methods To Improve Product Quality

Fadel Ramadhan S, Helena Juliana K, Mohammad Agung Saryatmo, Lithrone Laricha Salomon
Industrial Engineering Study Program,
Tarumanagara University,
Indonesia
fadel.545200042@stu.untar.ac.id, julianak@ft.untar.ac.id,
mohammads@ft.untar.ac.id, lithrones@ft.untar.ac.id

Abstract

This research focuses on heat-resistant products produced by the home industry from March 2023 to August 2023 with a total production of 42,123 pcs of products with 1252 pcs of untidy stitching defects and 106 pcs of unstitched lacing defects. This company itself is a home industry that produces heat-retaining products. Based on observations and research that has been carried out, there are product defects during the process of making heat-retaining products. This research aims to identify, analyze, and provide suggestions for improvements for this home industry so that it can reduce product defects produced. Based on the FMEA assessment, it can be seen that the causes of product defects are sloppy stitching and unstitched laces. Based on the RPN assessment which aims to determine the highest priority, defects in unstitched rope products with an RPN value of 192 and a severity value of 8. After carrying out an analysis using the FMEA and FTA methods, suggestions for improvement are given, namely, it is hoped that this research can provide benefits in the form of reducing the number of product defects during the production of this home industry.

Keywords
Product defects, FMEA, FTA, Improvement Proposals.

1. Introduction
Home means house, residence, or hometown. Meanwhile, the industry can be interpreted as crafts, goods product businesses, and/or companies. The home industry is a product house or small company. In general, the definition of SMEs (Small and Medium Enterprises) usually includes at least two aspects, namely the initial investment value aspect, the number of assets, and the number of personnel aspects. According to BPS, the number of workers includes the home industry with a workforce of 5-9 people, the small industry with a workforce of 10-19 people, medium industry with a workforce of 20-99 people, large industry with a workforce of 100 people or more. (Jakfat and Dian 2020).

This convection is a home industry that operates in the field of carpet and heat-resistant product manufacturing, founded in 2005 and located in Cikini, Central Jakarta. In the production process, a sewing machine is used, which is done with human assistance to control the operation of the machine. The process of making heat-retaining products begins by inserting tissue material and polyester knitting thread, then entering the weaving machine process which produces rope, after the tissue material and the polyester knitting yarn have become rope. The next process is to enter the production machine which will produce heat-retaining products.

The research was carried out in a home industry that operates in the manufacturing sector with the production of heat-retaining products. The production process for heat-resistant products includes forming and sewing processes. In the production process, a defect was found in the product produced. Based on the results of interviews and field observations, there are problems in controlling the quality of heat-retaining products, causing defects in the products. This research aims to identify and provide suggestions for improvements to reduce product defects in the production process. To reduce existing defects, the author will use the FMEA and FTA methods which aim to determine the causes of product defects and to reduce defects in the production process.

Based on the research conducted, the aim of this research is to find out the causes of failure and reduce product defects that occur. This research also aims to analyse the failure mode, causes of failure, and effects of failure. From the analysis carried out, the aim is to provide suggestions for improvements to improve the quality of home industry products.

2. Literature Review

Developments in the manufacturing industry, which is currently full of competition, encourage home industries to maintain their performance so as not to be left behind by other home industries or other companies. The world of the manufacturing industry has a system for using machines, labor, equipment, and also raw materials so that it can become a product that has selling value. (Ruihuang et al. 2020). Production machines and equipment are the main resources that cannot be separated from the overall resources owned by both home industries and companies. A machine is a tool that can determine the success in making a product to shorten the production process. The performance of the machine and the performance of the workers also determine the quality of the product that will be produced. (Singh et al. 2018) Basically, a machine has a lifespan and over time the machine's performance will decrease and it will not work optimally. Preventive efforts are needed as a basis for preventing defective products from occurring due to less-than-optimal machine performance. (Beatrix et al. 2020).

3. Methods

Research was conducted in the Cikini area, Central Jakarta. This home industry was originally a trading business that supplied necessities to homes or shops. This research focuses on heat-retaining products, to determine the types and causes of defects in the product. The research begins by making a control chart P to see the proportion of defects in the product whether it is still within the control limits or outside the control limits. If it is outside the control limits then improvements are needed. After making the control chart P the next stage is making a fishbone diagram, after analyzing the diagram the next stage is fishbone to carry out FMEA analysis and provide suggestions for improvements to the analysis results. Then the next stage is the analysis stage using the FTA method which aims to find out more deeply the causes of defects in the product. After that, recommendations for improvements will be provided regarding the known causes of the problem. Then, suggestions for improvements will be given so that they can provide improvements for the home industry.

4. Data Collection

The data used for research that focuses on improving the quality of heat-retaining products is based on defect data for home industry heat-resistant products. The following is production data and product defect data obtained from March to August 2023 in monthly form.

Table 1. Production and Product Defect Data March to August 2023

Time (Weekly)	Production Quantity (pcs)	Product with defective stitching that is non heat (pcs)	Unstitched Strap Defect Products (pcs)	Number of Defective Products (pcs)	Percentage(%)
1	2186	68	14	82	3.75%
2	2486	61	11	72	2.90%
3	2396	59	10	69	2.88%
4	2445	62	11	73	2.99%
5	2253	65	8	73	3.24%
6	2213	54	4	58	2.62%
7	2254	60	5	65	2.88%
8	2258	61	3	64	2.83%
9	1386	60	2	62	4.47%
10	1558	38	1	39	2.50%
11	1412	34	2	36	2.55%

12	1326	42	3	45	3.39%
13	1308	35	1	36	2.75%
14	1326	28	3	31	2.34%
15	1302	54	1	55	4.23%
16	1358	46	4	50	3.68%
17	1688	52	2	54	3.20%
18	1684	53	2	55	3.27%
19	1632	54	3	57	3.49%
20	1779	50	1	51	2.87%
21	1492	58	5	63	4.22%
22	1517	45	5	50	3.30%
23	1431	57	3	60	4.19%
24	1441	56	2	58	4.03%
Total	**42123**	**1252**	**106**	**1358**	**19,65%**

5. Results and Discussion

With the data collection that has been carried out, the next stage of analysis using FMEA & FTA will be carried out to find out more about the causes and repair solutions for the failures that occur.

5.1 Control chart P

The P control chart is one of the control charts used in attribute quality control, which aims to identify defects in the product produced. (Chanika et al. 2023). Control charts are also commonly used to monitor and evaluate activities or processes that are under quality control statistically so that they can solve problems and produce improvements in quality. (Mazen. 2022). Calculations carried out to create a P control chart from March to August 2023, resulted in CL = 0,032; UCL = 0,037; and LCL = 0,021. The following is a P control chart to determine the proportion of product defects.

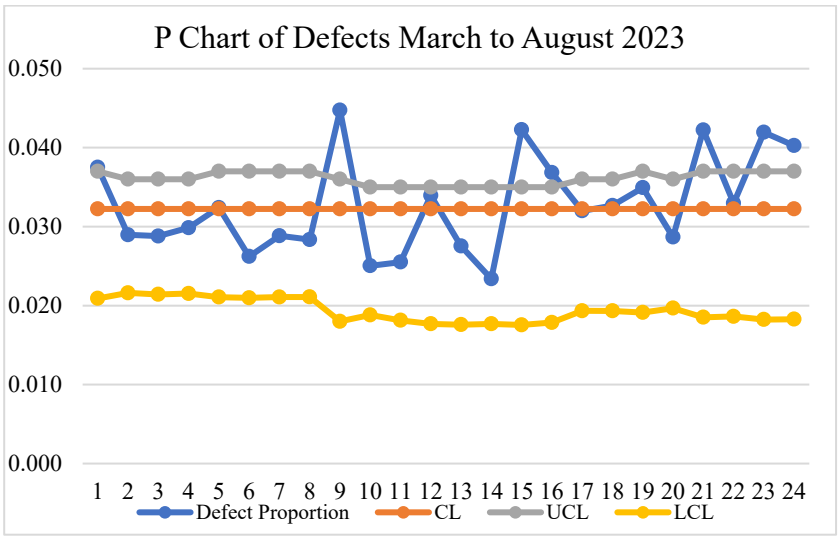

Figure 1. P Control Chart of Defects March to August 2023

Based on the P control chart that has been created, there are 7 production points (production week 1, 9, 15, 16, 21, 23, and 24) that are outside the UCL (upper control limits), so improvements are needed so that they can reduce the number of product defects.

5.2 Fishbone Diagram

Fishbone diagram is an analysis method used to identify quality problems and check points which includes four types, namely materials or equipment, labour, and methods. (Ravi et al. 2019). A fishbone diagram is a combination of lines and symbols that show cause and effect relationships. (Siti et al. 2022). The following is a fishbone diagram which contains the causes and effects that are factors in the occurrence of product defects.

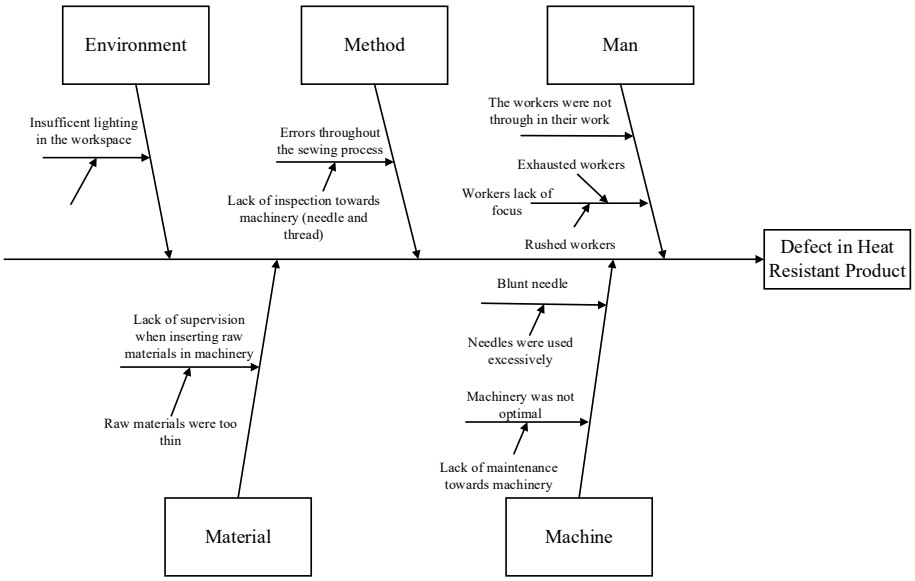

Figure 2. Fishbone Diagram of Heat Resistant Product Defects

5.3 FMEA (Failure Mode and Effect Analysis)

At this stage, the causes of defects in heat retaining products are analyzed. To find out the causes of product defects, use the FMEA (Failure Mode and Effect Analysis) method. FMEA functions to identify the cause of failure or the mode of occurrence of a failure. (Muhammad et al. 2021). Assessment of the level of damage (severity), possibility of (occurrence), and failure detection (detection).

Table 2. FMEA analysis

No	*Potential Failure Mode*	*Potential Failure Effect*	S	*Potential Failure Cause*	O	*Current Process Control*	D	RPN	*Rank*	*Action Recommended*
1.	Untidy stitching	The stitching thread is not sewn throughout the product	7	The needle used is blunt or bent	6	Change the needle to be used	4	168	2	Inspect needles on machines that have been used at the end of working hours
				Decreased engine performance	7	Carrying out maintenance on the machine sector	3	147		Carry out maintenance on the machine once a week or once every 2 weeks to ensure the machine continues to work optimally
2.	Strap Not Sewn	The product can be easily torn through gaps in the unstitched webbing	8	The needle used is blunt or bent	6	Change the needle to be used	4	192	1	Inspect machine needles that have been used at the end of working hours

Based on the results of the analysis and calculation results using the FMEA method, the highest RPN value was found from the product of the severity value, occurrence value and detection value. The RPN value for the non-stitched rope defect type is 192 and the parallel RPN value for the sloppy stitching defect type is 168 and 147. Proposed improvements are given regarding the analysis of the causes of failure in the FMEA table.

1. Inspect needles on sewing machine parts that have been used at the end of working hours.
2. Carry out maintenance on the machine once a week or once every two weeks to ensure the machine continues to perform optimally.

5.4 FTA (Fault Tree Analysis)

FTA (Fault Tree Analysis) is a method used as an analytical technique, analyzing the environment and operations to find a way or solution to problems that arise. FTA is a technique used to identify risks that contribute to failure. (Jakfat. 2022) The following is an FTA based on the results of analysis with the help of the FMEA method in Figure 3 and Figure 4.

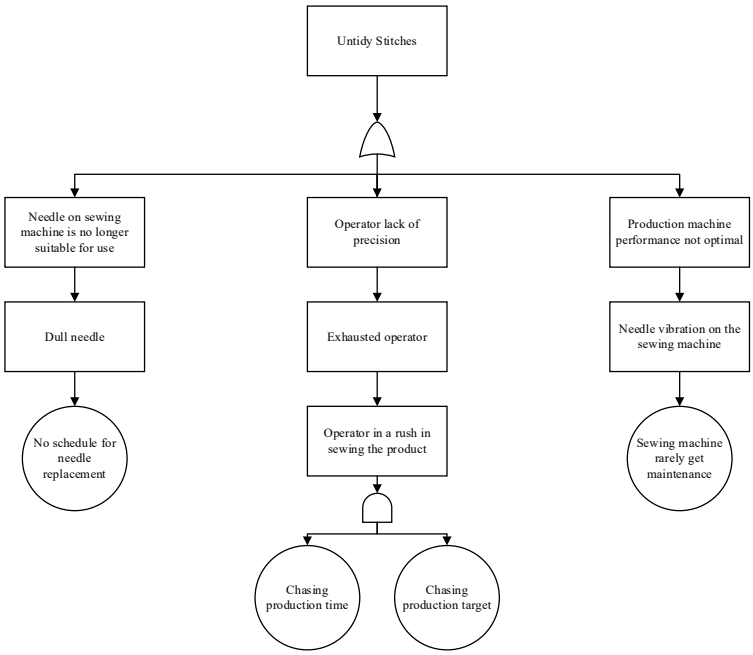

Figure 3. FTA Analysis of Untidy Stitches

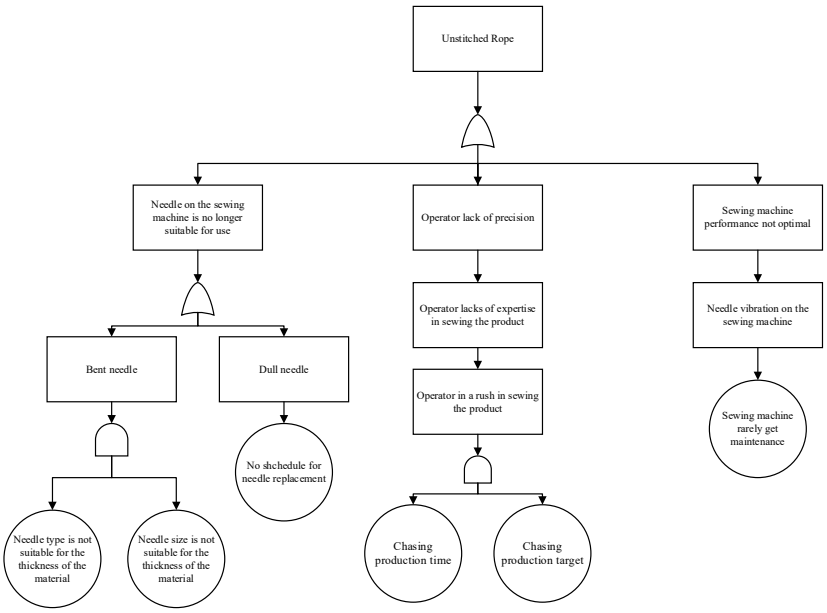

Figure 4. FTA Analysis of Unstitched Rope

In the two fault tree analysis using the FTA (Fault Tree Analysis) method that have been carried out, several basic events or root causes of defects in the product can be found. These include workers who are negligent in carrying out production due to being in a hurry, and lack of maintenance schedule on production machines. After carrying out an analysis based on searching for the root of the problem, the next stage is to provide suggestions for improvement which can be seen in Table 3.

Table 3. Proposed FTA Improvements

No	Factor	Proposal
1	Machine	• Scheduling is carried out for maintenance in the machine sector • Replacement of sewing machine needles from previously 1 month to 3 weeks
2	Operator	• Retraining was carried out for operators to reduce product defects when sewing
3	Environment	• Add ventilation or a fan so that air circulation can circulate • Adding lighting to production machine parts can minimize the occurrence of defects in products

Based on the results of the analysis using the FMEA and FTA methods, the results obtained were the causes of defects in the product, namely in the needle sector and in the sewing machine sector. Proposed improvements were given, namely replacing needles from previously once a month to twice a month, and making a regular machine maintenance schedule to reduce the occurrence of product defects due to less than optimal production machine performance, adding ventilation or fans to the room. production so that air circulation can circulate, and adding lighting to the production section to minimize the occurrence of product defects.

6. Conclusion

Based on the results and discussion in this research, researchers can conclude several research results, namely:

1. Factors that cause product defects are caused by human factors, the machines used, and the tools used. Identification is carried out by analyzing the production process, type of failure, potential consequences of failure, and causes of failure.
2. The results of calculations using the FMEA (Failure Mode and Effect Analysis) method for heat retaining products obtained the highest RPN value from the product of the severity value, occurrence value and detection value. The highest RPN value is found in the unstitched rope defect type with an RPN value of 192 and the lowest value is found in the sloppy stitching defect type with parallel RPN values of 168 and 147.
3. Based on analysis using the FTA (Fault Tree Analysis) method, defects in non-stitched ropes are caused by bent or blunt needles. Apart from that, this is caused by the inappropriate size or type of needle and operators being in a hurry during the production process due to chasing production times and targets.

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Biographies

Fadel Ramadhan Sofyan is a student at Industrial Engineering Department of Tarumanagara University. He was born in November 2001. With his confidence, he started to write a journal. He started his education at college in 2020. Apart from studying at college, he also likes to be active in a community and socializing.

Helena Juliana Kristina is a lecturer at the Industrial Engineering Department of Universitas Tarumanagara since 201. She graduated with her Bachelor of Industrial Engineering at Universitas Atma Jaya Yogyakarta, the she got her Master's Degree in Mechanical Engineering at University of Indonesia. She has been exploring research on Lean and Green Manufacturing and Participatory Ergonomics since 2015, which has been published nationally and internationally. She has also been exploring community service activities for the waste bank community and garbage collectors. She produced tow digital books with ISBNs from Community Service activities, entitled Guyup Garbage and Gyup Care for the Earth, Our Home Together.

Mohammad Agung Saryatmo is a full-time lecturer at Tarumanagara University's Department of Industrial Engineering. He holds a Bachelor of Engineering in Industrial Engineering from Gadjah Mada University in Indonesia and a Master of Management from Diponegoro University in Indonesia. He also holds a PhD from Asian Institute of Technology, Thailand. His research interests are in the areas of digital supply chain management, quality management, strategic human resources management and service quality.

Lithrone Laricha Salomon is a lecturer at Industrial Engineering Department of Tarumanagara University since 2006. He graduated from Tarumanagara University with a Bachelor's Degree in Mechanical Engineering. She continued her study and got her Master's Degree from Industrial Engineering Program at Universitas Indonesia. She teaches a subject related to quality management systems such as Total quality management, Quality Control, Design of Experiment and Industrial Statistics. Besides teaching she also did some research and carried out a number of community service activities in many places around Indonesia. She has written more than 50 publications on international and national proceedings and journals since 2007.