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Analysis Of Defects In Laminated Doors Using Failure Mode And Effect Analysis (FMEA) And Fault Tree Analysis (FTA)

Tifanny Giartania Nayoga [1] , M. Nushron Ali Mukhtar [2]
[1,2] PGRI Adi Buana University, Surabaya
e-mail : tgiartanianayoga@gmail.com[1], nushron@unipasby.ac.id[2]

Abstract— Quality control is an crucial part of the production process because product quality must meet established standards. Based on drawback that happen in the laminating door production process, prioritizing different failure types is essential to reduce the occurrence of defects in the same production process. To enhance product quality and minimize defects, consider implementing by using Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA). The purpose of this study is to identify the types of factors causing product defects in the laminating door production process and provide recommended actions in the improve phase to minimize the number of defects. This study analyzes six types of defects in laminating door products. The results show that operator errors are the dominant cause, influenced by environmental conditions and an unsupportive work system. Based on the Risk Priority Number (RPN) values, the defects with the highest values are unsticky glue (RPN 294) caused by machine factors, crack (RPN 252) by method factors, incorrect size groove spesification (RPN 245) by man factors, peeling paint (RPN 180) by method factors, scratch on laminated surface (RPN 175) by man factors, and unprecision joint (RPN 120) by man factors. Improvement suggestions include operator training, machine maintenance, replacement of inadequate equipment, selection of appropriate raw materials, and implementation of clear Standard Operating Procedures.

Keyword : FMEA; FTA; Quality; RPN Value.

I. INTRODUCTION

Quality control is the most important part of the production process to ensure that products and services meet specified standards. One of the stages of quality control is inspection through product testing. If the product meets the standards, the next stage can proceed further. However, if the standards are not met, it will result in a reduction in production quantity. A carefully executed manufacturing process that focuses on quality aspects can prevent production defects, so that in operation, it does not cause damage to the product (Syahrullah & Izza, 2021). Therefore, quality control is more than just inspection activities or evaluating product quality to determine if it is feasible (Haryono & Sumiati, 2023). Quality involves all aspects of products and services, including marketing, engineering, production, and maintenance, aimed at ensuring that products and services will meet consumer expectations when used (Cahyono et al., 2023). Quality is not only the product produced but also viewed from the process. If a company neglects the quality of its products, market traction can decline (Andespa, 2020).

Basically, companies have made efforts to control product quality to satisfy consumers. However, in the production process, there are still often discrepancies with specifications, resulting in defective products. The more defective products, the greater the impact on the productivity of the production process. Product defects are not only caused by machines but also by worker negligence due to lack of thoroughness or not following procedures properly. One suitable technique to stabilize product quality and reduce the number of failed products is using Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA). Failure Mode and Effect Analysis (FMEA) is chosen as a method to analyze experiences using technology to find failures in the production process and plan to reduce defects (Ali M & Kusuma, 2019). FMEA prioritizes prevention, improves work safety, and customer satisfaction (Kartika et al., 2016). The assessment refers to the level of incidence (occurrence), severity, and detection to identify potential failures. Fault Tree Analysis (FTA) analyzes the correlation of origins and then presents it in the form of a fault tree. Fault Tree Analysis (FTA) is a method to find the root

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cause of failures. This analysis is carried out through a top-down approach, starting by assuming failure from the top event, then detailing the background of the top event to the root cause (Ariyanty, 2021).

II. RESEARCH METHODOLOGY

The following research adopts the FMEA and FTA methods. The selected data for analysis includes both primary and secondary data. Secondary data is collected from company defect information. Primary data refers to the results of interviews and field observations. The results of this field research will reveal the issues occurring in the laminated door production process. The next stage is to identify the causes of failure for each type of defect obtained using the FMEA method by calculating the values of Severity, Occurrence, and Detection, and then determining the RPN (Risk Priority Number) value. After obtaining the highest RPN value, the next step is the FTA analysis to analyze the root causes of the most at-risk product defect types, so that the improvement process to address these defects can be determined.

III. RESULTS AND DISCUSSIONS

1. Data Collection

Data Collection In the next process, the defect data of laminated door products for January 2024 was collected for analysis. This data was obtained from the Quality Department. The defect data of laminated door products is included in the following Table 1:

Table 1. Laminated Door Product Defect Data for January 2024

Date	Production Amount (pcs)	Defects Standart	Jenis Cacat						Defects amount (pcs)	Defects Precentages (%)
			Unsticky Glue	Crack	Unprecision joint	Incorrect groove size	Peeling Paint	Scratch on laminated surface		
3-Jan-24	505	2%	9	6	3	6	7	2	33	6.53
4-Jan-24	510	2%	8	3	5	6	5	7	34	6.67
5-Jan-24	508	2%	9	4	6	1	6	8	34	6.69
9-Jan-24	512	2%	6	7	5	4	5	5	32	6.25
10-Jan-24	508	2%	5	4	6	7	5	5	32	6.30
11-Jan-24	508	2%	9	6	4	4	6	5	34	6.69
12-Jan-24	515	2%	6	9	4	5	5	6	35	6.80
15-Jan-24	510	2%	7	4	2	5	7	8	33	6.47
16-Jan-24	505	2%	7	4	4	4	6	7	32	6.34
17-Jan-24	509	2%	7	4	4	3	7	7	32	6.29
18-Jan-24	507	2%	5	8	4	5	4	7	33	6.51
19-Jan-24	507	2%	9	4	6	3	5	4	31	6.11
22-Jan-24	505	2%	8	5	6	2	5	5	31	6.14
23-Jan-24	508	2%	7	7	4	4	4	6	32	6.30
24-Jan-24	505	2%	8	4	5	4	3	7	31	6.14
25-Jan-24	508	2%	8	8	2	6	8	2	34	6.69
26-Jan-24	511	2%	10	7	3	2	6	4	32	6.26
29-Jan-24	508	2%	3	7	5	7	5	5	32	6.30
30-Jan-24	506	2%	9	6	5	5	6	3	34	6.72
31-Jan-24	505	2%	8	5	4	3	5	7	32	6.34
Sum	10160	2%	148	112	87	86	110	110	653	128.54
Average	508	2%	7.40	5.60	4.35	4.30	5.50	5.50	32.65	6.43

Based on the data in Table 1, the number of defective laminated door products does not meet the company's standards and specifications. On average, the number of products experiencing defects is 33 pieces, with a percentage reaching 6.43%.

2. FMEA Analysis

The first step is to calculate Severity, Occurrence, Detection, and the RPN value calculation. Below is the FMEA table for laminated door:

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Table 2. Table for FMEA of Laminated Door Products

No	*Failure Mode*	*Effect of Failure Mode*	*Factor*	*Cause of Failure Mode*	S	O	D	RPN	*Recommended Action*
1	Unsticky Glue	Glue isn't stick to the product properly	*Man*	Untrained Operator	4	3	6	72	Conduct intensive training for operators on operating the lamination machine.
			Machine	Stability of the glue application machine	7	7	6	294	Routine maintenance on the machine.
			Material	Poor quality of glue	4	5	4	80	Check the quality of the glue before use and ensure it is within the recommended usable period.
			Methode	Not following procedures properly	4	4	5	80	Ensure that the glue application procedure is followed correctly by operators and conduct regular inspections.
			Enviroment	High Humidity	4	6	3	72	Control air humidity in the production area with appropriate ventilation systems.
2	Crack	The product cannot be used in the subsequent process (rejected)	*Man*	Untrained Operator	6	4	3	72	Conduct intensive training for operators on operating the press machine.
			Machine	The machine was not maintained properly.	4	4	5	80	Routine maintenance on the machine
			Methode	Unproperly Pressing procces	6	7	6	252	Ensure that procedures are followed correctly by the operator and conduct regular inspections.
3	Unprecision Joint	The joint tightness on the product is insufficient	*Man*	Untrained operator	6	4	5	120	Conduct intensive training for operators in performing the joint process.
			Material	Poor quality raw material	3	2	2	12	Check the quality of the joint materials before use.
			Methode	The joint process does not comply with the SOP	4	2	3	24	Ensure that the joint procedures used are in accordance with standards and effective.
4	Incorrect Groove Size	The product cannot be used in the next process (reject)	*Man*	Untrained operator	7	5	7	245	Provide training to operators to enhance their skills in operating the CNC router.
			Machine	The machine was not maintained properly	5	4	4	80	Routine maintenance on the machine
			Methode	The program is not suitable (the settings do not match the work loading being performed)	6	4	4	96	Ensure that procedures are correctly followed by operators according to product specifications, and conduct regular inspections.
5	Peeling Paint	Reduce product value	*Man*	Untrained operator	6	2	4	48	Conduct intensive training for operators on how to properly carry out the paint filler process.
			Material	Poor quality raw material	5	3	4	60	Check the quality of the paint before use and ensure that it is within the recommended shelf life.
			Methode	Wrong methode of painting	5	6	6	180	Ensure that the paint application procedures are followed correctly and meet the standards.
			Enviroment	Unstable room temperature	4	1	3	12	Maintain the paint application environment to be stable by controlling temperature and humidity appropriately.

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6	Scratch on Laminated surface	Reduce product value	*Man*	Untrained operator	5	7	5	175	Provide training to operators to improve their skills in the sanding process.
			Material	Poor quality raw material	4	2	5	40	Check the quality of the sanding material before use.
			Methode	Unproperly Pressing procces	6	7	6	252	Ensure that procedures are followed correctly by the operator and conduct regular inspections.

From the data of the FMEA analysis, the highest RPN values were obtained based on the 4M+1E factors as follows: adhesive not sticking with a machine factor of 294, cracking with a method factor of 252, imprecise joint with a manpower factor of 120, incorrect groove size specifications with a manpower factor of 245, paint peeling with a method factor of 180, and scratches on the laminated surface with a manpower factor of 175. Based on the results of the RPN from the FMEA analysis, the highest value will be analyzed using the FTA method.

3. FTA Analysis

Based on the highest RPN values obtained from the FMEA method, the next step involves conducting an analysis using the Fault Tree Analysis (FTA) method to determine the root causes of the existing problems. Below is the analysis using the FTA method for the defects: adhesive not sticking, cracking, imprecise joint, incorrect groove size specifications, paint peeling, and scratches on the laminated surface, with the aim of identifying the factors that contribute to these defects.

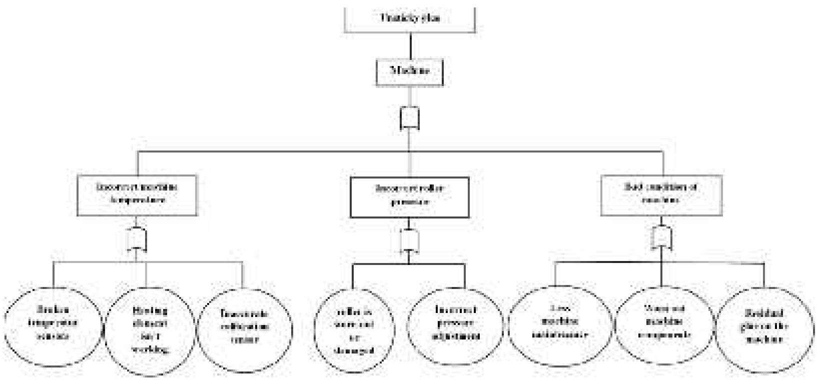

Figure 1. FTA Analysis Unsticky Glue Defect

In Figure 1, the defect of unsticky glue is caused by three main factors: incorrect machine temperature due to damaged sensors or heating elements, improper roller pressure due to worn-out rollers or incorrect adjustments, and poor machine condition due to inadequate maintenance or worn-out components.

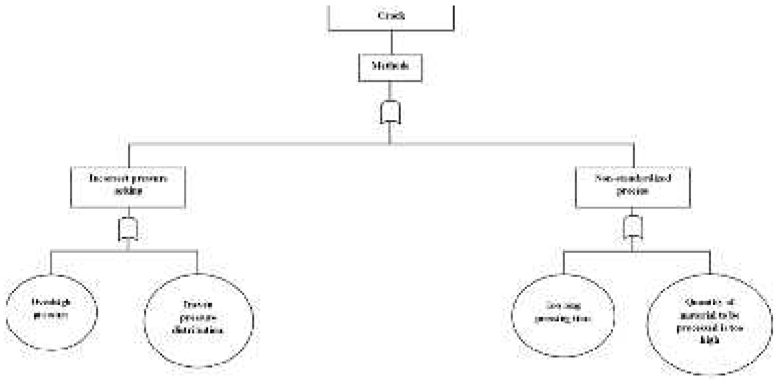

Figure 2. FTA Analysis Crack Defect

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In Figure 2, the cracking defect can be caused by two factors. Firstly, improper pressure settings. Excessive pressure or uneven pressure distribution can cause excessive deformation and internal stress in the door material, leading to cracking. Secondly, non-standardized processes. Without clear standards, machine settings such as temperature, pressure, and pressing time may vary between batches. Different operators may use different methods, resulting in inconsistencies in the final product outcomes.

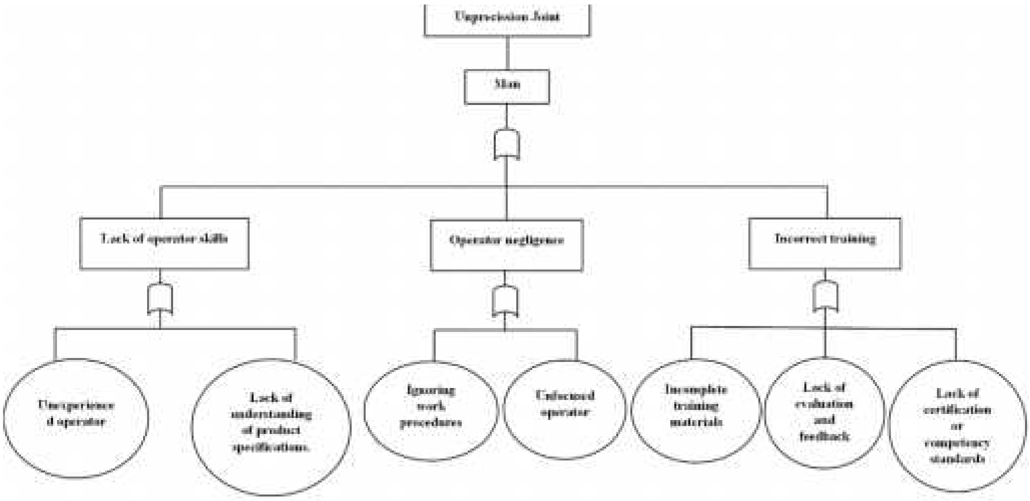

Figure 3. FTA Analysis Unprecision Joint Defect

In Figure 3, the unprecision joint defect can be caused by three factors. Firstly, lack of operator skill. Inexperienced operators may make errors in setting up and operating the equipment. Secondly, operator negligence. Lack of focus during the joint assembly process can lead to mistakes in assembling components. Thirdly, inadequate training. Without regular training, operators may not be aware of updates or procedural improvements, and without competency standards or certifications, operators may be insufficiently trained in equipment operation.

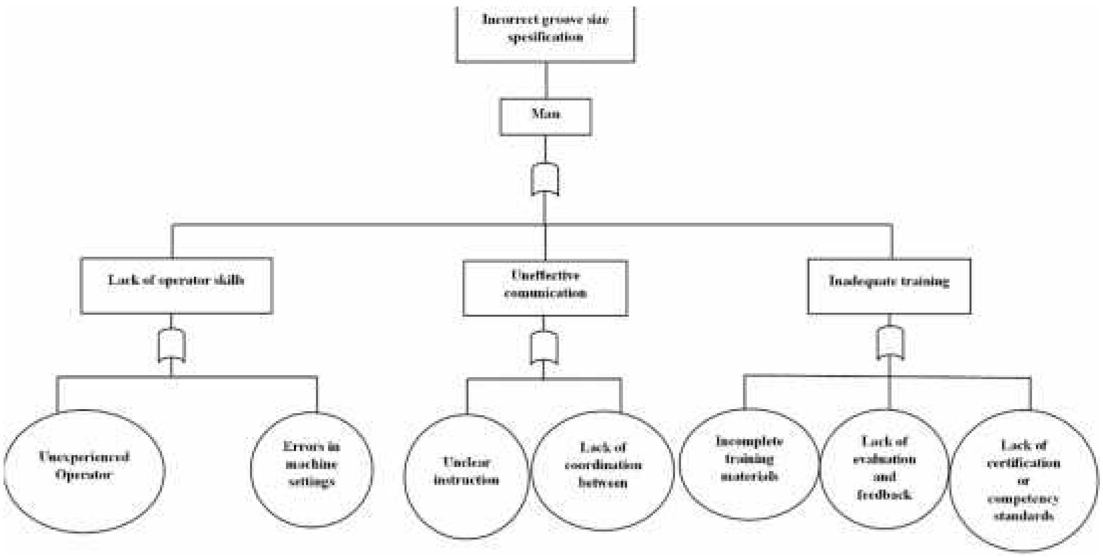

Figure 4. FTA Analysis Incorrect Groove Size Spesification Defect

In Figure 4, the defect of incorrect groove size specifications can be caused by three factors. Firstly, lack of operator skill. Inexperienced operators may make errors in setting up and operating the CNC router machine. Secondly, ineffective communication. Unclear instructions or lack of team coordination can lead to operators not fully understanding their tasks. Thirdly, inadequate training.

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Incomplete training materials and the absence of competency standards or certifications can result in operators lacking the knowledge and qualifications to operate the equipment effectively.

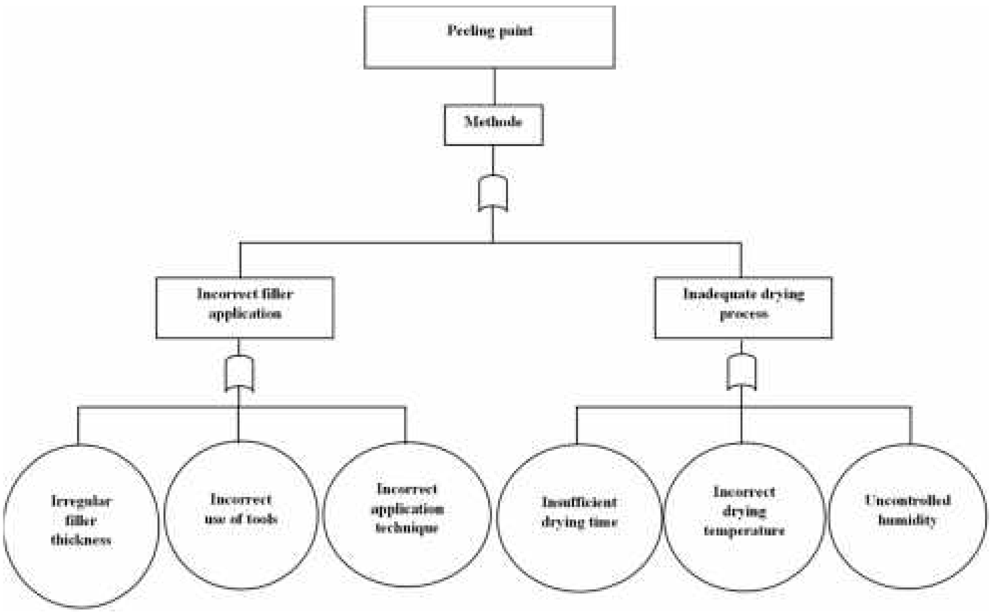

Figure 5. FTA Analysis Peeling Paint Defect

In Figure 5, the defect of paint peeling can be caused by two factors. Firstly, improper filler application can result in uneven paint application and tendency to peel due to incorrect techniques. Secondly, inadequate drying process, such as insufficient drying time or suboptimal temperature and humidity conditions, can also cause the paint to dry poorly and peel off.

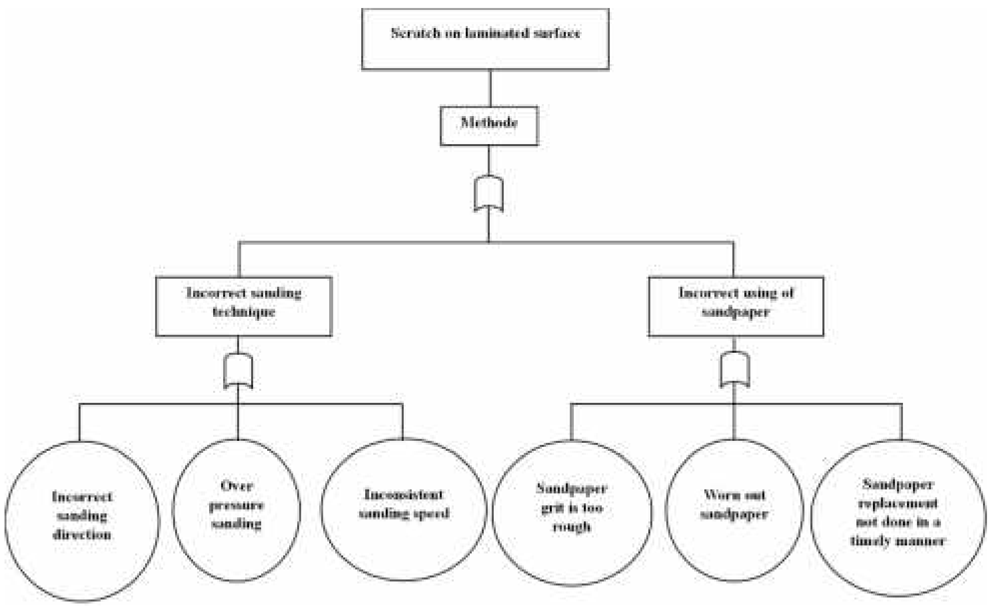

Figure 6. FTA Analysis Scratch on Laminated Surface Defect

In Figure 6, the defect of scratches on the laminated surface can be caused by two factors. Firstly, improper sanding techniques, such as incorrect sanding direction, can lead to scratches on the laminated surface. Additionally, excessive pressure and unstable

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speed during the sanding process can also result in imperfections on the laminated surface. Secondly, improper sandpaper usage, such as using grit that is too coarse, can cause scratches. Furthermore, not replacing the sandpaper at the right time can also lead to inconsistent results.

4. Suggested Improvements

Based on the FMEA and FTA analyses, here are the suggested improvements for each product defect with the highest RPN values:

1. Unsticky Glue (RPN 294) - Machine Factor
   a. Maintenance and Calibration of Machines: Conduct regular maintenance and calibration of the laminating machines to ensure optimal operation.
   b. Temperature and Pressure Monitoring: Implement an automatic monitoring system to ensure correct temperature and pressure during the laminating process.
   c. Replacement of Machine Components: Periodically replace worn or damaged machine components to prevent malfunctions.
   d. Operator Training: Provide training to operators on the proper operation and maintenance of laminating machines.
2. Crack (RPN 252) - Method Factor
   a. Standardization of Pressing Methods: Develop and implement standard procedures for the pressing process, including the correct pressure and time.
   b. Pressing Technique Training: Conduct training sessions for operators on the correct pressing techniques and the importance of following standard procedures.
   c. Quality Control During Process: Implement quality control measures during the pressing process to detect and correct errors immediately.
   d. Research and Development: Conduct research to better understand the optimal conditions that prevent cracking, such as material properties and temperature.
3. Unprecision Joint (RPN 120) - Man Factor
   a. Training and Certification: Implement training and certification programs for operators to improve their skills and knowledge in joint assembly.
   b. Supervision and Evaluation: Enhance supervision and evaluation of operator performance during the assembly process.
   c. Use of Accurate Measuring Tools: Provide accurate measuring tools and calibrate them regularly.
   d. Motivation and Incentives: Offer incentives to encourage operators to work with precision and adhere to standards.
4. Incorrect Groove Size Specifications (RPN 245) - Man Factor
   a. Training in Measurement and Marking: Conduct intensive training for operators on proper measurement and marking techniques.
   b. Calibration of Measuring Tools: Ensure measuring tools are regularly calibrated for accurate measurements.
   c. Standard Operating Procedures (SOPs): Develop and implement clear SOPs for the measurement and marking process.
   d. Supervision and Quality Control: Increase supervision and quality control during the CNC router process to ensure groove sizes meet specifications.
5. Peeling Paint (RPN 180) - Method Factor
   a. Standardization of Paint Application Process: Develop and implement standard procedures for paint application, including ideal environmental conditions.
   b. Paint Application Training: Conduct training sessions for operators on the correct paint application techniques.
   c. Selection of Appropriate Paint Materials: Use paint materials that meet specifications and are suitable for the application environment.
   d. Environmental Quality Control: Implement environmental controls such as humidity and temperature during the paint application process.
6. Scratch on Laminated Surface (RPN 175) - Man Factor
   a. Sanding Process Training: Conduct training sessions for operators on the correct sanding techniques and proper use of sanding tools.

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b. Use of Appropriate Sanding Tools: Ensure sanding tools are in good condition and suitable for the type of surface being worked on.
c. Supervision During Sanding Process: Increase supervision during the sanding process to detect and correct errors immediately.
d. Establishment of Cleanliness Standards: Ensure the work area is always clean to prevent scratches on the laminated surface.

IV. CONCLUSION AND SUGGESTION

Conclusion

The analysis conducted in this study using FMEA and FTA methods has been completed, revealing that out of the six types of defects in laminated door products, operator errors are the primary cause. However, the implemented work system and an unsupportive work environment also impact operator performance. The FMEA calculations indicate that each cause with the highest complexity levels should be analyzed further for more specific improvement suggestions. The highest RPN values based on the 4M+1E factors are as follows: unsticky glue with the machine factor at 294, crack with the method factor at 252, unprecision joint with the man factor at 120, incorrect groove size specification with the man factor at 245, peeling paint with the method factor at 180, and scratch on the laminated surface with the man factor at 175. Recommendations for improvements include conducting training for operators, paying more attention to machine maintenance and replacing substandard equipment or components, selecting appropriate raw materials, and implementing clear Standard Operating Procedures.

Suggestion

After conducting a study using Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) on laminated door products, the next direction for research to further deepen the analysis and improve production quality and efficiency is the implementation of Lean Manufacturing. The expected outcomes are increased production efficiency, reduced cycle time, and lower production costs.

REFERENCES

[1] Ali M, M. N., & Kusuma, A. (2019). Analisa Kinerja Mesin Wtp Menggunakan Metode Fmea Dan Penjadwalan Preventif Maintenance. *WAKTU: Jurnal Teknik UNIPA*, *17*(1), 15–25. https://doi.org/10.36456/waktu.v17i1.1829

[2] Andespa, I. (2020). Analisis Pengendalian Mutu Dengan Menggunakan Statistical Quality Control (Sqc) Pada Pt.Pratama Abadi Industri (Jx) Sukabumi. *E-Jurnal Ekonomi Dan Bisnis Universitas Udayana*, *2*, 129. https://doi.org/10.24843/eeb.2020.v09.i02.p02

[3] Ariyanty, R. (2021). Penerapan Metode FMEA dan FTA Dalam Mengidentifikasi Penyebab Kerusakan Mesin Vertical Shaft Pada PT.Prima Karya Manunggal Pangkep. *Penerapan Metode Fmea Dan Fta Dalam Mengidentifikasi Penyebab Kerusakan Mesin Vertical Shaft Pada Pt. Prima Karya Manunggal Pangkep Tugas*, 10.

[4] Cahyono, A., Ayu Titisari, M., & PGRI Adi Buana Surabaya, U. (2023). Jurnal Scientia is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0) APPLICATION OF THE FMEA METHOD IN DETERMINING IMPROVEMENT PRIORITIES IN THE PRODUCT QUALITY SYSTEM AT COMPANY X. *Jurnal Scientia*, *12*(2), 2023. https://seaninstitute.org/infor/index.php/pendidikan/article/view/1329

[5] Haryono, M. F. Y., & Sumiati. (2023). Analisis Pengendalian Kualitas Produk Paving Block Menggunakan Metode Statistical Quality Control (SQC) Dan Failure Mode Effect Analysis (FMEA) Di PT. Duta Beton Mandiri, Pasuruan. *Jurnal Penelitian Rumpun Ilmu Teknik (JUPRIT)*, *2*(3), 45–65.

p-ISSN 2622-2027
DOI : https://doi.org/10.36456/tibuana.7.2.9340.152-160 *e*-ISSN 2622-2035
[6] Kartika, W. Y., Harsono, A., & Permata, G. (2016). Usulan Perbaikan Produk Cacat Menggunakan Metode Fault Mode and Effect Analysis dan Fault Tree Analysis Pada PT. Sygma Examedia Arkanleema. *Jurnal Online Institut Teknologi Nasional*, *4*(1), 345–356.

[7] Syahrullah, Y., & Izza, M. R. (2021). Integrasi Fmea Dalam Penerapan Quality Control Circle (Qcc) Untuk Perbaikan Kualitas Proses Produksi Pada Mesin Tenun Rapier. *Jurnal Rekayasa Sistem Industri*, *6*(2), 78–85. https://doi.org/10.33884/jrsi.v6i2.2503