Available online at: http://publikasi.mercubuana.ac.id/index.php/ijiem

IJIEM (Indonesian Journal of Industrial Engineering & Management)

ISSN (Print) : 2614-7327 ISSN (Online) : 2745-9063

Implementation of Tree Diagram Method, Failure Mode Effect Analysis (FMEA) and 5W 1H to Reduce Corky Defective Products in PT. XYZ

Mohamad Solihudin*, Wakhid Nurhidayat, Suwandi, Candra Setia Bakti, Rachmat, Agus Hari Hadi, Sapta Nugroho

Universitas Yuppentek Indonesia, Kampus 2, Jl. Veteran Raya No.1 Babakan Tangerang, Banten

ARTICLE INFORMATION

Article history:

Received: 21 September 2022
Revised: 25 November 2022
Accepted: 29 November 2022

Category: Research paper

Keyword:
Corky defect
Tree diagram
FMEA
Potential failures
5W 1H

DOI: 10.22441/ijiem.v4i1.17237

A B S T R A C T

PT XYZ is a company that manufactures of tire fabrics in the Tangerang. Global competition force the company continues to strive to reduce process costs, one of which is by reducing the highest percentage of defects, namely corky defects, corky defects reach 39.7% of total defects. The tree diagram and FMEA methods, selected for the analysis of potential failures that cause corky defects are found namely: Threads are not clamped when changing pots, joints are not pulled at the beginning of running, roll regulator worn is used for the process, dirty of roll regulator is used for the process, wrong setting inner brake. The 5W 1H method results from corrective actions, namely: Refreshing programs for twisting production operators, checking periodically the roll regulator used by the process is still good, making schedules, and reporting on the implementation of cleaning roll regulators and evaluating by production leaders. From the corrective actions taken, it succeeded in reducing the percentage of corky defects in the twisting plant 2 process, down from 39.7% to 14.9% in semester 2 of 2021.

Corresponding Author
Mohamad Solihudin
E-mail: soleh0282@gmail.com

1. INTRODUCTION

Every business that is established must have the same goal of ensuring its survival through the achievement of optimal profits. The global competition that occurs today forces companies to be faced with very competitive competition in the sustainability process and make a profit. The competition requires companies to be creative in pursuing ways to survive either by increasing sales profits or reducing the cost of the production process.

PT. XYZ is a company that manufactures of tire fabrics in the Tangerang. Today's global market competition forces the company to continue to strive to reduce the cost of the production process, one of which is by reducing the percentage of defects that occur in the twisting process, namely the process of twisting several threads that will become cords to increase their physical properties. The result of the twisting process is in the form of a twisted cord rolled on the paper tube with a certain color.

Data from the 2020 production report twisting production defects averaged 0.30% per month, while the target of allowable disabled companies averaged 0.13 percent per month. For the company's goal of reducing the percentage of defects in the twisting process to be achieved, the research focused on the highest number of types of defects, namely corky defects as much as 39.7%, waste twist cords 19.1%, downy 18.9%, waste filament 17.7% and other defects 4.6% of the number of defects that occur.

Excerpts from several journals from previous researchers became the basis for the success of this study in reducing product defects including: Anthony (2018) in his journal stated, failure Mode and Effect Analysis is a method to find out the factors that cause products to become defective and provide proposed improvements on ways to reduce failure, Fauzi & Aulawi (2016) explained FMEA is a method that can systematically and structuredly analyze and identifying the consequences of system and process failures, as well as reducing or analyzing the chances of failure, Ardiansyah & Wahyuni (2018) revealed that the Failure Mode and Effect Analisys (FMEA) Method to identify each stage of the process and the Failure Tree Analisys (FTA) method to find the root cause of failure, Puspitasari, Arianie & Wicaksono (2017) stated that FMEA is one of the methods in detail to identify and analyze the failure mode until it can be known the causes and impacts of each existing failure, so that the right improvement proposal is obtained, then Suherman & Cahyana (2019) explained that the failure mode and effect analysis (FMEA) method is a method used to identify the causes of defects in the production process and use the Kaizen approach, namely in the concept of 5W + 1H.

Based on excerpts from several journals previous researchers stated that FMEA is an effective tool used to analyze process failures that can cause product defects, so by implementing the tree diagram method, failure mode and effect analysis (FMEA), and 5W 1H, are can use for analysis of potential failures of twisting processes that can cause corky defects and formulate corrective actions to lower the percentage of corky defects.

2. LITERATURE REVIEW

The production process is one of the activities of manufacturing carried out to run its business. The production process according to Reksohadiprojo, S. 2010 is an activity to create or add a good or service by using existing factors such as labor, machinery, raw materials, and funds to make it more useful. Meanwhile, the production process according to Sofjan Assauri, S. 2016 is "an activity that involves human labor, materials and equipment to produce useful products". The definition put forward by some of these experts, it can be concluded that the production process is a task or activity that is said to have added value if the addition of several inputs to the task will provide added value to the product (goods or services).

Defective/damaged products are one of the problems that often occur in the production process. The company's efforts are to reduce the number of defective products and damaged products so that the costs incurred are not too large and do not disappoint consumers. Trimarjoko, Fathurohman, & Suwandi (2020) in his journal explained "defective products will interfere with customer satisfaction".

The definition of defective products is put forward by Mulyadi, 2012 as follows, "A defective product is a product that does not meet the established quality standards, which automatically cannot be repaired into a good product." Defective products can be caused by two reasons, namely: (i) The product is damaged due to external conditions, for example, due to difficult workmanship specifications set by the customer or this condition is commonly called "abnormal cause", (ii) Damaged products caused by internal parties are commonly called "normal causes", for example not good raw materials, equipment, and expert labor.

Pareto Diagram is one of the tools of Quality Control seven (7) Tools that are often used in terms of quality control. A Pareto chart is a bar graph that shows a problem based on a sequence of the number of events. The order ranges from the number of problems that occur the most to the fewest that occur. In the chart, it is indicated by the highest chart bar (far left) to the lowest chart (far right) (https://ipqi.org). Tree diagrams are techniques used to solve any concept, such as policies, targets, goals, ideas, problems, tasks, or activities in more detail into sub-subcomponents, or lower and more detailed levels. Tree Diagram begins with one item branching into two or more, each branch then branching again into two or more, and so on so that it looks like a tree with many trunks and branches to decipher the problem into simpler ones (https://eriskusnadi.com).

The definition of FMEA (Failure mode and effects analysis) is a method of analysis of potential failures, which is carried out before the design of the product is realized or before the mass production process begins. The purpose of FMEA itself is as an "anticipatory measure" against the possibility of failure so that the failure can be prevented or reduced risk (Carlson, 2014).

After understanding the production process, the next step in FMEA is to identify and estimate all the damage that occurs. This identification, the amount of RPN (Risk Priority Number) can be determined based on 3 criteria (Carlson, 2014) namely: (i) Severity, which is identifying the level of seriousness of the result of damage seen from the point of view of the entire existing system, (ii) Occurrence, is identifying the level of frequency/frequency of occurrence of damage, (iii) Detection, is identifying the degree of probability that a malfunction can be found.

Of the three criteria, an assessment is carried out by giving weights value (can be used on a scale of 1-10 or 1-5) for each criterion, then calculations are carried out to obtain RPN by multiplying the three criteria. The concept of 5W 1H, is to formulate an action plan. The term 5W 1H is taken from the abbreviation of the word question in English, namely what, who, when, where, why, and how. A complete explanation of the 5W 1H elements is as follows: (i) What is the first element that must be present in writing or research? Because, what is used to ask the incident/core of the problem to be conveyed, (ii) Who is a question that suggests to the perpetrator involved in the event being reviewed. Who here not only refers to the main culprit in the story but also other people who support the story can be formed, (iii) When refers to the time description of the problem or event that occurred. With the time description, the information is clearer and more accurate, so that the truth can also be proved, (iv) Where describes the place where an event occurred. With the where element, readers can understand the storyline better. This element can also provide physical evidence related to the occurrence of an event, and (v) Why focuses on the reason or background of the occurrence of the event or problem being reviewed. With the why element, people will more easily understand the situation or conditions of the events that occur. How to focus on explanations and descriptions of an event. The answer to the question of the element how can support the statement of the element of why (https://kumparan.com).

3. RESEARCH METHODS

This study uses quantitative data and the data collection techniques carried out are documentation techniques obtained from the hungry data of twisting production in 2020 PT. XYZ with research instruments data recording tables and literature techniques from books and journals from previous researchers related to FMEA (Failure Mode and Effect Analysis) analysis. The analysis method can be seen in Fig. 1.

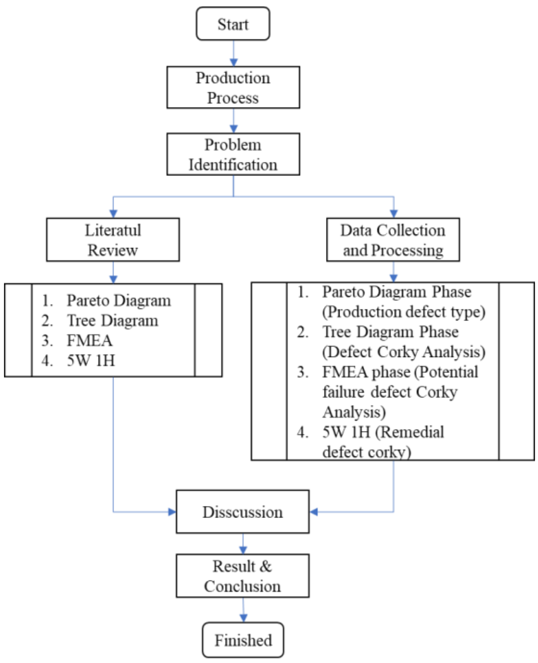

Fig. 1. Flow chart analysis stages
(Source: processed data, 2021)

4. RESULT AND DISCUSSION

The Twisting process is the process of twisting several threads into cords to increase their physical properties. The result of the twisting process is in the form of twisted cords rolled on paper tubes of a certain color. The Twisting process can be seen in Fig. 2.

Fig. 2. Twisting machine
(Source: PT. XYZ, 2021)

Based on the 2020 production report, it is known that the twisting production process has a percentage of defects exceeding the target set by the company, which is 0.13%. Twisting production process data can be seen in Table 1.

Table 1. Twisting production data

Plant	Production (kg)	Defect (kg)	Defect (%)
1	6.576.113,0	12.489,4	0.18
2	16.563.808,9	50.435,0	0.30
Total	**23.139.921,9**	**62.924,4**	**0.48**

(Source: Production data, 2020)

Based on Table 1, the twisting plant 2 production process contributed the largest number of defects, which was 0.30% of the total defects of 62,924.4 kg. So the focus of the research will be carried out on the production process of twisting plant 2. Still from the source of the report on the production results of twisting plant 2, the types of product defects in detail can be seen in Table 2.

Table 2. Defect data of twisting production plant 2

Defect type	Defect (kg)	% of Defect
Corky	20,032.8	39.7
Waste twist cord	9,625.5	19.1
Downy	9,567.0	18.9
Waste filament	8,912.5	17.7
Others	2,297.2	4.6
Total	**50,435.0**	**100.0**

(Source: Production data PT. XYZ, 2020)

Based on Table 2, there are 5 types of defects from the twisting production process plant 2, to see the most dominant defects, which can be seen in Fig. 3.

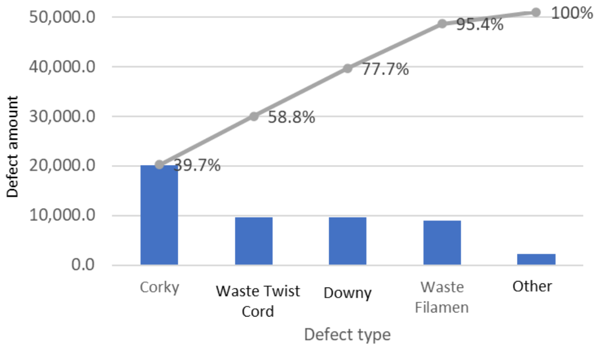

Fig. 3. Pareto diagram twisting production defects type plant 2
(Source: processed data, 2021)

Based on the Pareto diagram in Fig.3. it can be seen that the most dominant type of defect is the corky type of defect with a value of 39.7%, so this study will be limited to the analysis of corky defects in the twisting plant 2 process. The results of observations and observations of the twisting plant 2 production process, as well as brainstorming with reliable and competent speakers, namely production operators and related leaders, several potential failures were found that could cause corky defects, potential failures can be seen in Fig.4.

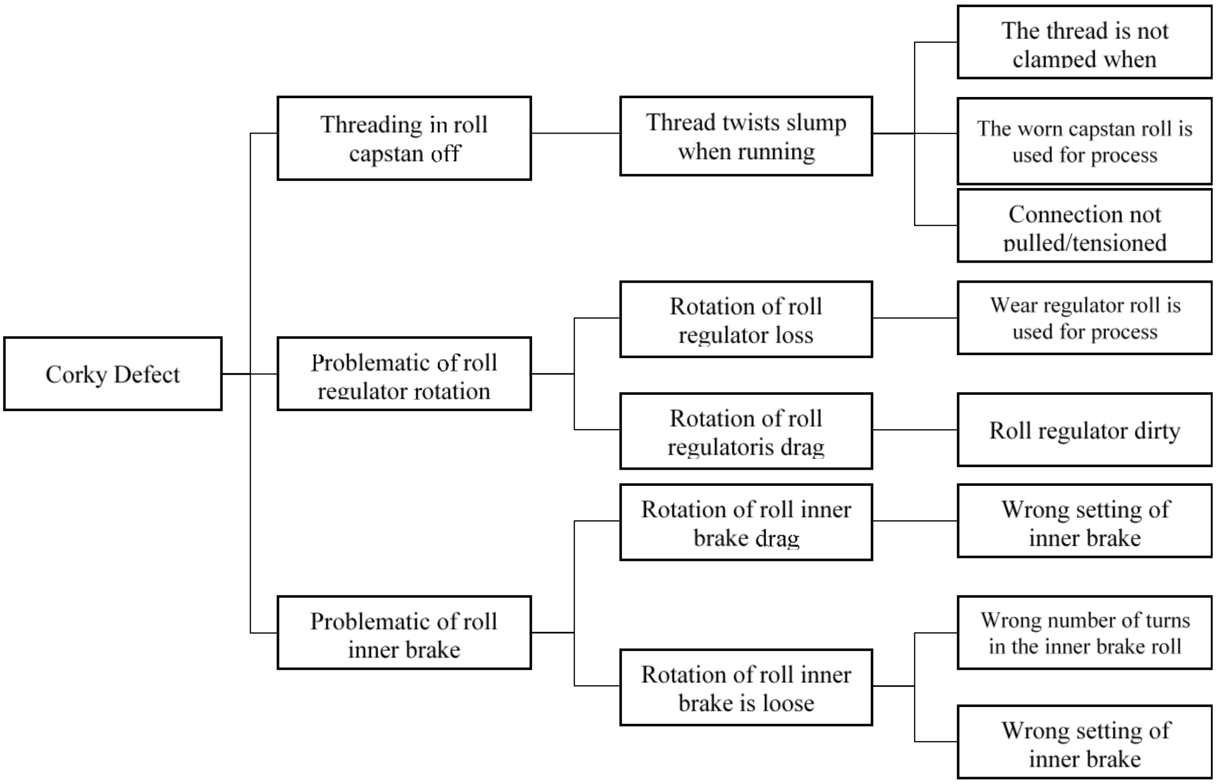

Fig. 4. The Tree Diagram of defect problems corky production process twisting plant 2 (Source: result focus group discussion with experts, 2021)

The results of the tree diagram analysis in Figure 4 found seven (7) potential causes of failure that can cause corky defects in the twisting plant 2 processes: thread not clamped when change pot, uses worn roll capstan for the process when running connection is not pulled, uses worn roll regulator for process, dirty roll regulator, improper setting inner brake and the wrong number of turn in roll inner brake. To see the impact and level of risk that is likely to occur as a result of the failure, it is analyzed using Failure mode effect analysis (FMEA).

The criteria for the level of risk in the FMEA analysis to be used from severity, occurrence, detection, and criteria value risk priority number (RPN) formulated by the QA department and by the Supervisor production department twisting plant 2 can be seen in Table 3, Table 4, Table 5, and Table 6.

Table 3. Scale number severity

Scale	Detection	Criteria
5	Very severe	Failure to cause the engine to stop
4	Severe	Failure to cause the product to scrap
3	Moderate	Failure to cause the product to rework
2	Slight	Failure to cause the quality to decrease
1	Very Slight	Failure has not to impact/very slight

Table 4. Scale number occurrence

Scale	Detection	Criteria
5	Very High	Failure occurs > 30 cases per month
4	High	Failure occurs in 26 ~ 30 cases per month
3	Moderate	Failure occurs in 16 ~ 25 cases per month
2	Low	Failure occurs in 6 ~15 cases per month
1	Very Low	Failure occurs in 0 ~ 5 cases per month

Table 5. Scale number detection

Scale	Detection	Criteria
5	Very Hihg	The inspection method is effective, and the possibility of immediate failure is detected
4	High	The inspection method is quite effective and can detect in a certain time, and is relatively shortly
3	Moderate	The inspection method is medium and takes a long time to detect
2	Low	The inspection method has not been effective to detect on time
1	Very Low	Not yet method to inspection

(Source: data processing, 2021)

Table 6. Value Risk Priority Number (RPN)

RPN value	Criteria
> 90	Very High
55 ~ 90	High
25 ~ 54	Medium
3 ~ 24	Low

(Source: Data processing, 2021)

Failures with RPN level ≥25 are set as RPN values that must be taken immediately. The criteria for severity, occurrence, detection, and RPN have been formulated in Table 4, Table 5, and Table 6, then applied to the analysis (FMEA) of corky defect problems in the twisting plant production process 2.

FMEA analysis of corky defect problems in twisting plant production 2 was carried out using the small group discussion method with the competent speaker, namely twisting production operators, twisting plant 2 production supervisors plus a board of experts from production managers. The team formulated the effects/impacts of failure, causal factors, and currently used control tools of the potential for agitation items found in Fig. 4. The results of the discussion of the scale values of severity (s), occurrence (o), and detection (d) can be seen in Table 7.

Table 7. Results of FMEA analysis of corky defects in twisting plant 2 production

Potential failure	Effects of Failure	Effect factor	Current Control	Value			RPN
				S	O	D	
Thread not clamped when changing pot	Thread loss so is the release from the coil which causes a change in the tension.	Not following the Standart Operating Procedure (SOP) the thread must be clamped when changing pots	Not Available	4	5	5	100
Worn out Roll capstan used for processing	cause change the tension	No periodic checking roll regulator	Not Available	4	2	5	40
The connection was not pulled at the beginning running	Thread loss so is the release from the coil which causes a change in the tension.	Not following the SOP the connection must be withdrawn/tightened at the beginning of running	Not Available	4	5	5	100

Table 7. Results of FMEA analysis of corky defects in twisting plant 2 production (continued)

Potential failure	Effects of Failure	Effect factor	Current Control	Value S	Value O	Value D	RPN
Worn out Roll capstan used for processing	cause change the tension	No periodic checking roll regulator	Not Available	4	3	5	60
Roll regulator dirty	cause change the tension	Roll regulator not cleaned	Not Available	4	5	5	100
wrong setting of the inner brake	cause change the tension	Not following the process specifications about setting the inner brake.	Preliminary report running machine	4	2	4	32
Wrong number of coil	cause change the tension	No following specification processes about the number of thread coil	Preliminary report running machine	4	1	4	16

(Source: result focus group discussion with experts, 2021)

The results of the failure mode and effect analysis (FMEA) analysis in Table 7 found that the causative factors of potential failures that have a value of RPN ≥25, then considered as the factors causing potential failures that most impact corky defects are as follows: (1) Not following the Standart Operating Procedure (SOP) the thread must be clamped when changing pots, (2) There is no periodic checking of the condition of the roll capstan, (3) Not following the SOP the connection must be withdrawn/tightened at the beginning of running, (4) There is no periodic checking of the roll condition of the regulator, (5) 5. The Roll regulator is not cleaned, and (6) Not following the process specifications about setting the inner brake.

After finding the causal factor that is considered the most potential for failure that causes corky defects in the production process of twisting plant 2, corrective actions must be taken to reduce the percentage of corky defects using the 5W 1H method as can be seen in Table 8.

Table 8. Remedial measures for potential causal factors of corky defects

Effect Factor	Why	What	Where	When	Who	How
Not following the SOP the thread must be clamped when changing pots	Avoid the thread not being clamped when changing pot so that the thread is loose causing the tension change	Create a program for operators to care for and comply with the SOP that the thread must be clamped when changing pots	Twisting machine) (Production Twisting Plant 2)	June 2021	Production and HRD	Refreshing program about SOP. Do a re-check at the beginning of the running machine. Giving rewards/punishments
No follow SOP the connection must be pulled at the beginning of running	Avoiding the connection not being pulled/tensioned at the beginning of running so that the loose thread causes tension	Create a program for operators to care for and comply with the SOP that the connection must be pulled/tensioned at the start of running.	Twisting machine (Production Twisting Plant 2)	June 2021	Production and HRD	Refreshing program about SOP. Do a re-check at the beginning of the running machine. Giving rewards/punishments

Table 8. Remedial measures for potential causal factors of corky defects (continued)

Effect Factor	Why	What	Where	When	Who	How
No periodic checking roll regulator	Avoid worn-out roll regulators used to process	Periodic inspection and change wore out roll regulator	Twisting machine (Production Twisting Plant 2)	June 2021	Engineering and production	Check the condition of the roll regulator and replace the damaged one Make a schedule to check the condition of the regulator roll regularly
Roll regulator not cleaned	Avoid roll regulator dirty used to process	Periodic cleaning Roll regulator	Twisting machine (Production Twisting Plant 2)	June 2021	Production	Create a scheduled cleaning roll regulator cleaning roll regulator and doing an evaluation
No follow process & specification setting the inner brake	Avoid wrong setting the inner brake	Create a program for operators to care about and comply with the SOP that the inner brake setting must comply with process specifications	Twisting machine (Production Twisting Plant 2)	June 2021	Production and HRD	Refreshing program about SOP Do a re-check at the beginning of the running machine. Giving rewards/punishments

(Source: Result focus group discussion with experts, 2021)

The corrective action formulated by the 5W 1H method in table 8 to reduce the percentage of corky defects in the twisting plant 2 process is as follows: (a) Refreshing program on standard operating processes (SOP), (b) Do a re-check at the beginning of running the machine, (c) Check the condition of the roll regulator and replace the damaged one, (d) Schedule condition checks and regular cleaning roll regulators and evaluate them, and (e) Giving rewards/punishments.

The results of corrective actions to reduce the percentage of corky defects in the twisting plant 2 production process can be seen from the production report in the second semester of 2021 with a total production of 18,862,805.9 kg, defects of 33,742.8 kg or (0.18%) and the percentage of corky defects can be seen in Table 9.

Table 9. Data defect production twisting plant 2

Type of defect	Defect (kg)	% Defect
Hairy	8,969.5	26.6
Waste twist cord	8,925.5	26.5
Waste filament	8,815.5	26.1
Corky	5,035.8	14.9
Other	1,996.5	5.9
Total	**33,742.8**	**100.0**

(Source: Processed Data, 2021)

Based on Table 9, it is known that the corky defects produced by twisting plant 2, after repairs in semester 2 of 2021, corky defects were 14.9%. The comparison of the percentage of corky defects before and after repair can be seen in Fig. 5.

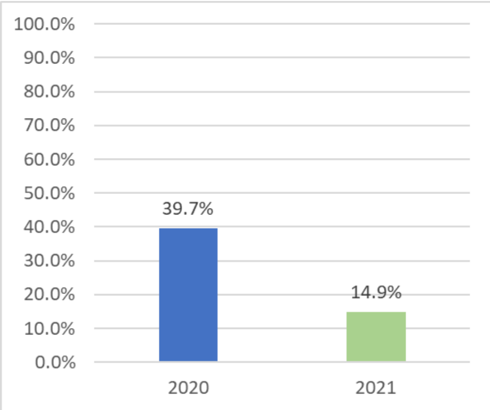

Fig. 5. Percentage defect corky
(Source: Processed Data, 2021)

Based on Fig. 5, it can see that there is a very significant decrease in corky defects in the twisting plant 2 production process, after repairs, from 39.7% in 2020 to 14.9% in semester 2 of 2021.

5. CONCLUSION

The results of research that has been done on the production process of twisting plant 2, PT. XYZ with the Tree diagram method, Failure mode and effect analysis (FMEA), and 5W 1H, concluded according to the research objectives, can describe the causal factors of potential twisting production failures that can cause corky defects, to reduce the percentage of corky defects from 39, 7% to 14.9%. Future research is expected to combine other methods with the FMEA method and can be analyzed for other problems.

REFERENCES

Assauri, S. (2016). *Manajemen Operasi Produksi* Edisi 3. Jakarta: PT Raja Grafindo Persada.

Anthony, M. B. (2018). Analisis penyebab kerusakan hot rooler table dengan menggunakan metode failure mode and effect analysis (FMEA). *Jurnal INTECH Teknik Industri Universitas Serang Raya*, 4(1), 1-8. https://e-jurnal.lppmunsera.org/index.php/INTECH/article/view/851

Ardiansyah, N., & Wahyuni, H. C. (2018). Analisis Kualitas Produk Dengan Menggunakan Metode FMEA dan Fault Tree Analisys (FTA) Di Exotic UKM Intako. PROZIMA *(Productivity, Optimization and Manufacturing System Engineering)*, 2(2), 58-63. http://ojs.umsida.ac.id/index.php/index/index

Berita hari ini. (2020). Apa Pengertian dari 5W 1H. (*online*): https://kumparan.com/berita-hari-ini/apa-pengertian-dari-5w-1h-simak-penjelasan-berikut-1trlKENy7GI/full (31 Juli 2022).

Blog Eris. (2012). Pemecahan Masalah dengan Tree Diagram atau Diagram Pohon. (*online*): https://eriskusnadi.com/2012/01/30/tree-diagram-atau-diagram-pohon/ (31 Juli 2022)

Carlson, C. S. (2014). *Which FMEA Mistakes Are You Making To Effective Audit Process*. Quality Progress, pp. 22-36.

Fauzi, Y. A., & Aulawi, H. (2016). Analisis Pengendalian Kualitas Produk Peci Jenis Overset Yang Cacat Di Pd. Panduan Illahi Dengan Menggunakan Metode Fault Tree Analysis (Fta) Dan Metode Failure Mode And Effect Analysis (Fmea)". *Jurnal Kalibrasi*, 14(1). https://jurnal.itg.ac.id/index.php/kalibrasi/article/view/331

Hidayat, A. A., & Kholil, M. (2018, November). The Implementation of FTA (Fault Tree Analysis) and FMEA (Failure Mode And Effect Analysis) Methods to Improve the Quality of Jumbo Roll Products. In *IOP Conference Series: Materials Science and Engineering* (Vol. 453, No. 1, p. 012019). IOP Publishing. https://iopscience.iop.org/article/10.1088/1757-899X/453/1/012019/pdf

Mulyadi. (2012). *Akuntansi Biaya* Edisi 5 Cetakan sebelas. Yogyakarta: STIE YKPN

Muhazir, A., Sinaga, Z., & Yusanto, A. A. (2020). Analisis Penurunan Defect Pada Proses Manufaktur Komponen Kendaraan Bermotor Dengan Metode Failure Mode And Effect Analysis (FMEA). *Jurnal Kajian Teknik Mesin*, 5(2), 66-77. http://journal.uta45jakarta.ac.id/index.php/jktm/article/view/2955

IPQI Indonesia productivity and quality institue. (2016). Pengertian diagram pareto dan cara membuatnya *(online):* https://ipqi.org/pengertian-diagram-pareto-dan-cara-membuatnya/ (31 Juli 2022)

Puspitasari, N. B., Arianie, G. P., & Wicaksono,

P. A. (2017). Analisis identifikasi masalah dengan menggunakan metode failure mode and effect analysis (fmea) dan risk priority number (rpn) pada sub assembly line (studi kasus: pt. toyota motor manufacturing indonesia). *J@ ti Undip: Jurnal Teknik Industri*, *12(2)*, 77-84. https://ejournal.undip.ac.id/index.php/jgti/article/view/15232

Panaitescu, M., Panaitescu, F. V., Voicu, I., & Dumitrescu, L. G. (2018). Fault Tree Analysis Used in Offshore Industry. *Hidraulica*, (1), 42-48. https://hidraulica.fluidas.ro/2018/nr1/42-48.pdf

Reksohadiprodjo, S. (2010). *Dasar-Dasar Manajemen*. In Edisi 5. Yogyakarta: BPFE-Yogyakarta.

Trimarjoko, A., Mukhlis, D., Fathurohman, H., & Suwandi, S. (2020). Metode Value Stream Mapping dan Six Sigma untuk Perbaikan Kualitas Layanan Industri di Automotive Services Indonesia. *Indonesian Journal of Industrial Engineering & Management*, *1*(2), 91-104. https://pdfs.semanticscholar.org/1c91/4acdae5f8b809557605e225946651dcf1588.pdf

Setyabudhi, A. L., & Sipahutar, I. (2019, May). Application Of Six Sigma Methodology To Improve the Product Quality Of Moldings Plastic (Case Study: PT Mega Technology Batam). In IOP *Conference Series: Materials Science and Engineering* (Vol. 505, No. 1, p. 012067). IOP Publishing. https://iopscience.iop.org/article/10.1088/1757-899X/505/1/012067/pdf

Wati, W. R., Anakotta, R., & Sudibyo, D. (2020). The Use of Tree Diagram Technique in Teaching Vocabulary. *INTERACTION: Jurnal Pendidikan Bahasa*, 7(2), 63-71. https://scholar.google.com/scholar?as_ylo=2018&q=tree+diagram+analysis&hl=id&as_sdt=0,5