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Optimizing Workplace Safety: A Comprehensive Analysis Of Accident Risks Through FMEA And RCA Methods

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ABSTRACT

Occupational health and safety (OHS) is the key to the company's growth in modern industry. Awareness of OHS has a positive impact on employees financially and non-financially. Indifference to OHS can be fatal, causing harm. OHS includes the establishment of a safe work environment through various approaches. Work accident data at PT. XYZ reaches 36% of the workforce, not yet meeting the government's zero accident policy—workshop at PT. XYZ has 9 types of OHS Risk. This study will use an assessment method using the Failure Mode and Effect Analysis (FMEA) method. After identifying and assessing these risks, improvement proposals will be made using Root Cause Analysis (RCA). Judging from the risks that need to be overcome immediately from the RPN value obtained, namely operating a gas-cutting machine with a value of 71.94, the eye is exposed to iron splashes during the turning process with a value of 64.51. Finally, interference with the eye during the welding process with a value of 60.11 is broken down through the RCA method to find the root cause of the problem. Then, a proposal for improvement is made.

Keywords: FMEA, OHS, PPE, Risk, *RPN*, *RCA*

Introduction

PT XYZ is engaged in the manufacturing and distribution of cement. The main task of PT XYZ is to focus on shipping, so many shipping processes use truck transportation, which occasionally experiences damage and requires quick repairs to speed up the shipping process. During the repair process on the truck, there is also a high risk of work accidents that can impact workers' safety and health. In carrying out machine repairs, many workers still ignore PPE and other aspects. OHS, which can have a negative impact if neglected.[1].

Occupational Safety and Health (OHS) helps support the progress of quality and sustainable development in human, economic, social, and environmental aspects and supports important values whose application benefits all aspects of human life. [1].

Work accidents can be caused by physical and mental injuries, as well as poor working conditions and lack of training for workers [2]. The company uses external resources, such as vendors, to manage machine repair in the maintenance department of PT XYZ. PPE equipment already owned includes gloves, welding glasses, safety shoes, sandblasting special masks, and protection helmets. However, this company has no specific plan to anticipate and reduce accidents during fabrication. All they do is provide regular safety explanations to workers.

When conducting operational analysis of work accidents using FMEA (Failure Mode and Effect Analysis) and RCA (Root Cause Analysis) methods to help identify potential hazards and find out the root cause of the problem [3]. The difference between this article and previous research is the addition of fishbone in the root cause analysis method. In contrast, the discussion and results in this study are more explicit and actual.

Research Methods

This chapter analyzes occupational health and safety risk factors in the maintenance dept of PT XYZ. With the Failure Mode and Effect Analysis (FMEA) technique and the Root Cause Analysis (RCA) method, a risk assessment is carried out in the company workshop area, and observation and interviews with related personnel staff carry out data collection.[2], [3]. The results of these observations are used to identify the causes and categorize the hazards for which improvement strategies can be developed.[4].

The data saw a high rate of accidents between January and November 2022, with 36% of the total accidents occurring at several locations, including Cargo Workshop, Workshop, Duta Seven, Barokah Sejahtera Workshop, and Aziz Motor. This study aims to identify factors affecting worker safety in PT XYZ's maintenance department using FMEA and RCA methods.

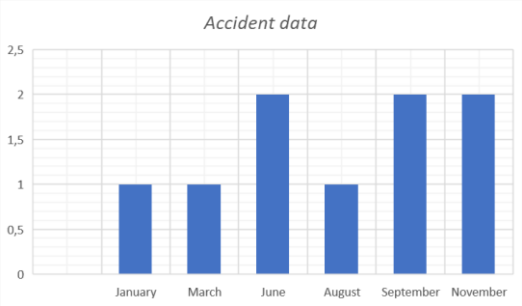

Figure 1 Accient data

Failure Mode and Effect Analysis (FMEA)

FMEA is an engineering technique used to determine, identify, and eliminate known failures, problems, errors, and the like from systems, designs, processes, and services before they reach consumers[5]. In the context of Occupational Health and Safety (OHS), a failure is a hazard that can arise from a process[6]. This is based on an analysis of the potential causes of the disturbance, the probability of occurrence, and how to prevent or handle it [7], [8]. The results of this analysis help determine which causes are prioritized. Furthermore, the main causal factors of work accidents are analyzed using the fishbone diagram. Risk analysis is carried out to determine the level of risk, which is a combination of the likelihood of occurrence and the severity of the risk occurring (severity or consequences)[9].

Severity (S)

Severity is set in levels ranging from 1 to 10. A score of 10 indicates the level with the most severe impact, while 1 represents the lowest impact level [10].

Occurance (O)

The occurrence or occurrence of occupational hazards is graded from 1 to 10. A score of 1 indicates an almost impossible event, while a 10 indicates an almost unavoidable event [10].

Detection (D)

detection or detection is determined in levels ranging from level 1 to level 10. Level 10 tools cannot control or detect the occurrence of work accidents, while level 1 work accident detection tools can control the occurrence of work accidents[10].

Root Cause Analysis (RCA)

Root Cause Analysis (RCA) is an in-depth investigation into the cause or causes of an identified problem, complaint, mismatch, unmet requirement, or undesirable condition. The simplest way to analyze the cause of an event is to describe 5 (Why) at least 5 times until finding the root cause of the event[3], [11].

Results and Discussion

Data Collection

This research uses the Failure Mode and Effect Analysis (FMEA) method to analyze the risk of work accidents using data from PT XYZ This research uses random sampling[12], ordinal scales, and Likert scales to measure variables and interpret social phenomena. Likert scales are used to compare and interpret the

behavior of individuals or groups within a particular group. This study uses four scales, SS, S, N, J, and TP, to comprehensively understand the research findings.

Table 1 Occupational accident data

No	Event data	Type of accident	Type of damage	Scene of the incident	Total
1	January	Electrocuted while checking electricity	Unstable electric current from battery to CDI	Landoh Cargo Workshop	1
2	March	Finger pinched when checking the clutch master	Loud clutch master sound when driving	Duta Tujuh Workshop	1
3	June	Dislocated Hand During the BAN Installation Process	Smooth tire thread on the rear tire	Barokah Sejahtera Workshop	2
4	August	Iron eye when lathe over transmission hole	Engine down due to oil blockage	AZIZ MOTOR	1
5	September	Red eyes during welding	Mounting plate for Differential Stel	Duta Tujuh Workshop	2
6	November	Getting burned while cutting iron	Addition of a trailer plate	Landoh Cargo Workshop	2

This study surveyed two respondents, an OHS employee and a staff member from a cargo plant, to understand the impact of failure modes on work schedules.

Table 2 Data failure mode

Failure mode	Risk	Causes
Repairing the battery on the truck	Electrocuted	Lack of worker vigilance when repairing batteries
Checking for repair of the clutch master on the truck engine	Hand pinched	Lack of worker knowledge of the dangers that will occur when not using PPE
Truck tire change	Dislocated hand	Lack of worker vigilance.
Truck machine turning	Eyes exposed to iron sparks	Lack of awareness of workers to wear glasses when turning
Welding Process	Red Eye	Lack of awareness of the use of PPE in the form of welding hoods
Cutting gas process	Sparks hit the hand	Lack of awareness of workers to wear hand gloves

Risk Assessment Data Based on Severity at PT. XYZ Workshop

Table 3 Risk assessment data based on severity

Failure mode	Risk	Correspondent					Average
		1	2	3	4	5	
Repairing the battery on the truck	Electrocution	2	2	2	3	4	2.6
Checking for truck engine repair	Hand pinched	2	3	4	2	5	3.2
truck tire change	Dislocated hand	2	3	3	4	2	2.8
Turning process of truck machine	Eyes exposed to iron sparks	2	3	5	2	2	2.8
Welding Process	Red eyes	3	2	3	5	4	3.4
Cutting gas process	Sparks hit the hand	2	3	4	4	4	3.4

Risk Assessment Data Based on Occurrence at PT. XYZ Workshop

Table 4 Risk assessment data based on occurrence

Failure mode	Risk	Corresponded					Average
		1	2	3	4	5	
Quality during battery repair on	Electrocution	4	3	5	4	3	3.8
Truck engine checks and repairs	Hand pinched	3	4	6	5	4	4.4
Truck tire changing process	Dislocated hand	4	3	7	4	3	4.2
Turning process of truck machine	Eyes exposed to iron sparks	4	3	7	6	4	4.8
Welding Process	Red eyes	5	3	7	5	6	5.2
Cutting gas process	Sparks hit the hand	5	3	4	5	6	4.6

Risk Assessment Data Based on Detection at PT. XYZ Workshop

Table 5 Risk assessment data based on detection

Failure mode	Risk	Correspondent					Average
		1	2	3	4	5	
Battery Repair	Electrocution	4	3	5	4	3	3.8
Truck engine repair	Hand pinched	3	4	6	5	4	4.4
Truck tire change	Dislocated hand	4	3	7	4	3	4.2
Truck machine turning	Eyes exposed to iron sparks	4	3	7	6	4	4.8
Welding	Red Eye	5	3	7	5	6	5.2
cutting gas	Sparks hit the hand	5	3	4	5	6	4.6

Risk assessment data based on Severity, Occurrence, and Detection scales for the PT XYZ study can be taken from the scales and ratios provided by respondents and committees.

Data Processing

The data processing carried out by researchers in this study consists of the following stages:

Calculation of RPN (Risk Priority Number) in the workshop of PT. XYZ

Table 6 RPN Calculation

Risk	S	O	D	RPN
1	2,6	3,8	4	39.5
2	2,8	4,2	4,2	49.4
3	3,2	4,4	3,8	53.5
4	3,4	5,2	3,4	60.1
5	2,8	4,8	4,8	64.5
6	3,4	4,6	4,6	71.9
Total	18,2	27	24,8	70.0
Average	4,55	6,75	6,2	58.4
Crisis value rpn risk				58.4

In Table 9, the RPN calculation shows that the 3 highest RPN values, namely 71.9, 64.5, and 60.1, must be handled immediately so that the risk impact does not exceed or become high. Which will be continued in the discussion of priority analysis[2], [13].

Prioritization Analysis at PT. XYZ Workshop

Ranking of risk factors based on RPN Value at PT. XYZ workshop when sorted from highest value to lowest value[14].

Table 7 Priority analysis results

Risk factor	Events and risks	Solution	Value of rpn
Burned while operating cutting gas	not wearing a hand glove	workers must wear hand glove	71.94
Eyes exposed to iron sparks	During the turning process	using lathe glasses	64.51
Eye disorders	During the welding process	use an automatic welding hood to be more efficient	60.11
TOTAL			196.25

Table 7 shows the priority scale for the PT XYZ control process, including risk assessment of gas use, material safety, and not using PPE. The results of the above data will be further processed in the next stage, namely the fishbone diagram, which will be developed further[15].

Fishbone Diagram

To analyze the causes of the many accidents at PT XYZ, we can use a Fishbone diagram, commonly called a cause and effect diagram obtained from the highest RPN value.

The explanation of the fishbone diagram picture of machine repair is as follows:

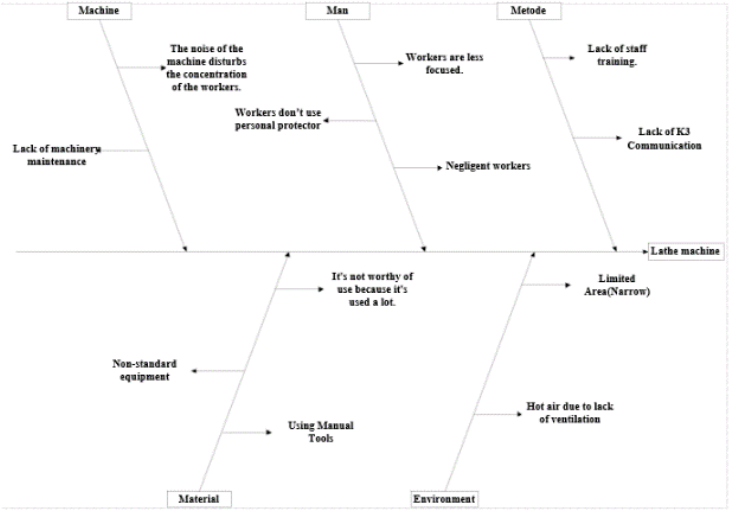

Figure 2 Fishbone repairing lathe machine

1. Environmental conditions or workplaces limited by hot air can affect worker safety.
2. Methods: Workers are not complying with Standard Operating Procedures (SOPs) and need to undergo retraining to improve their understanding of the importance of complying with SOPs.
3. Materials: Using improper materials can affect the quality of the truck engine.
4. Human: Lack of accuracy and discipline of workers using Personal Protective Equipment (PPE) can cause frequent workplace accidents.
5. Engine: Maintenance of the engine should be done by doing daily checks to maintain and control the engine, especially on truck engines.

The explanation of the welding fishbone diagram image is as follows:

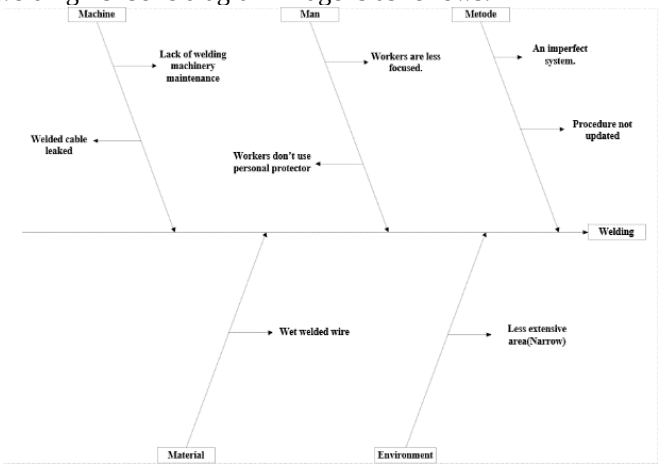

Figure 3 Fishbone welding machine

1. Environment: An inappropriate layout can majorly affect the welding process.
2. Methods: Workers do not follow SOPs. Training is needed to increase understanding of the importance of complying with SOP.
3. Material: Workers need to pay attention to the storage of welding wire to maintain quality and ensure the welding process runs smoothly.
4. Human: Lack of awareness of workers in using Personal Protective Equipment (PPE) when working.
5. Machine: Lack of worker awareness in maintaining welding equipment can result in unstable welding equipment performance.
6.

Explanation of the fishbone diagram of gas cutting machine repair, namely:

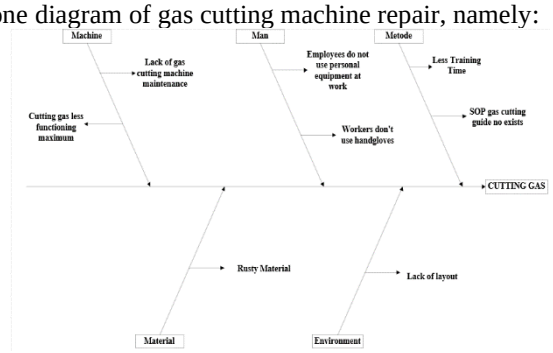

Figure 4 Fishbone cutting gas

1. Environment: Proper layout is important to avoid unwanted problems in the gas-cutting process.
2. Methods: Training and adherence to SOPs are required to ensure workers perform tasks according to procedures.
3. Materials: Rusty materials can hurt the gas-cutting process, so it is necessary to pay attention to the quality of the material to maintain performance.
4. Human: Workers' awareness and thoroughness in using PPE during the gas-cutting process is very important.
5. Machine: It is important to ensure the regulator functions properly by maintaining the gas-cutting tool to prevent damage.

After analyzing the fishbone diagram model, the 5 main causes of each accident can be identified[16]. The data obtained from the analysis of the fishbone diagram will be developed using the RCA method.

Root Cause Analysis

At this stage, RCA aims to analyze the root causes of the problem to mitigate the risks of the right work accident to prevent the re-occurrence of the same work accident[17], [18].

Table 8 Results of RCA analysis

Forms of work accidents	Causes	Solution
Eyes exposed to iron sparks.	Not using glasses	Using lathe glasses to protect the eyes
Eye disorders	Not wearing a welding helmet	Using an automatic welding hood to be more efficient
Burned while operating cutting gas	Not wearing a hand glove.	Workers are required to wear a hand glove.

After knowing the results of the analysis of the table above, it is continued by describing each form of work accident by using the question (why) at least 5 times, which can be seen in the discussion diagram below[19], [20].

RCA due to eye contact with iron sparks while operating the lathe.

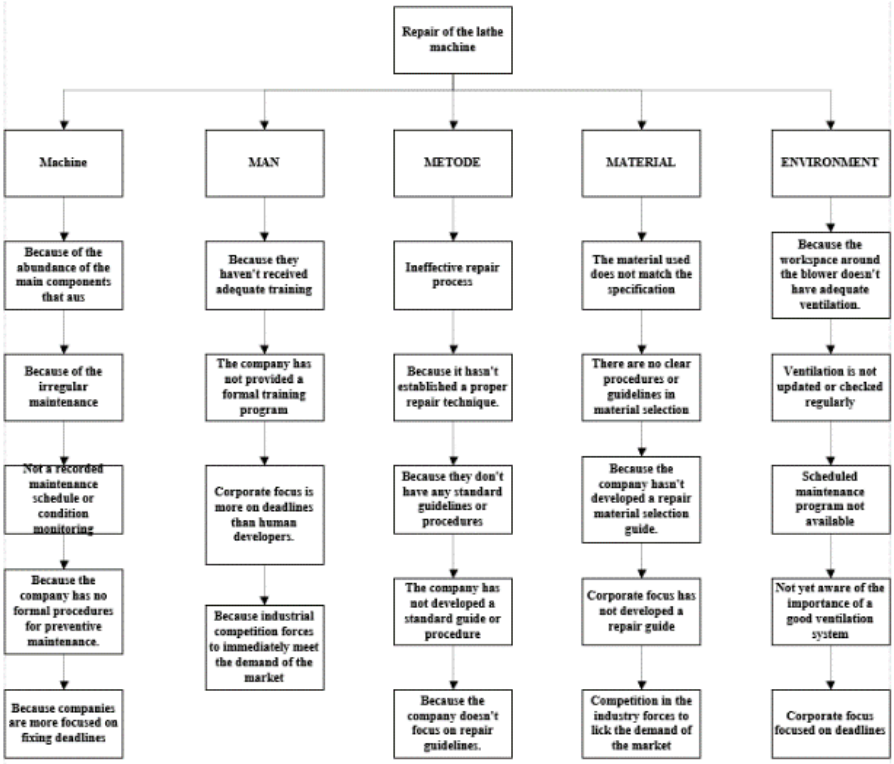

Figure 5 Rca operating lathe machine

RCA due to eye disorders in the welding process

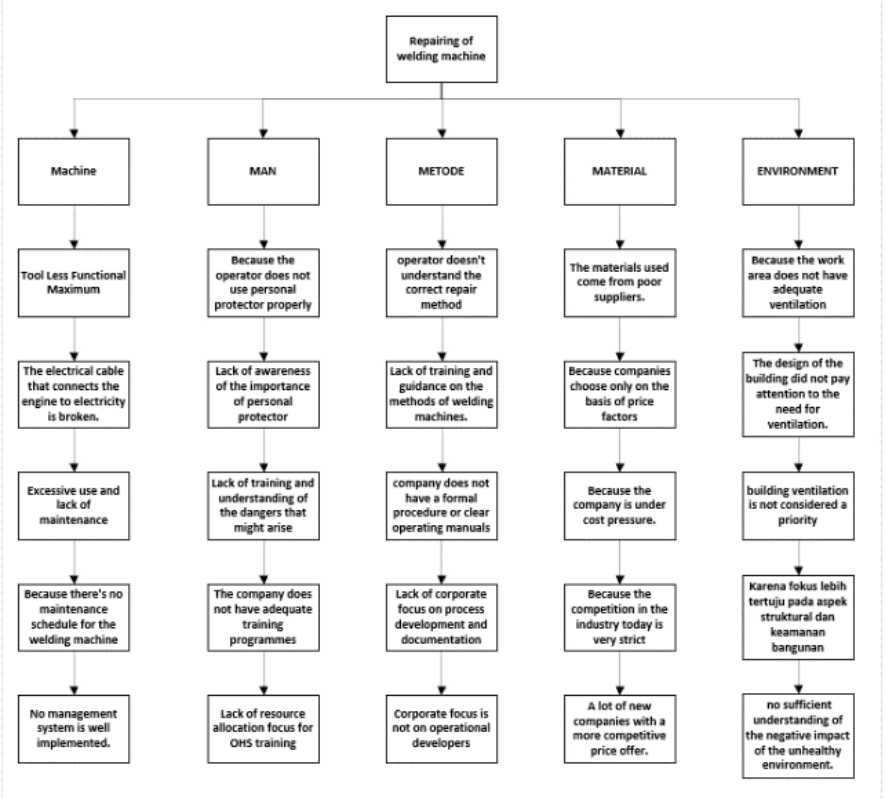

Figure 6 Rca operrating welding machine

Results of RC analysis due to hand burns when operating a gas-cutting machine

Proposed Solution

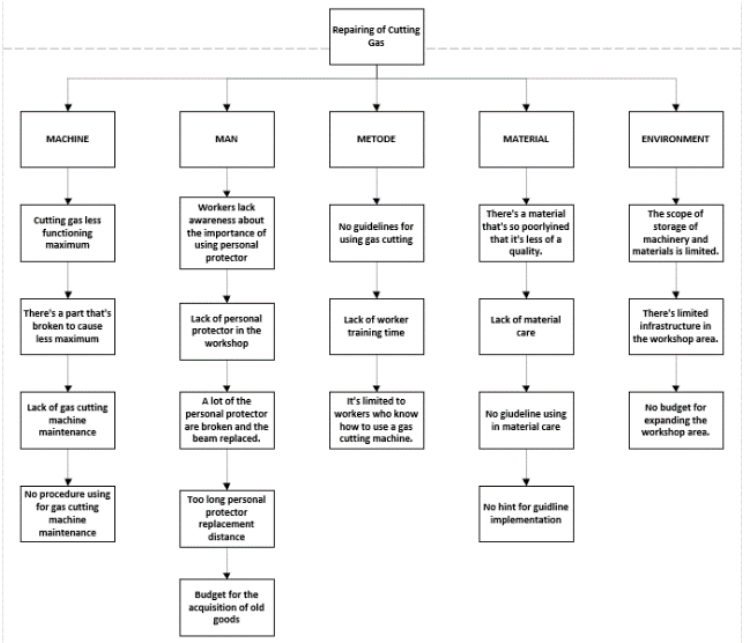

Figure 7 Rca operating cutting gas

The FMEA method analysis obtained the 3 largest RPN values to control and focus on the proposed improvements to the main causes of failure at the 3 largest RPN values[21]. Then, we continued with the proposed solution from the RCA method to find out the root cause of the results obtained previously from the FMEA method[22], [23].

Then, the stage of using RCA is the 5 why system, which is carried out by repeating the same question starting with the why question at least 5 times until finding the root cause of work accidents[24], [25].

Table 9 Proposed solution from the RCA method

No.	Forms of work accidents	Factor	Solution
1	Eyes Exposed to Iron Sparks	- Lack of training and experience - Absence of Standard guidelines - Lack of monitoring and evaluation - lack of awareness of environmental conditions	- Training and Experience - Standardized guidelines and procedures - Monitoring and evaluation - Environmental awareness
2	Eye disorders	- Lack of eye protection - lack of training - No supervision and assessment of working conditions	- PPE Adjustment - Training and Education - Implementation of surveillance system
3	Burned while operating cutting gas	- Lack of use of PPE - Lack of OHS training and awareness - Less than optimal machine conditions	- Proper use of PPE - Training and Education - Machine care and maintenance.

Conclusion

From the research conducted using FMEA and RCA methods, it is known that workers still lack awareness of the use of PPE, with the results of the calculation of RPN as many as 3 events with the highest value. After data processing, suggestions for improvements to the root causes of work accidents in the workshop process are given by providing proposals to minimize and overcome the occurrence of work accidents in the workshop PT. XYZ.

References

[1] D. R. Jenderal Pembinaan Pengawasan Ketenagakerjaan Dan Keselamatan Dan Kesehatan Kerja Kementerian Ketenagakerjaan, *Profil Keselamatan dan Kesehatan Kerja Nasional Indonesia Tahun 2022*. 2022.

[2] R. B. Kuncoro, S. S. Dahda, E. Ismiyah, and J. Artikel, "Analisis Risiko Limbah Cair Pada Unit Effluent Treatment Berdasarkan Sistem Manajemen Lingkungan Menggunakan Metode Fmea Dan Rca Di Pt. Petrokimia Gresik," vol. 2, no. 3, p. 403, 2021.

[3] N. Agus Firmansyah and Muadzah, "Manajemen Risiko OHS Pada Divisi Produksi Menggunakan Fmea Dan Rca DI PT.XYZ," 2020.

[4] M. R. Aftortu, I. Kustiani, and M. A. Siregar, "Analisis Risiko Proyek Konstruksi Studi Kasus Bendungan Way Sekampung Paket 2 Dengan Metode Failure Mode and Effect Analysis dan Domino," 2019.

[5] I. Bagus Suryaningrat *et al.*, "Identifikasi Risiko Pada Okra Menggunakan Failure Mode And Effect Analysis (FMEA) DI PT. Mitratani Dua Tujuh Di Kabupaten Jember Risk Identification on Okra Product Using Failure Mode and Effect Analysis (FMEA) (A Case Study at PT. Mitratani Dua Tujuh, Jember Regency)," 2019.

[6] R. S. Laali, "Analisis Kecelakaan Kerja pada Bengkel Bubut dan Las Wijaya dengan Metode Job Safety Analysis (Jsa) dengan Pendekatan Failure Mode And Effect Analysis (Fmea)," *Syntax Literate ; Jurnal Ilmiah Indonesia*, vol. 6, no. 4, p. 1967, Apr. 2021, doi: 10.36418/syntax-literate.v6i4.2473.

[7] S. Bastuti, "Analisis Risiko Kecelakaan Kerja Dengan Metode Failure Mode And Effect Analysis (FMEA) Dan Fault Tree Analysis (FTA) Untuk Menurunkan Tingkat Risiko Kecelakaan Kerja (PT. Berkah Mirza Insani)," 2019.

[8] J. Siahaan, E. Supriyadi, P. Studi Teknik Industri, and S. Tinggi Teknologi Bandung, "Analisis Resiko Kecelakaan Kerja Dengan Metode Failure Mode And Effect Analysis (FMEA) Di Bagian Produksi PT XYZ," vol. 10, 2022.

[9] J. Siahaan, E. Supriyadi, P. Studi Teknik Industri, and S. Tinggi Teknologi Bandung, "Analisis Resiko Kecelakaan Kerja Dengan Metode Failure Mode And Effect Analysis (Fmea) Di Bagian Produksi PT XYZ," vol. 10, 2022.

[10] B. M. Saputro Bayu Mohammad, "Risk Assessment OHS Pada Divisi Kapal Niaga Pt. Pal Indonesia Menggunakan Metode Fmea (Failure Mode And Effect Analysis)," 2022. [Online]. Available: https://ejurnal.itats.ac.id/semitan

[11] V. E. Ateng, R. Rahmawati, and Y. E. Prawatya, "Usulan Perbaikan Sistem OHS Menggunakan Metode Fmea Dan Rca Pada PT. XYZ," 2022.

[12] L. Munaroh, Y. Amrozi, and Nurdian A Risky, "Pengukuran Risiko Keamanan Aset TI Menggunakan Metode FMEA dan Standar ISO/IEC 27001:2013," 2021.

[13] F. A. Setyawan, D. Rahayu Widiana, and A. V. Sophia, "Analisis Akar Penyebab Kegagalan Instalasi Pengolahan Air Limbah Industri Kecap Menggunakan Metode Root Cause Analysis," 2022.

[14] Rezqi Malia, Raina Parmitalia Dinda, Alvisyahri, and Safrika, "Sosialisasi Peningkatan Pemahaman Keselamatan dan Kesehatan Kerja (OHS) sebagai Antisipasi Kecelakaan Kerja," *SEWAGATI*, vol. 2, no. 2, pp. 2962–4495, 2023.

[15] R. I. M. Risdianto Putra and S. S. Dahda, "Penilaian Risiko Pada Proses Pengambilan Sampel Di Pt. Xyz Menggunakan Metode FMEA Dengan Pendekatan RCA," *Journal of Industrial Engineering and Operation Management*, vol. 6, no. 1, Jun. 2023, doi: 10.31602/jieom.v6i1.11266.

[16] I. Mindhayani and P. Asih, "Pengaruh Edukasi OHS Terhadap Tingkat Pengetahuan Siswa Sekolah Dasar," 2022. [Online]. Available: https://ojs.uniska-bjm.ac.id/index.php/jieom/index

[17] N. Agus Firmansyah, "Manajemen Risiko OHS Pada Divisi Produksi Menggunakan Fmea Dan Rca DI PT.XYZ," 2020.

[18] R. I. M. Risdianto Putra and S. S. Dahda, "Penilaian Risiko Pada Proses Pengambilan Sampel Di Pt. Xyz Menggunakan Metode Fmea Dengan Pendekatan Rca," *Journal of Industrial Engineering and Operation Management*, vol. 6, no. 1, Jun. 2023, doi: 10.31602/jieom.v6i1.11266.

[19] J. Siahaan, E. Supriyadi, P. Studi Teknik Industri, and S. Tinggi Teknologi Bandung, "Analisis Resiko Kecelakaan Kerja Dengan Metode Failure Mode And Effect Analysis (Fmea) Di Bagian Produksi PT XYZ," vol. 10, 2022.

[20] P. Lubas Wahyudi and D. S. Widodo, "Integrasi Risk Based Thinking Dengan Process Approach Dalam Perencanaan Dan Penerapan Sistem Manajemen Mutu Iso 9001 : 2015," *Teknika : Engineering and Sains Journal*, vol. 3, no. 1, pp. 1–6, 2019.

[21] A. Fahlevi and D. Emra, "Perbaikan Tingkat Kebisingan Kerja Pada Area Produksi Pt. Bumi Karya Saranamas Work Noise Level Improvement In The Production Area Of Pt. Bumi Karya Saranamas."

[22] V. E. Ateng, R. Rahmawati, and Y. E. Prawatya, "Usulan Perbaikan Sistem OHS Menggunakan Metode Fmea Dan Rca Pada PT. XYZ."

[23] I. Bagus Suryaningrat *et al.*, "Identifikasi Risiko Pada Okra Menggunakan Failure Mode And Effect Analysis (FMEA) DI PT. Mitratani Dua Tujuh Di Kabupaten Jember Risk Identification on Okra Product Using Failure Mode and Effect Analysis (FMEA) (A Case Study at PT. Mitratani Dua Tujuh, Jember Regency)," 2019.

[24] I. Bagus Suryaningrat *et al.*, "Identifikasi Risiko Pada Okra Menggunakan Failure Mode And Effect Analysis (FMEA) DI PT. Mitratani Dua Tujuh Di Kabupaten Jember Risk Identification on Okra Product Using Failure Mode and Effect Analysis (FMEA) (A Case Study at PT. Mitratani Dua Tujuh, Jember Regency)," 2019.

[25] R. S. Laali, "Analisis Kecelakaan Kerja pada Bengkel Bubut dan Las Wijaya dengan Metode Job Safety Analysis (Jsa) dengan Pendekatan Failure Mode And Effect Analysis (Fmea)," *Syntax Literate ; Jurnal Ilmiah Indonesia*, vol. 6, no. 4, p. 1967, Apr. 2021, doi: 10.36418/syntax-literate.v6i4.2473.