

Work Accident Risk Analysis Using Failure Mode and Effect Analysis (FMEA) Method at PT. XYZ

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ABSTRACT

In the production process, the interaction between humans and machines is closely related. From this the higher the risk of accidents along with the higher workload. This study aims to identify the risk of accidents that may arise during the work in progress. In addition, to identify actions that can be taken to reduce these risks. This type of descriptive qualitative research was conducted to assess the risk of work accidents at PT. XYZ. The data used in this study is primary data obtained through interviews using a questionnaire on one of the workers of PT. XYZ. The data were analyzed using the Failure Mode and Effect Analysis (FMEA) method to find the RPN and critical values to find priority risks for action. The results obtained are that there are 4 work objects on the machine being analyzed, namely the stamping machine, lathe, welding machine, and milling machine. Based on the RPN value, it was obtained a value of 264 for a cut hand, 357 for a hand hit by a craft, 148 for a hand exposed to a welding spark, and 371 for a hand-carried by a machine. Based on the highest critical value, a stamping machine was obtained with a value of 66. The suggestion given to anticipate the occurrence of work accidents is by affirming SOPs in the use of Personal Protective Equipment (PPE), as well as workers' understanding of the risks of work accidents and their impacts.

Keywords: FMEA; Accident; RPN

ABSTRAK

Dalam proses produksi, interaksi antara manusia dan mesin sangat erat hubungannya. Dari sini semakin tinggi resiko kecelakaan seiring dengan semakin tingginya beban kerja. Penelitian ini bertujuan untuk mengidentifikasi risiko kecelakaan yang mungkin timbul selama pekerjaan berlangsung. Selain itu, untuk mengidentifikasi tindakan yang dapat dilakukan untuk mengurangi risiko tersebut. Jenis penelitian deskriptif kualitatif ini dilakukan untuk mengkaji risiko kecelakaan kerja pada PT. XYZ. Data yang digunakan dalam penelitian ini adalah data primer yang diperoleh melalui wawancara dengan menggunakan kuesioner pada salah satu pekerja PT. XYZ. Data tersebut dianalisis dengan metode Failure Mode and Effect Analysis (FMEA) untuk mencari RPN dan nilai kritis untuk mencari prioritas risiko yang perlu dilakukan tindakan. Hasil yang diperoleh adalah terdapat 4 benda kerja pada mesin yang dianalisis yaitu mesin stamping, mesin bubut, mesin las, dan mesin milling. Berdasarkan nilai RPN diperoleh nilai 264 untuk tangan terpotong, 357 untuk tangan terkena kerajinan tangan, 148 untuk tangan terkena percikan las, dan 371 untuk tangan dibawa mesin. Berdasarkan nilai

kritis tertinggi diperoleh mesin stamping dengan nilai 66. Saran yang diberikan untuk mengantisipasi terjadinya kecelakaan kerja adalah dengan mempertegas SOP dalam penggunaan Alat Pelindung Diri (APD), serta pemahaman pekerja mengenai risiko kecelakaan kerja dan dampaknya.

Kata kunci: FMEA; Kecelakaan; RPN

INTRODUCTION

The rapid industrial growth in the modern era now demands optimal work performance and productivity in a tight working time setting (Laali, 2021). With the increasing competition and the increasing burden of demand by consumers, most companies develop their machinery and equipment with high-tech machines (Mufik & Huda, 2020). The production process, which is very closely related between humans and machines, cannot be separated from uncertain risks. To approach this uncertainty, it can be anticipated through risk management (Mu'adzah & Firmansyah, 2020). Problems that are often encountered in companies are the lack of understanding of operators or workers about the importance of workplace safety, an uncomfortable work environment, and heavy loads that exceed the operator's ability to risk work accidents that will have an impact on operator productivity and product quality (Sukwandi, Wenehenebun, & Wenehenebun, 2017). A company or organization is bound by labor regulations to provide a comfortable, safe and healthy workplace which can be achieved by implementing Occupational Health and Safety (K3) rules (Mu'adzah & Firmansyah, 2020). Based on the International Labor Organization (ILO) every year there are more than 250 million accidents that occur in the workplace and 160 million workers become sick as a result of hazards in the workplace (Bukhori & Solihin, 2021). Work accidents are sudden and unexpected events that can cause significant losses, both for the company and the workers themselves (Suryani, 2018).

Various methods have been introduced as methods that can be used to identify potential work accidents, measure the level of risk of work accidents, and evaluate work accidents. These methods include a checklist, what if, FMEA, audits, CIA (Confidentiality, Integrity, and Availability), FTA (Fault Tree Analysis), and ETA (Event Tree Analysis) (J, H, & W.I, 2017). This research will analyze risk using the Risk Assessment with Failure Modes Effect Analysis (FMEA) method. The FMEA method is used to determine the greatest risk that exists in PT. XYZ workers are based on the largest RPN (Risk Priority Number) value (Nugroho, Suliantoro, & H, 2018). FMEA is a method used to identify risks that have the potential to arise, determine the effect of work accident risks, and identify actions to reduce these risks (Fatullah, 2020). The FMEA method helps to identify potential failure modes based on experience with similar projects (Susanto & Nursyachbani, 2018). FMEA aims to identify and assess risks that have a relationship with potential failure (Suparjo & Rochman, 2018).

PT. XYZ is a privately owned company engaged in fabrication, machining, and stamping parts. Inside the production floor of PT. XYZ has several production

machines such as lathes, stamping machines, and others. All these types of processes have a high potential for accidents, which can be seen from the use of sharp or rough workpiece materials. Of course, this is something that must be considered by PT. XYZ for prevention so that workers still feel safe during the production process. However, in carrying out prevention it is necessary to identify potential hazards and control risks. The applied FMEA method in help identifies potential accidents based on current or past events and experiences. In connection with a similar process, so that the results of identification that occur in the work field can provide benefits for the safety of workers and so that the application of occupational health safety has efficient and effective value for the company (Suparjo & Rochman, 2018). Therefore, this study is aimed at identifying the risk of accidents that could potentially arise. In addition, to identify actions to reduce these risks.

Some of the previous studies that were used as references include, Research conducted by Sofian Bastuti, 2019. The highest RPN results or the highest risk level of work accidents in the production division which includes 8 jobs are in the process and steps for sending CNG to the customer (PRS operations) when unloading load and operate CNG with a potential hazard or a pressure regulator system (PRS) explosion failure mode with a severity value of 5, occurrence 3, detection 4 and RPN 60 (Bastuti, 2019). Research conducted by Rizki Ilman Yaqin, et.al, 2020. The results of the identification of maintenance using FMEA, namely the injector and fuel filter components are components that must be prioritized for maintenance. The Risk Priority Number (RPN) values of the injector and fuel filter components are 192 and 168, respectively. The priority of maintenance is based on the fact that the RPN value of the component is above the critical RPN value of the main engine fuel system and includes components that are prioritized on the Pareto diagram (Yaqin, et al., 2020).

Research conducted by Putri Permata Yanda, et.al, 2020. The results of observations and in-depth interviews with informants revealed five risks at each stage of the agricultural process, in this case, chili planting, including the preparation of agricultural land with the risk of injury due to sharp hoe components RPN 27 was at the level of Very High risk. The risk of itching and water fleas at the planting stage of RPN 8 is of High risk, the risk of injury due to sickles when maintaining RPN 18 is of High risk. Chemical substances are absorbed when controlling OPT RPN 18 High-risk level and risk of being attacked by venomous animals RPN 8 Medium risk level in the harvest process, suggestions for farmer groups should be more active in increasing awareness of K3, and also for relevant agencies to pay attention to K3 especially the health department and agriculture in the working area of Rumbai Bukit District (Yanda, Herniwanti, & Makomulamin, 2020). Research conducted by Naniek U Handayani, et.al, 2018. The resulting Risk Priority Number (RPN) value is to determine which risks require more attention. Based on the RPN value, it is then used to determine the potential failure mode and the results show that the risks of R2, R17, R29, and R37 are potential failure modes on the Jatingaleh flyover. Mitigation strategies are proposed to anticipate the four potential failure modes so that they are

expected to overcome the risks that occur in the construction of the Jatingaleh flyover (Handayani, Wibowo, Nursyachbani, & Prihapsari, 2018). Research conducted by Diana Puspita Sari, et.al, 2018. Based on data processing, of the seven risk categories in Project Complexity and Risk Assessment and the calculation of scores and ratings, two categories with the highest score were obtained, namely project characteristic and project requirement risks with each rating of 36.4% and 34.4%. With a standard total score of 93.3%, it shows the Warungasem Batang Toll flyover project classified as level four for its complexity and risk (Sari, N, D, T, & A, 2018).

LITERATURE REVIEW

Work Accidents do not occur because of an element of intent, this reinforces that work accidents can happen anytime and anywhere (Afandi, Anggraeni, & Mariawati, 2015). The factors that influence work accidents. As some of the factors that affect work accidents are below:

1) Worker Behavior

Worker behavior is usually a fairly large factor in influencing the occurrence of work accidents. This is caused by the negligence of workers in completing safety procedures, the physical condition of the workers (tiredness) that causes concentration to decrease, and the ignorance of workers when doing a risky job.

2) Environmental Conditions

Environmental conditions also affect the cause of work accidents. That is why environmental conditions in the work must be considered to prevent accidents at work. One example is slippery floors. Even though it looks trivial, it can be a cause of work accidents.

The potential hazards of work accidents are divided into four categories based on their impact on victims of work accidents. This division can be seen in Table I.

Table I. Classification of Occupational Accident Hazards Based On Their Impact

Category A	Category B	Category C	Category D
Potential hazards pose a risk of impact long term to health	Potential hazards that pose an immediate risk to safety	Risks to everyday well-being or health	Potential hazards that pose personal and psychological risks
Hazards from chemical factors (dust, metal fumes, steam)	Fires	Drinking-Water	Harassment, Intimidation and Sexual Harassment

Biological factors (diseases) and interference with viruses, bacteria, animals, etc.)	Electricity	Toilets and Washing	Facilities HIV/AIDS Immunized
The danger of physical factors (noise, lighting, vibration, work climate, falls)	Potential mechanical hazard (absence of machine guards)	Dining room or Canteen	Violence in workplace
Ways of working and hazards ergonomic factors (bench position, repetitive work, long working hours)	Housekeeping (poor maintenance of equipment)	First aid in the workplace	Drugs in the workplace

Source: (J, H, & W.I, 2017)

Failure Mode and Effect Analysis (FMEA)

This FMEA method was developed used by reliability engineers in the late 1940s to study the problems that might arise from malfunctioning military systems. Failure Mode and Effects Analysis (FMEA) is one of the failure analysis methods or potential failures that is applied in product development, system engineering, and operational management. The steps needed to perform a Failure Mode and Effects Analysis (FMEA) are (Susanto & Nursyachbani, 2018):

- 1) Gather all team members.
- 2) Establish ground rules
- 3) Gather relevant information and conduct a review
- 4) Identify the items or processes to be analyzed
- 5) Identify the functions, failures, effects, causes, and controls of each item or process being analyzed.
- 6) Risk evaluation relates to issues or potentials identified through analysis.
- 7) Prioritize and formulate actions or solutions.
- 8) Take corrective action and re-evaluate existing risks.
- 9) Distribute, review and update the analysis as needed.

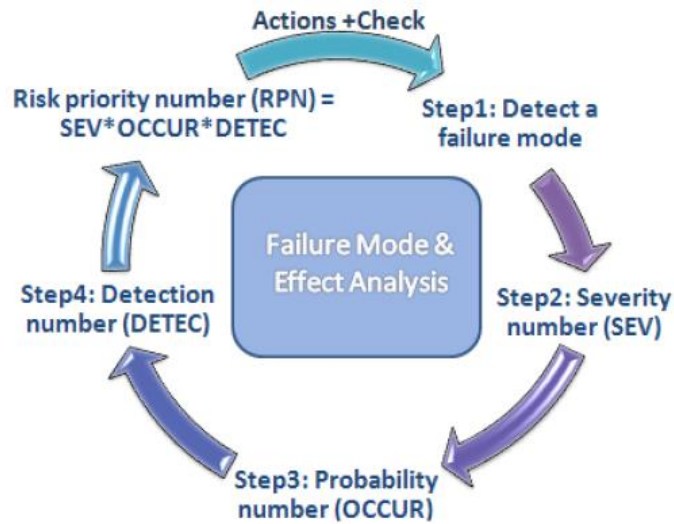


Figure 1. FMEA Cycle

Source: (Susanto & Nursyachbani, 2018)

RESEARCH METHODS

The methodology in this study is described using a flow chart as shown in Figure 2. below:

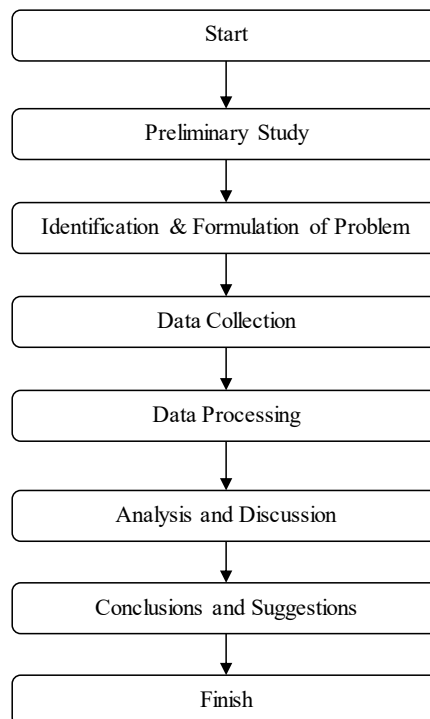


Figure 2. Research Methodology

- 1) Start, at this stage is the marking since the start of this research.

- 2) Preliminary studies are intended to seek information related to research such as literature studies and field studies to study the correlation between theory and field conditions.
- 3) Identification and Formulation of Problems, namely identifying and formulating problems that occur in the object of research, namely in the form of potential work accidents.
- 4) Data Collection, while the data used in this study is primary data. The procedure for collecting data in this study is by conducting interviews and observations to obtain the required data.
- 5) Data processing, at this stage, is done by making a fishbone diagram to identify the cause of the accident. Then it is made in the form of FMEA to identify critical risks of accidents to get a Risk Priority Number (RPN).
- 6) Analysis and Discussion, namely to analyze the results obtained at the data processing stage. Then discussed the purpose of these results to then be applied in the actual situation.
- 7) Conclusions and Suggestions, namely concluding when the intended results have been obtained. In addition, providing suggestions for companies and further research to be able to cover the shortcomings of this research.
- 8) Finish, that is marking the completion of the research.

RESULT AND DISCUSSION

The data obtained in this study is the result of an interview with one of the employees of PT. XYZ. The interview was conducted to provide an assessment of the risks that may arise in an accident in a job.

Making Fishbone Diagram

Making Fishbone Diagram is intended to identify the factors that cause work accidents. Making fishbone diagrams is based on the results of interviews and observations made directly. The results of the fishbone diagram are as follows:

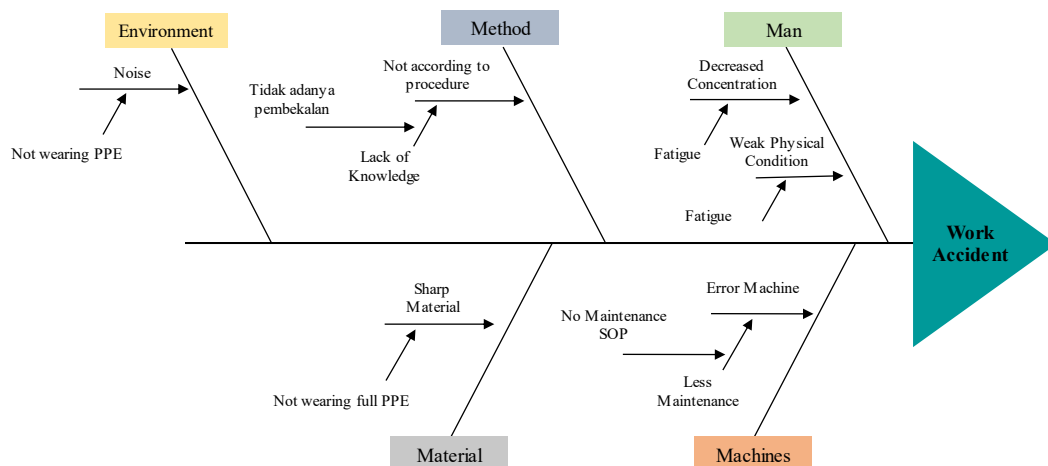


Figure 3. Fishbone Diagram Results

Based on the results obtained, it is known that in the process machining accidents occur due to humans, methods, machines, materials, and the environment. The human factor is one of the causes of accidents caused by the weak physical condition of the operator, the operator is not careful, and does not focus when working. Factors resulting machine accident on engine maintenance is not carried out periodically and is only carried out repairs when the engine experienced trouble only by the operator maintenance. Material factors are also related to the potential for work accidents caused by materials in the production process that are sharp, rough, and hot objects. The next factor is the method that has the potential for work accidents caused by inappropriate work steps so that it is very possible for fatal work accidents to occur and the last is environmental factors that make hearing and concentration decrease due to noise.

FMEA Analysis

Risk Identification

Based on the results of interviews and observations of the company's environment, several identifications of the risk of work accidents on each machine are obtained. Identification of this risk is the first step to find out the failure or accident in production in the company. The results of the identification of work accidents are as follows:

- a) Exposed to sharp material
- b) Machine error
- c) Noise
- d) Hit by blade
- e) Hand carried by machine
- f) Hit by object bounced
- g) Exposed to scrap from milling or lathe process
- h) Exposed to sparks
Exposure to welding light

Analyzing Severity, Occurrence, and Detection (SOD)

The next step is to analyze the value of SOD (Severity, Occurrence, and Detection). The SOD value was obtained based on the results of interviews conducted with one of the workers at PT. XYZ. SOD assessment is carried out on all machine work such as stamping, lathe, welding, and drilling. The results of the SOD values are as follows:

Stamping Machine

Table II. SOD Value Results In Stamping Machine

Process Description	Failure Mode Analysis			Action Result		
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D
Process of inserting material into the machine	Hand exposed to sharp material	Hand Scratched Hand	Not using PPE	2	5	4
	Mesis Error	Cut off Hand	Lack of care	7	2	4
Cutting Process	Noise	Damaged eardrum	Not using PPE	3	4	4
	Hit by blade	hand	The operator does not follow SOP	8	3	5

Lathe Machine

Table III. SOD Value Results in Lathe Machine

Process Description	Failure Mode Analysis			Action Result		
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D
Turning Process	Hand-carried by machine	Sprained hand	Operator Inaccurate	5	2	5
	Exposed to the blade	Torn hand	The operator is not careful	4	3	5
	Scraped	Hands scratched	Operators are not careful	2	6	5
	Objects bounce	Bruised body Not	strong grip	2	3	3
Scrap cleaning process	Broken chisel blade	Torn hands	Lack of care	4	3	4
	Scraped	Hand Scratched	Not using PPE	2	6	4
	Affected by lathe	Hand Scratched	Not Using PPE	4	3	4

Welding Machine

Table IV. SOD Value Results in Welding Machine

Process Description	Failure Mode Analysis			Action Result		
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D
Welding Process	Exposed to sparks	Blisters	Not wearing PPE	3	5	4
	Exposure to light	Eye irritation	Not wearing appropriate PPE	5	2	4
	Exposed to hot objects	Blisters	Not using PPE	3	4	4

Milling Machine

Table V. SOD Value Results in Milling Machine

Process Description	Failure Mode Analysis			Action Result		
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D
Milling Process	Hands carried by the machine	Sprained hands	Operators are not careful	5	3	5
	Scraped	Hands are scratched	Operators are not careful	2	6	5
	Hits blades	Hands are torn	Operators are not careful	4	3	5
Scrap cleaning process	Broken drill bits	Scratched hands	Lack of care	4	4	4
	Scraped	Scratched hands	Not using PPE	2	6	4
	Hit by a knife	Scratched hand	Not using PPE	4	4	4

Determining the Risk Priority Number (RPN)

The RPN (Risk Priority Number) value is obtained from the multiplication of the SOD values (Severity, Occurrence, Detection). The purpose of calculating the RPN value is to determine the sequence of failure modes that must be prioritized to be handled first. The results of the RPN calculation can be seen in the following table:

Stamping Machine

Table VI. RPN Value Results in Stamping Machine

Process Description	Failure Mode Analysis			Action Result			RPN (SxOxD)
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D	
Process of Inserting Materials into Machine	Hands exposed to sharp materials	Hands Scratched	Not using PPE	2	5	4	40
	Error Machine	Cut Hand	Lack of maintenance	7	2	4	56
Cutting Process	Noise	Damaged ear drum	Not using PPE	3	4	4	48
	Exposed to blade	Cut Hand	The operator does not follow SOP	8	3	5	120

From the results in the table above it is known that the accident was caused by a cutting knife with impact Cut hands get an RPN value of 120 points. This value exceeds the average value of the RPN of the stamping process. The main cause of the accident was the operator who did not follow the applicable SOP, namely the operator propped up against one of the buttons with the plate, causing an accident to cut his hand. Proposed control by the accident of truncated hands in the stamping process, namely by providing knowledge about work steps or SOP in running the stamping machine so that the operator understands how to run the machine. In addition, it also provides training to operators on the importance of occupational safety and health.

Lathe Machine

Table VII. RPN Value Results In Lathe Machine

Process Description	Failure Mode Analysis			Action Result			RPN (SxOxD)
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D	
Turning Process	Hand-carried	Sprained hand	Operator Inaccurate/Injured	5	2	5	50

	by machine						
	by blade	handTorn	Operators are not careful enough	4	3	5	60
	Scraped	Hands are scratched	Operators are not very careful	2	6	5	60
	Objects bounced	Body bruises	The grip is not strong	2	3	3	18
	broken chisels	Hand is torn	Lack of care	4	3	4	48
Scrap cleaning process	Scraped	hands Scratched	Not using PPE	2	6	4	48
	Affected by a lathe	Hand Scratched	Not Using PPE	4	3	4	48

In the results of the RPN analysis of the lathe, it is known that the largest RPN value is the value of the hand exposed to the craft. The causes are operators who do not use personal protective equipment and lack of awareness of work accidents. This causes a member of the body, one of which is the hand, which is hit by a scar resulting from the disposal of the material from the lathe process. The way to prevent accidents on a lathe is to use gloves and use a face shield at work. In addition, it also provides training on the importance of occupational safety and health to employees while in the field of work.

Welding Machine

Table VIII. RPN Value Results in Welding Machine

Process Description	Failure Mode Analysis			Action Result			RPN (SxOxD)
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D	
Welding process welding	Exposed to sparks	Scald	Not wearing PPE	3	5	4	60
	Exposure to light	Eye irritation	No using appropriate PPE	5	2	4	40
	Exposed to hot objects	Blisters	Not using PPE	3	4	4	48

From the results obtained in the RPN analysis of welding machines, it is known that there are several accidents from welding machines that often occur. Among them are exposed to sparks that make workers' hands blister and also have the potential to be dangerous to welding light when seen with the naked eye. Incidents like this often happen, therefore it is necessary to prevent it early by using gloves and welding masks. So that it can protect the hands and eyes of workers from the dangers of welding machine activities. After physical prevention is done, it is also recommended to conduct training for workers about the importance of implementing occupational safety and health.

Milling Machine

Table IX. RPN Value Results In Milling Machine

Process Description	Failure Mode Analysis			Action Result			RPN (SxOxD)
	Potential Failure Mode	Potential Effect of Failure Mode	Potential Cause of Failure Mode	S	O	D	
Milling Process	Hand-carried by machine	Sprained hand	The operator is not careful	5	3	5	75
	Scraped	Hand Scratched	operator slipshod	2	6	5	60
	Affected eye knife broken drill	hand tearing	been less scrupulous	4	3	5	60
Process Cleaning scrap	Affected scrap	hand scraped	Less Care	4	4	4	64
	Affected knife	hand scraped	Not using PPE	2	6	4	48
		hand scratched	Unable to use APD	4	4	4	64

In the RPN analysis of milling machines, it is known that there are several work accidents. In the FMEA table, the accident with the largest RPN value is the incident of the hand being carried by the machine. This is caused by the less careful operator; the fast rotation of the milling machine can make the operator's hand dislocate. So in this process, it is necessary to be careful in carrying out work activities that have the potential for accidents. The design of preventing work accidents that result in dislocated hands by machines can be prevented by making standard operating procedures that are good and correct. In designing SOPs, definite and accurate mechanisms and steps are needed so that workers can work safely. Do not forget to also provide education about the importance of occupational safety and health to employees.

Determining Critical Values

After obtaining the RPN value, the next is to identify the critical value of each process. This critical value will be used as an indicator in determining priorities for improvement or solving. The results of the critical value are as follows:

Table X. Critical Values Result

Engine Name	Total RPN	Total	Risk Critical
Stamping Machine	264	4	66
Lathe	357	7	51
Welding	148	3	49.3
Milling Machine	371	6	61.8

From the results obtained at the critical value, it is known that the stamping machine has the highest critical value with 66. This means that the company can prioritize or resolve the problems that occur in the stamping machine first before other machines.

Work Accident Control

The final step is to identify the controls that can be done in anticipating accidents. The proposed solution is based on the results of the analysis that has been carried out. In addition, the assessment indicators from the interviews also have a role in identifying proposals. The results of the analysis of the proposed problem solving are as follows:

Table XI. Analysis Result of Proposed Troubleshooting

No.	Area/Activity	Identification of Hazards	Causes of Accidents	OHS Targets Project	Risk Control
1	Operation of stamping machine	Hands Scratched and Hands Cut	Operators Not the following SOP	No fatal accidents	Combination gloves, earmuffs, conducts OHS training for employees.
2	Operation of the lathe.	Scratched hands.	Operators are not careful.	No fatal accidents	Combination gloves, Safety glasses, face shields, Safety glasses,

					conduct OHS training for employees.
3	Operation of the welding machine	Hands-on fire	The operator does not use PPE No	fatal accidents	Leather gloves, Welding mask, welder apron, conducts OHS training to employees.
4	Operation of milling machine Sprained	Hand	Operators are not careful	No fatal accidents	Combination gloves, safety glasses, face shield, OHS training for employees.

CONCLUSION

The results of the identification and risk assessment there are several accidents, namely, the hand is cut in the stamping process with a value of RPN 264, the hand is scraped on the lathe process with a value of RPN 357, the hand is exposed to welding sparks in the welding process with a value of RPN 148, and the hand is carried by the machine in the milling process with an RPN value of 371. Proposed control by the work accident of a cut hand in the lathe process, namely by providing knowledge about work steps or SOPs in running a stamping machine so that operators understand how to operate the machine and provide training to operators about the importance of safety and health work. The proposed control for hands exposed to scrap in the lathe process is to use a combination of gloves and a face shield. Furthermore, the suggestion to be exposed to sparks and eye irritation is to use leather gloves, welding masks, and an apron welder. And the proposed control that is carried out on the hands carried by the machine is that it is not recommended to clean the material or the milling place while the machine is still running and to train operators about the importance of occupational safety and health.

REFERENCES

- Afandi, M., Anggraeni, S. K., & Mariawati, A. S. (2015). Manajemen Risiko K3 Menggunakan Pendekatan HIRARC (Hazard Identification, Risk Assessment And Risk Control) Guna Mengidentifikasi Potensi Hazard. *Jurnal Teknik Industri*, 1-6.
- Bastuti, S. (2019). 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) .*Jurnal TEKNOLOGI*, 48-54.
- Bukhori, M., & Solihin, Y. M. (2021). Usulan Penurunan Tingkat Kecelakaan Kerja Dengan Menerapkan Metode Fmea Dan Fta Pada Pt. Jagat Interindo . *Jurnal Rekayasa Dan Optimasi Sistem Industri*, 20-24.
- Fatullah, F. (2020). Analisa Risiko Kecelakaan Kerja Dengan Menggunakan Metode Fmea (Failure Mode And Effect Analysis) (Studi Kasus: Proyek Orf (Onshore Receiving Facility) Bukit Tua Di Pt. Raga Perkasa Ekaguna, Madura Tahun 2018). *Jurnal Techlink*, 19-29.
- Firmansyah, R., & Yuliarty, P. (2020). Implementasi Metode DMAIC Pada Pengendalian Kualitas Sole Plate Di PT Kencana Gemilang. *Jurnal Penelitian Dan Aplikasi Sistem & Teknik Industri (PASTI)*, XIV(2), 167-180.
- Handayani, N. U., Wibowo, M. A., Nursyachbani, P. A., & Prihapsari, A. P. (2018). Analisis Risiko Pada Proyek Pembangunan Flyover Jatingaleh Dengan Kerangka Procrim Dan Metode Fmea. *Seminar Nasional IENACO* (Pp. 397-406). Surakarta: Universitas Muhammadiyah Surakarta.
- J, A., H, S., & W.I, E. (2017). Analisis Risiko Kecelakaan Kerja Pada Proyek Bangunan Gedung Dengan Metode Fmea. *Jurnal Muara Sains, Teknologi, Kedokteran Dan Ilmu Kesehatan*, 115-123.
- Laali, R. S. (2021). 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*, 1967-1976.
- Mu'adzah, & Firmansyah, N. A. (2020). Manajemen Risiko K3 Pada Divisi Produksi Menggunakan Fmea Dan Rca Di Pt.Xyz . *Jurnal Teknologi Dan Manajemen Industri*, 15-22.
- Mufik, M., & Huda, M. (2020). Risk Assesment Kecelakaan Kerja Pekerjaan Struktur Bangunan Mall Dan Apartement Menggunakan Metode Failure Mode And Effect Analysis (Fmea). *Jurnal Rekayasa Dan Manajemen Konstruksi*, 45-56.

- Nabila, K., & Rochmoeljati. (2020). Analisis Pengendalian Kualitas Menggunakan Metode Six Sigma Dan Perbaikan Dengan Kaizen (Studi Kasus : Pt. Xyz) . *Jurnal Manajemen Industri Dan Teknologi*, I(1), 116-127.
- Nindiani, A., Nursikin, R., Kustia, A., Sertiadi, T., Puji, N. W., & Wahyudi. (2019). Penurunan Cacat Produk Garnish-Assembly Tail Gate Di Perusahaan Otomotif Melalui Pendekatan Metode DMAIC. *Industry Xplore*, IV(1), 72-82.
- Nugroho, S. A., Suliantoro, H., & H, N. U. (2018). Analisis Risiko Kecelakaan Kerja Pada Proyek Pembangunan Dengan Menggunakan FMEA Dan FTA (Studi Kasus: Hotel Sronдол Mixed Used Kota Semarang). *Industrial Engineering Online Journal*, 1-11.
- Rinjani, I., Wahyudin, W., & Nugraha, B. (2020). Analisis Pengendalian Kualitas Produk Cacat Pada Lensa Tipe X Menggunakan Lean Six Sigma Dengan Konsep DMAIC. *Jurnal Pendidikan Dan Aplikasi Industri (UNISTEK)*, VIII(1), 18-29.
- Sari, D. P., N, A. D., D, A. M., T, E., & A, M. A. (2018). Analisis Risiko Pada Proyek Pembangunan Flyover Tol Warungasem Batang Dengan Kerangka Project Complexity And Risk Assesment Dan Fmea. *Seminar Nasional IENACO* (Pp. 314-321). Surakarta: Universitas Muhammadiyah Surakarta.
- Sukwandi, R., Wenehenebun, F., & Wenehenebun, T. W. (2017). Pendekatan Fuzzy FMEA Dalam Analisis Faktor Risiko Kecelakaan Kerja . *Jurnal Rekayasa Sistem Industri*, 29-38.
- Suparjo, & Rochman, A. (2018). Manajemen Risiko Operasional Pada PT. ABC Dengan Menggunakan Metode FMEA. *Jurnal UNTAG*, 106-112.
- Suryani, F. (2018). Penerapan Metode Diagram Sebab Akibat (Fish Bone Diagram) Dan Fmea (Failure Mode And Effect) Dalam Menganalisa Resiko Kecelakaan Kerja Di Pt. Pertamina Talisman Jambi Merang . *Jurnal Industrial Servicess*, 63-69.
- Susanto, N., & Nursyachbani, P. A. (2018). Analisis Risiko Kecelakaan Kerja Pada Proyek Underpass Jatingaleh Semarang Dengan Metode Failure Mode And Effect Analysis (Fmea). *Industrial Engineering Online Journal*, 1-30.
- Yanda, P. P., Herniwanti, & Makomulamin. (2020). Identifikasi Dan Analisa Risiko Kecelakaan Kerja Dengan Metode Fmea (Failure Mode And Effect Analysis) Pada Kelompok Tani Palas Baru Rumbai . *Jurnal Ilmu Kesehatan Masyarakat*, 10-16.
- Yaqin, R. I., Zamri, Siahaan, J. P., Priharanto, Y. E., Alirejo, M. S., & Umar, M. L. (2020). Pendekatan FMEA Dalam Analisa Risiko Perawatan Sistem Bahan Bakar Mesin Induk: Studi Kasus Di KM. Sidomulyo . *Jurnal Rekayasa Sistem Industri*, 189-200.