

Safety Analysis

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2 Safety Analysis at Weaving Department of PT. X Bogor Using Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA)

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Abstract—The research focus on reducing the number of occupational accidents by finding the root causes of work accidents and optimize the implementation of Health and Safety values in PT X. The possibility of risk identified using Failure Mode and Effect Analysis (FMEA) and analyze it by calculating Risk Priority Number (RPN). A list of critical risk then developed through calculation of total RPN value ratio. The cause of the accidents are analyze systematically using Fault Tree Analysis (FTA). Based on the largest RPN value on FMEA, the most dominant failure mode with the most dominant effect of the cable / source of electrical current is not in a safe condition with fire effects and operators work is not appropriate SOP with work accident effect (RPN : 172.99). FTA are designed to have 3 failures are fire failures, work accidents, and operators do not use personal protective equipment. Each FTA that has been designed contains a chart that is the cause and effect of an event.

Keywords—FMEA; FTA; accident; RPN; health and safety

I. INTRODUCTION

Implementation of Occupational Health and Safety in the workplace is an effort to create a safe, comfortable and healthy working environment. Nowadays, the problem about health and safety is forgotten (Landbergis, et al; 2014). The safety referred to herein is the safety of work associated with machinery, work tools, materials processing, workplace, and work environment, and work methods. Machines usage may pose risk of accidents that may harm to both the company and workers. Losses incurred by the company due to the risk of work accidents among others are decreased in production, in addition to the increased cost of medical care and worker absenteeism. While the risk of work accidents can cause temporary pain, disability and even death for workers.

PT X Bogor is one of the manufacturing companies engaged in fabric production. Most of Production process at PT X involves various machines to produce the finished product. Based on their own report several work accidents

has been occurred in PT X in the form of work accidents and fires. Working accidents are generally caused by negligence and errors in the use of work tools, while fires generally occur due to the faulty cable.

Because of that, safety, health, and environment management systems are need to be implemented based on the principle of prevention in order to conserve workforce in organizations (Yousefi, S. al; 2018) like PT. Unitex, Tbk. Swarup 2014 said that there are two safety assessment methods that mostly used in safety analysis, One of the method is Failure Mode And Effective Analysis (FMEA). Most studies used FMEA method (Arabian Hoseynabadi et al., 2010; Feili et al., 2013; Trafialek and Kolanowski, 2014) to identify potential hazard and risk possibility.

This research focus on reducing the number of occupational accidents by finding the root causes and optimize the implementation of health and safety values in the PT X. Research scope are limited on the weaving department with main research objectives are to identify the implementation of occupational safety and health, hazards, and work risk followed by recommend corrective actions that can be taken to prevent or at least reduce the probability of accidents. The possibility of risk identify using Failure Mode and Effect Analysis (FMEA) and analyze it by calculating Risk Priority Number (RPN). A list of critical risk then developed through calculation of total RPN value ratio.

Second method is Fault Tree Analysis (Swarup M. Ben and SrinivasaRao M, 2014). The cause of the accidents are analyze systematically using Fault Tree Analysis (FTA). The analysis can determine the causes and the hidden combinations that lead to accidents and the expected accidents can be avoided.

II. LITERATURE REVIEW

A. Potential Hazards in the Textile Industry

Today many industrial processes are conducted using machines. Therefore, potential hazards risk faced by machine tools operator is also increasing. To reduce the risk due to engine noise, the textile industry can refer to Circular Letter of Labor Department SE-01/MEN/1978 regarding threshold noise, temperature and humidity of workplace. The most known prominent effect of noise at work is Noise Induced Hearing Loss (NIHL), which is the loss of hearing ability permanently. The NIHL process takes place gradually due to exposure to noise for months to years (Nandi in Sukapto, 2013). The impact of NIHL can be prevented by providing ear protector equipment for operator (Morris in Sukapto, 2013). Workplace temperatures and humidity are other things that need to be considered. A hot and humid workplace affects operator to perform unsafe actions, especially if they must wear protective clothing (Malik in Sukapto, 2013).

B. Occupational Health and Safety

Occupational safety and health is a means to prevent accidents, disabilities and death as a result of workplace accidents. Occupational safety and health is important in both modern and traditional operational processes. If neglected, it will harm both the company and workers.

C. Definition of Accident

Accidents are unforeseen or unexpected events. Unexpected means that accident is not planned or deliberated.

D. Failure Modes and Effect Analysis (FMEA)

According to Mourby in Mukti (2014), Failure Modes and Effect Analysis (FMEA) is a method used to identify failure mode that may cause any malfunction and to analyze the relationship between failure modes. The potential failure mode can be suppressed through anticipatory steps based on a priority. Where in determining the priority scale is to get the value of Risk Priority Number (RPN). The resulting RPN value shows the priority level an area or component for improvement. This value serves to quantify the effect of each mode on the FMEA results. A reference priority for corrective action decision-making can be developed from RPN value.

E. Fault Tree Analysis (FTA)

Fault Tree Analysis (FTA) method is a technique used to identify risks that contribute to failure. This method use top down approach, which begins with the assumption of event failure at the peak (Top Event) and then details the causes of a Top Event until root failures are found. Logic gates describe conditions that trigger failure, either single condition or a set of various conditions. The construction of the Fault Tree Analysis (FTA) includes the logic AND gate and logic OR gates. (Yulinda, 2015).

III. RESEARCH METODOLOGY

The research methodology is the stages of research that must be determined first that serve as a direction in the analysis and problem solving.

Data obtained from the distribution of questionnaires to ten respondents working in the weaving department of PT X, which aims to provide an assessment for each type of risk. Recapitulation of Severity, occurrence, and Detectability average values can be seen in Table I.

TABLE I. RECAPITULATION OF SEVERITY, OCCURENCE, AND DETECTION VALUE

No Failure Mode	Severity	Occurance	Detection	RPN (S x O x D)
1	2.00	4.80	3.89	37.33
2	2.40	4.20	3.00	30.24
3	4.10	4.30	4.30	75.81
4	4.20	3.50	3.70	54.39
5	5.60	5.40	4.50	136.08
6	6.80	4.80	5.30	172.99
7	4.80	4.70	4.80	108.29
8	2.60	3.44	3.30	29.55
9	2.60	3.00	3.60	28.08
10	3.60	4.70	4.22	71.44
11	3.30	4.00	4.60	60.72
12	3.00	3.50	4.30	45.15
13	5.90	4.30	4.40	111.63
14	7.40	3.90	4.00	115.44
15	7.40	4.60	5.40	183.82
16	3.44	3.60	3.70	45.88
17	4.80	4.60	3.50	77.28
18	6.10	6.00	4.60	168.36
19	6.70	5.22	3.90	136.46

The analysis conducted through the assessment of Severity, Occurrence and Detection (SOD) values to obtain Risk Priority Number (RPN). Severity is an assessment of how bad or serious the impact of failure resulting in work accidents. Occurrence is the frequency of the specific failure causes. Detectability is a measure of the ability to detect or control failures that occur. High RPN values indicate a high impact failure mode.

IV. RESULTS AND DISCUSSION

Risk Priority Number (RPN) calculated by multiplying the severity, occurrence, and detection values. The type of work accident then sorted based on the greatest RPN value to the smallest. Ranking of occupational accidents from the greatest to the smallest risk can be seen in Table II.

Based on the RPN value, the most dominant failure mode is unsafe condition of power source which can cause fire in the work place, followed by operator's disobedience with SOP which can cause work accident. Company can use those result as a priority reference in solving their occupational safety and health problems. However, failure modes with low RPN value should not be forgotten because all aspects of occupational health and safety are important and

interconnected with each other. Each failure mode and effect has a cause and effect relationship.

TABLE II. RPN

NO	Failure Mode	Effect	RPN
	Unsafe act		
1	The power cord / power source is not in a safe state	Fire	183.82
2	Operators are working out of SOP	Work accident	172.99
3	Occupational checks / fixes are not regular	The machine is easily damaged	168.36
4	SOP less work	Work accident	136.46
5	Operator is not careful in working	Work accidents, product quality is reduced	136.08
6	The fire potential is quite large	Fire	115.44
7	Signs for less engine SOP	Work accident	111.63
8	The field supervisor is less intensive to oversee the operator	The work is not maximal	108.29
9	The work tool is not neatly arranged	Work accident	77.28
10	The operator does not wear safety shoes	Legs stricken	75.81
11	Dust is scattered	Shortness of breath, lung disease, cough, etc.	71.44
12	Less lighting	Eye pain, lack of concentration, work accidents, etc.	60.72
13	The operator does not wear a working cap	Head struck iron and machine tools	54.39
14	The cleanliness of the engine is not maintained	Product quality is reduced	45.88
15	Ventilation is lacking	No air circulation, stuffy, breathless.	45.15
16	The operator does not wear a mask while working	Inhalation of dust, yarn dust	37.33
17	The operator is not wearing an ear plug	Deaf ears	30.24

Based on work accident data, RPN value, and the result of interview and observation, three failure tree are developed: Failure tree for fire event, work accident, and work related illness.

Fault Tree Analysis (FTA) method used to detect the root cause of an accident problem that occurred. The method can identify potential occurrence of systematic hazards according to the process and use it to systematically analyze the cause of accident on production floor. FTA starts from Top events (peaks) and then developed in the initial event. Logic gates describe conditions that trigger failure, either single condition or a set of various conditions. The construction of the Fault Tree Analysis (FTA) includes the logic AND gate and logic OR gates. A fault tree illustrates the state of the system components (basic event) and the relationship between the basic event and the top event states the connection in the logic gate those relationship are generated through brainstorming.

The failure tree for fire event describes the sparks along with residual cotton and dust that are scattered in the air as the source of problem. This level is connected by AND logic gate due to the fire that occurs is the result of a spark ignited the residue of cotton. The working environment is not cleaned regularly thus causing residual cotton and dust to accumulate.

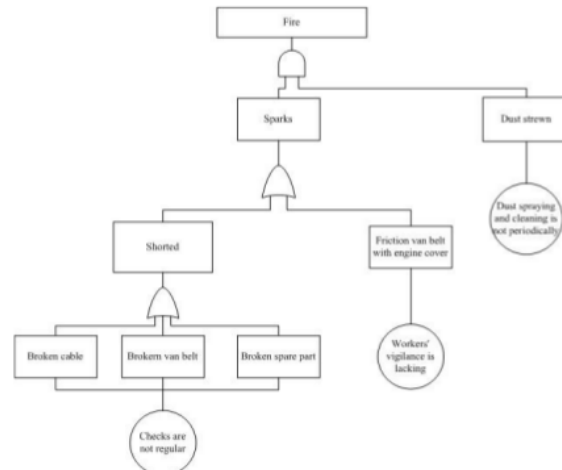


Figure 1. Fault tree for fire event.



Figure 2. Fault tree for work accident event.

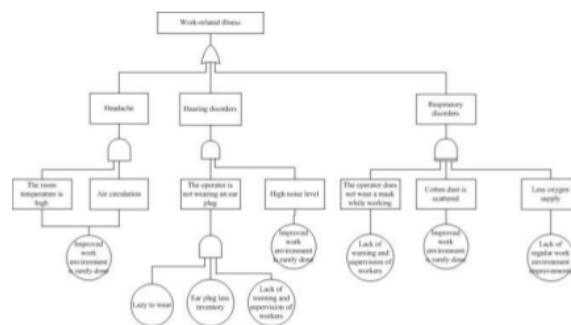


Figure 3. Fault tree for illness event.

FTA for work accident shows that operator who is not working in accordance with SOP, the influence of working environment, or the operator who does not use personal protective equipment while working as the problem sources.

The relationships are illustrated using OR logic gate. In other words, one of the three identified causes has the potential to cause an occupational accident. Analysis of FTA for work related illness also shows that the problem can be occur because of headaches, hearing and respiratory problems. The causes of occupational diseases are also described in the FTA.

In addition to FMEA, FTA can also be a benchmark in finding the root cause. The FTA also illustrates the cause of the incident in detail down to the root of the problem. This facilitates the company to solve the problems that occur. By understanding the FTA, the order of problem solving will be easier.

V. CONCLUSION

Solution of Occupational Safety and Health, hazards, and work risks in the weaving department PT X has been identified through FTA and FMEA methods. In general, the value of Occupational Safety and Health has been recognized in weaving department but has not been fully implemented. The hazards and risks in weaving department arising from work environment and operator. The most dominant hazards are fire caused by combination of faulty electrical component with working environment condition and disobedience of working SOP which still needs to be improved. Any remedial action that can be taken to prevent or reduce the chances of an occupational accident shall be made by all parties involved in the company on a regular basis and prioritizing the value of safety.

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