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ACCIDENT ANALYSIS WORK WITH FAILURE MODE AND EFFECT ANALYSIS METHOD AT COATING SERVICE INDUSTRY IN INDONESIA

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ABSTRACT

PT. Gansa Furindo Indonesia (GFI) is a company engaged in painting and powder coating services established in 1990. In the process of making such a long and involving painting machine and labor, it does not cover the possibility of work accidents. There are 3 categories of work accidents: minor accidents, moderate accidents, and serious/major accidents. For the 3 crash categories, it is seen how severe the injuries suffered in the work accident. This study aims to determine the steps to prevent and repair work accidents after knowing the categories of work accidents that occur. This research is focused on the production department, especially in the machining area where work accidents occur due to the lack of employee awareness of Health Safety and Environment (HSE). Work accidents include crashing objects with a static state of 108 RPN, contact with the machine while moving when taking the material inside the machine is 196 RPN, short circuit of 160 RPN, reverse mounting of 90 RPN and less neat cutting in the iron cutting of 168 RPN. Therefore, improvements are made in preventing work accidents that occur by making the latest Standard Operational Procedure (SOP).

INTRODUCTION

Increasingly intense industry competition demands companies to produce high-quality products; of course, the quality of the product is not apart from the role of human resources. The level of business care for Keselamatan dan Kesehatan Kerja (K3) is still low, in addition to it is a lack of fulfillment of requirements in the health and Work Safety, Besides safety and work accidents are very important for the company because the impact of the accident is not only detrimental to the employees but to the detriment of the company either directly or indirectly directly (Mutlu & Altuntas, 2019) (Kusuma, 2017) (Qin, Xi, & Pedrycz, 2020).

The phenomenon that occurs in a company, especially in the production division, is that employees must be able to create conditions that support comfort in work so that in these

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conditions employees can improve the quality and quality of output in their work. In addition, the leadership must provide safe facilities at work so that the work accident rate can be reduced and even should be zero accidents. The following is the number of work accidents that took place at PT. GFI during 2019. For more details, see Figure 1.

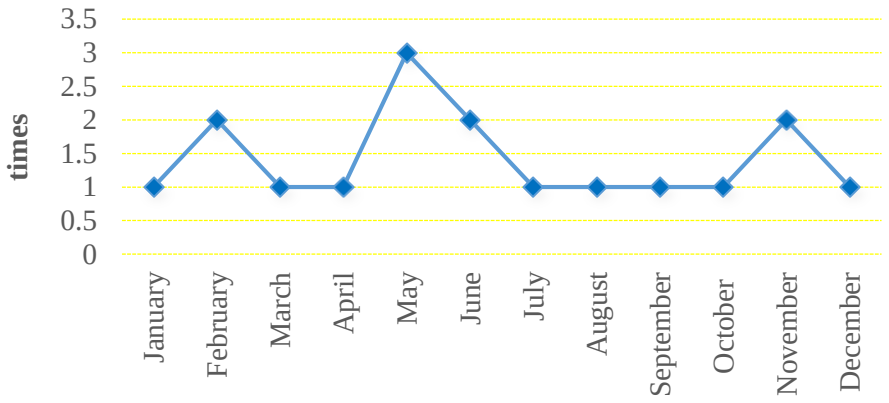

Figure 1. Number of work accidents at PT Gansa Furindo Indonesia 2019

Based on Figure 1, it is found that the number of work accidents during 2019 amounted to 17 accidents and the highest was in May 2019 with 3 accidents. The categories of work accidents found in this company are divided into three categories and one additional category, which is almost an accident. The additional accident means that there is a potential for an accident but it does not occur due to the availability of proper prevention. The division of work accidents that occur can be seen in Figure 2.

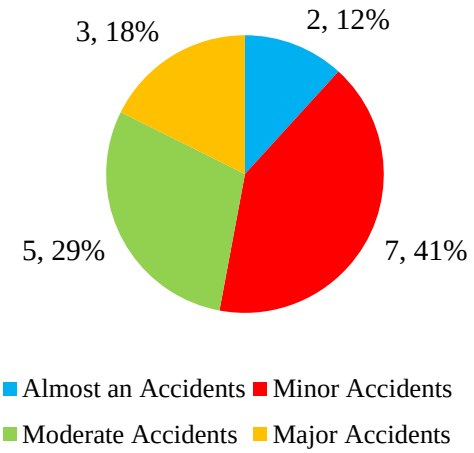

Figure 2. Recapitulation work accident by categories 2019

PT. GFI is a manufacturing industry company engaged in painting & powder coating services even though PT. GFI already has K2P3 teamwork accidents still occur frequently. This can be seen in the recapitulation of work accidents from January to December 2019, which has been there were 17 work accidents with three categories of work accidents, namely: Almost An Accident as much as 2, Minor Accident 7, Moderate Accident 5, Major Accidents 3. Work accident that occurred at PT. GFI itself started with indifferent workers to the prevailing K3, lack of concentration, and often neglect Personal Protective Equipment (PPE) when the production process is underway; workers perceive that PPE is uncomfortable and that ignoring it will invite danger. The cause of the work accident experienced in our company is also almost

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the same as the paper from (Karasan, Ilbahar, Cebi, & Kahraman, 2018) and (Suparjo & Rochman, 2018).

The priority value of handling the type of work accident by using the FMEA method (Shen, Cheung, Peng, & Haapasalo, 2009). Final result FMEA in the form of Risk Priority Number value obtained from multiplication between severity, occurrence, and detection, which then the result is sorted from the matter (Suryani, 2018) and (Helia & Wijaya, 2017). Based on the references above, it is necessary to immediately resolve the work accident at PT. GFI using the FMEA method and all improvements are included in the SOP.

RESEARCH METHOD

The research was conducted at PT. GFI located at Jl. Akasia II No.1, Sukaresmi, Cikarang Sel., Bekasi, West Java 17530. Types of Research by survey method with a quantitative approach that is studies that take samples directly from the population. Thus the sample in this research is part of the research population, namely several employees who work in the powder coating service. Data that has been owned from the results of the research are as many as 90 people. In deciding the number of samples in this study using the Slovin formula, namely:

$$n = \frac{N}{1+(N.e^2)} \quad (1)$$

n, N, and e are for number of samples, number of population, and level of error respectively.

International standards also recommend the FMEA methodology as one of the risk analysis techniques. By applying this methodology, companies can have a systematic process to identify potential Failure to fulfill its intended function, to identify the possible losses caused by causes that could be eliminated, and to find the impact of Failure so that the effects can be reduced (Firdausi, 2008; Nugroho, Suliantoro, & Utami, 2018). The steps in processing data FMEA are as follows:

1. Identify the system
   The systems observed in the study were health systems and safety (K3) at PT. GFI. One assessment of whether the company's K3 system is running properly refers to a work accident in the company.
2. Identify failure mode
   This step will be searched for the cause of the event's Failure until a work accident. Failure mode was obtained from categorizing the results of work accident incidents at PT GFI.
3. Identify the failure effect
   After obtained failure mode, then identified failure effect. Failure effect is defined as the result of failure mode.
4. Identifying causes
   Identify the causes of failure mode accidents at PT GFI.
5. Analyzing the severity
   Severity failure mode shows the degree of seriousness of the consequences caused. A failure mode is shown in rank one up to ten that indicate the degree of severity or danger caused. Scaling based on Incident Severity standards Scale (Pasaribu, Setiawan, & Ervianto, 2017) On this scale, it is clearly defined what the wounds are, diseases, social and psychological hazards, and the dangers of equipment or machinery. The determination of this scale is obtained from the results of discussions and interviews with the K2P3 Team.
6. Analyzing the frequency of occurrences
   Occurrence is the frequency of the cause of Failure. The specifics of a project occur and produce a form of Failure. Occurrence uses an assessment scale of one (rarely) up to ten (almost often). Level occurrence based on (Hidayatullah & Muliatna, 2018) (Rama Putra Perdana, 2014)

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7. Analyzing the difficulty of detection
   Detection is a measure of the ability to detect or control failures that may occur. Detection uses an assessment on a scale of 1 to 10. These steps are almost the same as references from (Zhai, Lv, Zhao, Wang, & Leung, 2021) and (Azad, 2018).

The steps of this research begin by collecting review literature, identifying problems, and formulating the problem. Then the source of data is collected from interviews, distributing questionnaires, and collecting work accident data for one year. The data that has been collected is then processed by calculating the validation and reliability tests, if the data is valid and reliable then proceed to the next stage and vice versa if the data is not valid then return to data collection. After that, the data was analyzed using the FMEA method and then all the data could be concluded and all inputs for improvement could be taken. More details can be seen in Figure 3.

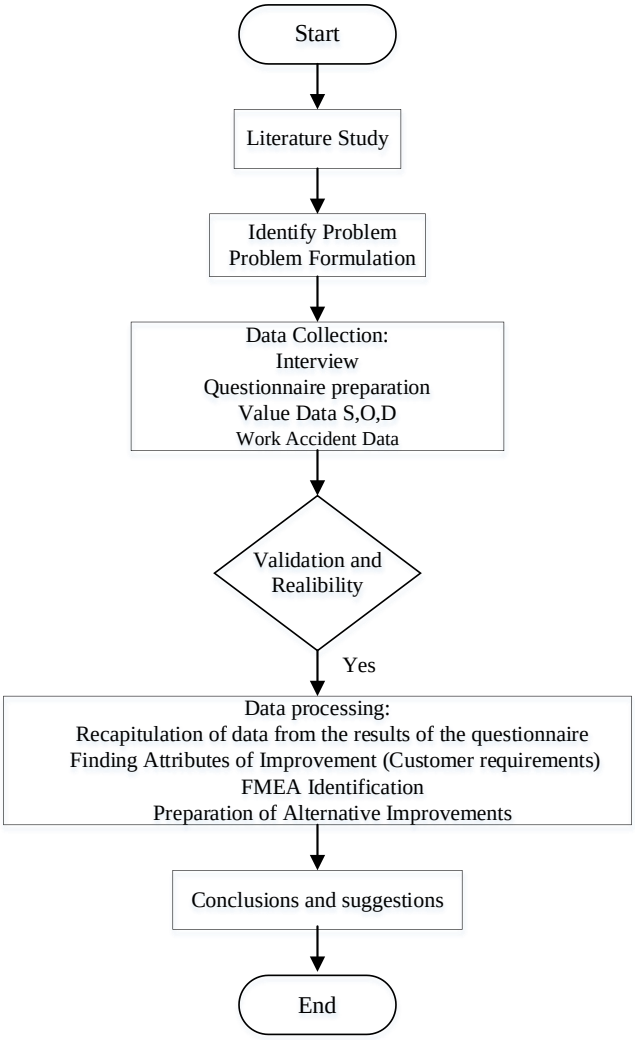

Figure 3. Research Framework

As for processing statistical data, it can be explained by validation tests and reliability tests (Nurmalasari, Kade, & Kamaluddin, 2014) are follows:

1. Validity Test, is the extent to which the accuracy and accuracy of measuring instruments in carrying out functions measure An instrument is said to be valid if r-count > r-table.
2. Reliability Test, is used to know the consistency of measuring instruments. Instrument used was reliable and consistent if the measurement is repeated. In other words, the reliability of the device characterizes the level of consistency. Reliability testing used in

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this research is by calculating the Cronbach Alpha. Cronbach Alpha is used to find the reliability of instruments whose scores range from multiple values or a scale (Martin et al., 2014).

RESULTS AND DISCUSSION

In this Research, the population used is employees of PT. GFI with 90 people, while the value of errors (e) is 10%. Based on the data, then in determining the size of the sample, reviewed in equation (1).

$$n = \frac{90}{1 + (90\ x\ 0.10^2)}$$
$$n = \frac{90}{1.9} = 47.37$$
$$n = 47$$

The study obtained the number of samples as many as 47 respondents with an error value of 10%, where the amount is obtained from the calculation above. The results of distributing questionnaires to several people can be seen in Table 1.

Table 1. Respondent Data

Criteria	Item	Number of respondents
Gender	Man	27
	Woman	20
Age	<25 years	10
	25-35 years	20
	40-50 years	12
	>50 years	5
Status	Married	33
	Not married	14
Residence	Local area	40
	Out of town	7

A. Safety Category Validity Test Results

Before data analysis is performed based on the results of the data collected data testing through data validity test. Test this validity was carried out to find out whether the items presented in the questionnaire were able to express exactly what to research. The method used is by item analysis, where each value is in each item of the question for a variable using the product-moment correlation formula. Condition the minimum to be considered valid is r-value > 0.248. The result of the validity test from 47 respondents with 8 question items. More details can be seen in Table 2.

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Table 2. Validity test result

No	Questions	r-Calculate	r-Table	Result
1	Socket damaged	0.664	0.248	Valid
2	Broken socket	0.428	0.248	Valid
3	Torn hand	0.308	0.248	Valid
4	Finger scratched	0.333	0.248	Valid
5	Broken socket index Push holder and die broken	0.474	0.248	Valid
6	Painting machine	0.298	0.248	Valid
7	Grinding machine	0.534	0.248	Valid
8	Iron cutting machine	0.534	0.248	Valid

The result of the validity test from 47 respondents with 3 question items was another variable. More details can be seen in Table 3.

Table 3. Recapitulation of Validity Test

No	Questions	r-Calculate	r-Table	Result
1	Occurrence	0.455	0.248	Valid
2	Severity	0.467	0.248	Valid
3	Detection	0.403	0.248	Valid

B. Reliability Test Results

The result of the reliability test from 47 respondents with 3 question items. More details can be seen in Table 4.

Table 4. Reliability test result

No	Variable	Cronbach's Alpha	Result
1	Occurrence	0,598	Reliable
2	Severity	0,627	Reliable
3	Detection	0,437	Reliable

Source: Data has been processed

Based on the reliability test of 47 respondents, all question items on each of these variables can be reliable or accurate if the Cronbach alpha value is > 0.2483 so that the data can be used in research.

C. Failure Mode and Effect Analysis Stage

Identify failure mode obtained is a category of work accidents described above, which is as follows:

1. Crashing into objects in a static state
2. Contact with a moving machine or material is in the machine
3. There is a short-circuit
4. Reverse hold push Installation
5. Less precise when cutting scrap

The description related to work accidents from several categories of accidents that can occur during work can be seen in Table 5.

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Table 5. Work accident category explanation

No	Categories	Description
1	Crashing into objects static state	This category of accidents is due to when driving a forklift wrongly stepped on the brakes but which was trampled by gas, finally the operator crashing into the panel in a silent state.
2	Contact with a moving machine or material in the machine	This category of accidents is due to the lack of concentration of employees while working and the absence of rechecks carried out by the leader
3	There is a relationship between short-circuit	This category is a category of workability because the operator interacts with scraps that can cause short circuits
4	Reverse hold push installation	This category of accidents is due to the lack of concentration of employees while working and the absence of rechecks carried out by the leader
5	Less precise when cutting scrap	Category of work accident is due to blunt socket knife and improper installation of the socket part

D. Identifying the Seriousness of The Consequences

Severity failure mode indicates the degree of seriousness of the consequences or effect of the appearance of a failure mode in the network. The severity scale used is a scale of 1-10 as in (Ririh, Sundari, & Wulandari, 2018) and (Ririh et al., 2018) shown in table 5 How serious the impact caused by failures that cause accidents to occur work is determined by how serious the influence is. In other words, the severity failure mode scale is determined by the severity failure value effect. The largest severity failure effect scale is used as a scale severity failure mode as shown in table 6.

Table 6. Severity assessment results

No	Failure Mode Effect	Potential Failure Mode	Severity
1	Crashing objects with static state	Grinding machine	6
2	Contact with the machine the move when retrieving materials in the machine	Index finger hit by machine	7
3	Short-circuit	Socket is broken	5
4	Holder installation reverse	Socket is broken	5
5	Less neat cutting in iron cutting	Iron cutting machine	6

E. Identifying The Detection Tool For Failure Mode

In the tool identification step or how to detect the cause of the failure mode (detection), collecting information to control the cause of Failure cause a work accident. The detection scale used assessment results for tools or ways of managing the cause of failure mode can be seen in Table 7. This investigation was obtained apart from field observations as well as from discussions and interviews with Environment Health Safety (EHS) managers and staff, operators, and managers responsible for related departments.

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Table 7. Results of detection assessments

No	Failure Mode Effect	Potential Cause of Failure	Detection
1	Crashing objects with static state	inspection of each departmental head section of the ministry of employees underneath	3
2	Contact with the machine on the move when retrieving materials in the machine	Socialization of the use of leather gloves as well as control of the stock of gloves and also inspection of the head of each department of the department to employees underneath	4
3	Short-circuit	Inspection of each head department to the employees under it as well as the Socialization of employees regarding voltage difference in electric current retrieval, step down transformer installation as well as SOP manufacturing	4
4	Holder installation Reverse	inspection of each departmental head section of the ministry of employees underneath	3
5	Less neat cutting in iron cutting	inspection of each departmental head section of the ministry of employees underneath	4

F. Identifying The Occurration Tool For Failure Mode

In the tool identification step or how to detect the cause of the failure mode (occurrence), collecting information to control the cause of Failure cause a work accident. The occupation scale used assessment results for tools or ways of managing the cause of failure mode. Then, it is continued by assessing the risk priority number (RPN) value of the potential failure mode. Each of the three risk factors is usually assigned a deal on a numerical scale ranging from 1 to 10. After there is a Risk Priority Number (RPN) value with the formula RPN = OxSxD, where Occurrence (O) is the probability, Severity (S) is the seriousness of the failure, and Detection (D) is the ability to detect failure before the impact of the failure effect manifests. The next step is to prioritize the RPN value that has been determined (rating scale). More detail can be seen in Table 8.

Table 8. Results of occurrence assessments and RPN result

No	Failure Mode Effect	Potential Failure Effects	Occurrence	RPN	Rank
1	Crashing objects with static state	Machine stop	6	108	4
2	Contact with the machine on the move when retrieving materials in the machine	The hand will be hurt	7	196	1
3	Short-circuit	The electricity will go out	8	160	3
4	Holder installation reverse	Machine can't run	6	90	5
5	Less neat cutting in iron cutting	Spare parts can't function	7	168	2

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G. FMEA Results in Analysis

FMEA is a method that is used to identify potential risks for arising, determining the impact of occupational accident risk, and remembering to mitigate such risks. The advantage of FMEA itself is the nature of FMEA itself, which is objective because it uses the assessment of some FMEA members, the head of the parts, and production operators. FMEA can be known priorities handling of a type of failure mode, taking into account three aspects: severity, occurrence, and detection. FMEA is a living document that can be updated according to the needs of the company due to the type of Failure of new failures arise or rule changes; if in this case, then the rules concerning the health and safety of PT. GFI The only drawback of using FMEA is the scheduled discussion time of the FMEA team, so if later the FMEA method is accepted company then the company needs to make a schedule to discuss the work accident problems by the entire FMEA team and their respective relevant departments. The number of work accidents that occur because operators do not use PPE when the production process is in progress, they assume when using PPE they are not aware of the employee's indifference to the PPE equipment used when working this can trigger work accidents. At the same time, failure mode occurrence that has a value lowest is in the number four that is not done twice checking. It is due to lack of recheck in push installation holder is not done when it should be done.

H. Proposed Improvements

For the results of the FMEA analysis of the failure detection mode, socialization to employees about the difference in electric current-voltage, installing a step-down transformer, and making SOPs with a detection value of 4, while for the lowest detection value of 5, re-checking with the department leader.

There is a stage of this fix providing a solution to the problem that occurred. Proposals or concepts of improvement in addressing work accidents by making SOP and add line type in the production area.

CONCLUSIONS

Based on observations, data processing, and analysis, it can be concluded as follows: There are five categories of work accidents at PT. GFI includes crashing objects with a static state of 108 RPN, contact with the machine while moving when taking the material inside the machine is 196 RPN, short circuit of 160 RPN, reverse mounting of 90 RPN, and less neat cutting in the iron cutting of 168 RPN. The results of all corrective actions have been included in the SOP and have been documented, so that all employees, both new and old, can understand their work to eliminate the potential for work accidents. For further research, researchers will link the potential for work accidents with the application of industry 4.0 as digitalization which can be expected to increase productivity and eliminate work accidents in the coating service industry.

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