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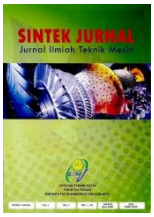

IDENTIFICATION OF POTENTIAL HAZARDS ON PRODUCTION MACHINES WITH HAZOPS AND FISHBONE DIAGRAM IN PT. SILINDER KONVERTER INTERNASIONAL

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ABSTRACT

PT. Silinder Konverter Internasional is a company in the field of Rotogravure Cylinders. The company is a chemical sector industry and has only been running for about 2 years, for that the company needs to pay attention to the issues of Occupational Safety and Health because this greatly affects the company's productivity. The purpose of this study was to identify the factors causing occupational safety and health hazards to avoid work accidents at PT. Silinder Konverter Internasional. From the results of the research using the Hazards Operability Study (HAZOPS) method, there was 38 potential (40%) chemical potential hazards, 28 potential (29.47%) overwritten materials, 14 potential scratches (14.73%), 12 potential pinches (12.63%), and 3 potential noise levels (3.2%). Furthermore, the causal factors are searched with the fishbone diagram of the most potential hazard cases, namely chemical exposure, there are 12 factors. Followed by finding the dominant causative factors with the Nominal Group Technique (NGT) there are 7 factors. Then plan improvement of the 7 factors with the 5W + 1H method so that the level of risk of work accidents decreases.

Keywords: Hazard Identification, HAZOPS, Fishbone Diagrams, NGT, 5W + 1H.

1. INTRODUCTION

Potential hazards exist in almost every place where an activity is carried out, whether at home, on the road, or at work [1]. If these potential hazards are not controlled properly, it will cause fatigue [2], pain, injury, and even serious accidents [3,4].

In-Law No.1 of 1970 on Occupational Safety and Health, The management of the company must provide a workplace that meets the safety and health requirements stipulated for it [5,6].

This research was conducted at PT. Silinder Konverter Internasional is a manufacturing company that produces Rotogravure Cylinders, A tool in the shape of a cylinder that functions as a component in printing plastic packaging. This company was only established in 2017 under the auspices of the Mayora Group. Therefore, as a new company to undertake a commitment to providing customer satisfaction, it must implement occupational safety and health system to ensure that all workers or other people in the company can be free from work accidents [7-9].

To reduce the risk level of work accidents, it is necessary to identify potential hazards in each work activity in the production area by conducting a hazard operability study (HAZOPS) and looking for the factors causing the problem with a fishbone diagram. Then look for the dominant causative factor with Nominal Group Technique (NGT), followed by providing suggestions for improvement using the 5W + 1H tools.

2. METHODS

Several data analysis methods can later be used in data processing from the problem in this study [10-12]:

a. Determine the Process Flow of the production area
b. Determine the work process
c. Description of Hazard's Findings
d. Determining Hazard Risk
e. Determining the Source of the Hazard
f. Risk Level Assessment

The determination of the level of risk is as follows:

Risk Level = likelihood x consequences

Likelihood / Probability Criteria as Table 1.

Table 1. Likelihood/ Probability Criteria

Level	Criteria	Description	
		Qualitative	Semi Qualitative
1	Rarely happening	Can be thought of but not only in extreme circumstances	Less than once in 10 years
2	Small possibility	It hasn't happened yet but can appear at a time	Occurs 1 time per 10 years
3	Maybe	It should have happened and might have been/appeared here or elsewhere	1 time per 5 years to 1 time per year
4	Most likely	Can occur easily, may appear in the most numerous circumstances	More than 1 time per year to 1 time per month
5	Almost certainly	It often happens, is expected to appear in the most occurrences	More than 1 time per month

Consequences/Severity criteria as Table 2

Table 2. Consequences/Severity Criteria

Level	Criteria	Description	
		Severity of Injury	Working days
1	Not significant	The incident did not cause harm or injury to humans	Does not cause loss of workdays
2	Small	Causing minor injuries, small losses and does not cause a serious impact on business continuity	Can still work on the same day/shift
3	Moderate	Severe injuries and hospitalized, do not cause permanent disability, moderate financial losses	Lost workdays under 3 days
4	High	Causing serious injury and permanent disability and large financial losses as well as having a serious impact on business continuity	Missing workdays of 3 days or more
5	Disaster	Resulting in casualties and severe losses can even stop business activities forever	Lost workday forever

Furthermore, the risk level is obtained in the form of a risk matrix [13,14]. Risk Matrix as Figure 1.

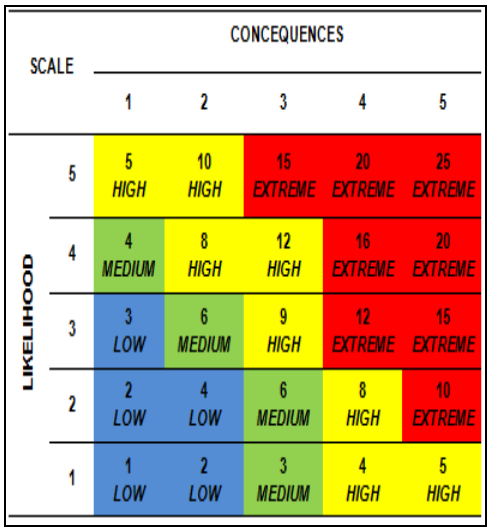

Figure 1. *Risk Matrix*

g. Finding the factors causing the most potential hazards with a fishbone diagram [15].
h. 8. Looking for the dominant causative factor with the nominal group technique (NGT).
i. Provide recommendations for improvements based on the 5W + IH method.

3. RESULTS AND DISCUSSION

3.1. Production Process Flow

In identifying the hazards, first of all, knowing the process flow to be identified, in this case, the researcher conducts his research in the production area PT. Silinder Konverter Internasional. The production process flow is as follows:

a. Electroplating machines for coating workpieces using chemical liquids as coating materials.
b. Grinding Machine For the process after the cupper process in electroplating, where the cylinder in this process is polished so that it is smooth when carved on the engraving machine, in addition to the polishing process the CFM machine also functions to cut if the cylinder being processed is too large in diameter than the desired standard.
c. Engraving machines are arguably the most important process in the manufacture of rotogravure cylinders. An engraving machine is a process of engraving a desired image or design on a cylinder using a diamond tool on an engraving machine. The more complicated the design and the number of images on the cylinder that are processed, the longer the engraving process will take.
d. Proofing machine for the finishing process where the cylinder is tried to print the image and the color is by the standard design desired before sending it to the customer.

3.2. Identification of Hazards in Production Machines

The next step is to identify the K3 hazards in the production area by interviewing workers who understand or are experts in the production process. Identification of K3 hazards on the production floor using the HAZOPS method on Electroplating, Grinding, Engraving, Proofing machines as in Table 3-6.

Table 3. Hazards Identification of Electroplating Machines

Activities	Potential hazard	Impact	Prob	Sev	Risk Level
Pouring chemical solutions on the machine	Exposed to chemical liquids	Can burn skin and perforate clothes	3	3	*Medium*
	Exposed to chemical liquid splash	Eye contact, visual disturbance	3	3	*Medium*
	Inhalation of chemicals	Respiratory disorders	3	3	*Medium*
Lifting cylinder on table setting	Pinched	Hand injured	3	2	*Medium*
	Fall of cylinder	Foot injury	3	2	*Medium*
	Heavy load of cylinder	Waist injury, *Fatality*	3	4	*High*
Cylinder setting with axles and chuck work aids	Pinched	Hand injury	2	2	*Low*
	Fall of axles and chucks	Foot injury	3	2	*Medium*
Lifting the cylinder using a hoist crane to be carried to the machine according to its stages	*The cylinder fell on the operator*	*Fatality*	2	4	*High*
	The head hits the cylinder while the crane hoist is running	Head injury	3	2	*Medium*

Clean the remaining ink on the cylinder with a solvent	Inhale the solvent	Respiratory disorders	3	3	*Medium*
	Direct contact with hands and skin	Hand and skin irritation	3	3	*Medium*
	Splashed by solvent	Eye irritation	3	3	*Medium*
Wash the cylinder with Nectar Clean soap	Hand scratched cylinder	Hand injured	3	2	*Medium*
	Got splashed by soap	Eye irritation, wet and dirty clothes	3	3	*Medium*
	Inhale the scent of Nectar Clean soap	Respiratory disorders	3	3	*Medium*
	Exposure to Nectar Clean soap	Skin irritation, especially hands	3	3	*Medium*
Flushing the cylinder with H2SO4	Got electric shock	Injured, *fatality*	2	4	*High*
	Was splashed by H2SO4	Eye irritation	3	3	*Medium*
	Direct contact with H2SO4	Hand and skin irritation	3	2	*Medium*
	Inhalation H2SO4	Respiratory disorders	3	3	*Medium*
Inserting the cylinder into the process engine	Inhalation of chemical solutions in the process machine	Respiratory disorders	3	3	*Medium*
	Has been splashed with solution	Skin irritation	3	3	*Medium*
Automatic plating process	Has been splashed with solution	Skin irritation	2	3	*Medium*
Drying the cylinder after the plating process	Ear noise	Ear disorders	5	3	*High*
Dismantling the axle settings on the cylinder that has finished the process	Stung by the heat of the cylinder setting tool	Burnt skin	3	2	*Medium*
	Overwritten by the setting tool	Foot injury	3	2	*Medium*
Lower cylinder from setting *table*	Fall of cylinder	Foot injury	3	2	*Medium*
	Over loaded	Waist injury, *fatality*	3	4	*High*
Carrying the cylinder by trolley to the next process	Hit the leg on the trolley	Foot injury	2	2	*Low*
	Fall of cylinder	Foot injury, *fatality*	3	3	*Medium*

Table 4. Hazards Identification of *Grinding* Machines

Activities	**Potential hazard**	**Impact**	**Prob**	**Sev**	**Risk Level**
Installation of the lathe chisel on the machine	Chisel scratched	Hand injured	3	2	*Medium*
	Inhalation of copper powder	Respiratory disorders	3	3	*Medium*
	Pinched	Hand injury	2	2	*Low*
Grinding / Polishing stone installation	Inhalation of copper powder	Respiratory disorders	3	3	*Medium*
	Pinched	Hand injury	2	2	*Low*
Place the cylinder on the preparation process bearing	Pinched	Hand injury	3	2	*Medium*
	The foot is crushed by a cylinder	Foot injury	2	2	*Low*
	Over loaded	Waist injury, *fatality*	3	4	*High*
Lifting and carrying cylinders by Hoist Crane to the machine	Fall of cylinder	*Fatality*, Foot injury	2	4	*High*
	Head hit cylinder	Head injury	3	2	*Medium*
Smoothing the end of the cylinder with a file before processing	Hand scratched the end of the cylinder	Injured	2	2	*Low*
	Inhalation of copper powder	Respiratory disorders	3	3	*Medium*
Automatic door closes before processing	Pinched	Hand injury	2	1	*Low*
Clean up waste copper scrap while the process is running	Hand scratched	Injured	2	2	*Low*
	Exposed to copper powder	Respiratory disorders	3	3	*Medium*
Drying cylinder	Ear noise	Ear disorders	5	3	*High*

Checking the cylinder resulting from the Polishing process	Inhalation of the remaining copper powder on the machine	Respiratory disorders	3	3	*Medium*
Grease the cylinder with oil	Hands, direct contact with oil	Skin irritation	3	3	*Medium*
	Smell the oil	Respiratory disorders	3	3	*Medium*
Bring the cylinder to the next process with a trolley	Hit the leg on the trolley	Foot injury	2	2	*Low*
	Fall of cylinder	Foot injury	3	3	*Medium*

Table 5. Hazards Identification of *Engraving* Machines

Activities	Potential hazard	Impact	Prob	Sev	Risk Level
Mounting the Head Stylus on the machine	Inhalation of copper powder	Respiratory disorders	3	3	*Medium*
	Pinched hands	Hand injury	2	2	*Low*
Place the cylinder on the preparation process bearing	Crashed by a cylinder	Foot injury	2	2	*Low*
	Pinched hands	Hand injury	3	2	*Medium*
	Over loaded	Waist injury, *fatality*	3	4	*High*
Putting a damper on the cylinder	Pinched hands	Hand injury	2	2	*Low*
	Inhalation of cylinder iron dust	Respiratory disorders	3	3	*Medium*
Lifting and carrying cylinders by Hoist Crane to the machine	Fall of cylinder	*Fatality*, Foot injury	2	4	*High*
	Head hit cylinder	Head injury	3	2	*Medium*
Wipe the cylinder with a solvent	Inhalation of solvent odors	Respiratory disorders	3	3	*Medium*
	Direct contact with solvent	Skin irritation	3	3	*Medium*
	Scratched the end of the cylinder	Hand injury	3	2	*Medium*
Close the machine door before processing	Wedged the door	Hand injury	2	1	*Low*
Check cylinder after processing	Inhalation of copper powder	Respiratory disorders	3	3	*Medium*
Wrap the cylinder in plastic and duct tape	Scissors or cutter scratched	Hand injury	2	2	*Low*
	Scratched the end of the cylinder	Hand injury	3	2	*Medium*
Take the vibration damping cloth on the cylinder	Inhalation of iron dust on cylinders	Respiratory disorders	3	3	*Medium*
	The cylinder has been exposed to iron dust	Eye irritation	3	3	*Medium*
Bring the cylinder to the next process with a trolley	Hit the leg on the trolley	Foot injury	2	2	*Low*
	Fall of cylinder	Foot injury	3	3	*Medium*

Table 6. Hazards Identification of *Proofing* Machines

Activities	Potential hazard	Impact	Prob	Sev	Risk Level
Doctor Blade Plate mounting	Scratched	Hand injury	3	2	*Medium*
	Scratched	Hand injury	2	2	*Low*
Installation of plastic printing on the machine	Scratched	Hand injury	2	2	*Low*
	Scratched	Hand injury	2	2	*Low*
Mixing the color ink to be printed	Inhalation of chemicals	Respiratory disorders	3	3	*Medium*
	Direct contact with ink and solvents on skin	Skin irritation, especially hands	3	3	*Medium*
Place the cylinder on the preparation process bearing	Crashed by a cylinder	Foot injury	2	2	*Low*
	Pinched hands	Hand injury	3	2	*Medium*
	Over loaded	Waist injury, *fatality*	3	4	*High*
Lifting and carrying cylinders by Hoist Crane to the machine	Fall of cylinder	*Fatality*, Foot injury	2	4	*High*
	Head hit cylinder	Head injury	3	2	*Medium*

Pour ink on the cylinder	Inhalation of ink and solvent odor	Respiratory disorders	3	3	*Medium*
	Got splashed by ink	Dirty clothes	3	3	*Medium*
Clean ink with vacuum	Noise	Ear disorders	5	3	*High*
	Ink splatter	Dirty clothes	4	2	*Medium*
Solvent cylinders	Inhalation of solvent and ink odors	Respiratory disorders	3	3	*Medium*
	Direct contact with solvent	Skin irritation	3	3	*Medium*
	Hand scratched cylinder	Hand injury	3	2	*Medium*
Clean ink on the doctor blade	Inhalation of solvent odors	Respiratory disorders	3	3	*Medium*
	Direct contact with the solvent directly on the hands	Skin irritation	3	3	*Medium*
	Scratched	Hand injury	3	2	*Medium*
Lowering the cylinder after processing with the crane hoist	Fall of cylinder	*Fatality*, Foot injury	2	4	*High*
	Head hit cylinder	Head injury	3	2	*Medium*

From the results of hazard identification using the HAZOPS method, activity data, and potential hazards can be obtained, as shown in Table 7.

Table 7. Data on Total Activities and Potential Hazards

No	Machine name	Number of Activities	Total Hazard
1	*Electro Plating*	13	31
2	*Grinding*	11	21
3	*Engraving*	10	20
4	*Proofing*	10	23
	amount	44	95

The following is data on potential hazards in the production area as shown in Table 8.

Table 8. Data on Potential Hazards in the Production Area

No	Types of Hazards	Total Hazard	Percentage
1	Chemical Exposure	38	40%
2	Overwritten Material	28	29.47%
3	Scratched	14	14.73%
4	Pinched	12	12.63%
5	Noise	3	3.2%
	amount	95	100%

From the results of the analysis of the most potential hazards, namely the types of potential hazards of chemical exposure reaching 38 potential, 28 types of potential hazards of being hit by material, 14 potential hazards of scratching, 12 potentials of squeezed and at least 3 potential noise hazards.

3.3. Analysis of Causal Factors with Fishbone Diagram

Based on Table 8, the analysis results show that the most potent type of hazard is chemical exposure. This is a problem that must be addressed, therefore analysis is carried out with a fishbone diagram on the potential hazards of chemical exposure, which aims to determine what factors cause the potential hazard of chemical exposure on the production floor. The causes of the potential hazard of exposure to chemicals were obtained from interviews with the production division and direct observations on the production line. To find out the causes of the hazard factors of chemical exposure can be done using a fishbone diagram by conducting interviews with the production division and direct observation on the production line. Based on the fishbone diagram, the factors that cause problems in the case of occupational hazards exposure to chemicals are as follows:

a. Less Work Discipline
b. Less socialization of occupational hazards
c. Lack of Awareness and Concern
d. Not Careful at Work
e. Spare part for the old order
f. Long time ordering rubber and letterhead
g. Maintenance Schedule Not Yet Arranged

h. There is no special vacuum pump or chemical solution drain hole in the machine
i. Distance The process of flushing the cylinder with H2SO4 is too close
j. There is no routine health check from the company
k. Lack of attention from management
l. The room blower is damaged

3.4. Analysis of Dominant Causing Factors Using the Nominal Group Technique (NGT) Method

The next step is to analyze using the Nominal Group Technique (NGT) method to find the dominant causative factor. Before making the Nominal Group Technique (NGT), we have to form a group of 5 people as the assessment team, this who helps as an assessment team can be seen in Table 9.

Table 9. Assessment Team

NO	Position
1	Operator 1
2	Operator 2
3	Group Leader
4	Junior Supervisor
5	Supervisor

After forming the assessment team, then starting the analysis, the results of the analysis using the Nominal Group Technique (NGT) can be seen in Table 10.

Table 10. Analysis of NGT Occupational Hazards of Chemical Exposure

No	Causative factor	Assessment Team					Score	Ranking
		1	2	3	4	5		
1	Less Work Discipline	6	6	7	6	12	37	VII
2	Less socializati on of occupationa l hazards	8	12	10	12	10	52	I
3	Lack of Awareness and Concern	3	2	3	2	2	12	XI
4	Not Careful at Work	4	1	2	3	4	14	X
5	*Spare part for the old order*	5	5	5	5	1	21	VIII
6	Long time ordering rubber and letterhead	12	8	6	7	8	41	V
7	Maintenanc e Schedule Not Yet Arranged	7	7	8	8	9	39	VI
8	There is no special vacuum pump or chemical solution drain hole in the machine	9	11	12	9	11	52	II
9	Distance The process of flushing the cylinder with H2SO4 is too close	2	4	1	1	3	11	XII
10	There is no routine health check from the company	1	3	4	4	5	17	IX
11	Lack of attention from manage ment	10	9	11	10	7	47	III
12	*Room blower is damaged*	11	10	9	11	6	47	IV

Information:

$N = \sum$ Assessment Team $\times \sum$ Tim Case Cause

$NGT \geq 1/2\ N + 1$

$NGT \geq 1/2\ 60 + 1$

$NGT \geq 30 + 1$

$NGT \geq 31$

Based on the above calculations, the NGT value is 31 and the analysis results show that there are 7 (seven) most dominant causes in the case of potential occupational hazards of exposure to chemicals. Factors that are thought to be dominant as a cause of chemical exposure include:

a. Less socialization of occupational hazards
b. There is no special vacuum pump or chemical solution drain hole in the machine
c. Lack of attention from management
d. The room blower is damaged

e. Long time ordering rubber and letterhead
f. Maintenance Schedule Not Yet Arranged
g. Less Work Discipline

3.5. Proposed Repair with 5W + 1H

The next step is to analyze using the 5W + 1H method, which aims to find a solution to this problem. Based on the problems that have been analyzed, improvements and development plans are proposed. The results of the 5W + 1H analysis of the occupational hazards of chemical exposure can be suggested for improvements:

a. The Human Aspect
   Provide work hazard and chemical hazard training regularly and Provide training and motivation and emphasize production operators to be disciplined in work.
b. Method Aspect
   Drain and make up of new chemical solutions using a vacuum pump
c. Management Aspect
   Management should study the PPE needed by workers such as hats, aprons, and corsets for heavy lifting.
d. Environmental Aspect
   Do 5S in the blower area once a month.
e. Material Aspect
   Warehouse management must further accelerate and prepare what the production team needs.
f. Machine Aspect
   Schedule periodic machine inspections.

4. CONCLUSION

The results of the identification of K3 hazards in the production area with HAZOPS obtained as many as 44 work activities and the number of potential work hazards reached 95 potential hazards. The types of hazard potential are as follows: The hazard potential of chemical exposure is 38 with a percentage of 40%. There are 25 potential hazards of falling material with a percentage of 29.47%. There are 14 potential scratches with a percentage of 14.74%. There are 12 potential dangers squeezed with a percentage of 12.63%. Improvement analysis includes human factors, methods, management, environment, materials, and machines.

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