Application of Hazard and Operability Study Methods (HAZOP) to asses and control hazard risk in spinning department using at textile industrial

by Novie Susanto

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Abstract. PT. XYZ is a textile industry company located in Sukoharjo, Central Java. PT. XYZ produces 4 products, namely, yarn, greige, dyed and printed fabric, uniform and apparel. Based on initial observations, sources of danger were identified with a low hazard percentage of 11.7%, medium danger of 29.4%, high danger of 47.05%, and extreme danger of 11.7%. In effort to minimize workplace accidents, work accident analysis can be carried out using the Hazard and Operability Study (HAZOP) method through ranking priorities. The study results found 17 hazards in the spinning division and can be categorized into four hazard classes. From the results of the risk level assessment, there are two hazard sources classified as extreme, eight hazard sources classified as high, five hazard sources classified as moderate risk, and two hazard sources classified as low risk. This study provides recommendations based on control hierarchy with examples of inspection form, signs or posters regarding the use and need for PPE, supervision (punishment system and reward), prohibition of entering the work area without wearing PPE or work cards, and engineering controls.

1. Introduction

PT XYZ is a private textile company in Indonesia that was founded in 1966. It has two main factories and several subsidiaries that are spread and integrated in a group. Products from PT XYZ are in the form of spools with various diameter sizes. The product is made in a department called the Spinning Department. The yarn spools are made from raw cotton balls in the form of blocks that come from within and outside the country. Usually the products from this department are sold in rolls or can be processed by PT. XYZ. The processed products produced are in the form of various kinds of clothing, such as government uniforms and army uniforms of various countries in Europe.

In the production process, workers are in direct contact with heavy machinery. The machine rotates at high speed and there are processes that are done manually so that it has the potential to cause work accidents. In the manufacture of yarn spools, a fairly long process is needed and is directly related to the machine. The process requires regular monitoring of the machine and needs to be cleaned while the machine is operating. At the time of cleaning, workers are required to use sticks as personal protective equipment to pick up waste cotton, but there are still workers who ignore this and take it directly by hand. This is certainly very dangerous for workers because workers' fingers can be run over by the machine, such as in the case of an accident in the dust filter where the worker's finger was broken because it was run over by a machine. The second stage of the yarn winding process uses a speed frame machine, in which the yarn is rolled in a larger cops size. The machine winds the yarn at a

high rotational speed. During operation the machine must also be supervised to ensure that no threads are entangled, not in position and to keep the thread spool free from waste. The work is supposed to be done when the engine stops spinning, but there are some workers who do the job without turning off the engine first. The machine should also be protected by a more closed cover to make it safer from the reach of the hands of workers who accidentally cross the machine's safe limit.

Judging from the production process, PT. XYZ will not be separated from the risk of accidents due to work. With the number of employees reaching 16,000 employees, the risk of work accidents can occur at any time when workers are doing their jobs. Field conditions show that there are still work accidents that occur at least one case every year in the factory area, especially those that occur in the carding machine, speed frame, ring frame, and dust filter. Based on an interview with the K3 section of the Spinning Department, the majority of workers in the carding department often lack concentration, especially employees who work on the night shift. Workers also do not use PPE when picking up waste so that it can cause their fingers to break off from being crushed by the machine. Workers do not use a stick when cleaning the rollers in the ring frame so that the fingers can be caught by the machine which rotates quite quickly and must lose the knuckles. In speed frame and ring spinning work stations that have noise levels up to more than 85 Db, workers also do not use PPE. With a room temperature above 30 degrees Celsius because the engine rotates quite fast and the micro cotton flying around, workers don't wear masks and earplugs. This can cause hearing problems to deafness and can cause respiratory problems due to the hot air and the accumulation of micro-cottons that enter the workers' lungs if left for a long time. Training on work accidents is only carried out once at the time of acceptance or training of new workers. What is often conveyed to workers when supervisors are around is only an appeal to always be careful when working and use the recommended PPE. Spinning Department has the highest number of accidents when compared to other departments. Judging from the high accidents at PT. XYZ, it is necessary to analyze the hazards contained in the Spinning Department of PT. XYZ and provide suggestions for improvement. This needs to be done in the Spinning Department because in that department workers are directly involved with large machines and high concentration is required when working. After repairs have been made and have produced positive results, improvements can be made in the entire spinning Department with the Spinning X Department as an example because all machines in the Spinning Department have the same number and type of machines and the same type of accident, namely fingers pinched on the machine even up to broken. In carrying out repairs, it is necessary to identify potential hazards first which is carried out using the HAZOP method.

HAZOP (Hazard and Operability) is a technique to identify potential occupational hazards by defining possible hazards, evaluating risks that occur through risk assessment using a risk assessment matrix. In addition, the HAZOP method also studies the flow of the machine operation that will be studied by interviewing field workers who work on the machine, it is hoped that more detailed potential hazards can be found in order to minimize and prevent accidents. This method is part of risk management and can determine the direction of the implementation of K3 in the company [1]. Several studies using HAZOP were carried out in different operating areas such as boilers [2], safety glass production [3], paper industry [4], garment companies [5], gas industry [6-7] and fertilizer factories [8]. The theoretical form of criticism of HAZOP is also discussed by [9-17].

Machines in the garment industry, especially the Spinning Department, have potential hazards and risks to workers in them. As a machine that requires regular direct supervision at the time of its operation, it causes the machine to be hazardous. This causes the need for a risk assessment to identify potential sources of danger and prevent the risk of accidents, even the loss of a person's life. So first, the hazard identification in the system is carried out using the Hazard and Operatibility Study (HAZOP) analysis. Through HAZOP, each part of the process can be tested to determine the possibility of deviations from the predetermined design state, and understand the causes and consequences. In addition, the HAZOP method was chosen because it has advantages, among others, it can be applied to all sequences of operations and can identify exactly what critical deviations occur and their causes. Hazard and Operability Study, otherwise known as HAZOP analysis is a standard technique used in the preparation of security establishments in new or modified systems against potential hazards or problems. Operate by identifying and evaluating hazards in planned or existing

processes and operating in the most effective, economical and timely manner when all relevant considerations and constraints are considered. HAZOP can be used simultaneously in the hazard identification process and also in continuous operating systems. The goals of this HAZOP are to identify risks associated with system operation and maintenance. It aims at identifying at potential operability problems and causes of operational disruptions as well as possible deviations in the product that lead to product non-conformance as well. Other methods such as checklists, Fault Tree Analysis, Event Tree analysis, Failure Mode Effect Analysis, etc. provide detailed hazard risk assessments for machinery, product development and events but do not provide solutions to reduce hazard risks in work systems.

Based on the problem formulation that has been explained, the objectives to be achieved in the implementation of this research are to identify the potential hazards in production activities in the spinning department, analyze the risk control of work accidents, especially in activities that have a high level of risk and provide recommendations in handling the highest risks so as to minimize the risk. accident at PT. XYZ.

2. Methods

In this study, a risk assessment of the production floor in the Spinning Department will be carried out. The assessment was carried out using the Hazard and Operability Study (HAZOP) method. The data needed in this study are primary data and secondary data. Primary data consists of data on employee instructions, production flow, and the physical work environment. Secondary data obtained from the company include SOP, work accident data, and input from the company. Primary data can be obtained by means of direct interviews and field observations. In this study, the authors conducted interviews and discussions with Spinning Supervisor as many as one person, male field workers in Spinning as many as seven people (raw material, carding, drawing breaker, drawing finisher, speed frame, ring spinning, and winding, 1 person supervisor), and the head of production as much as one person who has worked for four years at PT. XYZ. The interviews conducted were unstructured interviews. The participatory method is also used in this study, especially in making decisions that involve the role of stakeholders in the company. The company stakeholders participating in the research are operators, supervisors, and managers. The roles of each stakeholder are:

- Operator: as a direct or main source of interviews, fill out the hazop worksheet and provide further explanations about the machine.
- Supervisor: as a discussion mentor for field conditions, validating the results of worker interviews, and providing likelihood and severity scores.
- Manager: as a discussion mentor for field conditions and providing recommendations for improvement, because the manager knows the resources he has in the department he manages.

The data that has been collected will be processed so that a descriptive result will be obtained. The analysis aims to determine the ranking of jobs that have the highest to lowest risk so that they can arrange the necessary improvements. Preparation of improvement methods using a control hierarchy involving the company. In preparing the recommendations, the company is asked to provide input on whether the proposed improvements can be implemented or need to be reviewed.
The research materials used in this study are as follows:

- Open interviews to collect data in the form of machine performance, risks that may occur, physical conditions in the field such as noise and room temperature.
- HAZOP Worksheet to identify risks and conduct hazard assessments.
- UNSW Health and Safety 2016 as a reference in providing a risk assessment.

Data processing is carried out based on data that has been previously collected in the HAZOP study and refers to the International IEC Standard 61882. The HAZOP procedure has 4 stages, namely definition, preparation, examination, as well as documentation and follow-up. The implementation of

the HAZOP method starts from understanding the sequence of the production process, identifying potential hazards, completing the criteria in the HAZOP worksheet, ranking potentials by considering likelihood and consequences and making a risk matrix.

3. Results and Discussion

To identify any potential hazards contained in the production process of PT. XYZ, it is necessary to know the flow of the production process. The yarn production process of PT.XYZ Spinning Department is as follows: (1) Selection of raw materials to be used in the production process; (2) Mixing raw materials (from the same vendor) to reduce the unevenness of the yarn produced; (3) Blowing to distribute the raw material to the next process; (4) Carding to align the fibers to be made into yarn; (5) Drawing Breaker to align and add duplicates to the sliver; (6) Drawing Finisher to produce more even and parallel sliver; (7) Speed Frame to twist the sliver and result roving; (8) Ring Spinning to give the roving a twist until the yarn size (Ne) is in accordance with the desired yarn number; (9) Winding to roll the yarn in a cone and (10) Packing to pack the cones produced into cardboard and then stored in the finished product storage room. After that, direct field observations and interviews with trusted sources were carried out to obtain hazard findings. After that, ranking is carried out by taking into account the criteria for severity or risk ranking as follows:

- Likelihood (L) is the probability of an accident (table 1).
- Severity or Consequences (C) is the severity of injuries and lost working days (table 2)

Table 1. Likelihood Criteria.

Level	Likelihood Rate	Information
5	Almost Sure	More than 1 time per month
4	Most likely	More than 1 time per year to 1 time per month
3	Possible	1 time per 5 years to 1 time per year
2	Small chance	Happens once per 10 years
1	Seldom	Less than 1 time per 10 years

Table 2. Criteria Consequences.

Level	Likelihood Rate	Information
1	Not significant	Injury does not require first aid
2	Small	First aid needed
3	Medium	Medical treatment required
4	Heavy	Need to go to hospital
5	Disaster	Death, permanent disability

After determining the likelihood and consequences of each potential hazard, the next step is to multiply the likelihood and consequences values so that the risk level is obtained in the risk matrix which will be used in ranking the potential hazard sources that will be used as a reference. as a recommendation for improvement in accordance with the existing problems. The risk assessment itself is carried out using a risk matrix as shown in Table 3. From the risk matrix, it can then be calculated risk scores and priorities for taking corrective actions. Based on analysis and processing data, following results which could taken:

- High risk, namely in some work areas, including on *carding machines*, *ring spinning*, *speedframes*.
- Risk medium occur on two area work that ison draw *frame* and *winding*.
- And for risk low occur on machine *blowing*.

Table 3. Risk Matrix (UNSW Health and Safety, 2016).

Scale		Consequences				
		1	2	3	4	5
Likelihood	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

According to the risk matrix guidelines of PT. XYZ, the limit of the acceptable area is at the moderate level and the risk in the HAZOP result is the highest risk is extreme. In the attachment, it is known that there are several nodes that have the highest risk, the first is the Carding machine, the second is the Speed frame machine, and the third is the Ring Spinning machine. Based on the ranking, the above three machines will be prioritized for repair. As for the other machines, repairs will still be made but not as prioritized as the three machines above. This data does not directly provide an overview to PT. XYZ to pay attention to the operation process and to mitigate especially the risks that are of extreme value, namely Carding machines, Speed Frames, and Ring Spinning because they have the potential to harm workers if left unchecked. In accordance with the risk matrix guidelines of PT. XYZ risks with extreme to moderate levels of short-term risk mitigation plans must be approved by the line manager/equivalent.

Based on the results of the risk assessment, the highest deviation was caused by human factors with a percentage of 69%. These human factors are caused by the workers themselves who do not comply with regulations or lack of awareness of occupational safety and health. Furthermore, the second highest deviation was caused by miscellaneous and high temperature (28-30 Celcius degree) with a percentage of 12.5% and it causes a decrease in the level of worker and results in production defects to work accidents. Previous research on the spinning department has also been conducted at PT. Apac Core Corpora. Based on this research, the highest risk is based on the work environment and employee attitudes, while the lowest risk comes from OHC. The work environment and worker attitudes lead to the human factor. This is directly proportional to the research conducted by PT. XYZ, where the biggest risk occurs in the carding machine, namely pinched hands because workers do not use PPE in the form of sticks. It can be concluded that the main cause of extreme risk in the textile industry, both at PT. XYZ and PT. Apac Inti Corpora originates from the same thing, namely the human factor [18].

Based on the inspection process, the potential hazards that have been summarized in the HAZOP worksheet have their respective risk levels. This risk level will be translated into risk categories according to the risk matrix guidelines. Based on these guidelines, the classification of risk levels in the HAZOP study as follows: low (2 risks), medium (5 risks), high (8 risks) and extreme (2 risks). Each of these levels requires different actions. At a “low” level, it means that the area is still generally accepted where risk management is continuously embedded in the company's operations and there are no recorded incidents. Risk mitigation that is made must obtain approval from the highest field leader/supervisor/site controller. The “medium” risk level indicates the area is tolerable where short-term risk mitigation must be made appropriately with the approval of the line/equivalent manager to manage the risk. A “high” risk level indicates the danger is intolerable. A series of long-term and short-term risk mitigation plans must be carried out immediately to reduce risks with certain requirements, namely postponing work until the risk mitigation plan is carried out and the risk becomes medium, the short-term risk program must be approved by the HSE and the long-term mitigation plan is implemented and monitored. The "extreme" risk level is almost the same as the high risk level, except that continuing work and short-term risk program plans must be approved by HSE.

Recommendations are generated from evaluations related to deviations and causes that have the potential to occur. The focus of the recommendations is to complete safeguards in the form of instruments, operating procedures, mechanical tools, and static equipment. This recommendation is

expected to help the risk management program, especially in the carding area. It is known beforehand that there is a risk that has a high value at the extreme risk level with a value of 16. This needs to be given attention because if there is no proper mitigation or action, it can cause more victims. The list of recommendations made is not only related to the installation of safety instruments, but also preventive actions on certain tools or equipment. Recommendations for improvement are made based on the control hierarchy starting from elimination to the use of personal protective equipment. The next stage is filling out the HAZOP worksheet which contains information on deviation, causes, consequences, risk level, and recommendation (Table 4).

4. Conclusion and further study

The HAZOP study conducted in the Spinning Department area resulted in the fact that the sources of hazards and risks came from human factors and equipment or machines where the main focus of improvement was based on the top 3 hazard rankings according to the results of the risk assessment. The equipment is Carding, Ring Spinning, and Speed frame. The highest risk level found in the HAZOP study falls into the high category with the highest risk, namely the Carding machine and short-term risk mitigation must be approved by the line manager/equivalent. The priority recommendations for repairs on the Carding machine are providing a protective cover for the cotton roller gear, making a double safety lock on the machine cover, and making a bypass for the emergency button.

Some of the further study material that can be done is to revalidate HAZOP with a period of 2 to 4 years to update the potential hazards and risks that exist in production activities for the Carding machine area and in general for all facilities in the Spinning Department, follow up on mitigation plans risks, both short and long term (such as installation of engineering controls and preparation of SOPs) based on the list of recommendations that have been attached, taking into account company factors (costs, resources, etc.) in the research.

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Table 4. HAZOP Worksheet

No	Node	Guideword	Deviation	Causes	Consequences	Safeguard	L	C	RR
1	Raw material	HumanFactors	Humanfactors	Moveraw materials heavy with tool manual	fatigue, injury muscle	No	4	2	8 (high)
			Humanfactors	Stack raw material which tall	hit by rawmaterial	No	3	2	6 (medium)
			Humanfactors	Workers don't usePPE: shoe	unprotected in accident	No	3	3	9 (high)
2	Mixing	High	Human factors	Worker does not use PPE: mask	congested breath	Mask	3	2	6 (medium)
			High temperature	Air stuffy	Decrease concentration	No	5	2	10 (high)
			Humanfactors	Cleanwaste cotton without use PPE: shoe and mask	slipped andcongested breath	Mask	2	3	6 (medium)
3	Blowing	-	-	Automatic	-	-			
4	Carding	Human Factors	Human factors	Taking waste in the machine without using PPE: stick	Machine run over	Sticks (PPE)	4	4	16 (extreme)
				Workers don't use PPE: mask	Cause shortness of breath	Mask	3	3	9 (high)
				Night shift workers lack of concentration	Lack of focus increases risk accident	Arrangement of lighting	3	3	9 (high)
5	Drawing	Human Factors	Human factors	Workers don't use PPE: mask	Cause shortness of breath	Mask	3	2	6 (medium)
6	Speedframes	More	More speed	The engine speed is fast and sometimes the cover doesn't close	Fingers or hands can get caught in the machine	Protective cover	3	4	12 (extreme)
			Miscellaneous	Noisy work environment	Hearing diminished and lowered working comfort	The engine area has been given a silencer	5	2	10 (high)
			Human factors	Workers not wearing PPE: masks and earplugs	Impaired breathing and hearing	Mask	3	2	6 (medium)

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7	Ring spinning	High	Human factors	Workers not wearing PPE: masks and earplugs	Impaired breathing and hearing	Mask	2	2	4 (low)
			High temperature	Stuffy work environment	Concentration less workers	No	5	2	10 (high)
			Miscellaneous	engine sound noisy	Convenience interrupted work	Machine area has been dampened	5	2	10 (high)
8	Winding	Human Factors	Human factors	Workers do not use PPE: mask	Breathing can disturbed	The company provides mask	2	2	4 (low)

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9