Analysis of occupational health and safety at skin cracker factory using Hazard and Operability Study (HAZOP)

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ARTICLE INFO	ABSTRACT
	The Mubarok Skin Cracker Factory is a home industry that produces skin crackers from cowhide, raw, and cooked crackers. Based on the interviews with factory owners, there have been several work accidents, and the production room has very minimal lighting and air ventilation. Based on these problems, the method used is the Hazard and Operability Study (HAZOP), which aims to identify sources of hazards and potential work accidents in the production process to prevent work accidents. The risk matrix analysis shows as much as 24% of the risk is classified as extreme, 65% is classified as high risk, and 12% is classified as moderate risk. In addition, 17 sources of danger were found, namely knives, slippery floors, smoke, hot water, drying roofs, fire, smoke, hot water, ash flakes, hot tanks, wooden board, chopper, loads carried by workers, ovens, hot oil, hot frying pan, hanging boards, and cramped workplaces. The recommendations given by the researcher are to apply health and safety environment regulations and use PPE (Personal Protective Equipment) for employees while working, replace damaged equipment, and implement health promotion in factories.

1. Introduction

All work activities have a potential hazard. Failure to recognize and control potential risks can lead to fatigue, musculoskeletal problems, injury and even workplace accidents. According to BPJamsostek, from January to June 2020, workers' compensation claims increased by 128% in the first half of 2020. This number increased from 85,109 to 108,573. In fact, according to the International Labor Organization (ILO), there are more than 250 million work accidents that occur each year and cause 160 million workers to fall ill [1]. In addition, there were also deaths experienced by workers and caused by accidents at work and occupational diseases, which amounted to 1.2 million workers [2]. From these data, we can conclude that the high number of work accidents worldwide can endanger workers.

The occurrence of work accidents will also worsen the company's image, affecting perceptions in the eyes of customers, media and other employees [3]. Therefore, it is necessary to control potential hazards in the work area by identifying them [4]. After successfully diagnosing the hazards present, we should assess workers' risk levels. This way, unexpected industrial accidents can be prevented [5], [6]. All parties, from management to the lowest level, must participate to ensure occupational safety and health. The description of workers' behaviour towards implementing health and safety environment rules and procedures is an example of workers' attitudes and perceptions regarding work safety so that it becomes a primary safety culture in the work environment [7]. Work accidents occur in large and small-medium enterprises (SMEs) and are riskier. ILO said that the problems in SMEs in

Indonesia include lack of records, spatial problems, lack of concern for health and safety environment (HSE) and others [8].

One of the SMEs in Indonesia is the Mubarok Skin Cracker Factory. This factory has been managed by a family for generations and has been operating for approximately 35 years. To survive and compete with other crackers, the Mubarok cracker factory needs to improve quality and reduce costs, one of which is the introduction of HSE into production. In addition, they want their workers to stay productive by working safely, comfortably and safely.

The results from direct field observations found that HSE implementation was not managed properly at the factory. As a result, several accidents have occurred, such as a worker's hand bled by a knife while cleaning the cowhide before it was boiled. In addition, workers who work in non-ergonomic and repetitive positions can cause fatigue and musculoskeletal disorders, such as peeling, boiling, and frying steps. The condition of the production room that lacks lighting and air ventilation is also a potential hazard that needs to be realized. Many potential sources can pose a danger to workers they are unaware of, leading to work accidents and occupational diseases. Therefore, risk management activities are needed to reduce or eliminate factors that can potentially cause accidents in the workplace, such as identification of risk factors, analysis of potential risks, risk assessment, risk management, monitoring, and evaluation.

Based on those mentioned above, analyzing the production process's potential risks to health and work safety at the Mubarok Skin Cracker Factory workplace is necessary. The owner also needs to identify different factors systematically, including causes, incidents, and negative consequences of deviations from OHS procedures, in order to reduce the impact of hazards that have the potential to be identified using the

Hazard and Operability Study (HAZOP) method, as previously conducted by Mindhayani at a snack cracker home industry in Bantul [9], Anggraini at a fabrication company in Pekanbaru [10], and Anwar et al. at a state-owned water company [11].

HAZOP is a helpful method for identifying potential hazards in the workplace. Several authors have successfully implemented HAZOP in their research. The studies about automated hazards were performed separately by [12], [13]. They found that automated hazard is effective in being implemented in the workplace, and they can increase productivity. Feng et al. used artificial intelligence to make the HAZOP report [14]. They implemented their method in the chemical industry.

A fuzzy multi-attribute HAZOP method was proposed to identify the hazard on a gas wellhead shop floor [15]. First, the importance of risk factors and hazard priority was determined using Analytic Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Next, HAZOP and fault tree analysis (FTA) were used to analyse the risk of loading and unloading chemical substances [16]. Finally, fuzzy-AHP and HAZOP were used to identify the hazard in the process industry [17], [18].

The discussion above shows that HAZOP is applied in many industries. Furthermore, HAZOP is flexible because it can be combined with other techniques to identify hazards and calculate risk. Therefore, this research uses HAZOP as a well-suited Mubarok Skin Care Factory technique. This research aims to identify hazards in skin care production, calculate risk, and give some recommendations to the factory's owner. The result of this research can be used as feedback for the owner regarding its factory's health and safety environment.

2. Literature review

2.1. Definition of Hazard and Operability (HAZOP)

According to [19], HAZOP is a routine hazard analysis method to prepare safety definitions in new or modified systems for potential hazards or performance problems. In addition, the HAZOP method is a hazard identification method that provides systematic and structured results for identifying hazards contained in equipment that can present various problems that interfere with processes and hazards that can endanger people or objects in the system. According to [20], HAZOP aims to identify hazards that arise in management facilities and eliminate the primary source of accidents. According to [21], HAZOP study is a disciplined procedure to identify how a process can deviate from its design conditions. The application comes from a systematic critical review of process and engineering conditions to evaluate the potential for malfunctioning individual parts and equipment and indirect effects on the facility [22].

The following are terms used to simplify the implementation of HAZOP:

a. Something that happens and where it happens in a process.

b. Discovery of the sources of danger in the field
c. Any form of any possible deviation that may pose a risk.
d. The possibility of occurrence causes deviations.
e. The system must accept the results of deviations.
f. There are two categories of actions to reduce or eliminate consequences.
g. Efforts are made only when necessary to eliminate the cause and reduce the effect. Severity is the severity that can occur.
h. Likelihood or probability estimates the occurrence of an impact on a security system.
i. The magnitude of the risk comes from a combination of probability, probability, and severity.

2.2. Hazard identification

There are several steps to identify hazards using the HAZOP worksheet and risk assessment, which are as follows:

a. The activity sequence, including its composition, must be known.
b. In the research area, all existing hazards can be identified immediately.
c. Sort the criteria listed in the HAZOP worksheet, namely:
- Hazards found can be classified by source and frequency of occurrence.
- Deviations are described during the ongoing operation process activities.
- The cause of the discrepancy needs to be explained.
- The results based on existing deviations need to be explained.
- Temporary measures can be established within a short period.
- Assess the risk of outcomes (consequences) by describing the likelihood (likelihood) and outcome criteria.
- Use the HAZOP worksheet to rank the identified risks and calculate their likelihood and consequences. Also, use the risk matrix to prioritize the risks that need to be improved.
- If a risk is found at the '"Extreme" level, it is better to make improvements as recommendations in the system.

Table 1 shows the criteria likelihood of the hazard occurring, whereas Table 2 shows the criteria consequences and severity. Both tables are used to identify the hazard.

3. Methodology

This research was conducted at the Mubarok Skin Cracker Factory. This study applies data analysis techniques with quantitative and qualitative descriptive research approaches. In quantitative descriptive research, the HAZOP method is used to calculate the frequency of accidents for each hazard, the severity of an accident, and the level of risk. In this study, primary data were obtained from direct observation of the research site and the results of interviews with the owners and workers of the Mubarok Skin Cracker Factory.

Table 1.
Criteria of likelihood

Level	Criteria	Description	
		Qualitative	Quantitative
1	Rare	Thinkable but not only in extreme circumstances	Less than 1 time/ 10 years
2	Unlikely	Hasn't happened yet but could appear/happen at some time	Happens once/10 years
3	Possible	It should have happened and may have happened/appeared here or somewhere else	1 time/years to 1 time/year
4	Likely	Can happen easily, may appear in the most circumstances	More than 1 time/year to 1 time/month
5	Almost certain	Occurs frequently, is expected to appear in the most frequent circumstances	More than 1 time/month

Table 2.
Criteria of consequences and severity

Level	Description	Injury severity	Working days
1	Insignificant	Events do not cause harm to humans	Do not cause loss of work
2	Minor	Causing minor injuries, small losses, and not causing an impact on business continuity	Still able to work on the same day
3	Moderate	Severe injuries and being treated at the hospital do not cause permanent disability and moderate financial losses	Can lose working days under three days
4	Major	Cause severe injury and permanent disability and large financial losses and can have a serious impact on business continuity	Loss of workdays 3 days or more
5	Catastrophic	Can result in large casualties and financial losses	Lost workdays forever

Table 3.
Production process data

No	Process	Source of hazard	Risk
1	Cutting the large cowhide into 4 parts	Knive	Sliced
2	Boiling water for brewing	Fire, smoke, hot water, ash flakes, hot tanks, slippery floors	Burnt, respiratory distress, eye irritation, Skin blisters, slipped
3	Exfoliating the skin from the fur by brewing it using boiled water	Hot tank, hot water	Skin blisters
4	Cutting the skin to make sure the fur on the cowhide comes off	Knive	Sliced
5	Boiling the skin in the tank	Fire, smoke, hot water, ash flakes, hot tanks, slippery floors	Burnt, respiratory distress, eye irritation, Skin blisters, slipped
6	Scraping the skin on the scraping board	Wooden board, knive	Hit by the board, sliced
7	Drying skin	Hanging board, sharp hanging iron	Hit by the hanging board, torn palm
8	Cleaning the dry skin	Knive	Sliced
9	Chop the skin into cubes	Chopper	Sliced, finger cut
10	Drying the chopped skin	Ladders, carried load, drying area (roof), oven	Slipped, musculoskeletal disorders, tetanus, skin blisters
11	Semi-frying skin that has been dried in the sun	Hot oil, hot frying pan	Blistered skin
12	Salting the skin after semi frying	Hot oil, hot frying pan	Blistered skin
13	Frying the skin that has been soaked with spices	Smoke, hot oil, hot frying pan	Eye irritation, blistered skin
14	Packing skin crackers	Narrow place	Stumbled, bumped

Table 4.
Risk calculation

Source of hazard	L	C	L x C	Risk Level
Knive	4	4	16	Extreme
Fire	2	4	8	High risk
Smoke	4	3	12	High risk
Hot water	4	3	12	High risk
Ash flakes	3	3	9	High risk
Hot tank	3	3	9	High risk
Slippery floors	3	5	15	Extreme
Wooden board	5	2	10	High risk
Hanging board	2	3	6	Moderate risk
Chopper	4	3	12	High risk
Ladders	3	4	12	Extreme
Carried load	3	3	9	High risk
Drying area (roof)	3	4	12	Extreme
Oven	3	3	9	High risk
Hot oil	3	3	9	High risk
hot frying pan	4	3	12	High risk
Narrow place	3	2	6	Moderate risk

The process of making skin crackers is selected as primary source data. The process consists of: cutting the large portion of skin into four parts, boiling water for the brewing process, exfoliating the skin from the feathers through the brewing process, slicing the skin to remove hair, boiling the skin, dredging the skin, drying the skin, cleaning the skin, chopping the skin into cubes, drying the skin, semi-frying the skin, salting the skin, frying the skin, and packaging. At the data processing stage, risks and sources of danger are identified from each skin cracker production process. Then the likelihood and consequences are calculated so that the risk matrix value is obtained and the risk level can be determined from each previously identified hazard source.

4. Result and discussion

4.1. Data collection and processing

Data were collected by observation and interviews. The flow of the skin cracker production process and the work

environment at the research site are known by observation. Meanwhile, from the interview results, the factory's production process and work accidents are discovered. The data of the source of hazard in production process is shown in Table 3. After collecting the required data on process flow for the skin cracker production, the next step is to process the data by calculating the likelihood, consequences, and risk matrix values. Based on the calculated likelihood (L) and Consequences (C) values, a risk matrix is obtained, as shown in Table 4.

4.2. Analysis

Data from Table 3 are summarized in Fig. 1. We can see that the risk is classified as almost frequent (level 1) by 6% or 1 of 17 sources of hazard, namely wooden boards. Therefore, the risk is classified as possible (level 2) by 53% or 9 of 17 sources of hazard, namely ash flakes, hot tanks, slippery floors, ladders, loads carried, drying areas (roof), ovens, hot oil, and narrow places. The risk is classified as the low probability (level 3) occurring by 12% or 2 of 17 sources of hazard, namely fire and hanging boards. Finally, the risk is classified as most likely to occur (level 4) by 29% or 5 of 17 sources of hazard, namely knives, smoke, hot water, chopping utensils, and hot frying pan.
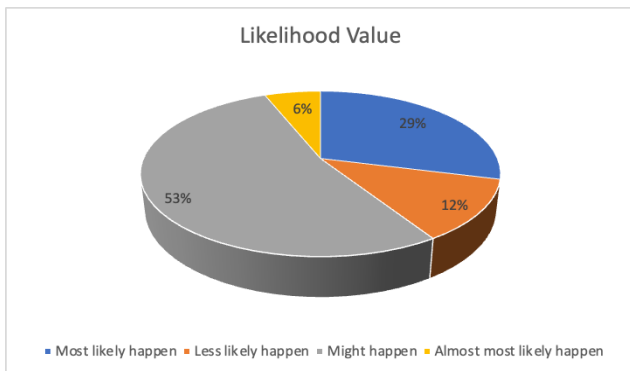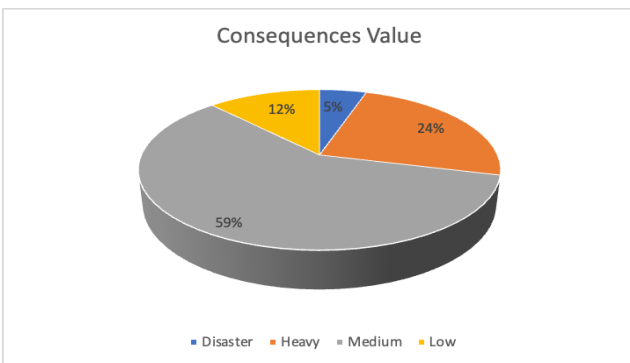

Figure 1. The summary of likelihood

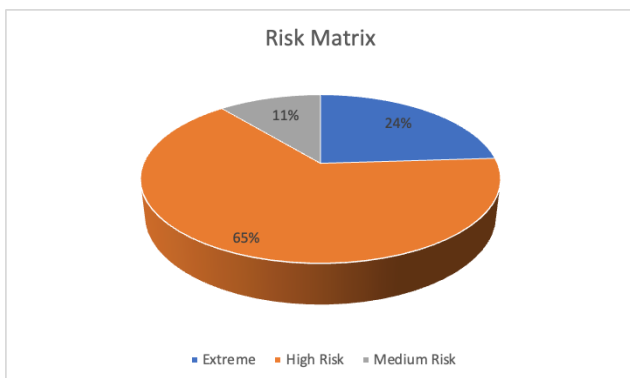

Figure 2. The summary of consequences

Figure 3. The summary of risk matrix

Fig. 2 shows the summary of the consequences. Based on Fig. 2, we can see that the risk is classified as a disaster (level 4) by 6% or 1 of 17 sources of hazard, namely slippery floors. The risk is classified as severe (level 3) by 24% or 4 of 17 sources of hazard, namely knives, fire, ladders, and dryers. The risk is classified as moderate (level 2) by 59% or 10 of 17 sources of hazard, namely smoke, hot water, ash flakes, hot tanks, hanging boards, choppers, carried loads, ovens, hot oil, and hot frying pan. Finally, the risk is classified as small (level 1) of 12% or 2 of 17 sources of hazard, namely wooden boards and narrow places.

Lastly, Fig. 3 shows the summary of the risk matrix. Based on the diagram above, it can be seen that the risk is classified as extreme by 24% or 4 of 17 sources of hazard, namely knives, slippery floors, ladders, and dryers (roof). The risk is classified as high risk of 65% or 11 of the 17 sources of hazard, namely fire, smoke, hot water, ash flakes, hot tanks, wooden boards, choppers, carried loads, ovens, hot oil, and hot frying pan. Finally, the risk is classified as a moderate risk at 11% or 2 of 17 sources of hazard, namely hanging boards and narrow places.

4.3. Managerial implications

From the analysis results, it is necessary to make some improvements at the Mubarok cracker factory, such as promoting a health and safety environment culture. According to [23], accident prevention is fundamental for the business world because it impacts workers and the workplace that causes accidents. Therefore, promoting occupational health and safety among workers, employers, and society is crucial for the company. Promoting it can reduce accidents, reduce work stress, increase productivity, reduce employee turnover, reduce accident-related medical costs for workers, and increase profits and reputation. The following are the steps and strategies proposed by the company to implement Health Promotion.

Figure 4. Display of "Beware of slipping"

Figure 5. Display of "Hot Surface Do Not Touch"

Figure 6. Display of "Beware of Hot Liquids"

Figure 7. Display of "Use Safety Shoes"

Figure 8. Display of "Danger of Sharps"

Figure 9. Display of "Beware of Stumbling"

Firstly, the company needs to provide several visual displays for workers where hazards are likely to occur. For example, Fig. 4-7 display the warning sign at the workstation of boiling water for brewing, boiling the skin in a tank, drying the skin in the oven, semi-frying the dried skin, salting the skin after semi-frying, and frying the skin that has been soaked with spices. Fig. 8 shows the display on the workstation of cutting the skin, scraping the skin, cleaning the dried, and chopping the skin. Lastly, Fig. 9 shows the display on the workstation of drying the skin on the roof and packing the skin crackers. Secondly, the company should provide OHS education and training to workers to grow and improve individual knowledge, willingness, and ability to prevent disease, improve health, create a healthy environment, and play an active role in implementing any health efforts. Lastly, the company must provide a first aid kit (First Aid in Accidents).

5. Conclusions

The following conclusions were obtained based on research and discussion on analysing occupational safety and health risks using the HAZOP approach to workers at the Mubarok Skin Cracker Factory. There are 17 types of sources of danger from equipment or the work environment that may cause work accidents. The sources include knives, fire, smoke, hot water, ash flakes, hot tanks, slippery floors, wooden boards, hanging boards, choppers, ladders, loads carried, drying areas (roof), ovens, hot oil, hot frying pan, and narrow workplace. Based on the HAZOP method's hazard analysis, we can conclude that

work equipment and environments such as knives, slippery floors, ladders and drying places (roofs) have a risk ranking classified as extreme. The sources of danger from fire, smoke, hot water, ash flakes, hot tanks, wooden boards, choppers, carried loads, ovens, hot oil and hot frying pan are included in the high-risk category. Other sources of danger, namely wooden boards and a narrow workplace, are included in the moderate or moderate risk category.

Acknowledgement

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