HAZARD IDENTIFICATION AND RISK CONTROL IN ROTARY KILN WITHIN THE CEMENT MANUFACTURING COMPANY

Afrigh Fajar Rosyidiin[1], Moses Laksono Singgih[2] and Patdono Suwignjo[3]
Department of Industrial and Systems Engineering
Institut Teknologi Sepuluh Nopember
Surabaya 60111 Indonesia,
E-mail: afrighfajar7@gmail.com[1], moseslsinggih@ie.its.ac.id[2], patdono@ie.its.ac.id[3]

ABSTRACT

This paper presents the situation of a cement manufacturing sector company. The company has implemented work safety regulations and programs, but the problem of work accidents will always be an unexpected threat. Several aspects of work accidents occur due to unsafe actions and unsafe conditions. A rotary kiln is an area that has a high potential for danger because the process requires high temperatures, chemical reactions, and rotating machines. So in this study carried out identification of hazards and risks that occur and repaired work problems using Hazid Methodology. Used hierarchy of control to provide proposals for risks with a very high level, While the risk matrix determines the risk level mapping. Hazard identification is carried out using Electrical, Mechanical, Physical, Chemical, Biological, Ergonomic, Psychosocial, Environmental hazards, Natural phenomena, Locative. The results of the hazard identification are 25 hazards and 40 risks. There are 35% very low, 20% low, 35% moderate, 5% high, 5% very high at the risk mapping level. The proposed improvement for two risks with a very high level is Co-processing to replace coal with solid waste and replace clinker with fly ash.

Keywords: Rotary Kiln, Hazid Methodology, Risk Matrix, Hierarchy of Control

1. INTRODUCTION

Occupational safety and health are essential for the company because accidents and occupational diseases harm employees and the company both directly and indirectly. Occupational safety and health is an interdisciplinary field concerned with maintaining the safety, health, and well-being of people involved in a job or the workplace. Safety is associated with the physical condition of both mind and body of everyone in the workplace, including workers, contractors, and visitors, which protects them from harm in the form of injury or illness. Safety is concerned with the physical conditions in the workplace and applies to situations where the risk of harm and damage has been eliminated or reduced to a tolerable level (Khan, 2017). Aspects of work accidents in the industry are 88% of industrial accidents caused by unsafe action, 10% of accidents caused by unsafe conditions, and 2% of accidents caused by other factors (Heinrich, 2009)

The company under study is a company engaged in the cement industry. This company is very concerned about safety by continuously improving safety by creating innovative programs to increase employee and contractor awareness of the importance of workplace safety. Based on the researcher's interview with one of the workers and recent research on cement manufacture, Rotary kiln is an area that has many sources of potential hazards. Among other things, there is a combustion process with temperatures reaching 1500 °C. These potential hazards can cause many losses, including explosions, fires, and leaks that result in injury, physical disability, death toll, environmental damage, psychological impacts, and financial losses (Ewais & Bayoumi, 2018).

The kiln is where the sound intensity exceeds the threshold value of up to 88dB. Prolonged exposure to noise over 85dB NAB can cause physical damage and potentially cause hearing loss. Noise pollution has a detrimental effect on human health and environmental quality. In addition, noise interferes with speech communication which risks reducing performance to some extent (Bolaji et al., 2018). Cement production, more precisely in the Rotary Kiln, is a significant contributor to anthropogenic greenhouse gas (GHG) emissions, and therefore cement in the industry is the primary driver of global warming (Wang et al., 2013). The impacts of greenhouse gas emissions include climate change, formation of photochemical oxidants: ecosystem damage, formation of fine particles, and terrestrial acidification (Tun et al., 2021).

This research aims to improve work safety by identifying the hazards that exist in the research area, mapping the level of risk, and selecting the best work accident prevention mechanism. This study uses the integration of the Hazid Methodology, Risk Matrix, and Hierarchy of Control that can be applied to the company. The combination of several methods from various disciplines is expected to solve the problem.

2. LITERATURE REVIEW

Using most of the references from international journals. The literature review describes the literature that is relevant to a study. The literature review then contains a description of the theory of a research result, findings, and materials in research activities. This can then be used as a theoretical basis when conducting research or compiling scientific papers.

2.1 Rotary Kiln

Rotary Kiln is a device used to burn raw meals into a semi-finished material called clinker. It requires the highest consumer of thermal energy in its operation. This equipment requires a continuous input of fuel to facilitate the chemical reactions required for clinker production (Csernyei & Straatman, 2016). Rotary Kiln has the function of burning so that the fed raw meal reacts to become clinker. In the initial planning for the establishment of a factory, the calculation basis is the kiln capacity, while other equipment is adjusted to the kiln design. Other information about the rotary kiln on the object of research is as follows:

- Capacity : 7800 ton/day
- Length : 84000 mm
- Slope : 4% of the length
- Rotation : 3 rpm
- Power drive: 2 x 600 kW

The Rotary Kiln Production Process is Kiln feed entering the kiln through the end of the kiln and then heated by the heat from burning coal in the burner. Due to the kiln slope, the material will move to the other end of the kiln while continuously being heated and rotated. The kiln is rotated so that there is an even distribution of heat on the kiln wall. The inside of the kiln is lined with refractory bricks to reduce the heat load on the kiln walls and minimize radiation heat loss. The rotary kiln is divided into four zones according to the reaction at the temperature at which the reaction takes place. The zones are

a. Calcination zone at 800 -1200 °C
b. Transition zone at 1200 -1400 °C
c. Clinkerization zone at 1400 -1520 °C
d. Cooling zone at temperature 1520 -1290 °C

2.2 Hazid Methodology

Hazid Methodology is a systematic analysis that is critically analyzed by a team in which the operations and processes that are running are assessed to be able to find out the potential dangers of maloperation or malfunction of one tool of equipment and the consequences that arise as a whole (Rivera Domínguez et al., 2021). This method serves to identify hazards that may occur in the workplace. Identify specific hazards with several aspects, namely sources, environmental, physical, and mental overload, surrounding, natural and locative, storage, and administrative. Hazard identification will be carried out in several areas within the company's location.

2.3 Risk Matrix

Risk Matrix is a semi-quantitative assessment tool used to categorize an event risk that decides whether a particular risk is acceptable based on historical statistical data (Duijm, 2015). A risk matrix in mapping risk levels is used to determine and calculate between severity and probability (Luo et al., 2018). Table 2.1 is a risk matrix for determining risk level mapping.

Table 2.1 Risk Matrix

Probability	**A**	**Frequent**	Low	Medium	High	Very High	Very High
	B	**Probable**	Very Low	Low	Medium	High	Very High
	C	**Occasional**	Very Low	Low	Medium	High	High
	D	**Remote**	Very Low	Low	Low	Medium	High
	E	**Improbable**	Very Low	Very Low	Low	Medium	Medium
			1	**2**	**3**	**4**	**5**
			Negligible	**Minor**	**Moderate**	**Major**	**Catastrophic**
			Impact Severity				

Table 2.2 Colour Code Description

Colour	Risk Description	Risk Qualitative Description
Red	Intolerable	Risk must be mitigated; either decrease the probability or relieve consequence
Orange	Unwanted	Unwanted and only accepted when risk reduction is impracticable
Yellow	Tolerable with Control	Acceptable after review and safety measures imposed
Light Green	Reasonable tolerable	Risk reduction is not needed
Dark Green	Tolerable	The risk could be neglected

2.4 Hierarchy Of Control

Risk control is an activity carried out sequentially so that the existing risks are reduced by using a hierarchy. Hierarchy of Control is a sequence in the prevention and control of risks that may arise, consisting of several levels in sequence (Ramadhan, 2017). The following is a sequence of controls according to the Hierarchy of Control.

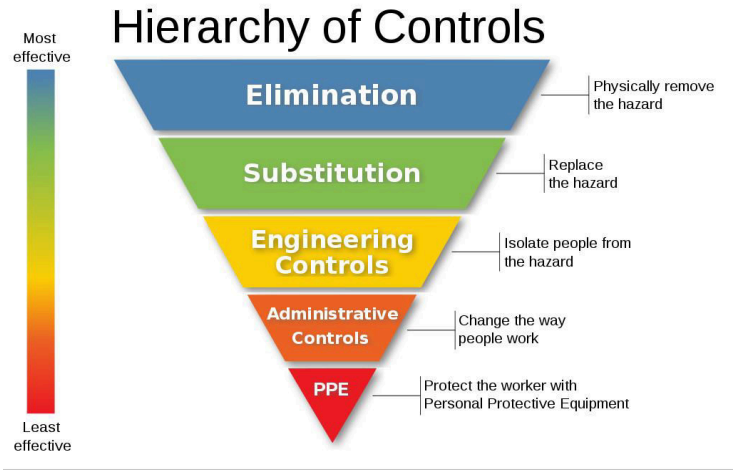

Figure 2.1 The Hierarchy of Control

3. METHODS

The first process that must be carried out in this research is Hazard Identification. In the Hazard Identification Process, researchers use the Hazid Methodology to identify hazards that may occur in the workplace. Identify hazards with several aspects: sources, environmental, physical, and mental overload, surrounding, natural and locative, storage, and administrative.

The following process, namely Risk Assessment, is by conducting risk assessments and mapping according to safety or the impact received on the environment. This risk assessment uses a risk matrix; the steps taken are to determine and calculate between severity and probability. The risk assessment results with a very high-risk level will be given control.

Risk Control is the last process in this research. Risk control will produce output in the form of risk mitigation. The approach used for risk control is the Hierarchy of Control. The results of the previous stage will be analyzed and given improvements based on 5 control hierarchies, namely elimination, substitution, planning, administration, and personal protective equipment.

4. RESULTS

This section presents the results of the research in this paper. The stages for this research are Hazard Identification, Risk Analysis, and Risk Control. The approach used has been described in the previous section.

4.1 Hazard Identification

The first stage in this research is hazard identification. Identification starts from determining the research area and then analyzing the potential hazards contained in that area. The last step is to determine the risk of potential hazards. The risk will be obtained from 10 hazard categories in the Rotary kiln area. Table 4.1 and Table 4.2 below are the results of hazard identification using the Hazid Methodology.

Table 4.1 Hazard Identification Results in Rotary Kiln with Hazid Methodology

Business name: **Cement**	Diagnosis: **Area**	Date: **November 8, 2021**
Area Identification : **Rotary Kiln**	Number of workers: **8**	Economic activity: **Cement Production**
Hazard Category	**Danger (potential source of damage)**	**Risk (consequence of damage)**
Electrical	Electric current	Electrocution resulting in injuries to workers and death
		Explosions that damage equipment and facilities
		Fires that cause financial losses
Mechanical	Kiln Machine	Exposure to the heat of the kiln engine causes blisters on the hands
		Hot dust from the manhole or leaking equipment
		Wedged the rotating kiln machine
		Material or equipment fall
		Collision due to getting pressure from a leaky manhole or equipment
	Apron Conveyor	Pinched hands during the repair
		Scratched by rotating objects during inspection and repair activities
	Hoist Crane	Material transported fall
		Squeezed and scratched by transported material
		Hit by the swing of transported material
Physical	Temperature	skin irritation, blisters, and loss of concentration
	Noise	Noise that can cause hearing loss and headaches
	Radioactive Radiation	Cause genetic disorders and cancer
Chemical	Clinker Dust	Pneumoconiosis, eye & skin irritation, and cancer
	Combustion Emission	Air pollution causes the Greenhouse Effect
	Poison gas	Toxic gas in a confined space that causes suffocation, unconsciousness, and death
	Hot Gas	burns, redness of the skin, blisters
Biological	Bacteria/virus	Decreased immunity and contracting various diseases
	Snake	The snake enters the panel causing damage etc
		Disturbing the comfort of workers
Ergonomic	Workplace design	Falls from heights and limb injuries
		Inhibiting activities
	Work Position	Injuries to limbs
		Struck by material or tools
Psychosocial	Workload	Work results are not optimal and stressful.
	Worker conflict	The team is not solid, causing the work to be unfinished and stressful.
	Career path	Tired and lazy at work
	Personal problems	Negligence at work due to lack of concentration

Table 4.2 Hazard Identification Results in Rotary Kiln with Hazid Methodology (Continuance)

Business name: **Cement**	Diagnosis: **Area**	Date: **November 8, 2021**
Area Identification: **Rotary Kiln**	Number of workers: **8**	Economic activity: **Cement Production**

Hazard Category	Hazard (potential source of damage)	Risk (consequence of damage)
Surrounding Danger	Material from the cyclone to air	Air quality is declining
		Respiratory disorders
Natural Phenomena	Earthquake	Damage equipment and facilities
	Rain	Corrosion on equipment
	Lightning	Reduced functionality of the equipment
	Tsunami	Fire due to the lightning strike
Locative	Smooth Work Floor	Slip
		Falling from a height
	Scattered tools	Stumble

4.2 Risk Assessment

Risk assessment uses a tool, namely the risk matrix. The steps taken are to determine and calculate between severity and probability. After that, a risk level mapping will be carried out according to the risk assessment results. Figure 4.1 is the percentage of risk level mapping in the Rotary Kiln area.

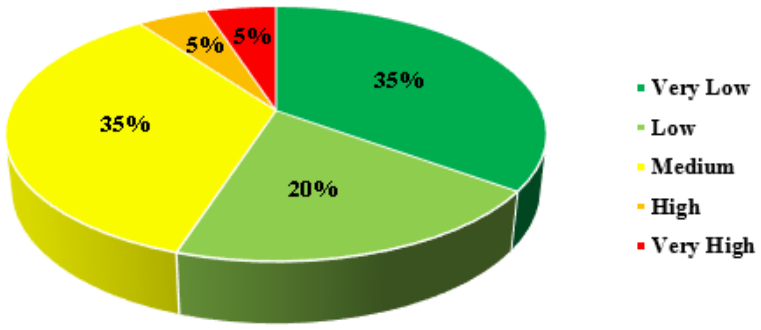

Figure 4.1 Percentage of risk assessment of kiln area

Risks that get a very high level will be suggested improvement. The following are risks that get a very high level:

Table 4.3 Risiko yang memiliki level very high

No	Danger	Risk	Level
1	Combustion Emission	Air pollution causes the Greenhouse Effect	Very High
2	Clinker Dust	Pneumoconiosis, eye & skin irritation, and cancer	Very High

4.3 Risk Control

Risk control is given to reduce or prevent potential hazards that cause losses to the company. Two risks will be given control because it has a very high level. The following is given risk control and a description of the reasons and benefits of the proposed improvement.

- **Combustion Emission**

The proposed improvement is given to prevent the risk of air pollution that causes the greenhouse effect by using **Co-processing as a substitute for coal fuel with municipal or industrial waste**. This risk control uses a Substitution from the Hierarchy of Control because the leading cause of this risk is coal. So that the replacement of coal can certainly reduce air pollution that causes the greenhouse effect, the advantage that the company can get financially is that the company will get compensation from a customer or company which will dispose of the waste, and the replacement of coal will reduce the company's expenses.

- **Clinker Dust**

The manufacture of clinker requires materials that harm health. Besides that, the manufacturing process is also long. Workers exposed to clinker dust can infect Pneumoconiosis, eye irritation, skin irritation, and cancer. The control will be given by **Replacing clinker with fly ash from power plant waste**. The proposed improvements include the substitution from the Hierarchy of Control. Fly ash can replace clinker as the main ingredient for making cement with an appropriate composition. From this material replacement, the company reduced production costs because the long process of making clinker was no longer carried out. In addition, the suggestions given can prevent workers from being exposed to clinker dust which causes adverse health effects.

5. CONCLUSIONS

Work safety regulations and programs at the company have been implemented, but the problem of work accidents will always be an unexpected threat. Therefore, it is necessary to continuously improve safety by making program innovations to prevent accidents and increase employee and contractor awareness of the importance of workplace safety. This study will integrate several methods: hazid methodology, risk matrix, and control hierarchy. The integration is expected to reduce or prevent the impact of potential hazards in the Rotary kiln area. The results of this research are that hazard identification is 25 hazards and 40 risks. There are 35% very low, 20% low, 35% moderate, 5% high, 5% very high at the risk mapping level. The proposed improvement for two risks with a very high level is Co-processing to replace coal with solid waste and replace clinker with fly ash. In addition, periodic maintenance must be carried out to prevent damage to the machine, which adversely impacts the company. The proposed improvements are expected to reduce greenhouse gases released into the atmosphere and prevent respiratory diseases caused by clinker dust.

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