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Hazard Risk Assessment in Post Weld Heat Treatment Process Using the Fine-Kinney Method

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A B S T R A C T

Hazards in the workplace are sources that have the potential to cause work accidents that can harm workers, therefore it is important to carry out a hazard risk assessment as an effort to eliminate or reduce the risk of hazards in the workplace to protect workers. The purpose of this study is to asses the risk of hazards of Post Weld Heat Treatment (PWHT) process for pipes in a manufacturing company through identification of potential hazards, risks analysis and evaluation to determine control measures. Hazards identification in the PWHT work revealed there are 34 hazards that have the potential to cause work accidents. Hazard risk analysis using Fine-Kinney method shows the hazard risk levels in the PWHT work is from low to high, with a low level risk percentage of 23.5%, a possible risk level of 20.6%, a substantial risk level of 47.1% and a high risk level of 8.8%. The proposed control measures for eliminating or reducing the risk of hazard in each task is carried out by hierarchy of controls through the elimination, substitution, engineering controls, administrative controls and personal protective equipment.

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1. INTRODUCTION

The Indonesian manufacturing industry plays an important role in supporting the national economic growth and creating many jobs. However, Indonesia's manufacturing industry still faces the problem of high number of work accidents in this industry. In 2020, the manufacturing industry is a sector that has a high contribution to occupational accidents together with the construction sector, which is 63.6% (Muhammad & Susilowati, 2021).

An occupational accident according to the International Labor Organization (ILO), is an unexpected and unplanned work-related event that results in death, injury, illness in one or more workers (International Labour Organization-ILO, 2020). The occurrence of work accidents is mainly due to the lack of attention of business people and the public to occupational safety and health (OSH) issues. In addition, the implementation of the OSH program has not been seen as an investment to prevent work accidents, even considered as an additional cost burden for companies so that the implementation of OSH has not been carried out optimally (Yuliandi & Ahman, 2019). The problem of work accidents should get more serious attention from the company, because work accidents will cause losses to labor, property and assets, reputation, and credibility of the company.

According to Heinrich (1931, as cited in Sunday, 2022) an industrial accidents that occur in workplace can be caused by unsafe acts of a person and unsafe a mechanical or physical hazard. Unsafe human actions are actions that violate or are not in accordance with safe work standards so that they have the potential to cause work accidents, such as working at an inappropriate speed, using work tools in the wrong way, failing to use the correct personal protective equipment, repairing equipment while the equipment is operating (Larasatie et al., 2022). Hazard is any unsafe condition or potential source of an accident. Hazard is a source that has an intrinsic potential to cause loss or damage, for example fire contains heat properties that can cause damage to objects or can injure if exposed to the human body (Ponda & Fatma, 2019).

This study was conducted in a manufacturing company located in Jakarta, Indonesia. One of the works carried out at the company, is the Post Weld Heat Treatment (PWHT) process for pipes. PWHT is a heat treatment process carried out after the welding process, with the aim of reducing residual stresses on materials due to local heating caused by the welding process (Purba et al., 2020). Residual stress due to welding can cause weld cracking which can harm the welded structure when it receives loading. In addition, PWHT processes are also useful for reducing hardness and increasing toughness in heat-affected zones (Nasra et al., 2020).

PWHT's work in the company involves workers who are directly exposed to hazards that have the potential to cause work accidents. Based on interviews with workers, there were work accidents that occurred at PWHT work area such as workers being punctured and pinched by wires which resulted in injuries. In addition, observations have shown that workers were not fully aware of all the hazards in PWHT work that have the potential to cause accidents. The company has also not conducted a hazard risk assessment for PWHT's work. Therefore, it is urgent to carried out the research related to risk assessment in PWHT work so that the hazards that can cause work accidents and their impacts can be identified and analyzed. In addition, with the information of the risk obtained, strategies and effective action needed to prevent accidents in PWHT work can be immediately formulated by the company.

The purpose of this study is to conduct a hazard risk assessment using the Fine-Kinney method on the PWHT process for pipes in a manufacturing company. Another objective is to suggest control measures to eliminate or reduce the risk of hazard to the PWHT process.

2. LITERATURE REVIEW

In manufacturing industry, work accidents caused by unsafe mechanical or physical hazard can occur due to machinery and equipment that are no longer suitable for use, the presence of fire in hazardous places, noise, exposure to radiation, temperature conditions exceeding thresholds, insufficient lighting and ventilation. A workplace according to Law of the Republic Indonesia No. 1 of 1970 concerning work safety, is a room or field, open or closed, moveable or fixed where workers do work, or which are often entered by workers and where there are sources of hazard. In addition, according to the same Law, sources of hazard are related to the condition of machines, work tools and equipment, materials, the environment, the nature of work, work methods, production processes. Hazards can be categorized into safety hazards and health hazards. Types of safety hazards include mechanical and electrical hazards, fire hazards and explosion hazards. Health hazards include physical hazards, chemical hazards, biological hazards, ergonomic hazards, and psychosocial hazards (Ayuningtyas & Nasri, 2021).

According to the Occupational Safety and Health Administration (OSHA), the categories of hazards are: safety hazards, biological hazards, physical hazards, ergonomic hazards, chemical hazards and work organizations hazards (Occupational Safety Health

Administration, n.d.). Examples of safety hazards are spills on the floor, tripping, working at heights (including ladders, roofs), unprotected machinery, moving machine parts, electricity (eg: frayed cables, improper wiring), confined spaces, hazards related to machinery (for example: logout/tagout, boiler safety, forklifts). Biological hazards include the hazards of fungi, bacteria and viruses, plants, insect bites. Physical hazards include radiation, ultraviolet light, extreme temperatures, noise. Ergonomic hazards include workstations that are not set up correctly, poor posture, frequent lifting, vibration. Chemical hazards include chemicals, steam and smoke, gas, flammable materials. Hazards of work organization, for example violence in the workplace, work intensity, flexibility, social relations.

To avoid hazards and reduce or eliminate work accidents that may occur, it is necessary to take action to control work accidents. One of the efforts that can be done is the implementation of OSH risk management in the company. Risk is the chance that a hazard can actually cause injury or damage, while OSH risk management is risk management in a systematic, planned, structured and comprehensive manner to reduce the presence of factors causing work accidents so as to prevent unwanted accidents (Jaya, Dharmayanti, & Mesi, 2021). The risk management process according to ISO 31000: 2018 involve communication and consultation, determination of scope, context and criteria, risk assessment, risk treatment, monitoring and review. The risk assessment process consists of risk identification, risk analysis and risk evaluation (Hamir, 2021). Risk identification is the process of identifying hazards that have the potential to cause harm, risk analysis is the process of analyzing and assessing the risk, while risk evaluation is the process of evaluating the risk and determining its level so that the actions can be taken to control the risk that may occur. As part of risk management, risk assessment is very important to determine the level of potential hazard from a work so that control measures can be taken to reduce the risk level to an acceptable risk level. In a company that has carried out a risk assessment and implemented preventive measures to control hazards, the risk assessment will have a positive impact on production and workers which will also positively reflect the company's level of well-being (Bagdatlı & KILIÇ, 2020).

To carry out risk analysis, it is necessary to determine a measurement system and method for assigning risk scores that can measure and compare risks. In the literature there are various methods for analyzing risk which can be classified into three analysis techniques: qualitative, semi-quantitative and quantitative (Luri & Rinawati, 2019). Qualitative analysis uses words such as ‘High’, ‘Substantial’, ‘Low’ to indicate the value of risk factors. Risk assessment methods using qualitative analysis, for example the Job Safety Analysis (JSA) (Albrechtsen, Solberg, & Svensli, 2019), Safety Checklist (Sari & Satrio, 2022), Failure Mode and Effect Analysis (FMEA) (Ramadhan et.al 2019), What ifLyon & Popov, 2021b), Hazard and Operability (HAZOP) (Penelas & Pires, 2021). Semi-quantitative analysis uses numerical ratings for risk factors that are based on qualitative data to determine risk levels. As examples of methods with semi-quantitative analysis are Preliminary Hazard Analysis (PHA) and (Lyon & Popov, 2021a),Hazard Identification (HAZID) (Rivera Domínguez et al., 2021).Quantitative analysis uses estimated values of risk factors to determine risk values in certain predetermined units. Examples of quantitative analysis risk assessment methods include Fault Tree Analysis (FTA) (Budiyanto & Fernanda, 2020), Hazard Identification and Ranking (HIRA) (Srinivas, 2022), Layers of Protection Analysis (LOPA) (Sotoodeh, 2023), Quantitative Risk Assessment (QRA) (Weng, Gan, & Zhang, 2021). The Fine-Kinney method was proposed by G.F Kinney and A.D Wiruth in 1976 is a method for assessing the risk of a hazardous situation. This method is a development of the method previously proposed by William T. Fine (1971, as cited in Uslu & Uslu, 2022)The Fine-Kinney method is a quantitative risk assessment method (Kuleshov et al., 2021)and has been applied to assess risk in various fields. In the literature the Fine-Kinney method has been used to assess and control the risk of work accidents in the food industry, metal processing, plastics and machinery industry (Bagdatlı & KILIÇ, 2020) and the leather processing industry (Milli, Salman, & Sancak, 2021). The Fine-Kinney method has also been integrated with multi-criteria decision making methods and fuzzy logic, for example Fine-Kinney is integrated with fuzzy logic, AHP and TOPSIS to assess the hazards risks in a medium sized gas filling facility (Dogan et al., 2022) and combined with a two-stage hesitant fuzzy linguistic approach to assess safety and occupational health in a hospital (Çalış Boyacı & Selim, 2022)

3. RESEARCH METHOD

The method used in this hazard risk assessment study is quantitative risk analysis and evaluation using the Fine-Kinney method. Data collection was carried out through observation and interviews with company employees who served in the PWHT work section. The flowchart of the research process for hazard4 risk assessment is shown in Figure 1. In the Fine-Kinney method, the level or level of risk of a hazard is determined based on the risk score for that hazard which is obtained from mathematical calculations. To obtain the hazard risk score, first each risk factor for the activity must be determined based on the hazard classification and rating that has been determined in Table 1 (Kuleshov et al., 2021). Next, the risk score R can be obtained from multiplying the three risk factors using equation 1 (Kuleshov et al., 2021)

$$R = L \times E \times C \quad (1)$$

Where: L is the likelihood factor, E is the exposure factor, and C is the consequence factor.

A risk score of less than 20 is considered a hazard with a low risk level, and the risk is considered acceptable. Hazards with a risk score between 20 and 70 are included in the hazards with a possible risk level and attention (monitoring) is needed to reduce the risk. Hazards with a risk score between 70 and 200 are classified as hazards with a substantial risk level and corrections are required to reduce the hazard. Risks with a score between 200 and 400 are considered high risk and immediate correction is needed to prevent harm. Risks with a score above 400 are considered very high risks. For work with a very high risk level, consideration is needed to stop the work completely or temporarily until corrective action to reduce the risk is implemented. Table 2 shows the risk level and required actions based on the risk score (Kuleshov et al., 2021).

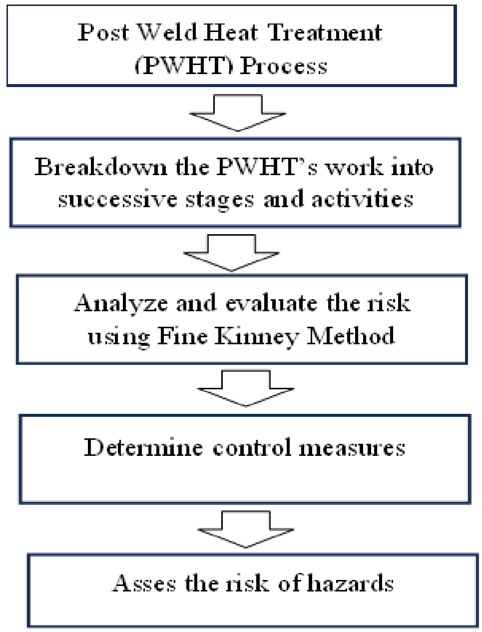

Figure 1. The study framework

4. RESULT AND DISCUSSION

This research was conducted at an Indonesian company specialize in the manufacture, installation and maintenance of industrial boilers. The company has long experience in boiler-related work and has customers from various industries such as food, textile, oil and gas industries. The PWHT work in the company is carried out in the work area involving company's workers, machinery and equipment. As previously explained, when working on PWHT process, workers are exposed to hazards which can lead to work related accidents, therefore a hazard risk assessment is very important to eliminate work accidents that may occur during the PWHT process.

4.1 Hazard identification

To carry out a hazard risk assessment in PWHT work, the first step is to identify potential hazards and their impacts. PWHT work at the company where the research was carried out consists of three stages of work : the preparation stage, processing stage and final stage (finishing) and each stage of work consists of several activities.

Table 1. Factor, classification and risk rating

Risk Factor	Classification	Rating
Likehood (L)	Might well be expected	10
	Quite possible	6
	Unusual but possible	3
	Only remotely possible	1
	Conceivable but very unlikely	0.5
	Practically impossible	0.2
	Virtually impossible	0.1
Exposure (E)	Continuous	10
	Frequent (daily)	6
	Occasional (weekly)	3
	Unusual (monthly)	2
	Rare (a few per year)	1
	Very rare (yearly)	0.5
Consequence (C)	Catastrophe (many fatalities or > $ 10 M damage)	100
	Disaster (few fatalities or > S1 M damage)	40
	Very serious (fatality or > $0.1 M damage)	15
	Serious (serious injury or > $0.001 M damage)	7
	Important (disability or < $1000 damage)	3
	Minor (minor first aid accident or < $ 100 damage)	1

Table 2. Risk Score, risk level, and action

Score	Risk level	Action
R < 20	Low	Perhaps acceptable
20 < R< 70	Possible	Attention indicated
70 <R< 200	Substantial	Correction needed
200<R<400	High	Immediate correction required
R > 400	Very high	Consider discontinuing operation

1. Preparatory stage

a) Transporting pipes. In this activity , the pipes that will undergo the PWHT process are transported from the warehouse where they are stored to the work location using a forklift. Transportation of pipes from the work site to the warehouse is also carried out after the PWHT process is complete.

b) Connecting the thermocouple cable to the pipe. In this work, the thermocouple cable is installed on the pipe by welding it using a thermocouple spot welding.

c) Installing ceramic heaters. In this work, ceramics are installed at each end of the pipe and then tied using wire so that the ceramic does not come off from the pipe (Figure 2). This ceramic functions to conduct heat provided by the PWHT machine.

Figure 2. Ceramic heaters installation

d) Insulating pipes by Rockwool. After the ceramics are installed, the next work is to insulating pipes by rockwool. Rockwool functions as an insulator to keep the PWHT temperature stable.
e) PWHT machine cable installation. In this work, the cable from the PWHT machine is installed in a ceramic heater that has been installed on the pipes (Figure 3)

Figure 3. PWHT cables machine installation

2. Processing stage
a) PWHT machine monitoring. In this activity, monitoring of the heating, holding and cooling processes of the pipes being processed by PWHT is carried out. This is done to avoid errors occurring when the PWHT process is carried out.
b) Material checking. This activity is performed when an error occurs during the PWHT process. This is usually caused by a detached conductor cable or a burnt conductor cable.

3. Final stage (finishing).
a) Dismantling of PWHT machine installation. In this work, the activity carried out was to dismantle all previously installed installations such as PWHT cables, conductor cables, ceramics and rockwool.
b) Marking pipes. After the PWHT process is complete, the pipes are given numbers (marking) to record the number of pipes that have been processed using the PWHT machine.
c) Storing pipes. The pipe that has been marked is then moved by lifting it onto a forklift and then transporting it to the storage warehouse.

In each activity, potential hazards that can cause work accidents are identified and the hazard categories and effects caused by these hazards. In Table 3, the hazards, hazard categories and possible effects of the hazards on the PWHT activities are shown

4.2 Risk analysis and evaluation

After the hazards in each activity are identified, a risk analysis is then carried out using the Fine-Kinney method. The risk analysis for each hazard is based on the hazard classification and rating for each risk factor of likelihood (L), exposure (E), and consequence (C) in Table 1, then the hazard risk score R for each activity is calculated using equation 1. Based on the risk score obtained, the hazard risk level of each activity can be determined using Table 2. Table 4 shows the risk score and the level of risk for each hazard in PWHT work.

From Table 3, it can be seen that the highest risk of hazard category in PWHT work is safety hazards (50.0%), followed respectively by ergonomic hazards (32.4%), physical hazards (8.8%) and chemical hazards (8.8%). In Figure 4 a comparison diagram of hazard categories in PWHT work is presented.

Table 3. Hazard, category and effects

Work activity	Hazard	Which can cause	Effects	Hazard Category
Transporting and storing pipes	Moving forklift	1. Struck by forklift	Injury, fatal	Safety
		2. Forklift rolling over	Injury	Safety
	Material handling	3. Hit by falling pipes	Injury	Safety
		4. Lifting heavy pipes	Musculoskeletal disorders	Ergonomic
		5. Repetitive bending	Musculoskeletal disorders	Ergonomic
Connecting thermocouple cables to pipes by welding	Welding	6. Hit by sparks	Burns	Physical
		7. Electric shock	Burns	Safety
		8. Welding light	Injury, flash burns	Physical
Installing ceramics heater	Installing on pipe	9. Punctured by pipe	Injury	Safety

		10. Punctured by wire	Injury	Safety
	Installing in a squatting position	11. Squatting too long	Musculoskeletal disorders	Ergonomic
Insulating pipes by Rockwool	Exposure to rockwool	12. Exposed to dust	Eye irritation	Chemical
		13. Touching rockwool	Itching, skin irritation	Chemical
	Insulating pipes in a bending position	14. Repetitive Bending	Musculoskeletal disorders	Ergonomic
Installing PWHT machine's cables	Electrical	15. Electrical shock	Burns, fatal	Safety
	Disorganized cables	16. Tripping over cables	Bruised, sprain	Safety
	Installing cable in a squatting position	17. Squatting too long	Musculoskeletal disorders	Ergonomic
Monitoring PWHT machine	Heat	18. Heat stress	Dehydrated, hot	Physical
	Monitoring the panel	19. Monitoring the PWHT panel too long	Eyestrain	Ergonomic
	Exposure to dusts	20. Exposed to dust	Short of breath, eye irritation	Chemical
	Monitoring in a squatting position	21. Squatting too long	Musculoskeletal disorders	Ergonomic
Checking materials	Electrical	22. Electric shock	Burns, death	Safety
	Disorganized cables	23. Tripping over cables	Bruised body, sprained	Safety
	Hot pipe	24. Touching hot pipe	Blistered skin	Safety
	Checking in a squatting position	25. Squatting too long	Musculoskeletal disorders	Ergonomic
Dismantling the PWHT installation	Electrical	26. Electric shock	Burns, fatal	Safety
	Disorganized cables	27. Tripping over cables	Injury	Safety
	Hot pipe	28. Exposed to hot pipe	Blistered skin	Safety
	Dismantling the in a squatting position	29. Squatting too long	Musculoskeletal disorders	Ergonomic
Marking pipes	Standing on pipe	30. Slipping	Injury	Safety
		31. Hit by pipe	Broken bones, bruised body	Safety
	Hot pipe	32. Hit by hot pipe	Blistered skin	Safety
	Marking in a squatting and bending postures	33. Squatting too long	Musculoskeletal disorders	Ergonomic
		34. Repetitive bending	Musculoskeletal disorders	Ergonomic

Table 4. Risk Analysis and evaluation

Activity	Hazard	L	E	C	R	Risk Level
Transporting and storing pipes	1. Struck by forklift	1	6	15	90	Substantial
	2. Forklift rolling over	1	6	7	42	Possible
	3. Hit by falling pipe	1	6	7	42	Possible
	4. Lifting heavy pipe	6	6	3	108	Substantial
	5. Repetitive bending	6	6	3	108	Substantial
Connecting thermocouple cables to pipes	6. Hit by sparks	6	6	3	108	Substansial
	7. Electric shock	1	6	7	42	Possible
	8. Welding light	10	6	3	180	Substansial
Installing ceramics heaters	9. Punctured by pipe	3	6	1	18	Low
	10. Punctured by wire	3	6	1	18	Low
	11. Squatting too long	6	6	3	108	Substantial
Insulating pipes by rockwool	12. Exposed to dusts	3	6	1	18	Low
	13. Touching rockwool	6	6	1	36	Possible
	14. Repetitive bending	6	6	3	108	Substantial
Installing PWHT machine's cables	15. Electric shock	3	6	15	270	High
	16. Tripping over cables	3	6	3	54	Possible
	17. Squatting for too long	6	6	3	108	Substantial
Monitoring PWHT machine	18. Heat stress	3	6	1	18	Low
	19. Looking panel too long	0.5	10	3	15	Low
	20. Exposed to dust	10	6	3	180	Substantial
	21. Squatting too long	6	6	3	108	Substantial
Checking material	22. Electric shock	3	6	15	270	High
	23. Tripping over cables	6	6	3	108	Substantial
	24. Exposed to hot pipe	3	6	1	18	Low
	25. Squatting too long	6	6	3	108	Substantial
Dismantling PWHT installation	26. Electric shock	3	6	15	270	High
	27. Tripping over cables	3	6	3	54	Possible
	28. Hit by hot pipe	3	6	1	18	Low
	29. Squatting too long	6	6	3	108	Substantial
Marking pipes	30. Slipping	6	6	3	108	Substantial
	31. Hit by falling pipe	1	6	7	42	Possible
	32. Exposed to hot pipe	3	6	1	18	Low
	33. Squatting too long	6	6	3	108	Substantial
	34. Repetitive bending	6	6	3	108	Substantial

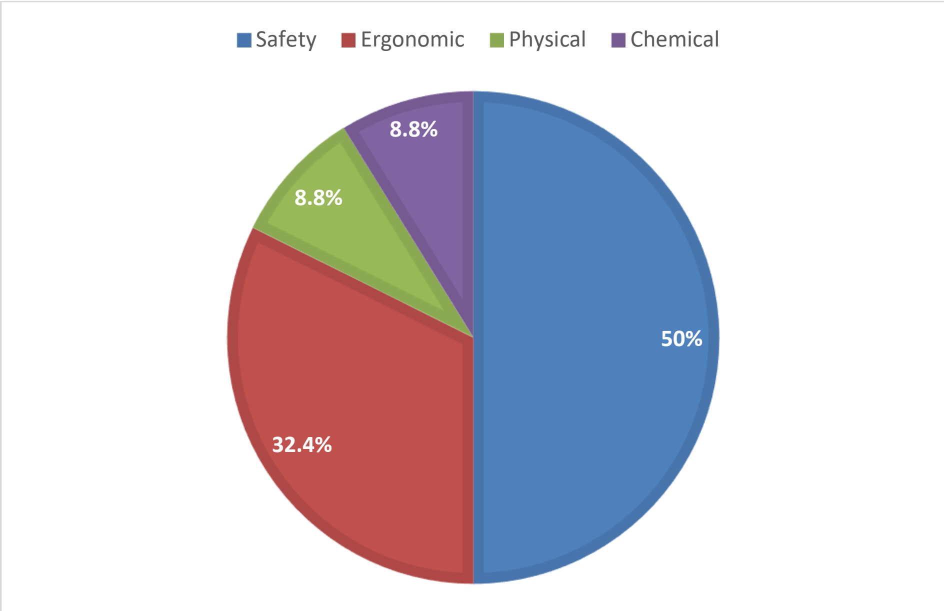

Figure 4. Hazard category comparison

From the risk analysis, for 34 identified hazards it were obtained: the number of hazards with a low risk level is 8 hazards (23.5%), hazards with a possible risk level are 7 hazards (20.6%), hazards with a substantial risk level are 16 hazards (47.1%), hazards with a high risk level are 3 hazards (8.8%) and there are no hazard with a very high risk level. Figure 5 shows a risk level comparison diagram for the PWHT work.

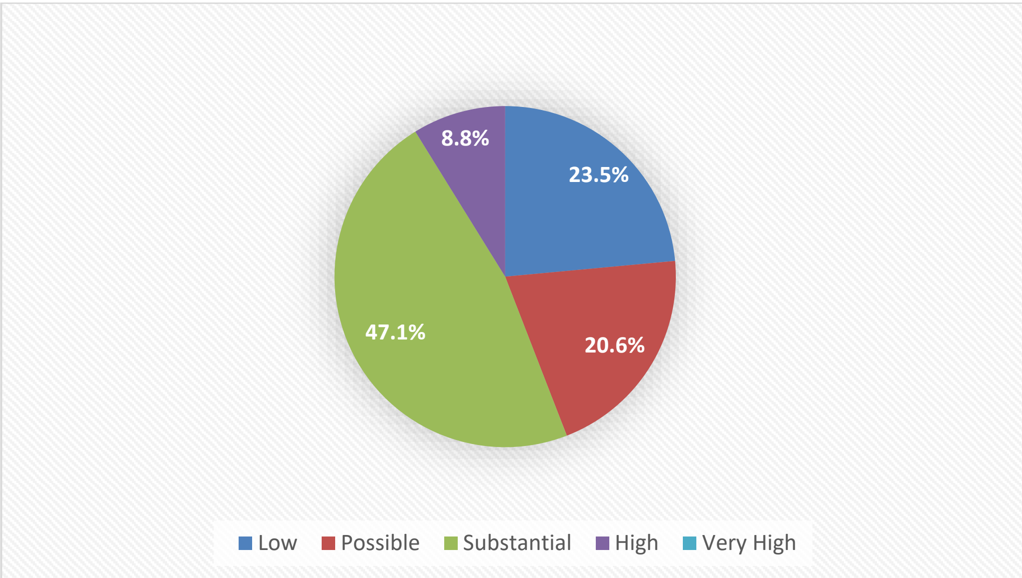

Figure 5. Risk level comparison

Most hazards in PWHT work are at the level of substantial risk, which means correction is needed to reduce hazards (Table 4). Of the 16 hazards with substantial levels, 10 hazards or 62.5% were ergonomic hazards, such as squatting for too long or repetitive bending, and lifting or moving heavy pipes manually. The impact of this ergonomic hazard is that workers can experience musculoskeletal disorders (MSDs), which is disorders or damage to muscles, tendons, ligaments, peripheral nerves, joints, cartilage, spinal discs, bones, and blood vessels (Tamene et al., 2020). MSDs can occur due to workers doing work with improper or awkward posture and workers do not pay attention to posture and physical ability when doing manual material handling work.

4.3 Control Measures

The results obtained in the previous step are evaluated to provide advice on control measures needed to reduce the risk of hazards to PWHT work. To plan control measures so that control measures that will be implemented in the workplace can effectively eliminate and reduce the risk of hazards, the National Institutes for Occupational Safety and Health (NIOSH) recommends a hierarchy of controls, a model for determining how to implement hazard control solutions effectively (The National Institute for Occupational Safety and Health (NIOSH), 2023).

The control hierarchy is divided into five levels of action to eliminate or reduce hazards, as follows: elimination, substitution, engineering controls, administrative controls and Personal Protective Equipment (PPE). Elimination is eliminating the hazard at its source. Elimination is the most effective control method among other control methods to protect workers. Substitution is replacing the material or process used so far with another safer material or process. Engineering control separates hazards in direct contact with workers through physical means such as barriers, insulation, enclosures. Administrative controls are basically control measures to change the way people work through work practices or policies. The control measure considered the least effective in reducing hazards is protecting workers with PPE or personal protective equipment. Control used and method by a hierarchy of controls for PWHT work can be carried out as can be seen in Table 5

Table 5. Control used and method

Work activity	Hazard	Which can cause	Control used	Control method
Transporting and storing pipes	Moving forklift	1. Struck by forklift	Engineering	Use of physical barriers and guard railing
			Administrative	Provide forklift safety training, use signs and warning labels
		2. Forklift rolling over	Administrative	Provide operator training. Don't exceed the forklift's weight capacity
		3. Hit by falling pipes	Administrative	Provide operator training related to lifting operations
	Material handling	4. Lifting heavy pipes	Engineering	Use handtruck with mechanical lift platforms
		5. Repetitive bending	Administrative	Short breaks between work activity
Connecting thermocouple cables to pipes by welding	Welding	6. Hit by sparks	PPE	Use welding goggle
		7. Electric shock	PPE	Use welding gloves and insulation boots
		8. Welding light	PPE	Wear welding goggle
Installing ceramics heaters	Installing on pipes	9. Punctured by the end of pipe	PPE	Wear gloves
		10. Punctured by wire	PPE	Wear gloves
	Installing in a squatting position	11. Squatting too long	Engineeering	Provide a stool
Insulating pipes by Rockwool	Exposure to rockwool	12. Exposed to dusts	Engineerimg	Provide blower and good ventilation
			PPE	Use face mask with particle filter
		13. Touching rockwool	PPE	Use gloves

	Installing in a bending	14.	Repetitive Bending	Engineerimg	Provide a stool
Installing PWHT machine's cables	Electrical	15.	Electrical shock	PPE	Use gloves and insulation boots
	Disorganized cables	16.	Tripping over cables	Administrative	Implementing a 5S housekeeping program
	Installing in a squatting position	17.	Squatting for too long	Engineering	Provide a stool
Monitoring PWHT machine	Exposure to heat	18.	Heat stress	Engineering	Provide air conditioning, fans
	Monitoring the PWHT machine panel	19.	Looking panel too long	Subtitution	Use camera for monitoring
	Exposure to dusts	20.	Exposed to dusts	Engineering	Provide exhaust and good ventilation
	Installing in a squatting position	21.	Squatting too long	Engineering	Provide a stool
Checking materials	Electrical	22.	Electric shock	PPE	Use gloves and insulation boots
	Disorganized cables	23.	Tripping over cables	Administrative	Implementing a 5S housekeeping program
	Hot pipes	24.	Exposed to hot pipes	Administrative	Comply to SOP
	Installing in a squatting position	25.	Squatting too long	Engineerimg	Provide a stool
Dismantling the PWHT installation	Electrical	26.	Electric shock	PPE	Use gloves and insulation boots
	Disorganized cables	27.	Tripping over cables	Administrative	Implementing a 5S housekeeping program
	Hot pipes	28.	Exposed to hot pipes	Administrative	Comply to SOP
	Installing in a squatting position	29.	Squatting too long	Engineering	Provide a stool
Marking pipes	Standing on pipes	30.	Slipping	Substitution	The marking process is carried out on the floor surface, not on stacked pipes
		31.	Hit by falling pipe	Substitution	The marking process is carried out on the floor surface, not on stacked pipes
	Hot pipe	32.	Exposed to hot pipes	Administrative	Comply to SOP
	Marking with a squatting and bending postures	33.	Squatting too long	Administrative	Short breaks between work activity
		34.	Repetitive bending	Administrative	Short breaks between work activity

5. CONCLUSION

In this research, a hazard risk assessment was carried out using the Fine-Kinney method for Post Weld Heat Treatment (PWHT) work. Hazard risk assessment through identification of hazards and their impacts as well as risk analysis and evaluation has been carried out to determine useful control measures to eliminate or reduce hazards that may occur in PWHT work. From the identification of hazards, it was found that the most common hazards in PWHT work were hazards in the safety category, followed respectively by ergonomic hazards, physical hazards and chemical hazards. Hazard risk analysis using the Fine-Kinney method found that the risk of hazard in PWHT work was at a low level to a high level, with the greatest risk of hazard being at a substantial level. Proposed control measures with a hierarchy of controls implemented in the workplace by the company can be effective in eliminating or reducing the risk of hazard in PWHT work which in turn can maintain the health and safety conditions of workers to remain in an optimal condition. Suggestions that can be given are related to the development of this research, for further research it is possible to carry out a hazard risk assessment using quantitative analysis integrated with fuzzy logic and multi criteria decision making method.

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