Evaluation of OHS practices based on work accident risk analysis using HIRA, FTA, and WISE methods (Case study: plastic recycling business X)

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Abstract. The lack of OHS implementation is particularly notable in Small and Medium Industries (SMI), primarily due to limited knowledge and motivation concerning OHS application in their work systems. SME X, a plastic recycling business, has experienced several work accidents and necessitated hazard identification and OHS implementation for hazards with high and extreme risks. The HIRA method was employed to assess the extent of risk posed by various types of hazards. After identifying these hazards, the root causes of high and extreme-risk hazards were determined using FTA. Subsequently, measures were taken to mitigate the risks associated with high and extreme-risk hazards through WISE. The results revealed 28 potential hazards, with improvements focused on six high and extreme-risk categories. Proposed WISE interventions include the provision of Personal Protective Equipment (PPE), the use of ramps, the utilization of wheeled aids, and other enhancements to techniques and methods at each workstation.

1 Introduction

Workplace accidents are unforeseen events that occur without intent or suspicion, leading to the loss of time, company assets, and even casualties during work processes [1]. Ensuring workplace safety is the primary means of preventing work accidents, disabilities, or fatalities resulting from workplace incidents [2]. Prevention of work accidents, in the context of occupational security, safety, and health (OHS), is intricately linked to the cause-and-effect relationship of accidents. It emphasizes the need to control all potential accident causes by minimizing them [3].

According to data from BPJS Employment in 2022, work accidents and occupational diseases in Indonesia have seen a consistent yearly increase. In 2021, there was a 5.7% rise compared to 2020, with a total of 234,370 cases, resulting in 6,552 fatalities. These statistics underscore the importance of prioritizing occupational health and safety (OHS) programs within the Indonesian workforce [4]. According to Maulana [5], numerous companies have yet to implement OHS programs due to the misconception that the associated costs are merely an expenditure, rather than an investment in safeguarding company assets, including machinery, infrastructure, and human resources. The challenge of limited OHS adoption is particularly prevalent in Small and Medium Industries where knowledge and motivation regarding OHS integration into their operational systems are lacking [6]. It is also noted that the proper implementation of OHS management has been deficient due to insufficient awareness and appreciation of its advantages [7]. This aligns with the findings presented by the International Labour Organization (ILO) which indicate that SMEs in Indonesia face challenges related to the imbalance between their human resources and financial capabilities, resulting in a heightened risk of work-related diseases and accidents. Furthermore, many SMEs pay minimal attention to OHS standards, resulting in numerous OHS violations [8]. Nonetheless, the statement of an OHS culture is pivotal in every workplace activity, significantly affecting the risk of work-related accidents by promoting proactive safety measures and safe behaviors among employees [9].

Small and Medium Enterprises (SMEs) in Indonesia operate in various sectors. One such SME, referred to as "X SME," is involved in the plastic waste processing industry. This SME encompasses four workstations, including sorting, milling, drying, and finished goods warehousing. The establishment of this SME has been marred by several work-related accidents, with some individuals requiring hospitalization. To address these challenges, it is imperative to conduct research aimed at identifying potential work accident risks and uncovering the root causes of the hazards responsible for these risks. Subsequently, it is crucial to implement occupational health and safety (K3) measures tailored to the specific conditions of SMEs. This serves as a fundamental strategy for preventing work-related accidents. The HIRA (Hazard Identification and Risk Assessment) method proves
invaluable in identifying potential hazards within the operational processes and determining the associated risk levels [10]. Once the hazard category has been determined, the next step involves identifying the root causes of the hazards using the Fault Tree Analysis (FTA) method. FTA is employed as an analytical tool to investigate problems by employing a top-down approach to identify events that lead to failures. In the context of this study, FTA plays a critical role in pinpointing the fundamental causes of work-related hazards [11]. Subsequently, the control of occupational hazards is implemented through the utilization of the Work Improvement in Small Enterprises (WISE) occupational safety and health program. This program, developed by the International Labour Organization (ILO), is designed to aid Micro, Small, and Medium Enterprises in enhancing working conditions. It achieves this by implementing straightforward, cost-effective techniques that yield immediate and enduring benefits for both business owners and employees [12].

2 Methods

The first method used in this study is HIRA, based on research that has been conducted by [13], HIRA is a suitable method for identifying potential hazards, conducting risk assessments, and implementing risk control measures in a work environment. Using brainstorming in the data collection process during the HIRA (Hazard Identification and Risk Assessment) is an effective technique for obtaining information in the field [14]. In this research, addressing the issues faced by SMEs, the Hazard Identification and Risk Assessment (HIRA) method plays a fundamental role as the initial step and a valuable tool for identifying workplace hazards and assessing work-related risks in Small and Medium Enterprises (SMEs).

Fault Tree Analysis is the second tool employed in this study. After categorizing the occupational risks, the subsequent step is to perform a comprehensive analysis using FTA diagrams to uncover the root causes of potential issues. This aligns with prior research conducted by [6][15]. In this context, Fault Tree Analysis (FTA) functions as a continuation of the Hazard Identification and Risk Assessment (HIRA) method. It is utilized to conduct a more in-depth analysis of the underlying causes of the hazards and risks identified during the HIRA process.

The third tool employed in this study is the Work Improvement In Small Enterprises (WISE). This tool, in the form of a checklist questionnaire developed by the International Labour Organization (ILO), is recommended for enhancing the working environment and facilitating the implementation of occupational safety and health (K3) in SMEs. In this research, WISE functions as a control mechanism, offering improvement suggestions based on the root causes identified through Fault Tree Analysis (FTA) diagrams, incorporating OHS measures. WISE is considered an appropriate approach for implementing K3 in SMEs due to its simplicity and practicality [6].

3 Result and Discussion

![Fig 1. Production Flow Process](https://example.com/fig1.png)

Data is systematically collected following the production process flow illustrated in Figure 1. The production process commences at the goods sorting area. Upon the arrival of raw materials, they are placed in the goods sorting area for immediate organization and sorting.

Based on the hazard identification conducted using HIRA, SME X. exhibits a total of 28 hazard risks. Within this range, 2 hazard types categorized as "High" and "Extreme" will be subjected to further analysis using FTA diagrams. A summary of the high and extreme hazards slated for identification is presented in Table 1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Activity Description</th>
<th>Hazard</th>
<th>Risk</th>
<th>L</th>
<th>C</th>
<th>Scale</th>
<th>Risk Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorting</td>
<td>The process of introducing materials into the grinding machine</td>
<td>Workers being hit by mill flakes</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>Extreme</td>
<td></td>
</tr>
<tr>
<td>Drying</td>
<td>The process of drying plastic in the open-air drying area</td>
<td>Plastic material infiltrates the soles of the feet</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Drying</td>
<td>The process of machine-assisted drying</td>
<td>Workers getting splashed with plastic debris</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Drying</td>
<td></td>
<td>Plastic particles getting into the eyes and causing eye irritation</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>Extreme</td>
<td></td>
</tr>
</tbody>
</table>

Following the summary of high and extreme risks identified through HIRA, the next step involves analyzing...
high and extreme risks using FTA. Once the results of the FTA analysis are obtained, the subsequent step is to utilize the WISE method to identify appropriate solutions for addressing the existing issues. The recapitulation of the FTA and WISE analyses is presented in Table 2.

### Table 2. FTA and WISE Recapitulation

<table>
<thead>
<tr>
<th>Location</th>
<th>Hazard</th>
<th>Hazard Causes</th>
<th>WISE Point</th>
<th>Improvement Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling</td>
<td>Noise generated by the grinding machine</td>
<td>No ear protection</td>
<td>Provision of personal protective equipment</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>The load is too heavy</td>
<td>Brainstorming: Provision of personal protective equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Issue related to head area health</td>
<td>No load intermediary other than stair</td>
<td>1. Provision of a flat path instead of using stairs 2. Using wheel assisting tools for transporting goods</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Worker s being hit by mill flakes</td>
<td>No face protection PPE</td>
<td>Provision of personal protective equipment</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Expose to dirty water for 8 hours</td>
<td>Lack of awareness of good sanitation</td>
<td>Use of visual displays</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Plastic material infiltrates the soles of the feet</td>
<td>Uncomfortable</td>
<td>Simplifying OHS policy determinatio n</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Worker s being hit by mill flakes</td>
<td>Insufficient quantity of goods</td>
<td>Provision of personal protective equipment</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Worker s being hit by mill flakes</td>
<td>Insufficient quantity of goods</td>
<td>Brainstorming: Compacting the quantity of goods during drying</td>
<td>V</td>
</tr>
</tbody>
</table>

#### 3.1 Noise generated by the grinding machine

The primary source of noise at the milling station is the machines that operate while in use. Mill workers directly experience discomfort and, at times, even suffer from dizziness, which leads to a loss of focus. This is due to the nature of the work, which requires employees to spend approximately 8 hours at the station each day. It is essential to reduce noise exposure as prolonged exposure can lead to issues in the circulatory system, heart problems, and even hearing loss [16]. WISE recommendations that can be implemented include providing personal protective equipment, such as ear protection. Earplugs are a type of ear protection device that can effectively minimize the impact of noise [16]. Earplugs were selected due to their efficiency in reducing noise levels. These protective devices are lightweight, cost-effective, and readily available. Furthermore, the proximity of workers on different levels ensures that the use of earplugs does not hinder communication among them. Below is documentation of the earplugs used in SMEs:

![Earplug for milling area](image)

#### 3.2 Issue related to head area health

This hazard arises from workers manually carrying sacks weighing between 30-50kg on their heads. Given that the milling production capacity typically reaches 3 tons in a day, and if each bag weighs 50kg, workers need to ascend and descend the stairs approximately 60 times a day. This movement is necessitated because the milling machine is positioned at an elevated location, requiring workers to transfer goods to be milled using stairs as intermediaries. After consulting with workers and taking into account cost considerations, a proposed solution for mitigating this hazard is to reduce the weight of the loads being lifted. The recommended maximum load for manual lifting in Indonesia is 20kg [17]. Nevertheless, implementing this weight reduction strategy comes with the drawback of requiring workers to perform twice as many trips for activities involving the stairs. On the positive side, this proposal offers benefits for companies facing declining revenues as they won't need to bear the repair costs associated with equipment damage.

As an alternative to using the head to lift heavy loads from the lower floor, a suggestion is to employ stacked sacks. Unprocessed items within sacks can be temporarily stacked to eliminate the need for head lifting. This recommendation comes with the drawback that workers will need to recreate sack piles continuously, as there is no fixed design for them and it may reduce the available workspace. The second recommendation involves...
redesigning the workstation on the stairs by replacing the stairs with ramps and introducing wheeled aids for the process of transporting goods up and down. The design aligns with the guidelines outlined in Regulation of the Minister of Public Works Number 30 of 2006. According to these regulations, outdoor ramps should not exceed a slope of 6°, the minimum ramp width is 1.2 meters, with a safety edge featuring a handrail height of 65-80 cm, a resting level of 1.2 meters, and a track length of no more than 9 meters. However, considering the conditions of SMEs and the results of calculations, the proposed design features a 16° angle, a minimum ramp width of 2.4 meters, a 65 cm high guardrail, a track length of 5.2 meters, and a resting level of 2.4 meters. Below are examples of ramp usage based on calculations and examples of applicable wheeled aids, along with a reference image design using a 4:3 scale:

![Fig 3. Flat path example (PermenPU30-2006)](image3)

![Fig 4. Flat path recommendation](image4)

![Fig 5. 3D flat path recommendation](image5)

### 3.3 Mill flakes hit workers

The issue of mill debris hitting workers is attributed to two factors: human error, particularly the failure to wear a face shield, and positional error during grinding. To mitigate this issue, personal protective equipment (PPE) in the form of safety glasses or face shields can be employed to reduce the risk of foreign objects entering the eyes [18]. In this case, the use of protective glasses alone is considered less effective because plastic fragments or foreign materials produced during milling can potentially impact not only the eyes but also other areas of the face. Therefore, the use of a face shield is necessary to provide comprehensive protection for the facial area. The priority recommendation from WISE to be applied is the use of personal protective equipment in the form of a face shield to minimize the risk of facial injuries. Additionally, addressing improper worker positioning during milling is crucial, as it is a primary cause of plastic debris exposure. To minimize the risk, workers should turn their backs to the machine to allow debris to bounce forward without directly impacting them. Furthermore, the use of visual displays can serve as reminders to workers about the importance of wearing personal protective equipment (PPE).

![Fig 6. Example of wheel assisting tools](image6)

![Fig 7. a. Position improvement; b. Visual display; c. 6a and 6b Implementation](image7)

### 3.4 Exposure to dirty water for 8 hours

Exposure to dirty water for extended periods, around 8 hours, poses a significant risk to the mill workers responsible for handling milled products immersed in water. The absence of worker awareness to maintain proper hygiene after work, along with the lack of sanitary equipment like soap, contributes to the development of skin diseases, such as water lice, which are caused by wet working conditions and exposure to dirty water [19]. One of the recommended WISE measures is to provide sanitation equipment such as soap at the water sources to promote proper sanitation practices. Additionally, the use
of visual displays can be employed to raise awareness among workers regarding the importance of practicing good sanitation. Encouraging workers to wash their hands and feet with soap during breaks throughout the day is crucial to minimize the risk of water lice and other skin diseases [20]. The use of visual displays illustrating the potential consequences of not washing hands and feet with soap is intended to encourage workers to prioritize proper hand and foot hygiene by using soap [21].

Fig 8. a. Worker feet condition; b. Visual display; c. Installation of visual display; d. Provision of soap

3.5 Plastic material infiltrates the soles of the feet

Exposure or scratches on the soles of workers' feet due to plastic materials or other objects occur because some workers do not wear appropriate footwear while working. This reluctance is primarily due to discomfort and the absence of proper supervision. Workers may experience discomfort because they are not used to wearing footwear during work. However, this practice can be very hazardous if continued. Wearing suitable footwear during work is essential to protect the feet from dangerous objects and potential health risks [22]. The WISE point taken is to set a simple OHS policy, where visual displays will be installed and PPE (footwear) checks will be carried out every morning by OHS officers.

Fig 9. a. Visual display; b. Visual display installation

3.6 Worker being hit by mill flakes

Employees are exposed to plastic debris due to the insufficient quantity of items placed in the dryer, resulting in a low density that leaves empty spaces and allows the plastic to bounce readily. Additionally, the absence of Personal Protective Equipment (PPE) in the form of face shields poses a risk in case plastic particles come into contact with the facial region, particularly the eyes. The utilization of a face shield serves as a preventive measure to shield the face, particularly the eyes, from direct impact by objects [18]. The strategic measures to be enacted include the acquisition of face shield Personal Protective Equipment (PPE), optimization of the quantity of goods being processed to enhance density, and the implementation of visual aids to promote heightened awareness regarding the imperative usage of face shields.

Fig 10. a. Provision of face shields; b. Faceshield visual display

4 Conclusions

There are 28 potential hazards identified within the workplace, distributed across various sections as follows: 4 medium-risk categories and 1 low-risk category in the sorting section, 1 low-risk category, 4 medium-risk categories, 3 high-risk categories, and 1 extreme-risk category in the milling section, 3 low-risk categories, 1 high-risk category, and 1 extreme-risk category in the drying section, and 2 low-risk categories and 7 medium-risk categories in the finished goods warehouse. Among these hazards, six categories with the most significant impact have been identified, including high and extreme-risk categories, which encompass concerns related to the noise generated by moving machinery, health issues in the head area, potential worker injuries from mill fragments, prolonged exposure to contaminated water for 8 hours, the use of plastic materials in footwear, and workers being exposed to plastic chip splashes. To address these concerns, a WISE (Workplace Improvement, Safety, and Efficiency) plan can be proposed, which includes measures such as the provision of Personal Protective Equipment (PPE), the installation of ramps, the introduction of wheeled aids, and an emphasis on enhancing techniques and methods at each workstation.

References