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Hazard Identification Risk Assessment and Determining Control (HIRADC) Method for Shoe Cutting Dies Production

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Abstract. Along with high orders from customers for shoe products in apparel companies, the production department must also support productivity results. The production process has experienced several problems, including the number of work accidents and potential levels of work accidents, and the absence of safe work accident control measures in the cutting die area for the shoe production process. The purpose of this study is to analyze the types of work accidents and provide recommendations for controlling sources of hazard to reduce or eliminate the level of risk involved in the shoe molding process. The method used in this study uses the Hazard Identification Risk Assessment and Determining Control (HIRADC) method combined with the Focus Group Discussion (FGD) method. The findings of this study have obtained data before repair with 16 hazard potentials consisting of 6 medium hazard potentials and 10 low hazard potentials. Improvements that have been made in accident risk control for each potential hazard include technical controls, administrative controls, and document controls. The results of this study resulted in a reduction in the risk of work accidents after repairs to 16 low hazard potentials and no moderate hazard potentials. So from these results, it can be concluded that the decrease in risk level from medium risk to low risk proves the success of corrective actions.

Keyword: Cutting Dies, HIRADC, Occupational Safety and Health, Shoe Production, Work Accident

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1. Introduction

Along with the high number of orders from customers for shoe products in the apparel industry in Indonesia, the production department must also support productivity results [1]. The production process of making shoe dies has problems including the number of work accidents and the potential level of work accidents [2]. These problems can disrupt the smooth production process of shoe making and become an obstacle in meeting customer demand [3]. Every work activity wherever there is the potential for work accidents both minor, moderate, and major accidents [4].

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Several kinds of work accidents are taken into account in the company, from the smallest to the biggest there is a possibility of work accidents [5].

Several types of work accidents that occur in shoe-cutting die companies are strongly influenced by unsafe actions and unsafe conditions. In the manufacture of shoe-cutting dies, some areas require safety equipment which is sometimes not paid enough attention to by all parties. Safety equipment is needed to protect workers in carrying out their work activities [6]. Therefore, companies must provide safety devices to eliminate workplace accidents and create methods for controlling them [7]. The problems that occur in the production of cutting dies for shoe products are still frequent work accidents in several parts of production, the data that has been collected so far (Table 6) has a work accident risk level with 10 low-risk potentials and 6 medium-risk potentials. Therefore, company management must be challenged to be able to reduce the potential hazards of this moderate risk.

The company tries to analyze the root causes of work accidents from the beginning to the end of the process [8]. The company found that there were no safe work accident control measures in the cutting dies area for the shoe production process. The company is aware that there are work-related incidents that cause problems that can injure workers and even cause workers to lose their lives [4]. In addition, obstacles and delays in production activities can occur due to work-related illnesses and work accidents [9].

The application of HIRADC is one part of the contents of the International Standards Organization (ISO) 45001 version 2018 [10]. ISO 45001:2018 is an international standard that specifies various requirements for the Occupational Safety and Health Management System (OSHMS) [11]. These standards enable organizations to actively improve OSHMS performance to prevent work accidents. This is also following clause 6.1.2 of ISO 45001:2018, which states that organizations must establish procedures and apply Hazard Identification, Risk Assessment, and Risk Control (Determining Control) or abbreviated as HIRADC [12].

Occupational Safety and Health (OSH) needs to be a consideration for the industry to avoid work accidents [13], [14]. Accident prevention can be done by analyzing existing risks, one of which is the HIRADC method, namely identifying hazards (Hazards Identification), assessing risks (Risk Assessment), and controlling risks (Determining Control) [15]. Risk control is due to working on the freight forwarder and calculating the level of risk according to the level of likelihood and severity [16]. Prevention of work accidents with the application of HIRADC in fabrication and machining companies has been able to reduce the potential hazard of work accidents [17]

Based on the above phenomenon, companies need to apply the Hazard Identification Risk Assessment Determining Control (HIRADC) method. HIRADC is a method for identifying hazards, and risks and determining control over a hazard in the work environment [12]. Companies should use the HIRADC method to minimize the number of work accidents in the work area so that the number of work accidents can be reduced, avoided, or even eliminated [18].

Other research can combine the HIRADC method with Failure Mode and Effect Analysis (FMEA) to produce a Risk Level [19] [20].

The new approach of this research is the HIRADC method which is applied in the apparel industry with shoe products, where before shoe production, you have to make cutting dies for the shoe base first to make it easier to make shoes. The HIRADC method is also combined with brainstorming in identifying accident hazards and the Focus Group Discussion (FGD) method in analyzing accident risk and the likelihood method to see how big the chance of uncertainty is for a risk to occur. The purpose of this study is to analyze the types of work accidents and provide recommendations for controlling sources of hazard to reduce or eliminate the level of risk involved in the shoe molding process. The limitations of this study only analyze the risk of work accidents in the cutting dies for shoe production. The benefit of this research is that it is hoped that the risk of moderate potential hazards can be eliminated, so that shoe production is not disrupted by a shortage of supply from the previous section, namely the cutting dies section.

2. Methodology

This research is a mixed method research type because there is quantitative data in the form of observations from primary data collection by going directly to the research object to take a close look at the activities carried out so that it can make research easier than recording the observations with other tools. While qualitative data in the form of interviews with several employees and literature studies are used to collect data or sources related to the main points raised in a study such as documents from books and journals that discuss supporting information if needed. For work accident data processing techniques in May 2022 to October 2022 as data before improvement, and then corrective actions are carried out so that work accident data can be known starting from November 2022 to March 2023. The research steps can be seen in Figure 1.

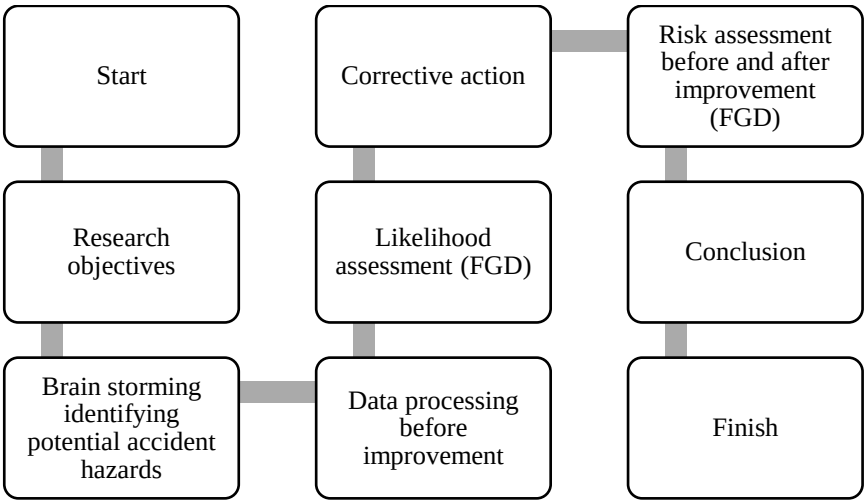

Figure 1 Research Methods

The stages of this research began with determining the research objectives, namely identifying types of work accidents using the HIRADC method while providing solutions to prevent recurring accidents. Then the identification can be obtained by brainstorming with several employees,

totaling 6 employees working on cutting dies for shoemaking. If the data has been obtained, it is necessary to process the data before improvement as a reference in conducting a Likelihood (L) assessment through FGD. The FGD was conducted with participants who were experienced in the field of OHS consisting of nine expert judgments. The provisions for conducting the Likelihood assessment have been determined by the previous researcher [2].

- Value (1) is almost impossible, can be considered, or except for extreme types of work accidents
- Value (2) sometimes happens, hasn't happened yet, and if it happens sometimes, it has accidents that are at the same time
- Value (3) may occur or may occur in one cycle
- Value (4) is very likely to occur, can easily, and probably occurs with the most common circumstances
- Value (5) is almost certain to occur, occurs frequently, and is expected to occur in the most common circumstances

The next step is to determine the value of the Risk Rating Number (RRN) multiplied by Severity (S) and Likelihood (L) or multiplied by the Degree of Possibility (DPH) and Likelihood of Occurrence (LO) according to the formula [12].

$$RRN=DPH \times LO \quad (1)$$

$$RRN=S \times L \quad (2)$$

If the RRN value has been obtained, to find out that the Risk Level of all potentially hazardous work can be determined by the Risk Level status in Table 1.

The next step is to carry out a Risk assessment before improvement which is useful as initial data and is carried out through FGD. Then take corrective actions from several activities that have the potential to produce medium and high hazard risks. After carrying out corrective actions, a risk assessment after repair can be carried out through the FGD that has been formed so that later it can be assessed what percentage of the potential hazard reduction in shoe-making cutting dies work. The final step is to conclude this research based on the report data that the improvement team has obtained.

Table 1 Risk Assessment [21]

Risk Level	Risk Score	Risk Remark
Extreme	20 – 25	Very High
High	10 – 15	High
Medium	5 – 9	Medium
Low	1 – 4	Low

3. Result and Discussion

In this section, the results of the research will be discussed and the discussion will be adjusted to previous research if there is relevance to the results of the research. The results of the research steps can be explained in this section.

3.1. Potential Work Accident Risk

This section generates report data from several employees who have experience in cutting dies for shoe products for more than 5 years. The employee sample interviewed by the improvement team totaled 6 employees with a brainstorming frequency of 1 year 2 times. In accident risk brainstorming after creating a brainstorming team, each operator gives the opinion they get from each process location and each operator gives an opinion from every risk hazard that has been found (Table 2).

Table 2 Accident Risk Brainstorming

No	Activities	Potential Accident Risk According to the Operator					
		Operator A	**Operator B**	**Operator C**	**Operator D**	**Operator E**	**Operator F**
1	Bending process	Pinched fingers	Scratched	Pinched fingers	Clipped finger	Scratched	Clipped finger
2	Streep plate-cutting process	Hand hurts	Pinched material	Etched edge material	Squeezed materials	Hand hurts	Etched edge material
3	Welding process	Caught sparks	Exposed Light weld	Scratched	Caught sparks	Scratched	Exposed light las
4	Grinding machine process cut	Machine pinched hand	Machine pinched hand	Eye irritation	Skin irritation	Eye irritation	Eye irritation
5	Welding process acetylene	Burn irritation	Scratched	Eye irritation	Squeezed materials	Scratched	Skin irritation
6	Hand grinding process	Burns	Exposed to sparks	Exposed to sparks	Burns	Electric Shock	Electric Shock
7	File process	Hand scratched	Hand truncated	Hand scratched	Hand scratched	Hand truncated	Hand scratched
8	Pass checking process	Hand hit by the hammer	Hand hit by the hammer	Not subject to visual inspection	Hand hit by the hammer	Not subject to visual inspection	Not subject to visual inspection
9	Paint Process	Out of breath	Out of breath	Out of breath	Out of breath	Out of breath	Out of breath

Based on Table 2, brainstorming has been carried out with several employee representatives who work in the cutting dies section. Some employees think that every job will have the potential for work accidents to occur in the parts of the body that are active in doing the job. The risk of an accident in each production process of cutting dies for shoes can pose a hazard to every worker [4].

3.2. Focus Group Discussion (FGD)

The FGDs that have been carried out in this study are tasked with determining potential hazards, current controls, and Likelihood on each job both before and after improvements FGDs can be carried out with different problem subjects in determining corrective steps [22]. The FGD team consisted of 9 people as representatives from several departments. The existence of the FGD team as a decision maker in prioritizing corrective actions and risk assessment of potential hazards.

Then the data is used as a reference in carrying out corrective actions with the internal improvement team. The members of the FGD can be seen in Table 3.

Table 3 Expert Judgment Members

Expert	Age (year)	Work experience (year)	Position	Skill	Remark
Expert 1	54	20	Board of Director	Budgeting, HSE management	Internal
Expert 2	51	23	General Manager	Saving cost, HSE management	Internal
Expert 3	47	17	Factory Manager	Safety management, Productivity	Internal
Expert 4	52	18	HSE Manager	HIRADC, Safety first	Internal
Expert 5	47	20	HSE Supervisor	Safety first, ISO 45001	Internal
Expert 6	45	23	HSE Staff Plant	HSE team, Safety first	Internal
Expert 7	53	17	Maintenance Manager	HSE team, Maintenance utility	Internal
Expert 8	41	15	HSE Trainer	HSE management	External
Expert 9	43	15	Auditor ISO	ISO 45001, ISO 18001	Consultant

The results of the FGD meetings that were held 2 times resulted in the following meeting resumes:

- Determination of the RRN value and Risk Level status must be adjusted to the level of work accident risk and work accident data for the previous 2 years
- Improvements that must be made are prioritized at medium Risk Level values to be carried out immediately, while Low-Risk Levels are more towards monitoring and repressing training
- For repairs that incur costs, the management agrees that operational costs will be incurred in repairing equipment
- The next target for work accidents must be zero accidents and each plant is evaluated, monitored, patrolled, and monthly reports

3.3. Risk Assessment on Potential Hazards

After analyzing potential hazards that potential hazards are found in each process. The likelihood rating mechanism is based on the severity of a work accident, the more severe the effect of a potential work accident, the higher the likelihood value. To be able to carry out a risk analysis of potential hazard risks, a value of likelihood and severity is needed. The likelihood is a value that describes a value in the frequency that occurs in each potential accident risk, while the severity value is a value that has a severity impact on the potential hazard.

Table 4 Likelihood of Cutting Dies for Shoes Production Process

No	Activities	Danger Source	Potency Danger	Current Control	Likelihood
1	Bending process	Broken materials	Scratched finger due to broken material	Gloves	1
		Bending machines	Pinched finger due to bending machine	Gloves	2
2	Streep plate-cutting process	Cutting machine heavy	Hand pain when operating the machine	Gloves	2
		Plate cutting machine strep	A hand-clamped strep plate-cutting machine	Gloves	3

No	Activities	Danger Source	Potency Danger	Current Control	Likelihood
		Plate blades strep	Scraped the knife edge of the strep plate	Gloves	2
3	Welding process	Sparks	Got sparks in the eye	Glasses	2
4	Grinding machine process cut	Sparks	Burns from sparks	Glasses	2
5	Welding process acetylene	Ray of light welding	The eye is hit by the welding beam	Glasses	2
		Gas cylinders	Burns from a gas explosion	Long-sleeved clothes	2
		Blade grinding	Grinding eye hands	Gloves	2
6	Hand grinding process	Electric current	Hand gets electric shock	Gloves	2
		Sparks	Eye irritation	Glasses	3
7	File process	Miser blade	Hand-scratched file knife	Gloves	1
		Material plate	Scratched edge of the sharp side of the material	Gloves	1
8	Pass checking process	Hammer	Hand hit by a hammer	Gloves	2
9	Paint Process	Paint smell	Shortness of breath exposed to paint vapors in the long term	Face mask	3

3.4. Corrective action

This section will discuss the corrective actions that have been taken to control the handling of potential hazards in the cutting dies for shoemaking. There are several controls including technical controls, administrative controls, and emergency controls. Some of the activities in the process of making cutting dies that result in a moderate hazard risk value are in Table 6, namely, the data before repair needs to be corrected. The detailed control over the handling of this potential hazard can be seen in Table 5.

Based on Table 5 that the administrative control utilizes providing first aid kits, OHS training for workers conducted every 3 months for all operators, and implementing comfortable use of equipment. Streep plate cutting machine operation training activities are scheduled and briefing before work every day. PPE equipment that is always available and easy to find so that operators must wear it, namely safety gloves, sunglasses, face shields, safety helmets, welding work clothes or aprons, welding masks, welding gloves, goggles, and special paint respirator gas masks. Other research shows that administrative control is very supportive in the daily supervision of controlling potential accident hazards [2].

Table 5 Handling Control of Potential Hazards

No	Activities	Potency Danger	Technical Control	Administrative Control
1	Streep plate-cutting process	A hand-clamped strep plate-cutting machine	Modification of the cutting machine with the addition of a safety cover	First aid kit and PPE checklist
2	Acetylene welding process	Body burns	The gas cylinder area is protected by a wall	SOPs and warning signs
3	Hand grinding process	Burns from sparks	Additional ring or bolt reinforcement	First aid kit and PPE checklist
4	Hand grinding process	Grinding eye hands	Modification of the grinding wheel is added to the cover or fender	PPE checklist, warning signs

5	Hand grinding process	Eye irritation	A flexible chimney is made for the disposal of residual grinding	PPE checklist, warning signs
6	Process Painting	Shortness of breath exposed to paint vapors in the long term	Good room ventilation for air circulation and additional exhaust	SOPs and warning signs

Additional handling that has been carried out is implementing substitution by replacing old tools with new tools, including: making Standard Operational Procedures (SOP) adapted to the latest conditions. SOP should be updated following changing conditions and work behavior [23]. Installation of dangerous signs as a warning to all operators while working. Preparation of a complete checklist of personal protective equipment (PPE) to be filled in by the operator and supervised by his direct supervisor [24]. Implementation of monthly health checks for workers so that health monitoring occurs so that employee health is under control and employee rotation can be carried out if there are symptoms of health problems. Medical Check Up (MCU) needs to be done as a healthy control for every employee [25]. There needs to be an encouragement to increase and apply the use of personal protective equipment (PPE) in each work process that focuses on the level of severity and allows for considerable danger. The application of specific and mandatory strict PPE in the welding and cutting process parts is consistent and documented.

3.5. Risk Assessment Results

After knowing the value of the likelihood and severity results in the process of making shoe product cutting dies, the next step is to determine risk control priority by determining it through the Risk Rating Number (RRN) value, which is the value obtained from the likelihood and severity rates. The simulation example number 6 before improvement applies formula 1. The results of the risk level assessment before and after improvement can be seen in Table 6.

Table 6 Results of Comparison of Risk Level Assessment Before and After Improvement

No	Activities	Potency Danger	Current Control	Before Improvement				After Improvement			
				S	L	RRN	Risk Level	S	L	RRN	Risk Level
1	Bending process	Scratched finger due to broken material	Gloves	1	1	1	Low	1	1	1	Low
2		Pinched finger due to bending machine	Gloves	2	2	4	Low	2	2	4	Low
3		Hand pain when operating the machine	Gloves	1	2	2	Low	1	2	2	Low
4	Streep plate-cutting process	A hand-clamped strep plate-cutting machine	Gloves	3	3	9	Medium	1	3	3	Low
5		Scraped the knife edge of the strep plate	Gloves	2	2	4	Low	2	2	4	Low
6	Welding process	Got sparks in the eye	Glasses	3	2	6	Medium	2	2	4	Low
7	Grinding machine process cut	Burns from sparks	Glasses	3	2	6	Medium	2	2	4	Low
8	Welding process acetylene	The eye is hit by the welding beam	Glasses	1	2	2	Low	1	2	2	Low

No	Activities	Potency Danger	Current Control	Before Improvement				After Improvement			
				S	L	RRN	Risk Level	S	L	RRN	Risk Level
9		Burns from a gas explosion	Long-sleeved clothes	2	2	4	Low	1	2	2	Low
10		Grinding eye hands	Gloves	3	2	6	Medium	2	2	4	Low
11	Hand grinding process	Hand gets electric shock	Gloves	2	2	4	Low	2	2	4	Low
12		Eye irritation	Glasses	2	3	6	Medium	1	3	3	Low
13		Hand-scratched file knife	Gloves	3	1	3	Low	3	1	3	Low
14	File process	Scratched edge of the sharp side of the material	Gloves	3	1	3	Low	3	1	3	Low
15	Pass checking process	Hand hit by a hammer	Gloves	2	2	4	Low	2	2	4	Low
16	Paint Process	Shortness of breath exposed to paint vapors in the long term	Face mask	3	3	9	Medium	1	3	3	Low

In the production process of making cutting dies for shoes, there are 9 processes with 16 potential hazards and 10 potential hazards with a low value and 6 potential hazards with a medium value. On the potential hazards that have a medium value, suggestions for improvements are made to reduce the potential hazards that occur in the production process of cutting dies for shoes. The results of the comparison of the Risk Level before and after the improvement can be seen in Table 7.

Based on Table 7, there is a decrease in the medium Risk Level from 6 cases to 0 cases, meaning there is a 600% decrease. After corrective steps have been taken starting from hazard identification, risk assessment, and hierarchical control, the result is a decrease in the hazard potential, from a total of 16 hazard potentials with details of 6 moderate risk levels and 10 low risk levels to 16 low hazard potentials. All corrective actions for the Risk Level have succeeded in eliminating the medium Risk Level from shifting to a low level. Other studies related to HIRADC in the construction industry have succeeded in reducing the risk level value from a medium level of 8 potentials to 0 potentials due to the implementation of the HIRADC method [26] and the electrical assembly industry [27].

Table 7 Comparison of Risk Levels Before and After Repair

Risk Level	Before Improvement	After Improvement
Low	10	16
Medium	6	0
High	0	0
Extreme	0	0

4. Conclusion and Future Research

This research has produced conclusions in identifying the types of work accidents in the process of cutting dies for shoe making using the HIRADC method combined with the FGD method in determining the risk level assessment. The types of potential hazards that have been found before carrying out corrective actions include 16 potential hazards consisting of 6 medium hazard potentials and 10 low hazard potentials. Meanwhile, after repairs, it was found that there was a potential hazard of 16 low hazard potentials, which means that the research has succeeded in reducing the potential risk of accidents from a medium level to a lower level, namely low (Table 7).

The proposed control measures that have been carried out using the HIRADC method are hierarchical controls for each potential hazard including technical controls including machine and environmental factors. Improvements in engine factors include modification of the cutting machine by adding a safety cover, adding reinforcing rings or bolts, and modifying the grinding machine by adding a cover or fender. While improvements from environmental factors consist of a gas cylinder area protected by a wall, made of a flexible chimney to remove residual grinding, and good ventilation of the room so that air circulation and additional exhaust.

This research also resulted in administrative control which included improvement of human factors and methods. Improvements in human factors include the provision of a controlled first aid kit once a month, and a PPE checklist that has been completed by the operator and supervised by his immediate supervisor. The improvement of the method factor includes changing the SOP according to current conditions and installing warnings. signs in the work area or equipment to remind operators to be more careful in doing their work, document control related to the control and supervision of potential accident hazards is controlled and regulated by the company.

In this study, the researchers recommend that further research be carried out for the continuous implementation of internal audit on OHS to determine the success rate of implementing HIRADC and provide OHS training consistently by involving external trainers and in the future start reviewing the implementation of ISO 18001 regarding Occupational Health and Safety Assessment. Series (OHSAS) 18001.

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This research has been conducted for 1 year at the shoe-making apparel company PT. Bintang Wijaya Abadi Tangerang Indonesia. The research team would like to thank the company for the opportunity and permission to collect data, corrective actions and evaluate risk-level results. It is hoped that the results of this research can be consistently implemented to prevent work accidents from recurring in the future.

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