International Journal of Economic, Technology and Social Sciences
e-ISSN 2775-2976
International Journal of Economic, Technology and Social Sciences
url: https://jurnal.ceredindonesia.or.id/index.php/injects
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Risk Assessment of Manufacturing Hydraulic Press Paving Block Machine

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ABSTRACT
Hazard is the intrinsic property of a substance, equipment or physical situation with potential to cause harm. Hazards can pose risks, and risks must be assessed. Assessing risk can be done by imagining the impact that will arise to determine the level of risk. Knowing the level of risk can make risk control more controlled and comprehensive. This paper describes the improvement of the risk assessment method in the manufacturing industry using the HAZOP. HAZOP approach applied to identify and control potential hazards, risks in the workplace. The HAZOP approach was chosen because HAZOP is a qualitative method that is easy to learn, thorough, systematic, logical, and demands to obtain accurate results. In the process of making paving block machines there are several processes carried out starting from the beginning of cutting the material to the completion of the machine and testing its operation. In this process, risk assessment procedures and identification of potential hazards must be carried out to plan to minimize or control them. It is proposed to control the problems and negative impacts on the paving block machine fabrication process by applying the HAZOP method.

Keywords: Hazard, Risk Assessment, Manufacturing, HAZOP

INTRODUCTION

Hazard is the intrinsic property of a substance, equipment or physical situation with potential to cause harm. Hazard must be controlled by being able to identify the source of the hazard. Hazards can create risks, and risks must be assessed. Risk is the likelihood of harm being realized. Assessing risk can be done by imagining the impact that arises to determine the level of risk. Knowing the level of risk can make risk control more controlled, comprehensive and effective.

These hazard identification processes can also be supported by checklists with relevant questions or topics; an example is given in Table 1 below.

Table 1. Hazard Checklist

No.	Hazard	Describe
1	Hazards from the process	Damage To The Environment, Fire, Flammable Substances, Hazardous Substances, Hot / Cold Materials, Pressure, Thermal Relief, Trapped Energy
2	Hazards From The Work / Tools	Electric Shock, Heavy Loads, Moving Machinery, Projectiles / Particles, Sparks, Vibration
3	Hazards From The Location	Confined Spaces, Falls, Falling Objects, Uneven Surfaces, Sharp Edges
4	Hazards From The People	Assumptions, Awkward Body Position, Lack Of Skill / Experience, Poor Communication, Taking Action In The Wrong Order

As it has already been acknowledged, there are a great many hazards in any workplace; the following Table 2 lists some possible categories and consequences.

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Table 2 Hazard categories and consequences

No.	Hazard Category	Hazards	Consequences
1	Ergonomic	Workstation layout	Tiredness, headaches, fatigue
		Moving equipment	Equipment damage, injury
		Machinery design	Inadequate use, injury
		Control room design	Inadequate control of plant
		Process plant design	Inadequate operation of plant
2	Mechanical	Rotating machinery	Permanent disability
		Mechanical lifting	Cuts, bruising, abrasions
		Operation of vehicles	Fatality, damage to equipment
3	Electrical	Static	Shock, fire explosion
		Voltage > 30 volts	Shock, burns, fatality
4	Chemical	Dust	Respiratory disease
		Vapor/gas	Poisoning, oxygen deficiency
		Particulates	Occupational disease
		Liquid	Burns, dermatitis, poisoning
		Solid	Burns, fire/explosion
		Flammable gas	Fire/explosion, burns
5	Physical	Noise	Reduced hearing capability
		Ionizing radiation	Cancer
		Slips, trips, falls	Bruise, fractured bone, fatality
		Compressed gas	Eye damage, tissues damage
		Temperature	Burns (cold and hot), fire
		Manual handling	Chronic back injury, general
		Explosion	Injury
		Confined space	Fatality, fire oxygen deficiency, poisoning
6	Biological	Microbiological organisms	Illness
		viruses	Illness, fatality
7	Psychosocial	Shift patterns	Fatigue, inadequate motivation
		Work organization	Inefficient work patterns
8	Natural	Earthquake, rain, lightning, winds (hurricane)	Structural and equipment damage, flooding, fire/explosion
9	Environment	Humidity	Fatigue
		Temperature	Inability to work adequately
		Lighting	Eye strain, headache
		Population	Fatigue
		Space	Inefficient work patterns

The level of the risk should be estimated by considering the potential for harmful consequences and the probability that these will occur. To help focus the team on the more important concerns, a general appreciation for the level of consequence and probability should be established. This can be handled by use of a tabular listing of hazards, consequences and risks with agreed priorities or by the use of a risk matrix, like the one in Table 3 below. A systematic approach is essential to promote consistency in determining whether an incident scenario is a tolerable risk.

Table 3 Risk Matrix - Basic Format (Somerville et al., 1997)

PROBABILITY / CONCEUENCES	High	Medium	Low
High	**H**	**H**	**M**
Medium	**H**	**M**	**L**
Low	**M**	**L**	**L**

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The fabrication industry is an industry where the work process is engineered and made a product from the original material into a certain product. Implementing a technique or procedure for the production process can not only produce products that meet the target but also has the potential to cause problems and negative effects such as work accidents, damage to equipment, damage to assets and also to the work environment.. Hazards and problems in the technique or procedure of the production process must be identified and controlled properly so as not to cause harm. The main purpose of the discussion in this paper is how to control hazards in a manufacturing process in industrial machine fabrication. According to Irfan and Indri (2021), that in Indonesia the manufacturing industry has a high contribution to work accidents along with construction, which amounted to 63.6% recorded in 2020. Work accidents can occur, one of which is due to the management of occupational safety and health risk management in the company which is not implemented properly.

Many companies in the field of manufacturing, machining, small and medium scale fabrication have several problems in the production process which are more or less the same, among others, namely the quality of the work environment, work quality, awareness of work safety is relatively low, potential hazards are quite high, not there is or does not comply with SOPs, relatively long product manufacturing times and others when compared to large-scale manufacturing companies. Orders for products at these small and medium-sized fabrication companies still exist but are small in scale, product prices are relatively cheap and relatively difficult to develop. Industrial machinery is one of the fabrication companies that engineer and manufacture various types of industrial machine tools such as the manufacture of components, jigs and machines. Industrial machinery also experienced relatively the same production process problems. This will be the main discussion to be analyzed in this paper.

LITERATURE REVIEW

According to Anizar 2009, risk can be described as the opportunity and probability of a hazard to produce a work accident and the severity that can be caused if an accident occurs (severity). Risk can be broadly defined as a chance of danger, damage, loss, injury or any other undesired consequences. It is the product of two factors: Probability of an event which might occur and severity of the event if it occurs (Risk = Probability x Severity) (Harland et al., 2003). Risk Assessment is a formal and systematic approach to identify manufacturing practice risks related to equipments and supporting systems. It is a very helpful tool that can be applied to plant, equipments and systems which have been in use for many years (Kashif and Eduard, 2015).

Sofyan and Lien Herliani (2017) defined that risk assessment is part of risk management which presents a structured process that identifies how targets can be affected, and analyzes risk with respect to its consequences and probabilities before deciding what further action is needed. The risk assessment attempts to answer the following fundamental questions (ISO 31010:2009, 2009):

- What could happen and why (with risk identification)?
- What are the consequences?
- What is the probability of this happening in the future?
- Are there any factors that mitigate the consequences of the risk or that reduce the likelihood of the risk?

Procedures for identifying and assessing risks have been developed by companies and

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institutions with various methods adopted. Identifying hazards based on the analysis of the causes of hazards can be done using the Fault Tree Analysis (FTA) method and analyzing the effects using the experience method, Event Trees, FMECA, Consequence Analysis, as well as assessing risk is something that must be done. Hazard identification can be done by several methods such as experience, Checklists/Audits, Preliminary Hazards Analysis (PHA), Failure Modes and Effects Analysis, (FMEA) and HAZOP.

In the plant industry processes that have been designed according to seven major disciplines field (Table 4) the HAZOP method can engineer and control complicated and complex Health, Safety and Environment (HSE) factors in the engineering process.

Table 4. Major diciplines of engineering in the process plant industry (Jae-Young and Sang-Hoon, 2022)

Discipline	Activity
Process	Overall process system design
Equipment/mechanical	Mechanical item design in the process plant
HSE	Technical safety design related to the process plant
	Fire safety design related in the process plant
Civil	Civil factors related to the design of the process plant
Piping	Plant layout, plant piping layout, 3D piping modeling, piping material
Instrument and control	Instrument and control design of the process plant
Electrical	Electrical design of the process plant

According Marlies et al., (2009), that Assessment of risk caused by machinery or other work equipment is a part of work place assessment required by Directive 89/391/EEC. Steps of risk assessment and taking measures when assessing the risks caused by machinery and other work equipment the following procedure can be used (Figure 1). According Rahmatullah et al., (2022), that work accidents that occur are actually the end result of a rule and unsafe working conditions. 85% of the causes of accidents are human factors.

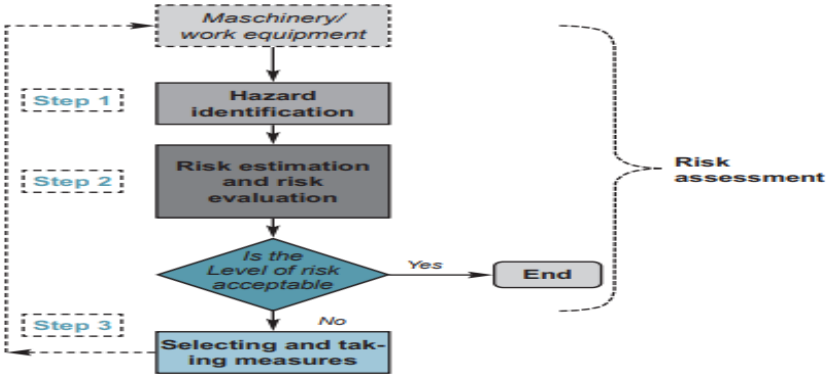

Figure 1: Iterative process of risk assessment – risk management

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e-ISSN 2775-2976
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Vishal and Charan 2016, defined that pprinciples of HAZOP is a detailed hazard and operability problem identification process, carried out by a team. HAZOP deals with the identification of potential deviations from the design intent, examination of their possible causes and assessment of their consequences. Key features of HAZOP examination include the following.

- The examination is a creative process. The examination proceeds by systematically using a series of guide words to identify potential deviations from the design intent.
- The examination is carried out under the guidance of a leader who ensures comprehensive coverage of the system under study.
- The examination relies on experienced specialists from various disciplines.
- The examination should be carried out in a climate of positive thinking and frank discussion.
- Solutions to identified problems are not a primary objective but are recorded for consideration by those responsible for the design.

Sarsama et al., 2017, defined that the primary strength of HAZOP is that it presents a systematic, diciplined and documented approach. To achieve full benefits from HAZOP study, it has to be properly documented and followed up. An important benefit of HAZOP studies is that the resu lting knowledge, obtained by identifying potential hazards and operability problems in a structured and systematic manner, is of great assistance in determining appropriate remedial measures.

METHODS

Based on the main purpose of the discussion in this paper is to risk assessment of manufacturing of industrial machinery. Industrial machinery activities is manufacture various types of industrial machine tools such as components of hydraulic press paving block machine (Figure 2), mixers for palm oil processing and other machines. The manufacturing process of industrial machine tools is carried out with various types of equipment and manufacturing processes. The process of fabricating and manufacturing these industrial machines is generally carried out using various methods and tools according to the purpose of production, such as; turning, welding, grinding, drilling, cutting, rolling, bending and others. In the application of such varied processes and equipment, it is very potentially hazard. It is necessary to identify firstly on the type of method, equipment and working environment conditions to plan appropriate controls (Figure 3). In this discussion, it is proposed to control the problems and negative effects around the manufacturing process for the fabrication of the hydraulic press paving block machine by implementing the Hazard and Operability Study (HAZOP) method.

Figure 2. Components of hydraulic press paving block machine

This paper describes the improvement of the application of occupational safety and

International Journal of Economic, Technology and Social Sciences
e-ISSN 2775-2976
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health methods in industrial machinery using the HAZOP approach and technique to identify and control potential hazards in the workplace. The HAZOP technique was chosen because HAZOP is a qualitative method that is easy to learn, thorough, systematic, logical, and demands to obtain accurate results.

The condition of the production area as shown in Figure 3 below is recommended for immediate arrangements to reduce potential hazards, risk and avoid work accidents. Grouping the type of machine component production process that is being worked on before installation can reduce potential hazards and risk. Several things must be considered to avoid or reduce work accidents in the Hydraulic Press Paving Block Machine fabrication process, including: Immediately removing the remaining cutting material to another place, using PPE, adjusting the temperature, lighting, adjusting the direction of the wind or welding fumes in the work area, adjust the working distance with other workers, tie production equipment that is easy to fall, reduce the condition of continuous squatting and standing positions, adjust the position of the equipment to be used according to working conditions.

Figure 3. working environment conditions

Based on the production process carried out in the fabrication workshop to manufacture or produce paving block machines, with manufacturing activities carried out such as turning, welding, grinding, cutting, drilling, welding or cutting with torch cutting, rolling and other processes as well as assembly, then the sequence of the manufacturing process in outline and the equipment used in the fabrication process of the hydraulic press paving block machine is as shown in Table 5.

Table 5. The steps of the manufacturing process and the tools used in the fabrication of the Hydraulic Press Paving Block Machine

No.	Processes Name	Tools
1	Cutting material	Cutting grinding machine, carbide welding (acetylene), sawing machine, measurement tool, support tools, personal protective equipment (PPE)
2	Manufacturing, turning, welding parts and components	Lathe machine, electric welding machine, rolling machine, measurement tool, support tools, PPE
3	Finishing part and components	Hand drill machine, measurement tool, PPE
4	Joining of several components ✓ Welding ✓ Drilling ✓ Bolts and nuts ✓ Finishing	Welding machine, boring machine, hand grinding machine, measurement tool, support tool, PPE
5	Assembly of components: machine construction H Beam, molding, prime mover electric motor 5.5 HP, pump, Hidrolic, 12 Valve, supported electric motor 4 HP, become a machine product	Welding machine, bolt and nut fastening machine, grinding machine, measurement tool, calibration tools, support tool, PPE

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	✓ Welding ✓ Checking ✓ Finishing	
6	Machine and production test ✓ Checking ✓ Service	Measurement tool, calibration tools, PPE
	Finished hydraulic press paving block machine	

The discussion on HSE engineering in the process of manufacturing a Hydraulic Press Paving Block machine is categorized into eleven HSE engineering sections as described in the Table 6 below.

Table 6. HSE engineering parts

No.	HSE Engineering Parts
1	Workplace building
2	Safety shower and eyewash
3	Self-contained breathing apparatus
4	Evacuation, escape, rescue analysis
5	Workplace monitoring system
6	Toxic-gas, radiation detector
7	Personal protective equipment (PPE)
8	Offsite consequence analysis
9	Scrap material detector
10	Quantitative risk assessment for toxic-gas, radiation and scrap dispersion
11	Safety fence and sign

The procedure for risk assessment and identification of hazards in the process of manufacturing or fabricating a hydraulic press paving block machine in this paper is proposed as shown in Figure 4, as below.

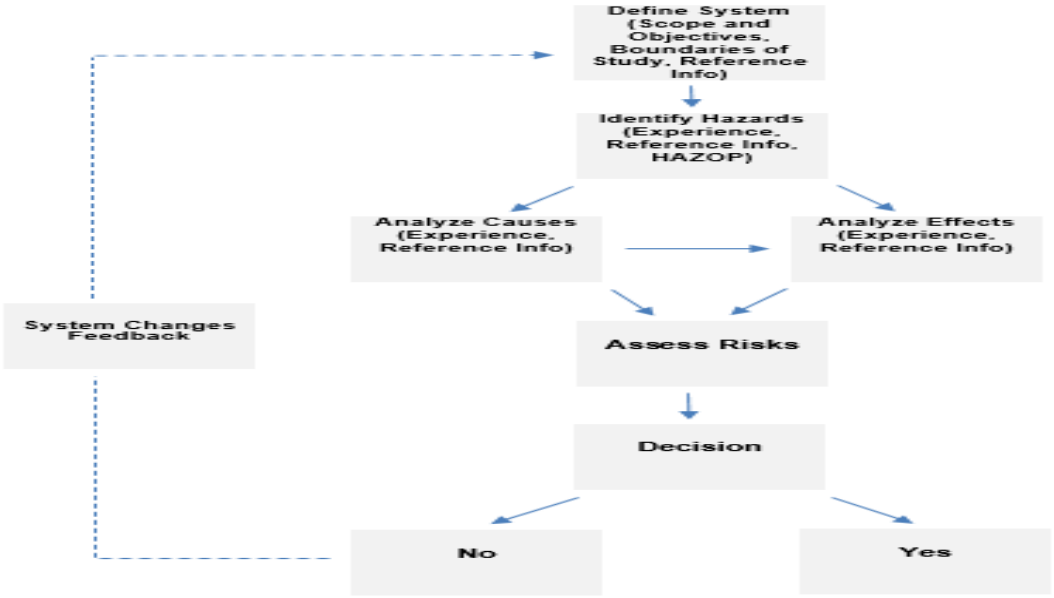

Figure 4. The propose of risk assessment procedures

RESULTS AND DISCUSSION

Results

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e-ISSN 2775-2976
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Hydraulic press paving block machine is a machine for making paving blocks using a hydraulic press system. The material for making paving blocks is inserted into the mold on the machine then the machine presses the material in the mold with a press system, so that the results of paving blocks that have the shape, size, hardness in the classification are relatively the same. In the process of making the hydraulic press paving block machine, there are several processes that are carried out from the beginning of cutting the material until the installation of the machine is completed and tested for operation. In these processes, procedures for risk assessment and identification of hazards that have the potential to occur must be carried out for plans to minimize or control them. Hazard identification around the work area in the fabrication workshop and its production process can be seen in Table 7, where the identification data was obtained based on observations, interviews, and direct observations of the leaders and operators of the fabricated production unit.

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Table 7. Hazard and risk identification of process and area fabrication of Hydraulic Press Paving Block Machine

o.	Task	Hazard	Consequence	Action	Recovery
1	Move material	Long material, not careful	Some fingers are swollen	First aid procedures performed	Workers brought to the health room
2	Cutting materials with a cutting grinder	Without handglove and safety glass	Sore eyes, torn finger	First aid procedures performed	Workers brought to the health room
3	Cutting material with carbide (acetylene)	Without Safety glass	Sore eyes	First aid procedures performed	Workers brought to the health room
4	Welding of part and components	Narrow work area and welder exposed to gas	Sore eyes and irritation	First aid procedures performed, rest	Workers brought to the health room
5	Material handling	Overload	Wounds and swelling of the finger bones	Referred to hospital	Workers brought to the health room
6	Turning of work piece	Without PPE and finger wound	Torn finger, sore eyes	First aid procedures performed	Workers brought to the health room
7	Boring of work piece	Narrow work area, hit by sharp iron	Right hand injured	First aid procedures performed	Workers brought to the health room
8	Joining with bolts and nuts	Not follow procedures	Torn finger	First aid procedures performed	Workers brought to the health room
9	Finishing with hand grinding machine	Grinding without PPE and protection	Causing injury	First aid procedures performed	Workers brought to the health room
10	Construction H Beam assembly	Narrow work area, overload material, gas in the eye	Leg injury, eyes irritation	Referred to hospital, rest	Workers brought to the health room
11	Machine base assembly	Without safety shoes	Torn leg	Referred to hospital	Workers brought to the health room
12	Prime mover electric motor assembly	Narrow work area, there are sharp materials	Injured leg	First aid procedures performed	Workers brought to the health room
13	Moulding assembly	Not careful	Injuries due to pinched hands	First aid procedures performed	Workers brought to the health room
14	Hydraulic and systems assembly	Without handglove	Injured hand	First aid procedures performed	Workers brought to the health room
15	Pump assembly	Narrow work area	Body aches	First aid procedures performed	Workers brought to the health room
16	Valve assembly	Narrow space, exposed to gas and wind	Sore eyes	First aid procedures performed	Workers brought to the health room
17	Overall assembly	Wrong procedure	Injured hand	First aid procedures performed	Workers brought to the health room
18	Hydraulic test	Not careful	Minor head injury	First aid procedures performed	Workers brought to the health room
19	Motor test	Not communicating	Injured hand	First aid procedures performed	Workers brought to the health room
20	Production test	Hit the machine	Swollen elbow	First aid procedures performed	Workers brought to the health room
21	Production noise	The sound of drilling and grinding machines is very noisy	Ringing or deaf ears	First aid procedures performed	Workers brought to the health room

Discussion

The application of HAZOP method resulted in the form of hazard identification and risk assessment. Table 5 shows the findings of hazard and risk assessments on the processes and area of production and fabrication hydraulic press paving block machine. It has found 21 hazards in fabrication of hydraulic press paving block machine workstation. The potential hazard can be classified into several groups based on the source of hazard as in Table 8.

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Table 8. Identify the source of the hazard hydraulic press paving block machine

No	Source of hazard	Number of hazard
1	Workers attitude	11
2	Work procedure	2
3	Workplace	3
4	Working conditions	3
5	Work environment	2

The 21 of potential hazards in the production or fabrication of hydraulic press paving block machine workstation can be further grouped into five types of hazards include: workers attitude (11), working conditions (3), work procedure (2), workplace (3), and work environment (2).

CONCLUSION

The main causes of the most dominant accidents in this study were workers who did not equip themselves with PPE at work, namely glasses and hand gloves. HAZOP table is very helpful in collecting company hazard data based on production flow. Based on the data from Table 6 above regarding the sources of danger in the manufacture of hydraulic press paving block machines, the main and highest potential source of hazard now and in the future is from workers attitude, after that working conditions and then with the same amount is work procedure, workplace and work environments. The suggestion for future improvement is to improve the work attitude of workers by training workers with competency-based training and testing, assessing their competence for the work they do, after changing and being good at their work attitudes, they can do their work again. Another way that can be done is to provide punishment and reward for the treatment that workers do to their work.

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