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Risk Assessment in a Metal Processing Factory in Malaysia

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Abstract. This paper evaluates the workplace hazard and safety and analyzes the case studies that happened in a metal manufacturing company. Type of incidents include fire, explosion and trapping in between objects in which one of the employees were reported death crushed by the die casting machine and the explosion of the furnace of the die casting machine. Root cause analysis techniques like Fish Bones technique was used to determine machine, method, materials, environment and personnel of the five hazards in the workplace. HIRARC analysis is performed by highlighting the hazards such as not wearing protective mask and gloves, smoking at workplace, entangled wires cable of machine, operating injection moulding machine insufficient space around furnace in the HIRARC analysis. After Pareto analysis was carried out, it was found that operating injection moulding machine shows the highest risks followed by working around furnace. The incidents can be avoided if the workers are more exposed to SOP of the operation of the machine and protective measures are taken.

INTRODUCTION

Safety and health have become crucial in manufacturing industries. A safe workplace is important for preventing accidents and maintaining optimum performance in the work. In any situation, though, mistakes happen anywhere. Therefore, a risk management assessment is critical in determining possible risks and therefore a mitigation plan can be developed.

Risk is defined as the product of the hazard having a probability resulting in the adverse event multiplied by the severity of the event [1-4]. This paper analyses a case study reported on a metal factory, in which they had an employee who worked at a die casting section. The employee was operating the die casting machine when he was found dead in a tragic accident where he was squashed by the machine. This happened when he probed his head into the machine to take out the moulded part and cleared the scrap at the inside. Another worker that was in-charge of the same machine with him was unaware of the conditions when he accidentally pressed the buttons that closed the door of the injection moulding machine. According to the witness, he would know the importance of the Standard Operating Procedure (SOP) of the machine.

Another case studies that also happened was that they had an employee who worked in the moulding machine department as well. The employee was required to take the scrap out from the inside of the machine and melted them in the furnace that was placed at the side of the machine. As the employee put the scrap into the furnace using a metal clipper, he placed a lot at a fast pace. This has resulted in a large explosion where the molten metal in the furnace splashed out. The molten metal was high in very high and can cause casualties if in contact with human. As an operator, the employee should have a good deal of knowledge by having the metal scrap cooled at a cooling temperature so that it would not have had an explosion when there is direct contact between still heated metal with the lava. It was fortunate that the employee managed to escape himself from the splashed molten. In another cases reported, an employee was

operating a band saw cutting machine. The operation of the machine should be lowered at a slow pace but he did not follow the standard operating procedure.

METHODOLOGY

The case reported was analysed and the risks as reported were studied and identified. Hazard Identification, Risk Assessment, and Risk Control (HIRARC) was carried out based on the case reported. The procedure is performed based on the outlined published by the Department of Occupational Safety and Health [5]. The risk evaluation was evaluated based on the 5×5 matrix calculation. The relative risk was evaluated based on the likelihood and severity of the risks as shown in Eqn. 1 [5].

$$\text{Relative Risk} = \text{Likelihood} \times \text{Severity} \quad (1)$$

The values for the rating are shown in Table 1 and Table 2, respectively. The risk relative values obtained are evaluated with the risk matrix as shown in Table 3. The Hazard Identification, Risk Assessment, and Risk Control (HIRARC) are performed for evaluation [5].

TABLE 1. Likelihood rating [1]

Likelihood	Example	Rating
Most Likely	The most likely result of the hazard/ event being realized	5
Possible	Has a good chance of occurring and is not unusual	4
Conceivable	Might be occur sometime in future	3
Remote	Has not been known to occur after many years	2
Inconceivable	Is practically impossible and has never occurred	1

TABLE 2. Severity rating [1]

Severity	Example	Rating
Catastrophic	Numerous fatalities, irrecoverable damage and productivity	5
Fatal	Approximately one single fatality major property damage if hazard is realized	4
Serious	Non-fatal injury, permanent disability	3
Minor	Disabling but not permanent injury	2
Negligible	Minor abrasions, bruises, cuts, first aid type injury	1

TABLE 3. The risk matrix [1]

Likelihood (L)	Severity (S)				
	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Quality and safety issues in manufacturing industries are very crucial [6,7]. One of the common tool used in quality and safety issues to find root causes of certain issues is a Fish Bone diagram [8]. Fish bone diagram as shown in Fig. 1 was then developed based on the case studies reported and possible causes are listed on the sub bone under a number categories. Step to build a fishbone diagram are:

Step 1: Identify and state the problem as clearly and clearly as possible.

Step 2: Identify main categories usually include: equipment or supply factors, environmental factors, rules/policy/procedure factors, and personnel/personnel factors.

Step 3: Brainstorm all possible causes of the problem.

Step 4: Questioning again "Why is this happening?" and write sub-causes out of the main causes identified.

Step 5: Continue to ask "Why?" and produce a deeper reason and plan to solve the root cause to prevent future issues.

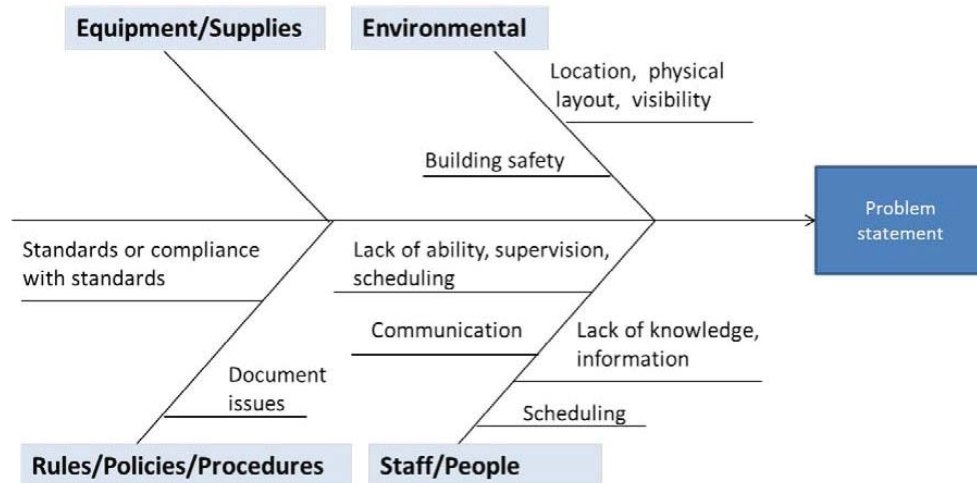


FIGURE 1. Example of fishbone diagram

A Pareto chart is a type of chart that includes both bars and line graph, where the individual values are represented in descending orders by bars, and the cumulative total is represented by line graph [9]. The Pareto principle states that, roughly 80% of the effects come from 20% of the causes. Many sectors use Pareto chart to obtain the results [10]. In occupational health and safety sector, Pareto chart acts as an important role using this principle to highlight the importance of hazard prioritization. Assuming 20% of the hazard that causes 80% of the injuries and accidents. Besides, Pareto principle ensures any concerned issues are sorted in prioritized order ensuring necessary actions will be taken based on priority ranked [11].

RESULTS AND DISCUSSIONS

Figure 2 shows the fish bone diagram performed on the case evaluated. It can be seen that, there are 6 major factors contributing to the hazards. For the case of excess of metal that will hurt the worker, it was found that the root cause was due to misleading and lack of knowledge amongst the workers. Apart from that, the machine is poor protection and maintenance after a long hour of usage. In addition, the method of cutting, grinding and sawing are improper and not follow the instruction at all. Besides that, the raw material which consist of aluminium, metal and etc. are in bad quality but still use it. Furthermore, incorrect measurement which cause the part are wrongly produced with excessive part throw around, and cause the workplace become messy.

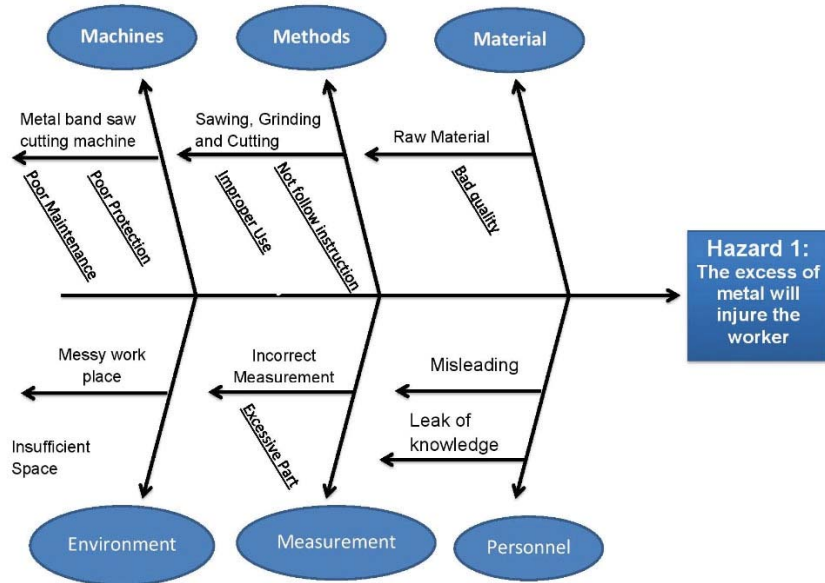


FIGURE 2. Fish Bone Diagram of Hazard 1

Figure 3 shows the fish bone diagram performed on the case evaluated. It can be seen that, there are 5 major factors contributing to the hazards. For the case of furnace cause explosion, it was found that the root cause was due to bad behaviour which is caused by less training and education amongst the workers that smoking at the workplace. Apart from that, the furnace is uncovered which exposes to the air and increases the chance of incident occurring. In addition, the smoking habit at the workplace that leaves cigarette butts and fire from lighter. Besides that, the hot and easy ignited environment leads to a high chance to have a small explosion too.

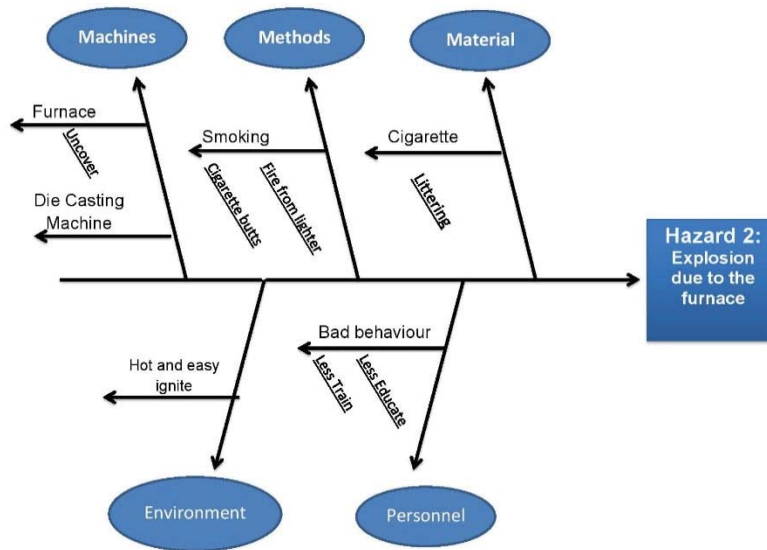


FIGURE 3. Fish Bone Diagram of Hazard 2

Figure 4 shows the fish bone diagram performed on the case evaluated. It can be seen that, there are 6 major factors contributing to the hazards. For the case of untidy exposure wires which causes electric shock or falling down when hooked it, it was found that the root cause was due to misleading and lack of knowledge amongst the workers. Apart from that, the machine is poor protection and maintenance while the wires are still exposed to the surroundings from the machine after use. In addition, while turning on and off the electricity on the machine, the improper way to use causes the

electric to be short.. Besides that, we found that the wire are extra long and incorrect measurement before install the machine. Furthermore, the untidy and messy workplace also make the wire exposure to the surrounding.

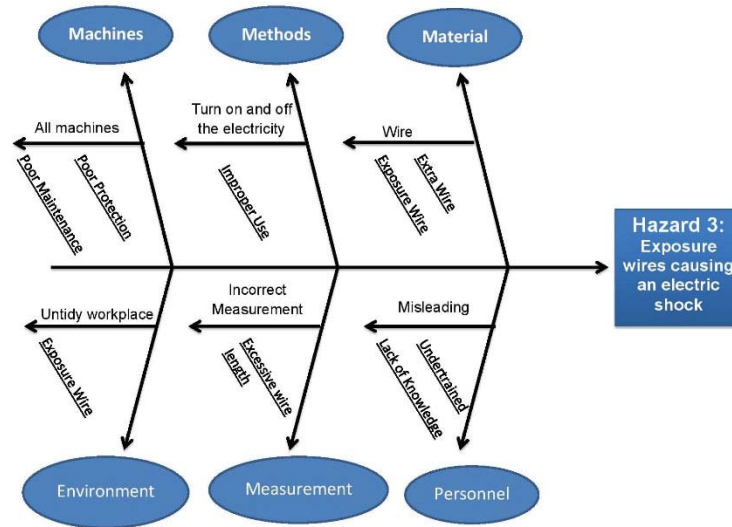


FIGURE 4. Fish Bone Diagram of Hazard 3

Figure 5 shows the fish bone diagram performed on the case evaluated. It can be seen that, there are 6 major factors contributing to the hazards. For the case of crush into the machine, it was found that the root cause was due to misleading and undertrained amongst the workers about the safety in workplace. Apart from that, the machine is uncover after each time of usage. In addition, the method of operating the machines are wrongly method and worker are not follow the instruction at all. Besides that, the raw material which is bad quality and wrong material will cause the worker to crush into the machine while doing some repairing. Furthermore, incorrect measurement of wrong setting and limited work space plus noisy environment cause wrong signal are given.

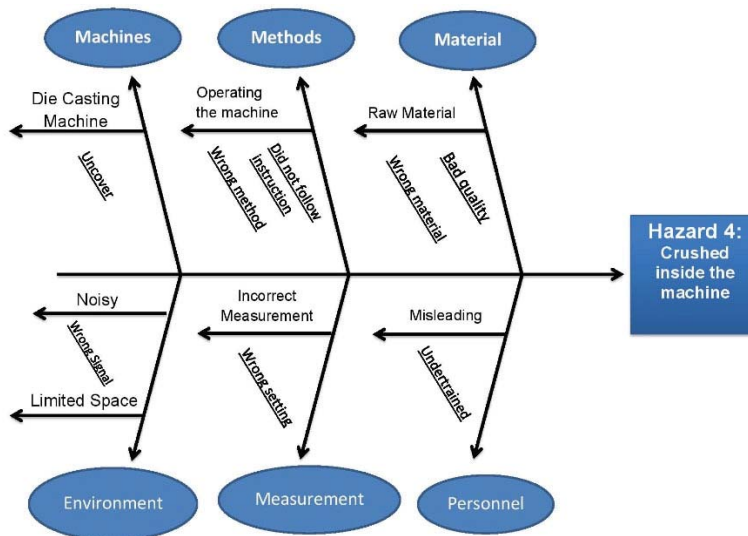


FIGURE 5. Fish Bone Diagram of Hazard 4

Figure 6 shows the fish bone diagram performed on the case evaluated. It can be seen that, there are 6 major factors contributing to the hazards. For the case of limited space , it was found that the root cause was due to misleading and lack of knowledge amongst the workers about the storage arrangement. Apart from that, all the machine are unorganised. In addition, the method of placement rules are wrongly applied and did not follow the instruction. Besides

that, the material are improper storage and arranged. Furthermore, incorrect measurement which cause the space measurement and wrongly calculation cause the space become narrow and over storage.

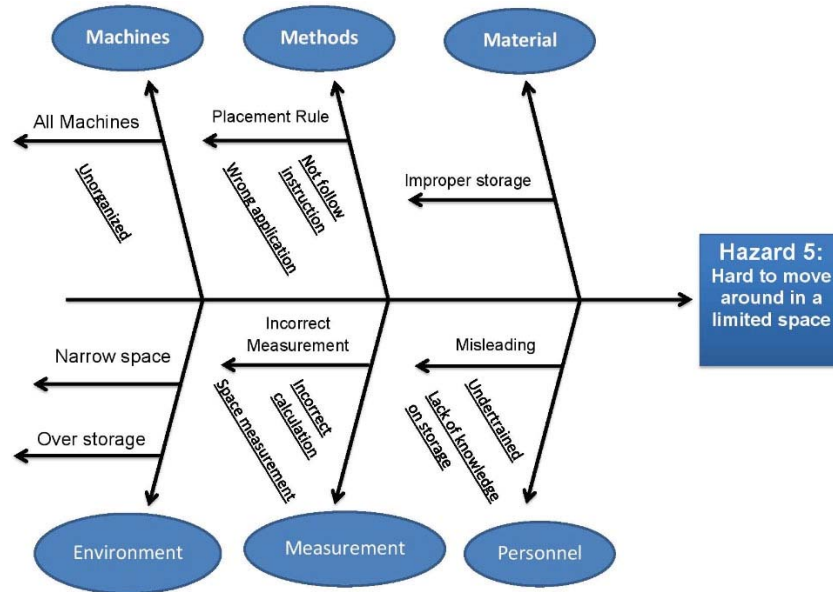


FIGURE 6. Fish Bone Diagram of Hazard 5

Table 4 shows the HIRARC analysis of the incident. It can be seen from the HIRARC that, three hazards are within the medium score while another 2 are rated as high. This indicate that all incidents are serious and need urgent responses from the company. Risk of skin burns during cutting, grinding and sawing process is highly likely for skin burns or skin injuries. By applying safe work practice, the management has advises the worker to wear protective shield, glove and mask during work. This risk is rated as 8 which is medium level risk. Besides, the risk for explosion occurs when there is smoking and ignite object around. By applying warning sign, the management team has provides a “No Smoking” sign in the working area. This risk is rated as 6 which is medium level risk. In addition, risk for electric shock occurs around the machine wires that are not cover properly. By applying safe work practices, the wires will be covered and arranged nicely without exposure it to the surrounding. This risk is rated as 9 which is medium level risk. In addition, the risk for death occurs when the workers are working at the injection machine and head crushed into the machine.

By applying safe practise, the management take a serious action to this incident and produce a SOP for every single step of the process and explain it in order to let all operators understand it. This risk is rated as 20 which is high level risk. Last but not least, the risk for falling occurs due to insufficient space at workplace. By applying safe work practice, the management team have well arranged the working place in order to save the space and create more space for the worker. This risk rated as 16 which is a high risk level too.

Figure 7 shows the Pareto Chart based on the result of HIRARC analysis. The bars are arranged with the highest risk score to the lowest from left to right. According to the Pareto Chart, it shows that the bar of operating moulding machine is the tallest with the score of 20 which is a high risk that requires the SOP of the machine and the worker should be understand. This means that it is the most significant problem and it needs attention first. This can be solved by providing SOP to the workers and ensure that they understand about it. The next problem is insufficient workplace around the furnace. This problem gives a risk score of 16 whereas is in a high risk. To overcome this problem, the furnace can be change their arrangement in that particular area so that at least 2 person are allow to move in the area. Wires cable of machine is not cover properly gives a risk score of 9. The actions that can be taken is need to cover the wires so that it is not exposure to the workers. Then, did not wear protective mask and gloves have a risk score of 8. The most relevant solution is to provide safety goggles and masks for the worker during the working hours. Smoking at workplace gives the least risk score which is 6. The effective solution to solve this problem is to provide a smoking area for the worker or paste the ‘Non-Smoking’ sign at the working area.

TABLE 4. HIRARC analysis for all incident.

Hazard Identification				Risk Analysis			Risk Control	
No	Activity	Hazard	Cause/Effects	Existing Risk Control	Likelihood	Severity	Risk	Recommended Control Measure
1.	Did not wear protective mask and gloves	The excess of metal will injure the worker.	Skins burns	Safe Work Practice	4	2	8	Advise the worker to wear a protective glove and mask when working.
2.	Smoking at workplace	Will cause an explosion due to the furnace.	Explosion	Warning Sign	3	2	6	The company manager should provide a “No Smoking” sign in the working area.
3.	Wires cable of machine is not cover properly	The wires will get exposure to the worker and may be causing an electric shock.	Electric Shock	Safe Work Practice	3	3	9	Cover the wires cable
4.	Operating injection machine	The worker’s head get crushed inside the machine	Death	Safe Work Practice	5	4	20	Produce the SOP of the machine to every worker and tell them to fully understand the SOP
5.	Insufficient space at workplace	Workers will be hard to move from one place to another and hence will affect the working performance.	Falling	Safe Work Practice	4	4	16	The management team have well arranged the working place

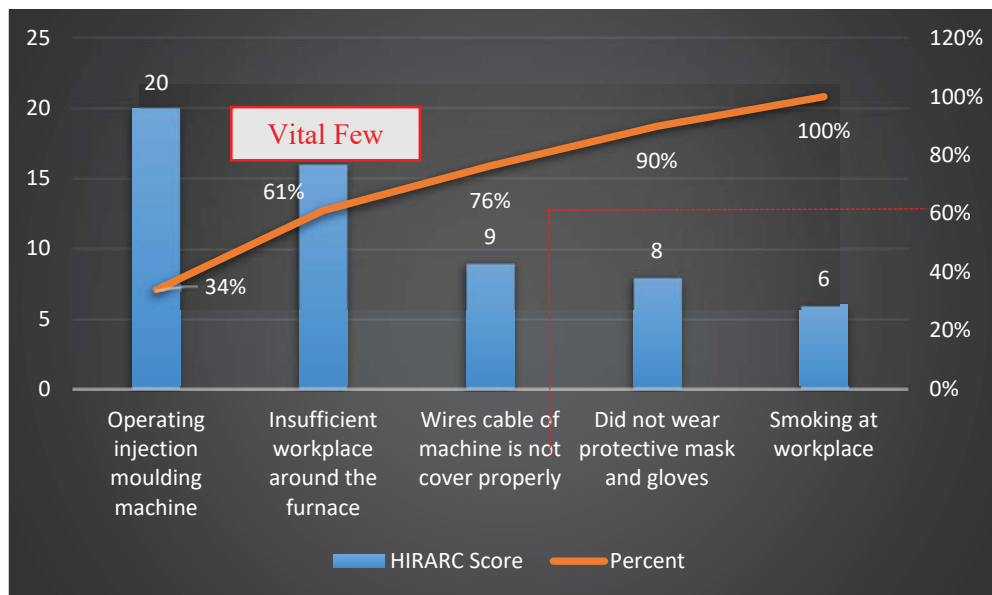


FIGURE 7. Pareto charting for the HIRARC score

The cumulative percentage line indicates that the hazard needs attention first to get the most for the overall improvement. The chart shows that the line rises steeply at first then levels off. In the Pareto Chart, there are 'Vital Few' and 'Trivial Many' area that been labelled. 'Vital Few' is the area of 20% which can considered as the most critical hazards and they have to be focused and prioritized first as compared to the 'Trivial Many' area. Based on the Pareto Chart, the hazards that need to attention first are operating moulding machine, insufficient workplace around the furnace, wires cable not cover properly whereas the others two hazards that are trivial are did not wear protective mask and gloves and smoking at workplace.

CONCLUSIONS

In conclusion, through carrying out the HIRARC analysis, hazard sources have been analysed in each job description. Hence, the cause from machines, practicum equipment, working environment and materials used in the process of potentially hazardous work can be prevented by prioritizing the probability, exposure and consequences for assessment of identified hazards using PARETO analysis.

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