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Hazard Identification and Risk Assessment in Fettling Process

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Abstract - *Hazard Identification and Risk Analysis were carried out in different fettling process foundry. Risk rating has been calculated from the point of view of the severity, probability and frequency of occurrence. Risk rating was been divided into three categories. Low, medium and high risk rating were assigned depending upon the severity of occurrence. Different control measures were identified and suggested to ensure safety of the workforce in the fettling process.*

Key Words*: *hazards, risk, fettling, shot blasting, bench grinding

1. INTRODUCTION

Hazard identified of different activities in a fettling process has been carried out. These activities have been classified into 5 processes and risk assessment has been carried out severity, probability and frequency of occurrence.

1.1 Fettling process

1. Knockout processes
2. Shot blasting
3. Bench grinding
4. Swing grinding
5. Portable grinding

2. LITERATURE REVIEW

Clean, unobstructed aisles and gangways, well-defined working areas, and adequate storage areas contribute to safe and healthful working conditions. Ignoring these factors may undermine the safety and health program. Housekeeping can also have a marked effect on production efficiency. Special attention should be given to: storing raw materials and scrap in bins, compartments, or other appropriate forms of containment or separation. providing a constantly maintained means of access for operations such as metal pouring; removing items not required for immediate use from the foundry working area; and providing and encouraging the use of specified areas for tools, lubricants, and other equipment **[1]**

When the molten metal in a mold has solidified to a point where it will not distort when removed from the sand, the casting is removed from the flask in an operation called knockout or shakeout. Except for those molds produced without flasks or bottom boards, this procedure consists of opening the flask or mold frame and removing the casting. Usually the casting is then cleaned in the shakeout operation, which involves shaking off adhering sand and binder materials from the casting and sometimes breaking out the cores. The castings are then taken to the cleaning department and the flasks and sand are returned for recycling. These operations generally produce dust, and a green sand knockout gives off steam as well as dust. The shorter the interval between pouring and knockout, the larger the amount of steam but the smaller the quantity of dust liberated. When the knockout process is performed at one location, local exhaust ventilation can be used to control the dust and steam **[2], [3].**

Musculoskeletal Disorders are the most common work related injuries/ disabilities problem in any manufacturing industry, especially in manual assembly line. Forceful exertions, awkward posture, pulling, lifting and prolonged standing in the manual assembly line can increase the MSD risk level. MSD can be reducing by proper design of workplaces, implementing the job rotation and use of mechanical material handling equipment. Proper ergonomics principles can improve productivity, comfort to the workers and reduce work- related disorders [3]. The types of exhaust ventilation that can be used to control the dust and steam are total enclosure, sidedraft, downdraft, and updraft. Care must be taken to prevent dust plugging when designing ventilation systems where steam and moist dust are involved. Recommended ventilation designs are presented in detail in Industrial Ventilation— A Manual of Recommended Practices **[4]**

In one foundry without the enclosure, the noise level permitted an allowable exposure of about 3 hours per day. With the shakeout enclosure, the overall noise level was reduced by about 16 dBA. Noise levels at the operator position were 89 dBA with the enclosure and about 105 dBA without the enclosure. The enclosure reduced the noise level of all the frequencies above about 100 Hz by 8 to 25 dB **[5].**

In iron and steel foundries, after the shakeout operation, the sprue or pouring hole is knocked off or cut off and the castings are sorted and cleaned. The main hazard in this process is respirable silica dust. Dust can be controlled by using a conveyor belt made of a metal mesh with a downdraft exhaust system [7]. Control of torch cutting and arc-air gouging operations is not within the scope of this document but is discussed in the NIOSH criteria document on welding, brazing, and thermal cutting **[6]**

Excess sand is removed from the castings by abrasive blasting operations and/or in tumbling mills. These operations produce high noise and dust levels. The engineering control of air contaminants in abrasive blasting booths is addressed in the NIOSH document, Abrasive Blasting Operations: Engineering Control and Work Practices Manual **[7].**

Practical approaches to controlling dust in the cleaning operations after shakeout are to: (1) eliminate casting defects; (2) ensure that unnecessary cleaning operations are eliminated and essential ones are reduced to a minimum; (3) clean the castings as thoroughly as possible by abrasive blasting and tumbling operations before entering the cleaning room; and, (4) apply local exhaust ventilation to the cleaning operations **[8],**

hand-operated power-driven tools such as pneumatic chisels, portable grinders, and wire brushes include: (1) the castings may be cleaned on benches that are fitted with stationary sidedraft or downdraft local exhaust ventilation; (2) a mobile extraction hood may be used; (3) a low-volume, high-velocity ventilation system may be applied to the tool itself; and, (4) a retractable ventilation booth may be designed for castings too large for benches. Local exhaust ventilation should always be used to control the dust produced by hand-fettling operations **[5] [9].**

Safe-operating procedures, if followed, can decrease the risk of these worker injuries. An evaluation of foundry accidents has shown that one of the major contributing factors in foundry injuries was lack of, or violation of, safe-operating procedures**[10]**

In the 1977 California report of injuries in iron and steel foundries, burns accounted for 25% of the injuries in the melting and pouring operations. Strains and overexertion injuries accounted for 43% of the injuries in molding and core making operations. Being struck by or coming in contact with objects accounted for 31% of the injuries in the cleaning and finishing operations **[11].**

For efficient production and personal safety, manual and mechanized materials handling should be performed according to safe standard operating procedures to prevent musculoskeletal injuries, hernias, overexertion, and traumatic injuries. Workers should be instructed in and practice the proper lifting techniques and should be encouraged to ask for help in lifting heavy objects. The National Safety Council's (NSC) publication, **[12].**

Mechanical handling involves the use of lifting and hoisting devices, such as cranes and chain hoists, and of forklifts and conveyors for transporting materials **[13].**

Impact injuries most often occur from mishandling or from using mechanical devices in which suspended objects or materials may slip off hooks or accidentally fall off cranes, hoists, conveyors, or forklifts onto workers **[14].**

To reduce injuries while using forklifts and other lifting devices the following principles should be adopted: (1) the mechanical devices should not be loaded beyond their rated capacity; (2) workers should stand clear of loads; (3) suspended loads should always be attended; (4) overhead materials handling equipment should never be used for transporting personnel during normal operating conditions; (5) where molten metal is being handled overhead, crane operators should be instructed in the proper handling of the load **[15].**

Housekeeping can also have a marked effect on production efficiency. Special attention should be given to: (1) storing raw materials and scrap in bins, compartments, or other appropriate forms of containment or separation; (2) providing a constantly maintained means of access for operations such as metal pouring; (3) removing items not required for immediate use from the foundry working area; and (4) providing and encouraging the use of specified areas for tools, lubricants, and other equipment **[16].**

To help reduce the incidence of injuries, floors should be made of concrete, brick, steel, iron plate, or other suitable material except in areas where the nature of the work requires refractory floors. In foundries where pit molding is performed, a refractory floor and a guardrail are required, but proper gangways should still be provided and constructed of concrete, brick, steel, or iron plate **[17].**

It is important to clean overhead plant fixtures, roof trusses, and hoists. Movement of poorly cleaned overhead cranes and hoists and the vibration of machines can cause dust to fall on workers. Good housekeeping requires an easy and safe access to overhead structures; this is sometimes difficult in older foundry structures **[18].**

Another important consideration is lighting. The lighting in any foundry must be adequate to perform the jobs safely . Lighting fixtures have to withstand a somewhat corrosive atmosphere, operate well in dusty conditions, and withstand high temperatures and vibrations. The cost-benefit advantages of capital investment in lighting are achieved through increased safety, greater productivity, better quality work, and greater job satisfaction for the worker **[19], [20], and [21].**

Constant vigilance to ensure that all equipment is in safe condition and that operations are proceeding normally is critical to safety and to accident prevention. Adequate maintenance and immediate replacement and repair of any worn or suspicious equipment or component parts are essential. Inadequate training and experience in how to cope with emergency maintenance situations is often a major contributing factor in foundry accidents. Equipment design, construction, use, inspection, and maintenance are key goals for foundry safety **[22].**

Inspection and maintenance of ventilating and other control equipment are also important. Regular inspections can detect abnormal conditions, and maintenance can then be performed. All maintenance work should include an examination of the local exhaust ventilating system at the emission source. This may require testing for airborne chemicals or measurement of capture velocity **[23].**

3. METHODOLOGY

3.1 Identification of Occupational Hazards and Risk to Health:

A) Activity / Hazards & Risks Analysis is conducted for all activities considering followings :

- Listing of activities/ processes in the company.
- Involving skilled / regular / contract workers depending upon the activities.
- Studying of their activities / behaviour / reactions.

B) Whenever new processes / activities are introduced or any of the existing process / activities is to be altered then the impact of the change is reviewed before incorporating the change. In addition once a year HIRA is reviewed to identify the changes.

C) While identifying OH&S hazards and risks following issues are considered.

3.2 All routine & non routine activities.

- Activities of all personnel having access to the work place (including subcontractors and visitors).
- Human behaviour, capabilities and other human factors. Identified hazards originating outside the workplace capable of adversely affecting the health and safety of person in the organization / within
- the workplace.

- Hazards created in the vicinity of the workplace by work related activities.
- Infrastructure, equipment and materials at the workplace whether provided by the organization or others.
- Changes or proposed changes in the organization, its activities or material.
- Modifications , including temporary changes and its impact on operation, processes and activities.
- Legal requirements related to activities performed and related controls.
- Design of work areas, processes, installation, machineries / equipment, operating procedures and activities performed including their adaption to human capabilities.
- Investigation results of previous incident, accidents.
- Feedback, suggestion, observation from workmen or any person.

3.3 Type /Conditions of the Job:

During the risk assessment following type of jobs/situations/conditions was considered.

- Routine: Done by usual / regular method of procedure.
- Non Routine: Unusual / non-regular method of procedure.
- Normal Condition: Risks converted to tolerable condition by way of engineering control or by using PPE.
- Abnormal Condition: Deviation from normal condition, which requires immediate attention.
- Emergency Condition: Hazards and Risks, which are contained or mitigated by invoking emergency procedures.

3.4 Evaluation of Occupational Hazards & Associated Risks to Health and Identification of Significant Occupational Health Hazards & Risks

Criteria for Risk assessment is developed through brain storming and discussion by core team. The scoring is based on

- **Severity to health/safety:** Type of injury or the effect of injury on the persons and type of intervention required / expected duration.
- **Probability:** Chances / likelihood of occurrences or past data on when it had occurred.
- **Control Ranking:** type of control and issues related to implementation / adherence.

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4. Result and discussion:

HIRA CHART

SEVERITY	PROBABILITY	FREQUENCY	RISK RATING
1= Minor 3= Seriously 6= Major 10= Fatal	1= Unlikely 2= Possible 4= Probable 6= Certain	1= No recorded occurrence 2= One occurrence 3= Two occurrence 4= More than two occurrence	1-7 = Low 8- 14 = Medium 15- 20 = High

RISK ASSISMENT

S.no	Activity	R / NR	Hazards / Concern	severity X	probability Y	frequency Z	risk rating X+Y+Z	EXISTING CONTROL MEASURE	ADDITIONAL CONTROLS
1	KNOCKOUT	R	Loading the hot mould trolley in the knockout bed which creates emission of hot fumes.	1	6	4	11		All the work is done in the closed structure minimum of 0.9m for each machineries and 1.2m for rapid movement machineries to be provided along with proper ventilation.
		R	Using crane to load the hot mould trolley on knockout bed which creates dust scattering leading to inhalation of dust particles.	1	4	4	10	Respirators are provided.	To follow SOP and to do regular behavioural analysis among the workers for the better usage of respirators.
		R	During the separating of sand from casting material dust is accumulated.	1	2	4	7	Respirators are provided.	Installing of Local Exhaust Ventilation and following SOP.
2	SHOT BLASTING	R	Splashing of metal balls from the shot blasting machine from the minute gap	3	2	3	8		Provide barrier for entire machine
		R	Metal balls were spread around the machine in ground surface will cause slip hazards	1	6	4	11	Removing the metal balls once in a day	Balls must be removed after completion of each cycle
		R	Doors in shot blasting machine will open in outward direction, If people are standing near the door will cause hit injury.	3	6	4	13	Safety alarm which is provided for safety measure, but here the alarm machine is not in working condition	Employees where to be trained of SOP(standard operating procedure) and there must be periodical checking of alarm indication.
		R	After completion of each cycle a person is entering into machine to insert or remove the component, because conveyer belt fault which will cause sudden slip leads fall of person.	3	2	4	9		Repair the conveyer belt and for every shift there must be a frequent checking of conveyor belt by supervisor and management should take care of periodical checking conveyor belt
		NR	Severe accident will occur under the machine during the maintenance	3	1	1	5		Provide LOTO before entering under the machine where the balls are collected
3	SWING GRINDING	R	High amount of noise will produce during grinding operation	1	6	1	8		Use the earplug or ear muff
		R	Grinding spark which is falling on the electrical wire , there may be a chance of electrical hazards	3	2	1	6		Wheel guard must be provided to avoid the sparking over the area
		R	failure in swing grinding chain due to worker is applying high pressure on the swing grinding	1	2	1	4		Worker must be trained on the basics of SOP
		R	Working without proper illumination will lead to cause accident	1	1	1	3		Carry out the work with proper illumination
		R	Huge amount of metal dust is accumulated during grinding	1	2	1	4	Local exhaust ventilation is available not in working condition	Repair the exhaust ventilation and for every shift their must be a frequent checking of ventilation belt by supervisor and management should take care of periodical checking exhaust ventilation.
4	BENCH GRINDING	R	Grinding without tool rest will cause injury in hand	3	4	1	8		Grind with proper tool rest
		R	Working without leather gloves will lead to finger injury	3	1	1	5		awareness given to employees about the importance of PPE usage.
		R	Huge amount of metal dust is accumulated during grinding	1	1	3	5	Local exhaust ventilation is not in working condition	Repair the exhaust ventilation and for every shift there must be a frequent checking of exhaust ventilation belt by supervisor and management should take care of periodical checking exhaust ventilation.
		R	Basement fixing of the bench grinder are not in proper condition	1	1	1	3		Fixing of the basement must be done and maintained properly with the help of maintenance department.
5	ANGLE GRINDER	R	Proper guarding system is not for the angle grinder thus leading to the splashing of sparks on employee.	3	2	1	6		Regular training must be given on safe usage of guarding system.
		R	Fall hazard due to improper disposal of waste in work area.	1	1	2	4		Provide proper bins for disposing the waste materials
		R	Electrical shock due to damaged wire	3	1	1	5		Proper insulation must be provided and regularly inspected for wear and tear.
		R	Trip and fall hazard due to Laying of wires on the floor after the work	1	1	2	4		Training must be provided on proper usage of portable electrical equipment.
		R	Breakage of grinding wheels in the angle grinder due to usage of damaged wheel	1	1	2	4		Creating a inspection checklist for angle grinder which must be inspected on daily basis and check for proper spikes distance between them and do ring test regularly.

5. CONCLUSION

Risk analysis in fettling process has been performed in this study. Different Activities Knockout processes, Shot blasting, Bench grinding, Swing grinding, Angle grinder and work environment were investigated for possible hazards. Hazards in each activity were identified and rating has been assigned to understand the intensity of risk associated with each activity in the fettling unit. It has been observed that a risk rating of 8 has been obtained in the majority of activities. Hence it can be concluded from this study that medium risk is associated in performing various activities in a fettling process. Different control measures have also been suggested for each activity.

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