Analysis in the Foundry Industry during Overall Process Flow using Hazard Identification and Risk Assessment

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Abstract— Foundry work is the process of making a metal casting of an object by pouring molten metal into a mould. The mould is made using a pattern of the article required. In some cases, the mould contains a core that determines the dimensions of any internal cavities. Foundry industry deals with hazardous operations which are resulted as high risk area for past 10 decades. Identifying the risk and controlling the risk within the standards in Occupational health and safety aspect is more difficult in foundry. The purpose of this project is to describe the steps involved and the method of identifying and controlling various health and safety Risks, defining a method to priorities the identified risk and identify the significant ones, related to manufacture and supply of castings and related support activities. We also explain the work under Casting taking as base which has been a large manufacturing method for very long time, hence the foundry industry have a long tradition of how they are working. Many foundries have grown independently and developed their own characteristics. The aim of this thesis is also to evaluate the possibilities of building a specific simulation model which corresponds with the production flow of one foundry, while being generic enough to be able to adapt to other foundries. Possible benefits of production flow simulation in the foundry industry will also be investigated. The conclusions drawn from this study is that there are benefits to gain for the foundry industry from simulation modeling.

Keywords: Foundry, Generic Modeling, Specific Modeling, Control Measures, Foundry, Hazard, Identification, Risk Assessment, Health Hazards, Workers Exposure, Metal Fumes, Pollution, Solid Waste, Waste Water, Noise Etc.

I. Introduction

My project is to find out various hazards and suggest action plan and recommendations associated with the Foundry using the hazard evaluation and risk assessment technique. For any industry to be successful it should meet not only the production requirements, but also maintain the highest safety standards for all concerned. The industry has to identify the hazards, assess the associated risks and bring the risks to tolerable level on a continuous basis. Foundry operation being a hazardous operation has considerable safety risk to foundry. Unsafe conditions and practices in foundry lead to a number of accidents and causes loss and injury to human lives, damages the property, interrupt production etc.

Foundries are integral part of the history of mankind. Foundries have been known for thousands of years [1]. Founding is the simplest of all metallurgical processes and one of the oldest of all industries. Two main procedures are carried out in a foundry: sand molding and metal casting. The casting process consists basically of pouring liquid metal into a mould containing a socket in the geometry desired for the final part. The processes can be classified by the type of mould and model and by the force or pressure pair used to fill the mould with the liquid metal [2, 3].

1) Exposure to silica
2) Exposure to mineral wools and fibers
3) Contact with hot metal
4) Fire and explosion
5) Extreme temperatures
6) Non-ionizing and ionizing radiation
7) Noise and vibration
8) Inhalable agents
9) skin contact with chemicals [2]

A. *Hazard Identification*

Hazard Identification is “the process of identifying hazards, which forms the essential first step of a risk assessment. There are two possible purposes in identifying hazards:

- To obtain a list of hazards for subsequent evaluation using other risk assessment techniques. This is sometimes known as “failure case selection”.
- To perform a qualitative evaluation of the significance of the hazards and the measures for reducing the risks from them. This is sometimes known as “hazard assessment”.

B. *Risk Assessment*

Identification of hazards present in any undertaking and evaluation and the extent of the risks involved, taking into account whatever precautions are being undertaken. There are certain logical steps to take when carrying out a risk assessment

- Look for the hazard.
- Decide who might be harmed and how.
- Evaluate the risks arising from the hazards and decide whether existing precautions are adequate or more should be done.
- Record the findings.
- Inform colleagues of your findings.
- Review your assessment from time to time and revise it if necessary.

C. *Foundry Industry*

Foundries melt ferrous and non-ferrous metals and alloys and reshape them into products at or near their finished shape through the pouring and solidification of the molten metal or alloy into a mould. The foundry industry is a differentiated and diverse industry. It consists of a wide range of installations, from small to very large; each with a combination of technologies and unit operations selected to suit the input, size of series and types of product produced in the specific installation.

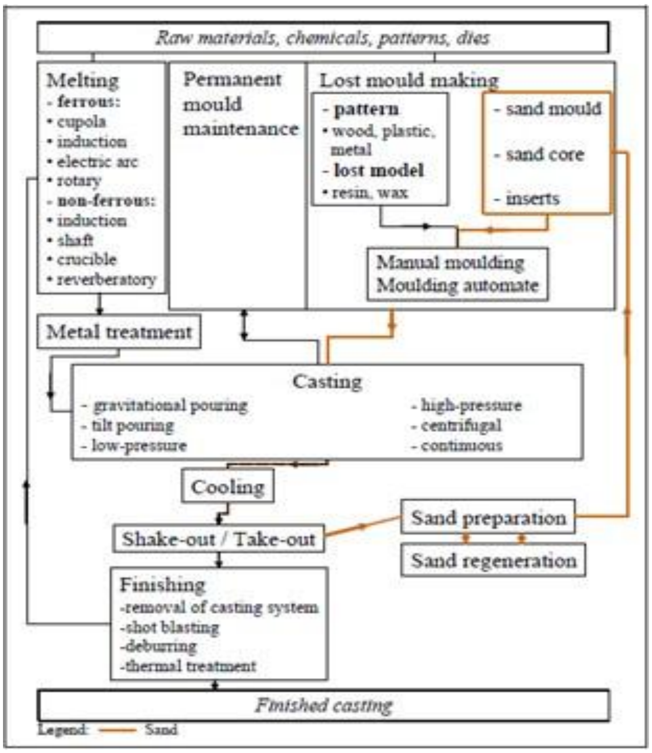

Fig. 1: the Foundry Process [11]

II. LITERATURE REVIEW

S. Karthikeyan et.al [17] India has 4,600 foundry units, 80 per cent of them in the SME sector. Annual production is 7.4 million tons, approximately valued at $8 billion. The sector employs 0.5 million people directly and an additional 1.5% of Export production, and 90% of local casting or manufacturing units. A hazard in foundries starts at the very initial stage – material handling, dust, fumes, gases, heat, stress and noise are some of the major parameters which affect an individual physically and they also affect the environment.

Marcela G.Ribeiro et.al [18] In Brazil, problems regarding protection from hazardous substances in small-sized enterprises are similar to those observed in many other countries. Looking for a simple tool to assess and control such exposures, FUNDACENTRO has started in 2005 a pilot-project to implement the International Chemical Control Toolkit. During the series of visits to foundries, it was observed that although many changes have occurred in foundry technology, occupational exposures to silica dust and metal fumes continue to occur, due to a lack of perception of occupational exposure in the work environment.

Larry DClaxton et.al [19] In excess of several million pounds of geno-toxic and/or carcinogenic industrial wastes are released into the U.S. environment each year. Chemical characterization of these waste materials can rarely provide an adequate assessment of their geno-toxicity and potential hazard. Bioassays do not require prior information about chemical composition and can effectively assess the geno-toxicity of complex waste materials. The most commonly used geno-toxicity assay has been the Salmonella mutagen city assay. Results with this system have shown that the geno-toxic potency of industrial wastes can vary over 10 orders of magnitude, from virtually non-detectable to highly potent. Industries employing similar industrial processes generally release wastes of similar potency.

Stefano Porru et.al [20] few intervention studies aimed at preventing occupational injuries (OI) are available, particularly in the foundry sector. Evaluation of effectiveness of an intervention to prevent OI was carried out in two foundries (cast-iron = A, non-ferrous = B). A multifaceted intervention was developed by a team composed of occupational physician, safety personnel and workers' representatives. Intervention focused on safety procedures, education, and health surveillance (HS), fitness for work and first aid.

Adel M. Zakaria et.al [21] the working environment of foundries is hazardous and characterized by multiple simultaneous chemical, physical and mechanical hazards exposure, which would lead to injuries of foundry workers. The aim of the present work is to evaluate occupational hazards in four foundries, two in Alexandria: El Nasr and Ramsis, and two in Behira: Miser Spinning and Weaving and Miser Rayon companies. Levels of total and respirable dust, free silica % in total dust and lead concentration in total and respirable dust; NO2, SO2 and CO concentrations; noise and heat stress levels have been determined in the present work. Occupational injuries data were analyzed in a three years period from 1998 to 2000.

Rohit Sharma et.al [22] The main aim of this paper was to identify job stressors, gender responses and association of psychosocial work stressors with prevalence of work related musculoskeletal disorders (MSDs) among foundry workers. The data were obtained with ergonomics checklist using Liker scale. The results of this study showed a high prevalence of MSDs among workers. The male workers were more prone to pain in neck while the female workers were more prone to MSDs in upper back and shoulders. Correlation analysis showed significant relationship of dimensions of work aspects with pain and discomfort.

Dushyant R. Bhimani et.al [23] Foundries for the metal-casting industry generate by- products such as used foundry sand. Metal foundries use large amounts of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. Foundry sand is uniformly sized, high quality silica sand that is combined with a binder and used to form molds for ferrous and nonferrous castings. Used foundry-sand properties vary due to the type of equipment used for foundry processing, the types of additives, the number of times the sand is reused, and the type and amount of binder. Within the concrete industry, the most successful examples have been using coal fly ash to make high-quality, durable concrete and recycling old, demolished concrete as aggregate for new concrete.

III. OVERALL PROCESS FLOW IN FOUNDRY INDUSTRY

Casting is one of the oldest manufacturing processes and has been used for more than 5000 years. From the beginning it was things for decoration and jeweler, mostly made of bronze that was casted. The use of casted products has since then increased dramatically and is used in several industries. Due to the heavy automotive industry, Sweden is one of the countries that per capita use most casted products. Generally, there are two kinds of casting, casting done with permanent molds and casting done with one-time molds. The method of interest for this thesis is casting in one-time molds and more specifically, sand molds.

In this process, the mold and eventual core is made out of sand, the sand is mixed with a binder to "glue" the grains together and to gain a more stable structure. The sand is then poured onto a pattern, which is a model of the desired product and pressurized to create a steady mold with a cavity in the shape of the pattern.

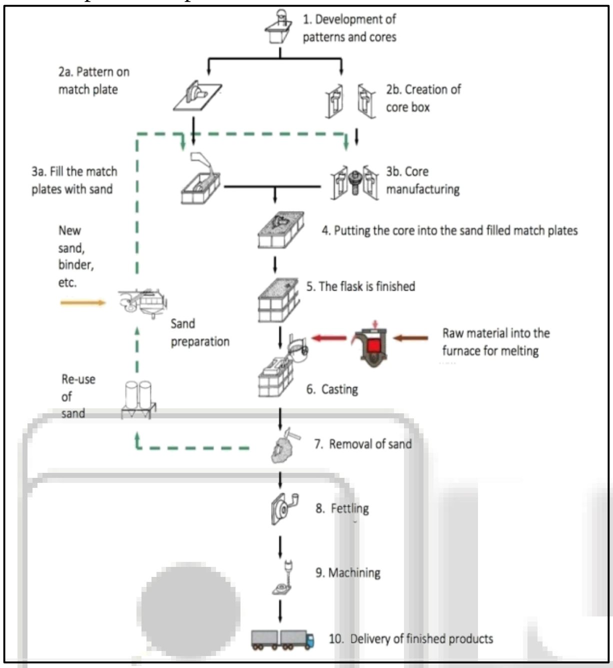

Fig. 2: The production flow of casting [27]

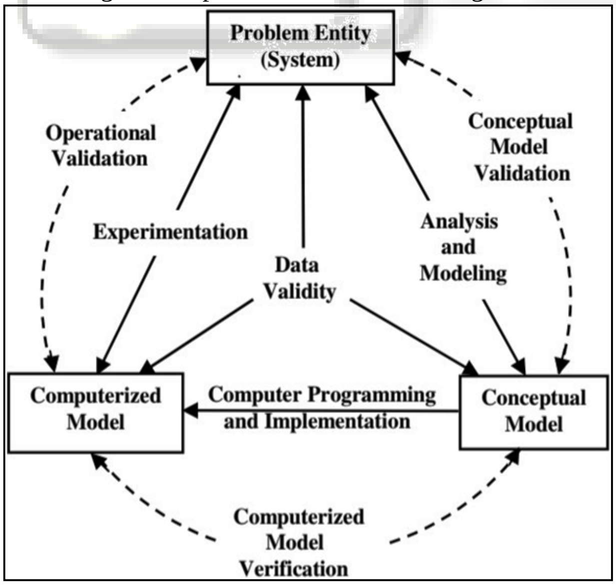

Fig. 3: Simple image of the model building methodology [38]

IV. METHODOLOGY

1) Identification of occupational hazards and risk to health
2) Type /conditions of the job
3) Evaluation of occupational hazards & associated risks to health and identification of significant occupational health hazards & risks.
4) Probability of occurrence
5) Severity rate
6) Hierarchy of controls

V. FOUNDRY HAZARD ZONE

The National Occupational Health and Safety Commission, Work safe is a tripartite body established by the Commonwealth Government to develop, facilitate and implement a national approach to occupational health and safety.

The National Commission comprises representatives of the peak employee and employer bodies. Since its establishment, the National Commission has produced occupational health guides. Before the National Commission was established, a series of similar guides was published by the National Health and Medical Research Council. This Guide has been reviewed and endorsed by a working group of the National Commission as part of the coordinated effort by the Commonwealth, State and Territory governments and employee and employer organizations to make workplaces safe and healthy.

Although this Guide has been endorsed by the National Commission, it is an advisory document only. It is produced and distributed in the interests of providing useful information on occupational health and safety for employers, employees and others. This document does not replace statutory requirements under relevant State and Territory legislation. This Guide is aimed primarily at workers and managers but should also be useful to occupational health and safety personnel and others. It may be used in conjunction with appropriate training and consultation, in line with good management practice.

This Guide should be read in conjunction with the following Work safe Guides:

– Atmospheric Contaminants;
– Occupational Diseases of the Skin; and
– Prevention of Eye Damage.

The National Commission publication, Exposure Standards for Atmospheric Contaminants in the Occupational Environment (latest edition), and the National Health and Medical Research Council publications, Silica (Silicosis) and Effects of Heat on Health, Comfort and Performance, should also be consulted.

– Molding and pattern making
– Core making
– Melting and pouring
– Shakeout (knockout)
– Dressing and cleaning

A. Foundry Health Hazards

– Potential health effects for persons under increasing levels of heat stress includes
– Health Effects of Hazardous Chemicals
– Health Effects of Airborne contaminants
– Health Effects of Manual Tasks
– Health Effects of Noise
– Health effects of vibration

- Health effects of molten metal
- Health effects of plant and machinery

VI. Prevention and Control Strategies Including Results

Evaluation of the workplace environment should be included in an established program addressing prevention and control measures. Attention should be given to gases, vapors, fumes and dusts.

Environmental sampling and analysis should be undertaken at regular intervals by qualified occupational health and safety professional in accordance with the methods recommended by the appropriate occupational health authority.

Monitoring may be used for the evaluation of a hazard and for assessing the effectiveness of control measures. The design and implementation of a monitoring program should be carried out by, or in consultation with, a properly qualified person. Monitoring of the work environment involves the measurement of atmospheric contaminants at selected locations in the workplace (static, positional monitoring). Personal monitoring involves the measurement of atmospheric contaminants in the breathing zone of the individual worker. Biological monitoring involves measurement of the concentration of a contaminant, its metabolites or other indicators in the tissues or body fluids of the worker. In some cases, biological monitoring may be required to supplement static or personal monitoring. When developing a monitoring program in foundries, due consideration should be given to heat stress, exposure to noise, gases, for example, carbon monoxide, vapors, fumes, for example, zinc and copper fumes, and dusts, for example, silica and olivine sand dusts.

A. Exposure Standards

Worker exposure to dusts, gases and vapors should be kept as low as workable. Every attempt should be made to keep exposures well below the exposure standards recommended in the National Commission publication, Exposure Standards for Atmospheric Contaminants in the Occupational Environment (latest edition). The exposure standards represent airborne concentrations of individual chemical substances which, according to current knowledge, should neither impair the health of, nor cause undue discomfort to, nearly all workers. Additionally, the exposure standards are believed to guard against narcosis or irritation which could precipitate industrial accidents.

B. Control Measures

Where there is a likelihood of worker exposure to foundry hazards, steps should be taken to minimize that exposure as far as workable. A thorough examination of work practices is essential. Procedures should be adopted to ensure that workers are not unnecessarily exposed to the hazard. Control measures include, but are not limited to, the following, which are ranked in priority of the ineffectiveness:

- elimination/substitution and process modification;
- engineering controls;
- administrative controls; and
- Use of personal protective equipment.

C. Preventing Physical Injuries

An understanding, appreciation and application of prevention and control measures can contribute greatly to the minimization of the risk of physical injury in foundry work. Some general principles are outlined below:

- Mechanically propelled vehicles or machinery should be inspected regularly, kept in efficient working order, and operated only by trained personnel.
- Maximum loads for winches, hoists, lifts and cranes should be clearly marked on the equipment. These maximum capacities must never be exceeded.
- Contact between molten metal and water must be avoided. All ladles and other equipment used for handling metal should be completely dry before contacting molten metal.
- Work areas should be checked regularly to ensure that good housekeeping practices are being followed.
- Any defective equipment should be repaired immediately or removed from service.
- Floors around furnaces should be of slip-resistant, non-combustible material, kept free of obstructions and cleaned regularly.
- Operating instructions for each furnace should be clearly displayed in the furnace area and issued to the person responsible for the furnace.
- Suitable protective clothing and equipment, including eye protection such as goggles, should be worn by furnace operators. This clothing and equipment should comply with the relevant Australian Standards.
- Eye protection should be required in all metal cleaning/dressing areas and should comply with the relevant Australian Standard.
- Barriers or other suitable shields against molten metal splashes should be installed where necessary.
- Persons should be prohibited from entering furnace areas when the temperature exceeds 50°C, except in cases of emergency.
- Foundries should be equipped with safety blankets, automatic emergency showers or hoses to extinguish burning clothing.
- Adequate lighting should be provided in all working areas in accordance with Australian Standard AS 1680.
- When machinery or equipment is being cleaned or maintenance carried out, lock-out devices or procedures should be employed to prevent the starting of the equipment.
- Workers who cannot be protected against falls from heights in any other way should be protected by wearing approved safety harnesses and lifelines.
- Self-contained breathing apparatus must be used in emergencies when high carbon monoxide concentrations are suspected.

VII. Conclusion

In a conservative industry like the foundry industry, there are many benefits to gain from production simulation modeling; however the road to get there might be long. To collect and gather data and information is in many foundries seen as something redundant, while it should be seen as something that opens up for many new possibilities.

Some of the possible benefits to gain from using simulation modeling of production systems are that a simulation model can be useful from a pedagogical point of view; it can aid the production planning and help investigating whether or not to make new investments. Also, it can be used as a boundary object to aid people with different perception understand each other and find a common ground.

Thus, when creating a model the purpose of the model should be known from the beginning, to enable the right level of detail. Also, a model that is both generic and specific at the same time is a contradiction. A generic model requires a low level of detail while a specific model requires a high level of detail and to meet both these requirements at the same time is difficult. The group's conclusion is that to have one generic model that will be adapted to different foundries is more difficult to create than one specific model for each foundry.

However, it is possible and favorable to use generic building blocks to help the builder and decrease the building time. Although, to be able to benefit from the simulation models, foundries needs to see the value in information and data gathering and develop a systematic way to collect and save this in one place.

A review on effects of hazards in foundries to workers and environment has been conducted where the general overview on foundry industry and the associated hazards was carried out. Major hazards in the foundry industry, the effects and control measures were presented.

- In the study, various hazards were identified and elaborated which are heat exposure, hazardous chemicals, airborne contaminants; manual tasks; noise; vibration; molten metal; plant and machinery and electricity.
- Finally the effects of hazardous materials to environment and their control were looked at. It has been revealed that hazards in foundries are many and very dangerous both to foundry workers' health and to the environment which eventually spread and affect the wider population.
- First aid procedures and facilities relevant to the needs of the particular workplace should be laid down and provided in consultation with an occupational physician or other health professional.
- Due to the nature of foundry work, medical emergencies such as burns, heat stroke, eye injury or carbon monoxide poisoning are sufficiently probable to warrant the development of special procedures and the provision of emergency equipment.
- Hazard Identification and Risk Assessment (HIRA) study were made on the Foundry and various hazards of different equipment's and process were found. Recommendations are provided to avoid the occurrence of such hazards.
- Applicable legal requirements are studied and provided in detail. Safety Instructions, Extract of MSDS, PPE matrix and Safe Operating Procedures were updated.

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