International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 18 (2015) pp 39775-39779

Study Assessment on Occupational Safety and Health in small scale foundry environment

N. Nandakumar

Asst. Professor of Mech. Engg Department of Mechanical Engineering, Government College of Technology, Coimbatore, Tamilnadu nannthu@yahoo. com

M. Arularasu

Principal Thanthai Periyar Government Inst. of Technology Bagyam, Vellore Tamilnadu

Abstract

The study of the physical interaction of workers with their tools, machines, and materials so as to enhance the occupational safety and worker's performance while minimizing the risk of Musculoskeletal disorders, physical hazards, chemical hazards and other safety aspects are prime consideration for the occupational safety and health. A comprehensive study is developed with integrated environmental risk assessment and human health risk assessment consisting of risk factors related with all of the possible risk sources in an industry with hazardous materials and environmental aspects. Data's were collected at regular period of frequency in various hazardous environment identified and assessed with the predefined factor. The four surveyed foundries around Coimbatore district were studied for chemical and physical hazards and the consequences factors were investigated. The results of the present study revealed that the majority of the occupational hazards were within threshold limits values with some exceptions; whereas physical hazards were exceeding threshold limit values. These hazards were evaluated through real time performance studies and few recommended measures were undertaken. The results of various analyses were represented graphically in order to ascertain that the recommended solutions will reduce the hazards to a certain level.

Keywords: Occupational hazards, Particulate matter, heat stress, pollution control,

Introduction

Safety is a very imperative issue and is defined as the condition of being safe and ensuring freedom from accidents. Accidents and their impacts can be seen as unexpected or undesirable events leading from an unmitigated risk or unidentified hazards. The working environments in foundries are characterized by combination of mechanical, chemical, physical and environmental hazards to mankind. Industrial Safety is an important aspect of Industries to protect the workers, supervisors, management and staff employed in them apart from improving productivity by reducing the losses that may arise due to occurrence of accidents. The work place environment influences significantly the health status of workers Toru *et. al.,* (1986). Foundry workers are exposed to a unique collection of environment challenges including noise, heat, vibration, organic and inorganic chemical dusts, residue, aerosols, gases, acids and other pollutants. The metal casting industry is regarded as a typical industry with complex work process generating almost all the risk factors of relevance. A combination of these exposures on the foundry workers are generally found anemic due to the unhygienic conditions and pollution. In previous study, More and Sawant (2001) have observed that the workplace environment in foundry was extremely adverse due to high concentration of coal dust, silica dust, extremely high temperature and noise. The physically demanding tasks performed during foundry operations may be responsible for the musculoskeletal disorders (MSDs) developed by workers in this industry. The recommendation based on the study may be beneficial for the occupational safety and health of workers.

Analysis of dust and its generation

In the foundry environment the dust and particulate matters emitted in each of the process steps with varying levels are mineral oxides, metals and metal oxides. Dust emissions arise from thermal activity (e. g. melting furnaces) and chemical / physical processes (e. g. molding and core production), and mechanical movements (e. g. handling of raw materials, mainly sand, and shaking out and finishing processes). A wide range of particle size is produced during a dust generating process. Particles that are too large to remain airborne settle while others remain in the air indefinitely. Dust is generally measured in micrometers. Respirable dust refers to those dust particles that are small enough to penetrate the nose and upper respiratory system and deep in to the lungs. These consequences lead to hazardous situation.

Hazard factors of dust

Most of the dust which carries toxic fumes and foreign matters will not produce the similar degree of health hazard; their harmfulness depends on the factors like: dust composition-chemical, mineralogical, dust concentration, on a weight basis: milligrams of dust per cubic meter of air (mg/m^3). Excessive or long term exposure to harmful respirable dust may result in a respiratory disease called pneumoconiosis. This disease is caused by the build-up of mineral or metallic dust particles in the lungs and the tissues which reacts to occupational ill effects.

Quantitative facts
Four small scale foundry industries were considered for data collection and analysis. It was analyzed by dust sampling on 2. 0 µm pore size Teflon filter at flow rate of 10. 0 litres/min. With the past research findings, the potential areas were identified in the company and found grinding section was found with highest dust concentration among all sections. The precipitator is kept near the grinding section where ten samples were collected at different frequency. Likewise in the moulding section ten samples, machining section ten samples and in the fettling section ten samples were collected. The data was statistically analyzed and the data is presented.

Arithmetical analysis
Mass of particles found on sample filter, $M_s = (M_2 - M_1)$
M_s-Mass found on the sample filter,
M_1-Weight of clean filter before sampling, mg,
M_2-Weight of the filter after sampling, mg.

The sampled volume is, Vs= Q x t/1000
V_s-Volume of the air sampled, m^3,
Q-Average flow rate of air sampled, L/min,
T-sampling time, min, 1000-conversion from L to m^3.

The concentration of the particulate matter in the sampled air is expressed in micrograms/m^3, $C = M_s/V_s$
C-Mass concentration of the particulate matter, µg/m^3.
M_s-Mass found in the sample filter, µg,
V_s-Volume of air sampled, m.

Results of findings
According to the various analyses made, the results of the analyses are presented accordingly. It is evident from the Figure. 1, that the dust concentration is highest in moulding/casting and in the grinding section. Whereas, the dust levels in the machining section of the foundry were least.

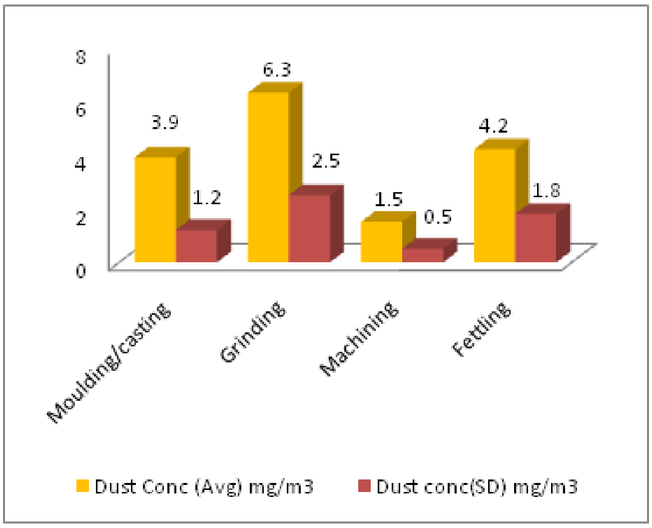

Fig. 1. Dust analysis and its generation

Recommended measures
Recommended prevention and control to reduce fugitive emissions of dust include the following:

- Use of pneumatic conveying systems, particularly for transferring and feeding additives into the process area
- Use of enclosed conveyers with dust-controlled transfer points, especially when transferring sand into the moulding shop;
- Clean return belts in the conveyor belt systems to remove loose dust;
- Use indoor or covered stockpiles or, when open-air stockpiles are unavoidable, use water spray system, dust suppressants, windbreaks, and other stockpile management techniques;
- Use of enclosed silos to store bulk powder materials;
- Implement routine plant maintenance and good housekeeping to keep small leaks and spills to a minimum.

Analysis of heat and its generation
A main source of heat stress in foundries is at the melting section where the metals are heated to very high temperature in order to melt the metals. Some of the areas such as pouring process from Cupola/Induction furnace into the crucible or ladle, carrying and then finally pouring into the mould. While working in heat the human body works at its best within a narrow temperature range. Shift of 2^o C or more above or below the normal temperature range of 37^o C can begin problems to happen. The body's core temperature, the temperature of the brain, heart, and other organs is 37^o C. Acute heat stress was found to lead to dehydration and loss of electrolytes. Hot environment was also found to increase oxygen consumption Bandopadhay *et. al.*, (1989).

Health hazard factors of heat.
The temperature of the environment is one of the factors affecting human performance. At body temperatures substantially higher than the optimal levels (36. 5 to 37. 5^o C), both physical and mental performance deteriorates due to the complicated relationships of physiological and pathological process. In addition, prolonged heat strain may impact mental and psychomotor functions, thereby affecting performance. In order to ensure optimal conditions for health and productivity, it becomes very important to assess the magnitude of the heat stress in the working environment and the workers physiological reactions to it.

Quantitative facts
The heat in various sections of the foundries is measured using a wet bulb thermometer. Each sample are analyzed and the results are provided in the form of a graph. Then the sections with higher temperatures are determined.

Findings of the facts

The results of various analyses carried out in foundries with respect to heat and its generation are provided below. It is evident from the graphical representation in Figure 2, that the heat stress is higher in the pouring section and the in furnace section.

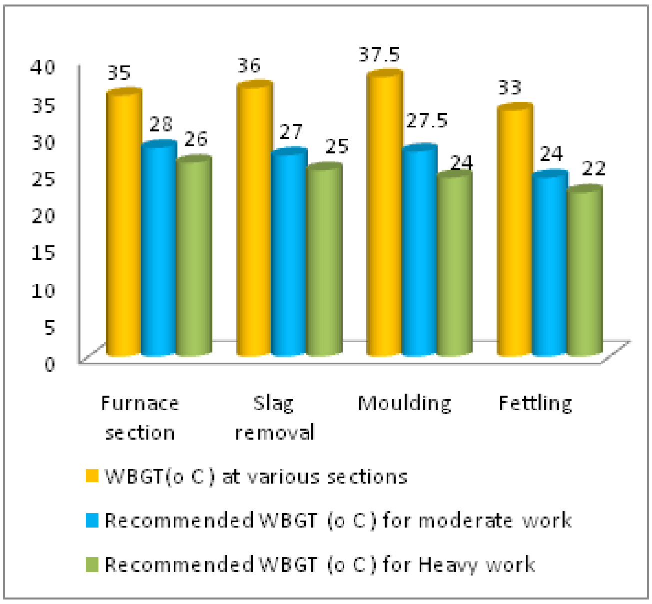

Fig. 2. Heat stress in different section

Recommended measures

High temperatures and direct infrared (IR) radiation are common hazards in foundries. High temperatures can cause fatigue and dehydration. Direct IR radiation also poses a risk to sight. Contact with hot metal or hot water may result in severe burns. The foundry worker experiences a total heat load which is determined by the time spent at each workstation, the intensity of work, the clothing worn and the immediate workstation environment, including air circulation. Recommended measures for prevention and control of exposure to heat and hot liquids / materials include the following:

- Shield surfaces where close contact with hot equipment or splashing from hot materials is expected (e. g. in cupola furnaces, EAF, induction melting ladles, and casting);
- Implement safety buffer zones to separate areas where hot materials and items are handled or temporarily stored. Rail guards around those areas should be provided, with interlocked gates to control access to areas during operations;
- Use appropriate PPE (e. g. insulated gloves and shoes, goggles to protect against IR and ultraviolet radiation, and clothing to protect against heat radiation);
- Implement shorter shift durations for work in high air temperature environments. Provide regular work breaks and access to drinking water for workers in hot areas;
- Install cooling ventilation to control extreme temperatures.

Analysis of noise and its generation

The foundry process generates noise from various sources, including scrap handling, furnace charging and EAF melting, fuel burners, shakeout and mould / core shooting, and transportation and ventilation systems. Evaluation by occupational health and safety personnel of noise should be undertaken to identify areas where noise levels may be excessive. Surveys of foundries have shown that dressing, fettling and shakeout operations give rise to considerable noise levels, with potentially harmful effects on the hearing of exposed workers. In addition to the workers immediately involved in these processes, people working in the vicinity may be exposed to noise levels well in excess of 85 dB.

The highest levels of noise in the foundry are usually found in knockout and cleaning operations; they are higher in mechanized than in manual foundries. The ventilation system itself may generate exposures close to 90 dB. Noise levels in the fettling of steel castings may be in the range of 115 to 120 dB, while those actually encountered in the fettling of cast iron are in the 105 to 115 dB range. Noise levels in the fettling of steel castings may be in the range of 115 to 120 dB, while those actually encountered in the fettling of cast iron are in the range of 105 to 115 Db. The sources of noise during fettling include:

- The fettling tool exhaust
- The impact of the hammer or wheel on the casting
- Resonance of the casting and vibration against its support
- Transmission of vibration from the casting support to surrounding structures
- Reflection of direct noise by the hood controlling air flow through the ventilation system.

Hazard factors of noise

High levels of noise in foundries affect the workers in the foundries directly and indirectly. Some fettlings workers have been shown to be exposed to levels of noise over 100 dB, shakeout and knockout processes are typically associated with readings of 90-110 dB. Mechanical sand mixing processes and forced draught furnaces may produce noise levels of 90-100 dB, averaged over an eight hour shift. It will also provide high levels of stress for the workers. This kind of stress will have direct effect on the workers physically and mentally.

Quantitative facts

A noise dosimeter is a specialised noise level meter which was used to measure the noise levels in each section of the foundry. In order to optimize the results, the noise level samples are measured in specific intervals of time. The data collected is then graphically represented in figure 3, in order to find the section where the noise levels are high. The data measured is taken for average dB levels. According to the various analyses made, the results of the analyses are presented.

Thus from the graph, grinding section produces high noise levels than the other sections. A variety of woodworking machines in the making of mould patterns also add to the noise exposure. All of these noise sources combine to create high ambient noise levels in foundries. The frequent use of compressed air systems to clean moulds or work benches, cause high noise levels consisting of predominantly high pitched components.

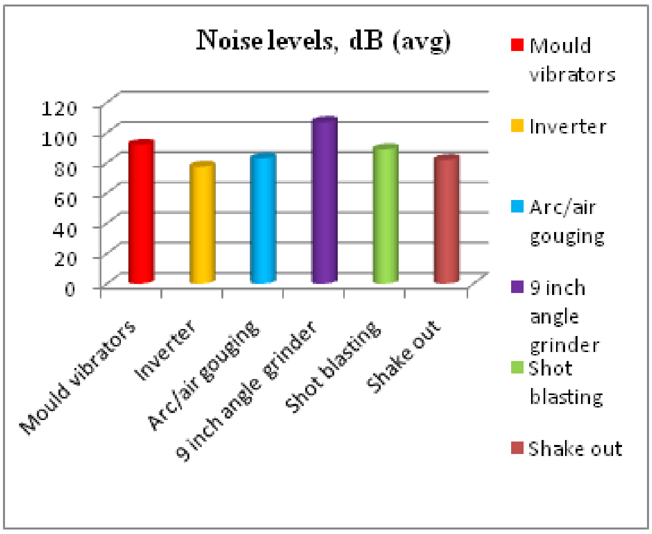

Fig. 3. Noise level at various sections

Recommended measures

Some of the recommended measures in controlling noise are provided below:

- Enclose the process buildings and / or insulate them;
- Cover and enclose scrap storage and handling areas, as well as shake out and fettling processes.
- Enclose fans, insulate ventilation pipes and use dampers.
- Implement management controls, including limitation of scrap handling and transport during night time.
- Installing vibration isolating mountings.
- Locating noisy equipment such as automatic moulding machines and vibrators in separate enclosures.
- Providing a sound proof enclosure for operators.
- Installing improved mould design that can eliminate or drastically reduce the amount of excess metal to be removed after casting. This in turn removes or reduces the need for fettling.
- Using low noise or noise reduced, grinding discs. This can reduce the noise levels by up to 5dB

Conclusion and recommendations

Foundry workers may be exposed to a variety of numerous health hazards and accidents, owing to inherent hazardous conditions in foundries including chemical, physical and mechanical agents. The four surveyed foundries for occupational hazards and accidents records in the present work were different mainly in applied technology and capacity of workload. The results of the present study revealed that the majority of the assessed occupational hazards were within threshold limits values with some exceptions; whereas physical hazards were exceeding threshold limit values. The study was carried out to understand and derive a clear-cut status on Occupational Safety, Health and environment standards and compliances in the small scale foundries such that the findings of the study will be utilized to protect workers by the reduction of accidents and dangerous occurrences. It has been arrived through the research study that the small scale foundries do have Occupational, Safety and Environmental issues, which often result in accidents, injuries and ill health including fatal accidents. The environmental status and performance of the case study company was determined and opportunities of reducing hazardous and increasing resource efficiency were modelled. These hazards were studied and few recommended measures were suggested to the industry to follow and reduce the occupational hazards. The results of various analyses were represented graphically and the recommended solutions will have the probability to reduce the hazards to a certain level.

References

[1] Adel M. Zakaria, Kamal H. Noweir, Gamal El-Maghrabi, (2005) 'Evaluation of Occupational Hazards in Foundries' *The Journal of the Egyptian Public Health Association* Vol. 80 No. 3& 4,

[2] Amitava Bandopathyay, Mishra K. K and Ramachandra rao, P. (1995) 'Pollution control in Foundries-The realities, problems and strategies for an economically viable solution'. *Indian Foundry Journal. pp 11-18.*

[3] Brooks B., (2008) 'The natural selection of organizational and safety culture within a small and medium sized enterprise (SME)', *Journal of Safety Research*, vol. 39, pp. 73-85.

[4] Frick, K., Wren, J., (2000). 'Reviewing occupational health and safety management: multiple roots, diverse perspectives and ambiguous outcomes' Systematic Occupational Health and Safety Management: Perspectives on an International Development. Pergamon, Amsterdam, pp. 17-42.

[5] Fore S, Mbohwa C. T (2010)"Cleaner production for environmental conscious manufacturing in the foundry industry", *Journal of Engineering, Design and Technology*, vol. 8 Iss: 3, pp. 314-333

[6] D. P. Mukharjee, (2011)"Barrier toward cleaner productionfor optimization energy use and control for foundry sector in Howrah, India", *Clean Technology and environmental policy*, vol:13, iss:1, pp 111-123.

[7] Koo, J. W., Chung, C. K., Chung, Y. P. Lee. S. H, Lee, K. S. Roh, Y. M., (2000) 'The effect of Silica dusts on ventilatory functions of foundry workers' *Journal of Occupational Health*, vol: 42pp 251-257.

[8] International Labour Office, Occupational Safety and Health in the Iron and Steel Industry, International Labour Organisation, Geneva, 1983.

[9] Y. S. Ahn, (2005) "Respiratory diseases in foundry workers, " in Training Materials for Occupational Respiratory Diseases, *Korea Occupational Safety Health Agency*, Ed., pp. 171-190,

[10] Gomes, J., Lioyd, O. L. Norman, N. J., Pabwa, P. (2001). Dust exposure and impairment of lung Functions at a small iron Foundry in a rapidly developing country. *Occupational EnvironmentalMed*., *vol*. 58 pp. 656-662.

[11] Roy A. C (1999) 'Pollution Preservation and Waste Management in Foundries' in the proceeding of the 47th Indian Foundry Congress, January 23-26, Calcutta, India

[12] Priyavart Thareja, (2012) "Holistic perspective and requirements of EMS in foundry Industry", *Indian foundry journal*, vol-56, no-6, p. p 35-43

[13] Dembe AE, Erickson JB, Delbos R. (2008), Predictors of workrelated injuries and illness: National Survey findings, *Occupational and Environment Hygenic*. Vol. 8 pp. 542-550.

[14] Yassin A, Yebesi F, Tingle R (2005) 'Occupational exposure to crystalline silica dust in the United States, 1988-2003'. *Environ Health Prospects*, vol. 113 pp. 255-260