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Assessment of Heat Stress and Noise Intensity Level in Workplace Area of the Iron Foundry

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Abstract

The aims of this study were to measure the workplace heat stress and noise intensity levels in different sections of the foundries. The study was carried out in a small industrial city of southern peninsular of India, known for cluster of foundry establishments. The heat and noise level were measured in melting, fettling, gas cutting, heat treatment furnace, and administrative sections measuring the dry bulb temperature(T_{DB} °C), wet bulb temperature (T_{WB} °C), globe temperature(T_G °C), wet bulb globe temperature(WBGT °C), and the relative humidity(RH%) at the work places. The noise level measurements were also carried out using portable integrated sound level meter. Extremely high levels of WBGT index was found in gas cutting section with an average of 33.73 °C followed by 29.68 °C in melting unit. The mean WBGT mean values obtained in other sections were, 28.37 °C in heat treatment, 28.25 °C in fettling and 25.84 °C in administrative sections respectively. The mean WBGT index levels are significantly higher ($p < 0.05$) in gas cutting, melting, heat treatment and fettling sections compared to the administrative section. The prescribed standard threshold limit value (TLV) of WBGT level was high in gas cutting, melting, heat treatment and fettling units. The values of equivalent noise levels were under control as per OSHA guidelines in all the process sections. The heat and noise may increase the health risk of worker with reduce the efficiency and consequently affect the production of the unit. The recommendations should be taken as indicative of stress areas and workers should be under constant medical supervision.

Keywords: *WBGT index, heat stress, noise, L_{eq}, foundry, workplace hazards*

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INTRODUCTION

Heat stress is one of the important occupational hazards in many industrial settings and can seriously affect the health and productivity of the individual. It also reduces the worker's tolerance efficiency like other environmental pollution and occupational risk. Especially in the iron foundry, workers are exposed to heat with other co-pollutants like noise, particulate dust, gases, fumes, etc. [1, 2]. Working in a hot environment induces a physiological strain on workers and leads to significant variations in the internal body temperature of 37 °C (98.6 °F) which interferes with body functions and normal homeostasis [3].

Heat stress is the net heat load on the body from the combined effect of hot environmental conditions such as air temperature, radiant heat, humidity, air movement and physical activity. They adversely affect worker safety and productivity because they can cause diversion, reduce concentration, and lead to fatigue and in acute cases it may cause also brain damage or death [4]. When ambient temperatures are extreme or when high temperatures are combined with high humidity, the fluid losses in sweat may exceed 1 L/h predisposing to progressive dehydration [5]. The biochemical changes accompanying cellular dehydration and impaired tissue perfusion contribute to headache, fatigue and other signs of heat exhaustion [6, 7].

Also reduction in plasma volume [8] may result in light-headedness or syncope. Ultimately, the inability to maintain cutaneous circulation and an adequate sweat rate permits core temperature to rise and the individual succumbs to heat stroke [9].

The foundry is one such work environment, where workers are exposed continuously to high temperatures during 8-h shift. Connective and radiant heat gains by the human body [10]. Heat stress naturally occurring due to the hot climate is augmented for the workers involved in work close to furnaces and other process activities. Noise is also another physical occupational hazard in different processes of the foundry. Noise pollution disturbs our health and behavior in a number of ways including deafness, causing lack of sleep, irritability, indigestion, heart burn, high blood pressure, ulcers, and release of adrenaline into the blood streams, heart disease and headache. Noise-induced hearing loss is one of the major occupational diseases worldwide and it has been reported among steel workers [11].

In the present study it is aimed to measure the workplace heat stress and noise in different sections of the foundries.

METHODOLOGY

Heat Stress

The monitoring of heat and noise was carried out in various sections of the foundry located in a small industrial city of southern peninsular of India, known for cluster of foundry establishments. The heat and noise level were measured in melting, fettling, gas cutting, heat treatment furnace, and administrative sections.

Measurement of Heat

A portable area heat stress monitor (Model QUEST Temp34, QUEST Technologies, Oconomowoc, WI, USA) was used to find out the heat by measuring the dry bulb temperature (TDB°C), wet bulb temperature (TWB°C), globe temperature(TG°C), wet bulb globe temperature (WBGT°C), and the relative humidity (RH%) at the work places. The instrument was set in the working zone where workers performed their routine work during the entire work shift. Hourly average values recorded at the end of each hour span the entire shift work. The readings were taken in 10 min intervals particularly at the work places where intense heat exposure spells were existent. Since the measurements were carried out inside the factory without direct exposure to sun, indoor WBGT values were calculated. (WBGTindoor = 0.7 TWB + 0.3 TG). The resulting WBGT was then compared to published charts of threshold limit value for continuous work and with varying duration of rest periods. The WBGT index prescribed by the American Conference of Government Industrial Hygienists (ACGIH, 2007) [12] was followed. Table 1 shows the ACGIH values of heat exposure. The WBGT index was calculated taking into consideration, the nature of job involved and the time taken for rest as prescribed by the American Conference of Governmental Industrial Hygienists (ACGIH, 2007).

Measurement of Noise

The noise level measurements were also carried out using portable integrated sound level meter (SLM) Model 2236 (Bruel & Kjaer, Nacrum, Denmark) having A-weighting mode. The instrument was calibrated, on daily basis, using a pistaphone. To characterize the equivalent noise level L_{eq} was used and is defined as the constant sound pressure level that would have produced the same total energy and A-weighted level as the current level over the given period of measurement:

Where T is the total measurement time, P(t) is the A-weighting instantaneous acoustic pressure, and P_0 is the reference acoustic pressure. The instrument used automatically computed:

$L_{eq} = 10\log_{10} 1/T_0\int^{T}[p(t)/P_0]^2 dt$ … at specific time.

SLM was mounted on a stand at a height more than 1 m from the ground level and the noise level was measured during the entire shift in each section. L_{eq} was continuously recorded for 8 h at the work spots by placing the SLM in the stand at 1 m distance from the sources, taking care that the microphone of the instrument was directed towards the sources. The 8-h average was considered to assess noise exposure in the given area of the foundry. Statistical analysis was carried out using SPSS17.0 version software.

RESULTS AND DISCUSSION

Heat Stress Evaluation

The heat stress parameters recorded in various sections of the foundry are statistically highlighted in Table 2. Extremely high levels of WBGT index were found in gas cutting with an average of 33.73 °C, followed by 29.68 °C in melting unit where the workers are involved in performing their job with molten metals having temperature of 1200–2000 °C. The mean WBGT mean values obtained in other sections were heat treatment 28.37 °C, fettling 28.25 °C and administrative section 25.84 °C, respectively.

Table 1: *Permissible Heat Exposure Threshold Limit Values (TLVs) (values in °C WBGT).*

Allocation of work in a cycle of work and recovery	TLV value for WBGT (°C) as per work load		
	Light	Moderate	Heavy
75–100%	31.0	28.8	-
50–75%	31.0	29.0	27.5
25–50%	32.0	30.0	29.0
0–25%	32.5	34.5	30.0

Table 2: *Heat Stress Parameters Recorded in Various Sections of Foundry Units.*

Sections	Variables	T_{WB} °C	T_{DB} °C	T_G °C	WBGT °C	RH%	Predominant work type	TLV (°C) (ACGIH)
Melting	Mean	25.60	37.82	39.32	*29.68**	29	Heavy	27.50
	Range	24.10–27.10	30.20–42.80	31.70-44.30	25.20–32.20	18-57		
Heat treatment furnace	Mean	24.66	35.62	37.58	*28.37**	33	Heavy	27.5
	Range	23.30–26.70	30.40–38.90	34.10–40.70	26.30–31.20	22–50		
Fettling	Mean	24.82	34.47	36.25	*28.25**	38	Heavy	27.5
	Range	23.40–26.50	29.80–38.60	31.70–41.70	26.10–29.60	26–58		
Gas cutting Department	Mean	31.25	34.67	37.71	*33.73**	34	Heavy	27.5
	Range	22.60–38.50	30.60–37.20	32.40–41.10	26.40–39.30	26–55		
Administrative section	Mean	22.89	32.00	32.64	*25.84*	40	Moderate	29.0
	Range	21.60–23.50	26.70–34.80	29.60–35.20	24.70–26.80	29–63		

**p < 0.05 compared to levels of administrative section*

The mean WBGT index levels are significantly higher ($p < 0.05$) in gas cutting, melting, heat treatment and fettling sections compared to the administrative sections. In gas cutting, melting, heat treatment and fettling units the recorded levels exceeded the threshold limit values of WBGT prescribed by ACGIH. The work-rest regimen noted in gas cutting, fettling, heat treatment and melting was of 50 to 75% each hour and the work load prevalent in these sections could be categorized as “heavy.” The permissible heat exposure TLV is 27.5 °C prescribed for heavy category of work (ACGIH, 2007). Compared to this value, heat stress was highest in the gas cutting unit than in other sections.

In the melting unit, heat exposure exceeded the ACGIH recommended level of WBGT index (27.5 °C). In the melting section, steel making process is carried out in electrical induction furnace. The raw materials used are scarp, different grades of carbon steels and foundry returns which are charged in furnace and melted at 1200–2000 °C. During this process, possibility of high exposure of heat occurs to workers, because the distance between the heat source and workers was very less. This may lead to high exposure of intense heat among the workers working in that particular zone. The work pattern at fettling was almost similar to that of gas cutting operations. Fettling is the process wherein the unwanted protrusions from castings are removed.

This is done with help of gas flame (or) sharp cutting tools depending on situation. As the duration of working hours increases the flaming requirement also increases, which may lead to continuous source heat in the section. At the end of this process, the material undergoes for heat treatment in furnace, to compose hard material at 1500 ºC. Due to this, the heat is transmitted to surrounding area and the heat reside stable up to 2 to 4 h. The temperature range varies slightly from morning to evening due to other weathering factors. Compared to other units, the WBGT level in administrative section was found within the prescribed limits and it was observed that there was no heating elements (or) heat furnace nearby.

ACGIH (2001) [13] has identified the threshold level for illness in terms of core body temperature. Mohan *et al.* [14] reported a study on stimulation of foundry environment for improving occupational exposure to heat stress conditions. During their study they assessed the ergonomic risk factors and musculoskeletal disorders like low back symptoms have been noted amongst foundry workers. In the present study, even though the authors did not attempt to include ergonomic risk factors and musculoskeletal disorders among the study subjects, but it is obvious that these workers may develop the warning sign in addition to physiological heat strain due to elevated heat levels in the shop floor.

Noise Levels

In the present study, considering the 8-h work shift, the equivalent noise levels in all the sections recorded high values compared to administrative section (Figure 1). The level of noise intensity was below the limit prescribed by OSHA (8-h exposure limit: 90 dB (A)). In the melting and heat treatment furnace section, the process does not involve noise production, the elevation in the noise level was episodic due to occasional siren, vacuum releases, etc., of short duration.

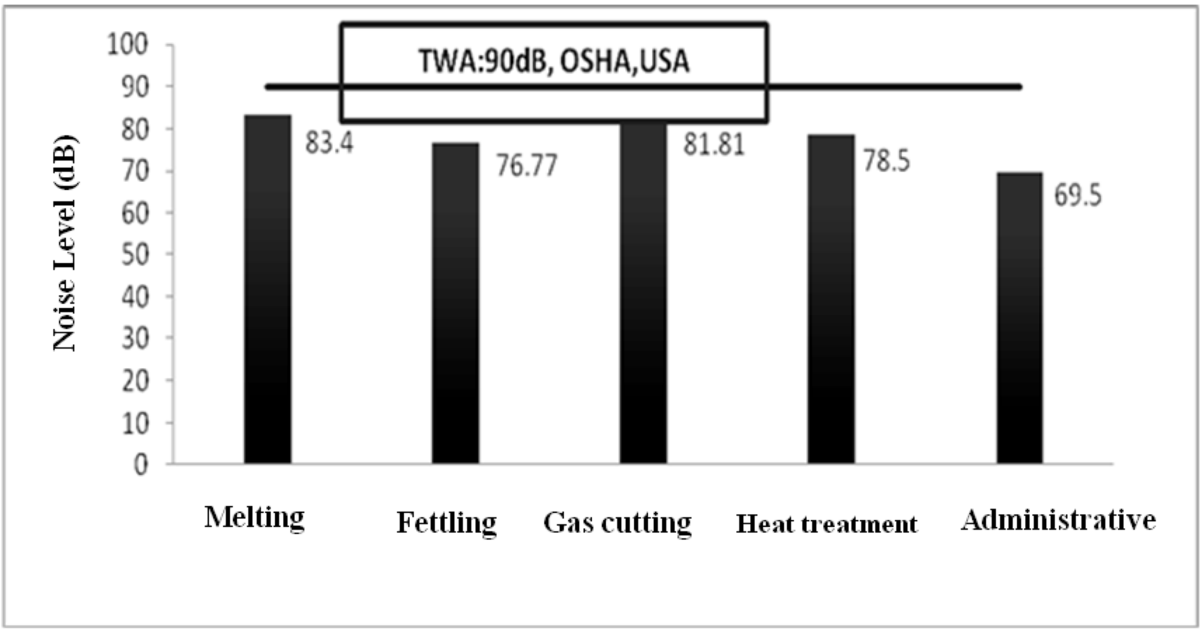

Fig. 1: *The Work Place Average Noise Level in Different Sections of the Foundry.*

CONCLUSIONS

The heat and noise exposure represents a major factor which may increase the health risk of worker with reduced efficiency and consequently affect the production of the unit. The recommendations of ACGIH should be taken as indicative of stress among workers and they should be under constant medical supervision for better healthy workforce. This would enhance the efficiency of the workers resulting in reduced reject quantity, improved production and hence increased profits. The physiological strain related to heat stress and noise levels should not be ignored by the management. Strategies for managing heat stress and noise exposure include engineering controls, administrative and work practice controls, personal protective equipment, water and salt intake and the findings of the present study were forwarded to the management of the plant to implement .

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