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Heat Exposure Study in the Workplace in a Glass Manufacturing Unit in India

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The heat exposure for working conditions in coastal areas of tropical and subtropical countries like India is a crucial factor in improved qualitative and quantitative production. The hot climate augments the heat exposure close to sources like furnaces. In the present work heat exposure to workers in glass manufacturing units in a coastal area of India has been assessed. The Wet Bulb Globe Temperature (WBGT), the Corrected Effective Temperature (CET) and Mean Radiant Temperature (MRT) were measured. The WBGT values much exceeded ACGIH TLVs. A revision of these standards to suit tropical and subtropical conditions is required. The recommended durations of work and rest have been estimated. © 2000 British Occupational Hygiene Society. Published by Elsevier Science Ltd. All rights reserved.

Keywords: heat stress; wet bulb globe temperature (WBGT) index; corrected effective temperature (CET); glass factory; tropical country

INTRODUCTION

Heat has been on record as a hazard to man since biblical times. Heat stress is still the most neglected occupational hazard in tropical and subtropical countries. Intense hot environments are prevalent in the iron, steel, glass and ceramic units, rubber, foundries, coke ovens, mines, and many other industries.

In India climatic heat exposure leads to high incidence of death and morbidity. However, limited information is available to estimate the combined effect of climatic as well as industrial heat exposure, known to cause physiological and psychological changes. The effects vary widely in different seasons. Consideration of the factors contributing to the total heat stress and knowledge of how people need to respond to different work conditions and climate will greatly help.

The maximum temperatures in the State of Gujarat in India range from about 32 to 42°C. Heat stress naturally occurring due to the hot climate is augmented for the workers involved in work close to furnaces. Glass manufacturing is one such work environment, where some workers are exposed continuously to high temperatures during the 8 hour shift. Convective or radiant heat gains by the human body can lead to heat disorders (Leithend and Lind, 1964; Minard, 1966). A case of heat exposure to the workers in different areas of glass manufacturing units with production capacities of 15 tonnes per day (TPD), 18 TPD, 75 TPD, 130 TPD and 230 TPD is presented.

DESCRIPTION OF THE PROCESS

Glass bottle manufacturing consists of batch preparation from raw materials, melting, forming, annealing, quality inspection and packaging. The

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flow chart of the manufacturing process in use in the unit studied is presented in Fig. 1. The operations, which involve increased heat levels and possibility of exposure to heat to workers have also been indicated in the figure. The furnace presents a dominant source of radiant heat. The temperature is very high around the furnace and the individual section (IS) machines forming the final products.

Molten glass is maintained at a temperature of 1590°C at all points. From the furnace molten glass passes through a throat to moulds where the temperature is maintained at about 1300°C. During forming, the temperatures of the IS machines are maintained at around 800–900°C. The annealing section maintains a temperature range of 200–300°C.

METHODOLOGY

The heat stress on the workers depends on four environmental factors, namely the air temperature, humidity, mean temperature of the surrounding area and air movement. To assess the hazard, heat stress indices have been defined. Three heat stress indices generally used are Corrected Effective

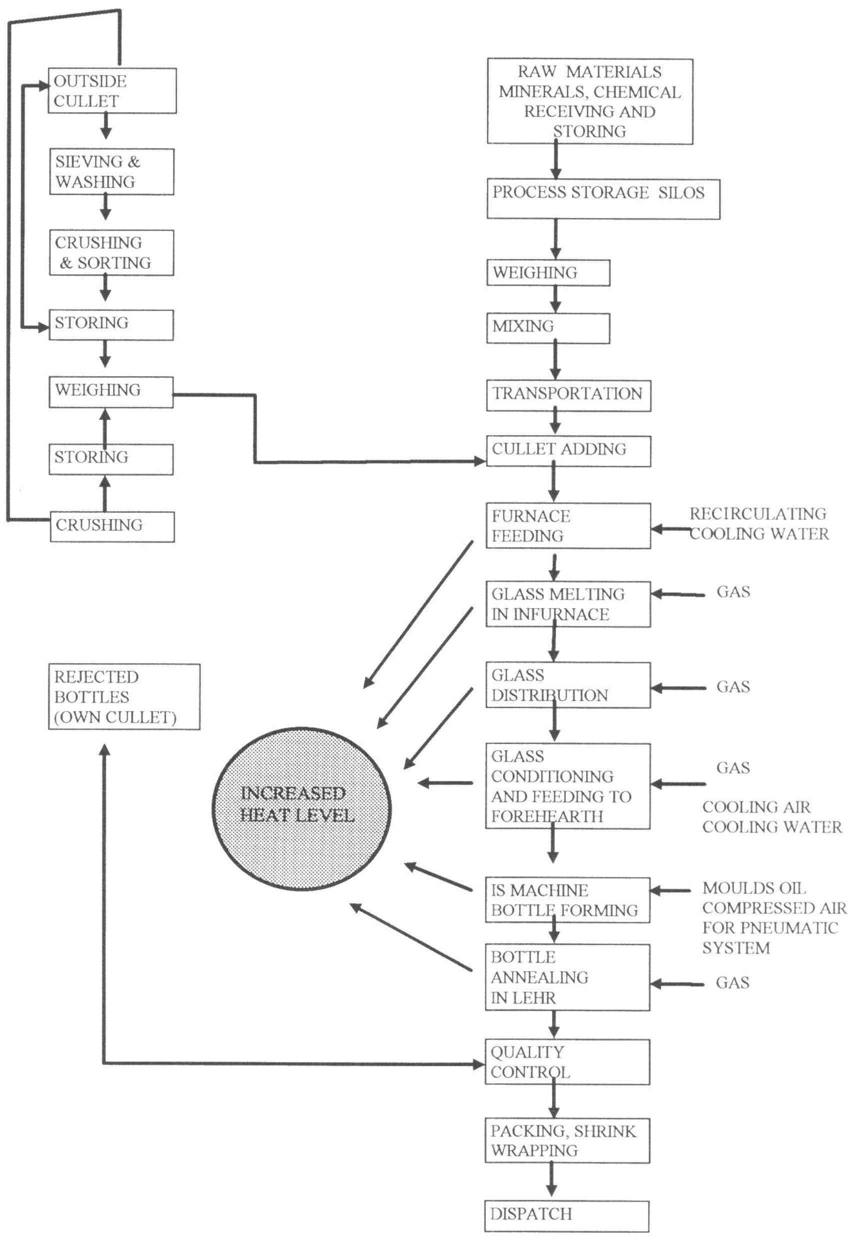

Fig. 1. Flow chart of the glass manufacturing process.

Temperature (CET), Mean Radiant Temperature (MRT), and Wet Bulb Globe Temperature (WBGT). The American Conference of Governmental Industrial Hygienists (ACGIH, 1999) relates WBGT and workload to arrive at a Threshold Limit Value (TLV) for continuous work and work with varying duration of rest periods.

In the present study CET, MRT and WBGT have been estimated at different locations in the glass bottle manufacturing unit. The workload of workers in these locations has been assessed as prescribed by ACGIH. Based on WBGT and workload, rest periods for workers in these areas have been assessed.

ESTIMATION OF WORKLOAD

The total heat load is estimated by taking into account the heat produced by the body as well as the environment. The workload at the different areas in the unit has been established by ranking workers' jobs using the metabolic rate tables available in the literature, and summarized by ACGIH (1999).

Workload category is determined by averaging metabolic rates for the tasks and then ranking them. Light work is categorized as up to 200 kcal h^{-1}, moderate work in the range 200–350 kcal h^{-1} and heavy work in the range 350–500 kcal h^{-1}. In the glass bottle manufacturing unit under study the workers near the furnace and bottle making area are involved in walking around with moderate lifting and pushing. According to ACGIH classification, this type of work falls in the moderate category.

ESTIMATION OF HEAT STRESS PARAMETERS

At a location indoors or outdoors with no solar load, WBGT is defined as

$$\mathrm{WBGT} = 0.7\mathrm{WB} + 0.3\mathrm{GT}$$

where, WB is the wet bulb temperature and GT is the globe thermometer temperature, and at locations outdoors with solar radiation load

$$\mathrm{WBGT} = 0.7\mathrm{WB} + 0.2\mathrm{GT} + 0.1\mathrm{DB}$$

where DB is the dry bulb temperature.

Mean radiant temperature, MRT, has been estimated from globe thermometer temperature and dry bulb temperature as

$$(\mathrm{MRT} + 273)^4 = (\mathrm{GT} + 273)^4$$

$$+ 2.5 \times 10^8 v^{0.6} (\mathrm{GT} - \mathrm{DB})$$

where all temperatures are in °C and v, the air velocity, is in ms^{-1}. Corrected effective temperature (CET) has been estimated from psychromatic charts, using a katathermometer.

RESULTS AND DISCUSSION

Table 1 summarizes the WBGT, CET and MRT calculated from the observed temperatures. The globe thermometer temperature observed at all the locations except the compressor room, is higher than the dry air temperature, indicating that all the surfaces which surround the globe are warmer than the air, thereby radiating heat to the atmosphere.

It is observed that WBGT peaked to 40°C against the ACGIH TLVs of 26.7°C in front of an IS machine. At all the points in the manufacturing section WBGT exceeds the TLV limits. The WBGT observation calls for a rapid action to control problems of heat stress in the manufacturing section of glass manufacturing units. However, according to a note to TLV for heat stress, higher heat exposure than those stated in the TLV are permissible if the workers are under medical surveillance and it is established that they are more tolerant to work in heat than the average worker. But under no circumstances should a worker be permitted to continue work when their deep body temperature exceeds 38°C.

The ACGIH recommendations for work and rest regime with respect to WBGT could not directly be extrapolated as the WBGTs are quite high, India being a tropical country. However, the observed values of WBGT can be said to require 25% work and 75% rest and 50% work and 50% rest each hour for workers working near IS machines and in front of furnaces, respectively. At other places, 75% work and 25% rest each hour is desirable. According to ACGIH recommendations, this is not practical and stresses the need for development of TLVs for tropical countries. It is observed that people in general are more tolerant to heat exposures as compared to people in colder regions. The TLVs for tropical countries should be based on local climatic conditions. Moreover, in developing and under-developed countries poverty invariably forces the labour class to work in unhygienic conditions.

CONCLUSIONS

The heat exposure represents a major factor which may have negative impact on worker efficiency and consequently the production of the unit. It may be concluded that to avoid heat stress problems in glass manufacturing units the recommendations of ACGIH should be taken as indicative of stress areas and workers should be under constant medical supervision. This would enhance the efficiency of the workers resulting in reduced reject

Table 1. Heat stress parameter in a glass manufacturing unit (all figures are in °C)

	Dry bulb	Wet bulb	Globe temperature	WBGT	MRT	CET	Predominant work type[a]	WBGT TLV1 continuous work (°C)
15 TPD								
IS machine	39	29	42	33	48	32	Moderate	26.7
Furnace	46	36	48	40	52	38	Moderate	26.7
Charger	45	34	48	38	48	34	Light	30
18 TPD								
IS machine	45	36	39.3	37	49	38	Moderate	26.7
Furnace	46	31	50	37	59	34	Moderate	26.7
Charger	40	34	44	37	53	35	Light	30
75 TPD								
IS machine	46	32	47	36	50	34	Moderate	26.7
Furnace	46	35	48	39	53	37	Moderate	26.7
Charger	45	35	49	39	58	36	Light	30
130 TPD								
IS machine	37	34	49	39	73	35	Moderate	26.7
Furnace	45	35	48	39	55	36	Moderate	26.7
Charger	45	33	47	37	52	36	Light	30
230 TPD								
IS machine	39.7	27	49	34	68	31	Moderate	26.7
Furnace	47	29.5	57.2	38	77	33	Moderate	26.7
Charger	44.3	33.3	52.8	39	70	35	Light	30
Open yard	30	26	42.2	30	48	31	Light	30

[a]Moderate: 200–300 kcal h^{-1}; Light : 150–180 kcal h^{-1}.

quantity, improved production and hence increased profits.

In view of the high ambient temperatures prevalent in tropical and subtropical countries, it is felt that ACGIH standards would not suit local conditions leading to higher WBGT indices for the same type of work performed in cooler climates. A revision of these standards to suit tropical and subtropical conditions would be in order.

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