Analysis of the Effect of Excessive Temperature and Humidity in a Production Environment

L.U. Bakmeedeniya

Department of Mechanical Engineering, Faculty of Engineering, University of Peradeniya

Introduction

Provision of a congenial working environment is an important matter that affects productivity of any process or service. Various measures are in place in industrial environments to maintain conditions that make the working surrounding comfortable. In the relevant standards, specifications are stipulated on acceptable levels of temperatures, humidity, noise, etc., as applied to different working environments, which are to be strictly adhered to. However, the situation in most Sri Lankan industries is far from this, owing to lapses ranging from those in planning, to the implementation and commissioning of a process. Complaints about high temperatures and humid conditions are common on production floors where the number of workers per unit area or the generation of heat/moisture is relatively high. For examples apparel industries, footwear manufacturers, catering industry/hotels etc., are common instances where one experiences such adverse working conditions. In these cases, the main problem appears to be insufficient ventilation and heat and effluent removal. These two aspects are important to maintain a balanced heat and moisture exchange process between the process or the production floor, the workers and the surroundings.

The objective of the reported study was to identify prevailing problems that affect the human comfort in the working environments and to propose remedial actions using tools of computational fluid dynamics in accordance with the relevant standards. Investigations were carried out to study the factors and analysis done with the help of available thermal comfort standards to draw conclusions from an engineering view point.

This study looks into the present state of selected industries in the above context to understand the gravity of the issue using basic heat transfer and fluid dynamic principles applied to two-dimensional flow, as a part of the research. It is expected to extend the analysis to three-dimensional flow situations using tools of computational fluid dynamics.

Methodology

Two factories were selected as case studies where the occupants in the production floor experience thermal discomfort.

The geographical location and the factory layout were studied and suitable measurement grid was constructed to ensure accessibility, in order that the intended floor measurements and other readings could be obtained within an hour. At each grid point, dry and wet bulb temperatures were recorded for the different layers which were, respectively, 1 m and 2 m above the floor. The process was repeated throughout the working day (8 a.m. to 5 p.m.). Air flow velocity was also noted. The investigation procedure implemented in was repeated after one month.

Other observations made included the currently implemented solutions, inside/outside factory conditions and the environment, the number of occupants, sources of heat generation, location of fans and their effective region, blowers, diffuser fans, windows, doors and related measurements.

Analysis of observations

For both case studies, relative humidity was found from psychometric chart using dry and wet bulb temperature measurements, and hourly plots of relative humidity and ambient temperature contours were individually obtained.

The behaviour of temperature and RH variation were examined on an hourly basis and compared to detect special patterns as well as repetitive behaviours. In addition, the nature of the background, such as fans, occupants, functions etc., were considered to determine their contributions to the problem and the amount of heat generation was also calculated as necessary. Considering the results the existing problems were determined.

Table 1. Comparison between standard values and results

Parameter	Value in standards		Observed value	
	ASHRAE	BOI	Case 1	Case 2
Temperature / °C	23 - 26	23 - 26	29 - 35	29 – 34
Relative humidity / %	30 - 60	30 - 60	64 - 87	62 – 83
Space per occupant / ft^3		400 *	290	364

* Space per person should be more than 400 ft^3 where no space over height of 14 feet (BOI, 2004; ASHRAE 55, 1981)

Comparisons and discussion

***Case 1** – An apparel industry situated in the Central province*

It was observed that the temperature contours followed a similar pattern in some regions throughout the day. Figure 1 shows such a contour in the factory during the most critical period. All the pedestal fans were placed in a way that air movement was forced towards the rear wall. But the exit door and the window areas were not enough to provide sufficient space to expel the air. As a result, air was trapped in the vicinity of the wall, which also reaps the higher temperature. The corresponding RH contours did not reflect the pattern of the temperature contours. However, the humidity range in the floor was not at the desired level.

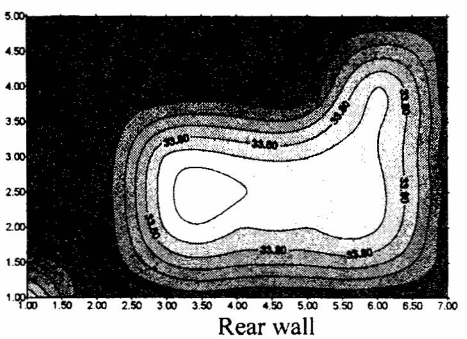

Figure 1. Temperature contours at 2 pm (Apparel industry)

***Case 2** – Footwear manufacturing factory situated in Western province*

Here again, the analysis of the observations (Figure 2) shows an example of a critical temperature contour in the factory, and other details show major factors, which affect the occupants' thermal comfort. Temperature at the floor was above the accepted level, and the relative humidity was also outside the comfort zone. In this factory, the presence of fumes from the chemicals used in the process contributes to the increase of temperature levels. There was also a high rate of heat gain from several sources. The presence of a wide monitor roof also led to the formation of eddies at the high levels leading to the stagnation of warm air in the breathing zone.

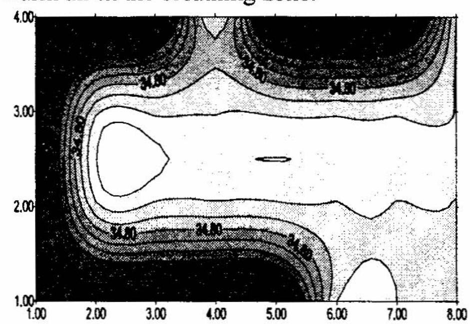

Figure 2. Temperature contours at 2 pm (Footwear manufacturing factory)

Conclusions

According to the results, observations and comparisons it can be seen that the factory floor environments did not have desired values of ambient temperature, relative humidity, and also the space per person. Thus, it can be concluded that the major contributory factors for the thermal discomfort are insufficient ventilation, insufficient heat and effluent removal inside the floor owing to improper implementation of the present solutions, noxious building configuration and inadequate space per person on the floor.

References

ASHRAE 55 (1981) Air quality and thermal comfort in factory buildings, *Construction Technology Update*, 64.

BOI Enterprises (2004) *General Guidelines for Factory Buildings*