A SHORT NOTE ON EXPERIMENTAL VERIFICATION OF ZONE MODELS WITH AN ELECTRIC HEATER

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ABSTRACT

An electric heater with adjustable thermal power output is proposed to verify results predicted by a two-layer fire zone model. This gives better control on the thermal output of the hot object. Experiments were performed in a fire chamber of length 4.0 m, width 2.8 m and height 2.8 m. The two-layer fire zone model CFAST was taken as the example, as it is now used as a popular engineering design tool.

1. INTRODUCTION

To verify the results predicted by both fire zone and field models [1] using full-scale burning tests [e.g. 2], it is important to have a good estimation on the heat release rate [3] of the fire. This is taken as the input parameter for most fire models because combustion, thermal radiation and turbulence are difficult to be simulated simultaneously. Accuracy of the modelling results such as smoke layer temperatures and interface heights depend on its value.

Before the oxygen consumption calorimetry was popular, heat release rate used to be determined experimentally from the measured mass loss rate of the burning fuel through the calorific value. The combustion efficiency of different values has to be measured to give a good estimation.

An electric heater of adjustable thermal power was proposed in this short note for verifying zone modeling results. Detailed description appears in elsewhere [4]. The popular two-layer zone model CFAST [5] was taken as an example.

2. EXPERIMENTAL STUDIES

Experiments were performed [4] in the fire laboratory of the Department of Building Services Engineering, The Hong Kong Polytechnic University. The chamber was 4.0 m long, 2.8 m wide and 2.8 m high. There was a door of width 0.9 m and height 2.0 m as shown in Fig. 1.

A 12 kW electric heater with dimensions 0.55 m long, 0.47 m wide and 0.47 m high was designed as in Fig. 1a. As the power supply available in the laboratory was 380 V/32 A, six heaters of rating 2 kW/220 V were selected. The transient thermal power curve is shown in Fig. 1b. The electric heater was placed at the corner of the fire chamber.

Two thermocouple trees T1 and T2, each with four type K chromel-alumel thermocouples at heights 1.35 m, 1.75 m, 2.15 m and 2.55 m above the floor placed at the corner above the fire and at the centre of the room respectively to measure the hot-air layer temperature and interface height.

3. TYPICAL RESULTS

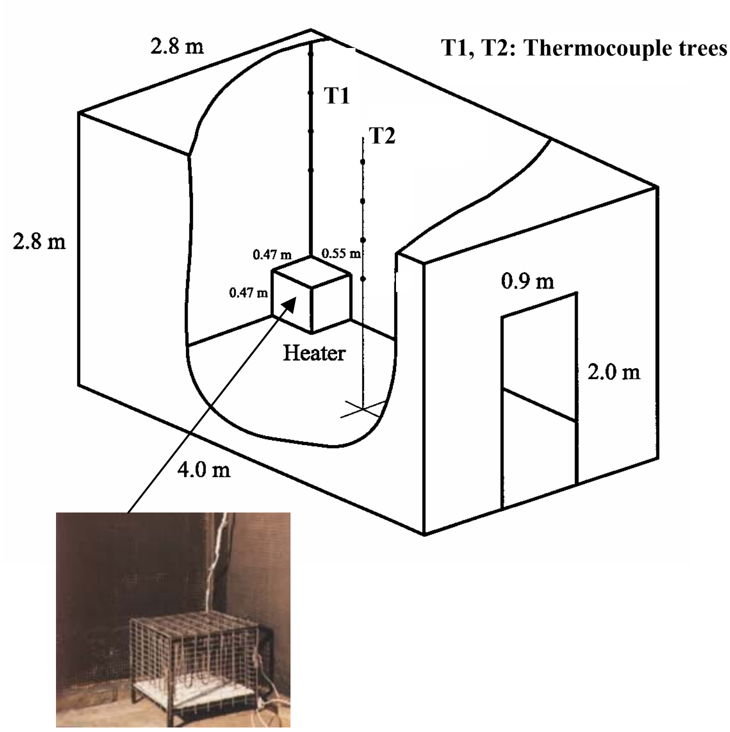
The interface height of the hot-air layer was deduced from the measured vertical temperature profiles. The position of the interface was taken as the one with 15% of the temperature rise measured at the uppermost thermocouple.

Putting in thermal powers of the electric heater into the two-layer zone model CFAST [5], the hot-air (or smoke layer) temperatures and interface heights were predicted. Comparisons on the measured transient hot-air (or smoke layer) temperatures and interface heights with the predicted values by CFAST are shown in Figs. 2a and b respectively.

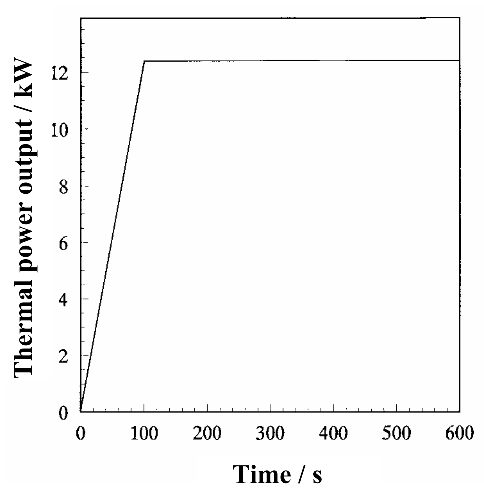
Predicted results on the average hot-air layer temperatures and interface heights by CFAST are similar to those measured values induced by the electric heater.

4. CONCLUSION

Experimental studies on the hot-air layer temperatures and interface heights were carried out with an electric heater. The two-layer zone model CFAST [5] was taken as the example since it is commonly used. It is observed that the measured results agreed satisfactorily with the predictions. This has the advantage of giving better input data on the thermal power outputs. The heat release rate curve is important in using fire models for studying hazard assessment. If this curve can be determined accurately, as illustrated by the case for the electric heater, the predicted value of zone model would give satisfactory agreement with the measured results on smoke layer temperature and interface height.

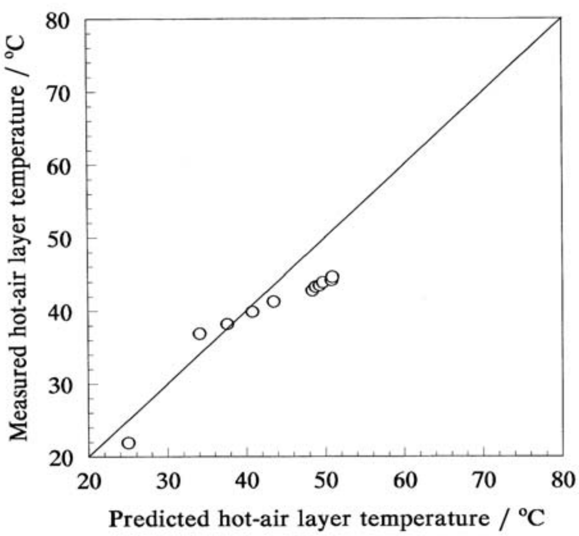


(a) The heater

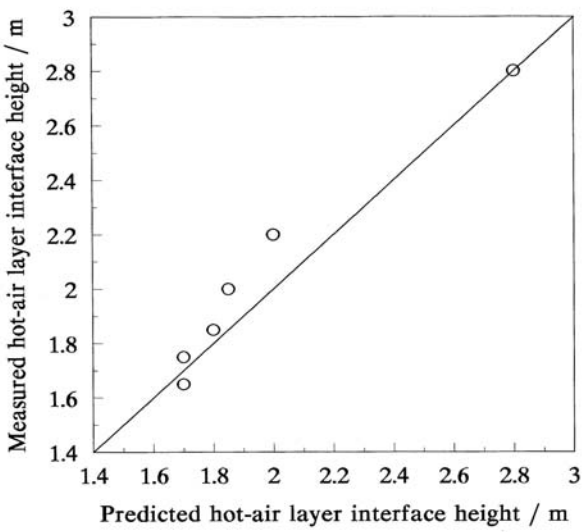


(b) Thermal power output

Fig. 1: Geometry of fire chamber



(a) Hot-air layer temperature



(b) Hot-air layer interface height

Fig. 2: Comparison of measured and predicted results

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