EXPERIMENTAL AND COMPUTATIONAL ASSESSMENT OF HOT SMOKE AND MORE REALISTIC FIRE TESTS IN LARGE ENCLOSURES, Part 2: Numerical Predictions

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ABSTRACT

Along with zone modelling prediction, COMPACT (Computer Analysis of Convective Transport, by Inres) is used for CFD modelling of the experiments described in Part 1. COMPACT follows finite-volume and finite-difference approach of Patankar [1]. Extensive use is made of the user programming capabilities of COMPACT for both representation and boundary conditions. Six different k-epsilon turbulence models [2] are examined in the COMPACT environment (here, k and epsilon are the turbulence kinetic energy and its rate of dissipation, respectively). The concentration of chemical species was obtained along with enthalpy, temperature and other flow properties. These predictions are compared with experimental results and each other.

In Figures 1 and 2, the 2D and 3D grids, respectively, are illustrated for the first warehouse mentioned in Part 1 as an example. In the simulations, gaseous ethanol C_2H_5OH enters from the center of the atrium, with a velocity and temperature [3]. Air enters at the same temperature as the fuel. Inflow conditions of 28 ^oC at $3x10^{-5}$ m/s are used for both air and fuel (ethanol), along with the standard properties of ethanol [4, 5]. Symmetry plane has been used for 2D and 3D cases to reduce simulation time and memory usage. Grid independent and converged results have been obtained for all cases.

In Figure 3, steady state temperature variation is presented along the height from the floor where Thermocouple Tree 1 was placed during the experiments in the first warehouse. In addition to the experimental results from Thermocouple Tree 1, numerical prediction with six different k-epsilon turbulence models are plotted. The best prediction is obtained with the Nagano and Hishida model, and the worst with the Hassid and Poreh model [2].

In Figure 4, smoke lowering from hot smoke and polyurethane tests is plotted along with the results obtained from CFAST calculations. During hot smoke tests, smoke lowering is faster than during polyurethane tests, as indicated in Part 1. CFAST predictions, as shown in Figure 4, show better agreement with polyurethane test results than with hot smoke results.

REFERENCES

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[4]Drysdale, D., 1994, An Introduction to Fire Dynamics. Wiley-Interscience Publication, pp. 1-32.

[5]SFPE Handbook of Fire Protection Engineering, 1995, National Fire Protection Association, Boston, USA, ed. 2, Chapters 2 (pp. 21-31) and 4 (pp. 246-258).

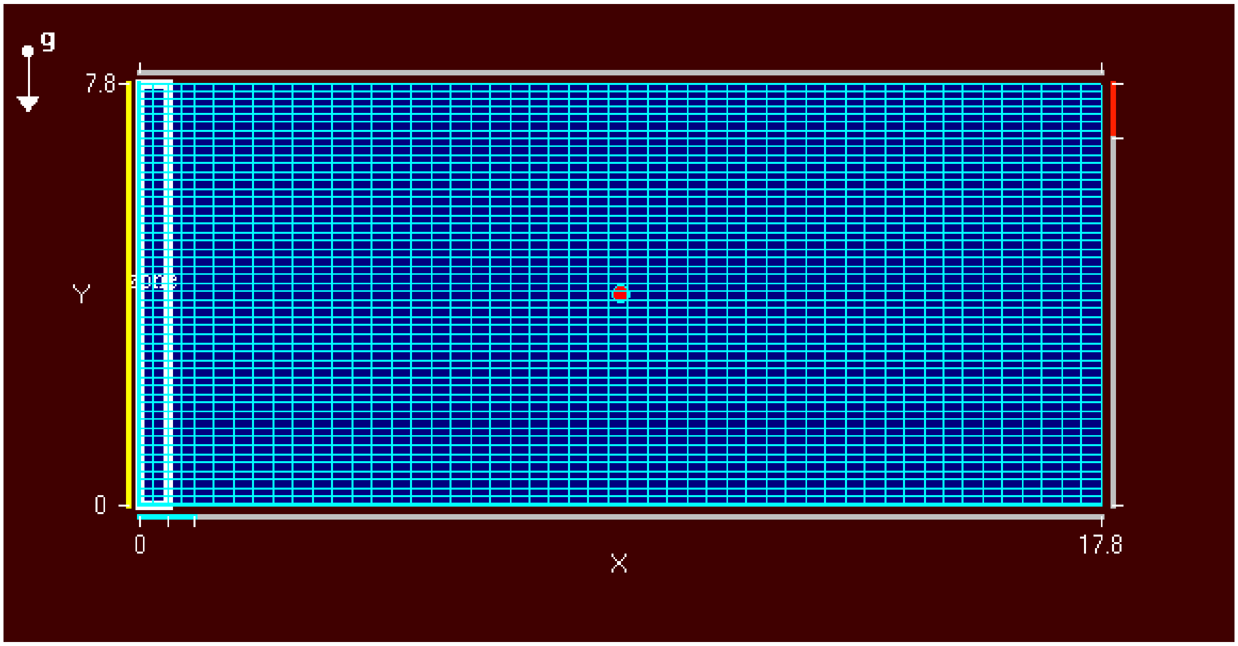

Figure 1. 2D numerical grid for the first warehouse. The left hand boundary is a symmetry plane. A vent is located at the top right corner. Fuel and air are injected from the bottom left for combustion. Unlike in the second warehouse, the fire was located at the centre of the first one.

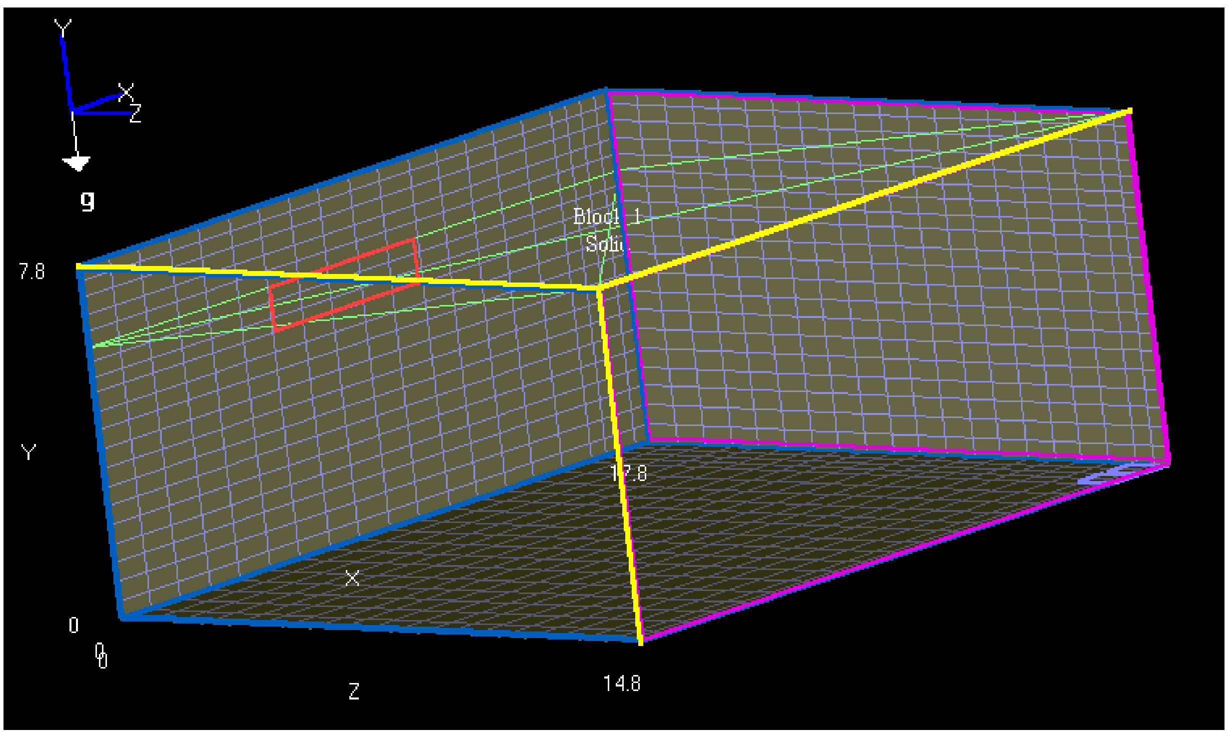

Figure 2. 3D numerical grid for the first warehouse. The front and back right walls are symmetry boundaries. A vent is located on the back left wall. The fuel and air injection is from the symmetry corner.

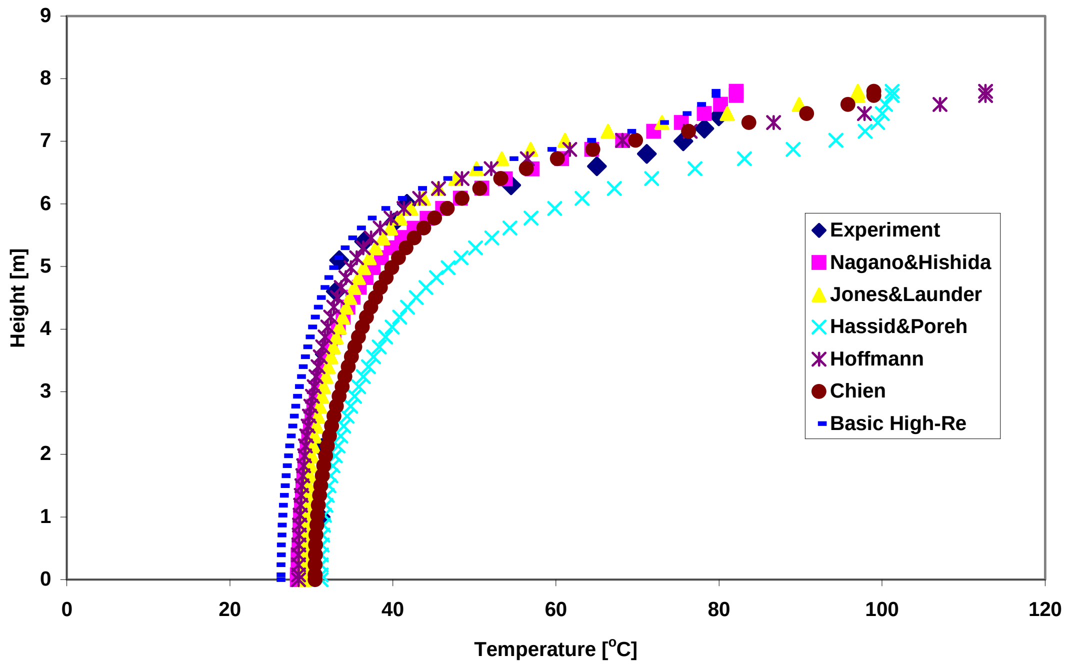

Figure 3. Experimental and predicted temperature results. The six k-epsilon turbulence models are as indicated in the legend.

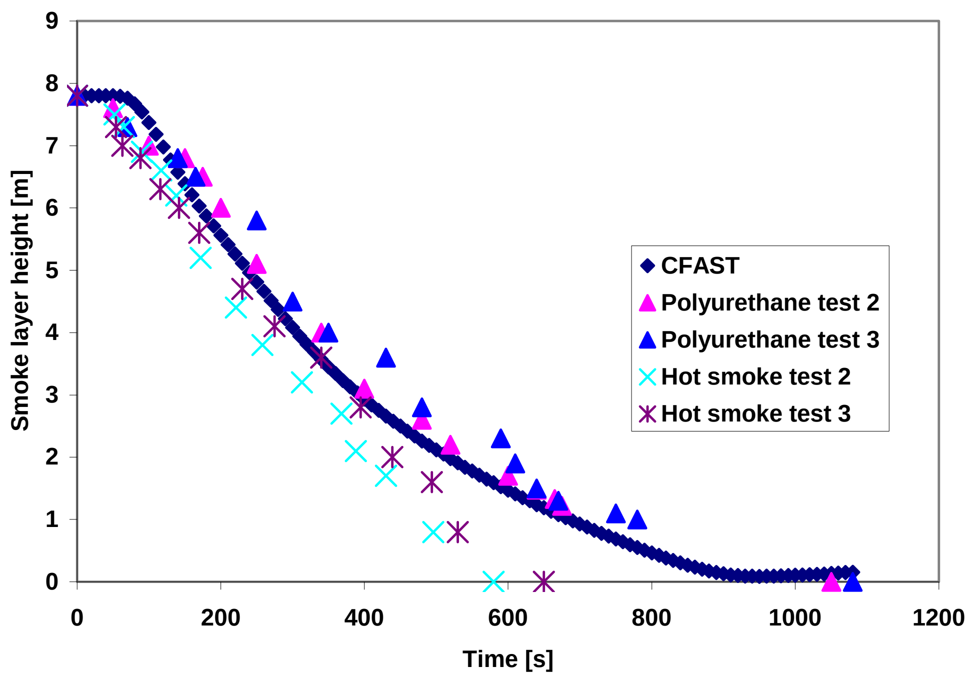

Figure 4. Experimental and CFAST predicted smoke lowering results for hot smoke and polyurethane tests.