PRELIMINARY STUDY OF NUMERICAL SIMULATIONS OF FLAME SPREAD ON MEDIUM DENSITY FIBERBOARD MATERIAL IN A CORNER CONFIGURATION

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Introduction

Fire safety of high-rise buildings has attracted extensive attention, especially in cases where flames eject out from the opening and spread to the other floors and even adjacent buildings. Flame spread on building's façade is an extremely complex phenomenon, involving several processes including thermal heat transfer from the flame to the surface of a combustible material, pyrolysis of the solid material, and combustion reaction of volatiles released from the pyrolyzing solid. Pyrolysis modelling is an essential step towards the modelling of flame spread on building's façade.

Understandably, a lot of effort has been devoted to study this subject by means of theoretical analysis, experimental investigation and numerical modelling. The present work deals with the pyrolysis modelling of charring material using the CFD code Fire Dynamics Simulator (FDS version 6.1.2). The preliminary simulation results are presented and compared with large scale experimental results.

Experimental setup

D. Zeinali et al. [1, 2] conducted Single Burning Item (SBI) tests with the Medium Density Fibreboard (MDF) panels placed in a corner configuration. As a result of the hot-processing operation in the manufacture process, the MDF material formed non-uniform density along the thickness of the sample [3, 4]. Details of the density distribution and other thermal properties of the MDF material can be found in [1, 2]. Fig.1 shows the experimental setup of the SBI test.

Measurements including the Heat Release Rate (HRR), total heat fluxes, and temperatures at the front surface and back-side of the panel have been measured in these tests. More details and results of these tests can be found in [1, 2].

Numerical method

In FDS, Turbulence is treated by means of large eddy simulation. Four models can be chosen for the subgrid-scale turbulent viscosity, with the 'modified Deardorff' as default model.

FDS uses eddy dissipation concept combustion model, which is based on the mixing-limited, infinitely fast reaction of lumped species.

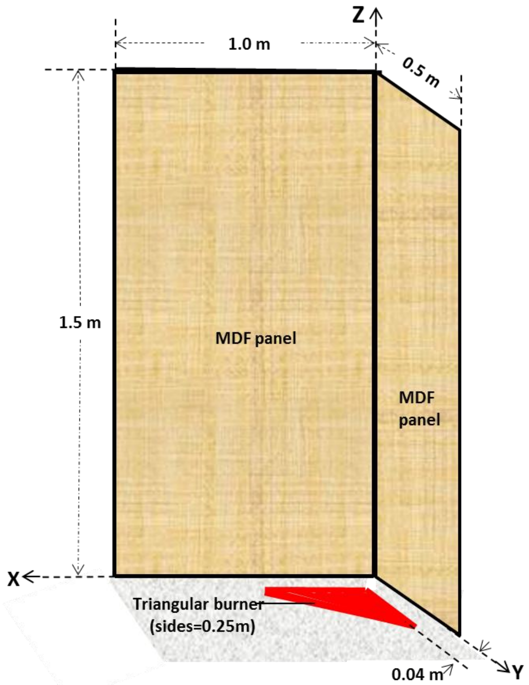

Figure 1. Experimental setup of SBI test using MDF panels in a corner configuration.

The radiative transfer equation is solved using the finite volume discrete ordinates methods. A radiation fraction of 0.35 is prescribed as a lower bound in order to limit the uncertainties in the radiation calculation induced by uncertainties in the temperature field.

A modified Arrhenius model [5] has been employed to simulate the pyrolysis process. With this model the pyrolysis process is simplified as a one-step finite rate reaction. The reaction rate is a function of solid and gas phase conditions and calculated as a combination of Arrhenius and some power functions. These power functions can be used to describe the dependence of the reaction rate on the concentration of the reactant, the material temperature, the local oxygen concentration, and a threshold temperature below which the reaction cannot occur. More details can be found in [6].

A computation domain of the size 1 m × 1.1 m × 3 m is used, which is shown in Fig.2. Two meshes are used within the simulation. The first mesh contains two MDF panels has 0.02 m cell size, and another one has 0.04 m cells. Total number of cells are 187 500. The MDF panel is 0.0182 m thick. There are 51 cells within 17 layers across the panels. In line with the experiments, the mass

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flow rate of the propane burner is fixed so that the burner reaches its peak HRR of 30 kW with a 20 s ramp. The measures include the heat release rate, total heat fluxes, and temperatures at the front and back side of the panel at several locations.

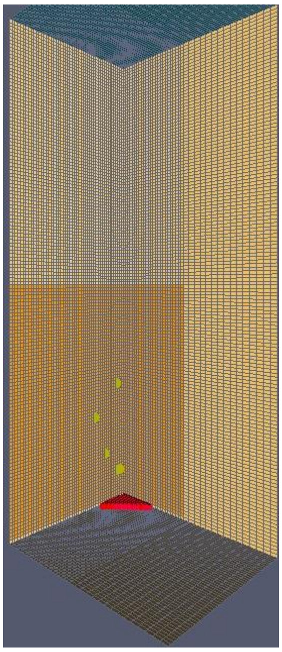

Figure 2. The computational domain and meshes in the simulations.

Results

Figures 3 shows the comparison between the HRR predicted in FDS and obtained from two SBI tests. Figure 4 presents the comparison of the total heat flux obtained in FDS and the experimental data at location 1 (x = 0.08 m, y= 0 m, z= 0.2 m) on surface of the panel. Due to the limitation of pages, only these results are presented here.

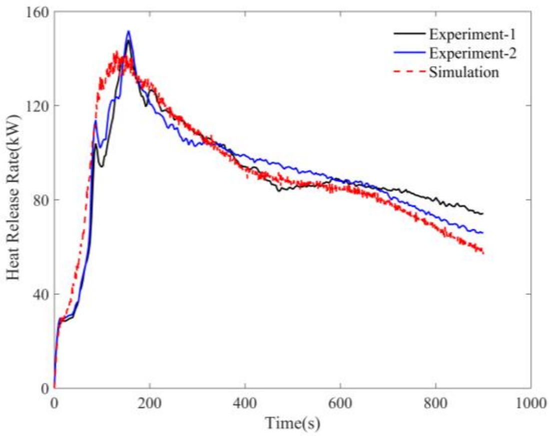

Figure 3. The evolution of total HRR in simulation and two SBI tests.

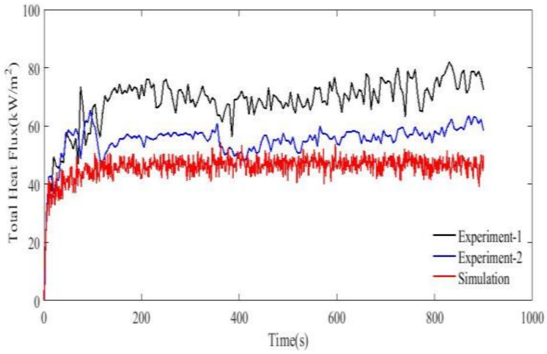

Figure 4. The evolution of total heat fluxes in simulation and two SBI tests.

Conclusions

A preliminary numerical investigation is reported of the flame spread with MDF material in a corner configuration using FDS (version 6.1.2). In general, good agreement with experimental data has been achieved with the total HRR. The overall trend of the predicted total heat fluxes is reasonable compared with the experimental data, but there is a notable underestimation.

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