Energy Balance in a Large Compartment Fire

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ABSTRACT

The experiments described here were part of an international collaborative project to assess and validate fire computer codes for nuclear power plant applications. Understanding the distribution of energy released by a fire is important for testing the accuracy of computational fire codes, which are used to design fire protection systems. This poster focuses on one of a series of experiments (Test 3 in Ref. [1]). Test 3 was selected as illustrative of the measurement approach used to track the time-varying enthalpy and its distribution in a compartment fire. Whereas several studies have considered the distribution of energy in a compartment fire, few have quantified measurement uncertainty, which is essential for model validation.

A goal of the test series was to fully characterize the experiment and the boundary conditions for subsequent comparison with fire models. Many measurements were made before the experiments even began. Compartment leakage, and the thermal and optical properties of the surface materials were measured. The combustion properties and behavior of the test fuel were characterized in a separate series of experiments that measured the heat of combustion, the combustion efficiency, the radiative fraction, and the yields of soot, CO_2 and CO in the same burner as used here.

The experiment consisted of a hydrocarbon spray fire with a heat release rate of nearly 1 MW, burning in a single compartment 7 m by 22 m by 4 m high. More than 350 instruments were used to make measurements. This poster focuses on measurements that were important to understand the enthalpy balance and the thermal environment in the compartment, including measurements of the fuel flow, the vertical profiles of temperature, the heat release rate via oxygen consumption calorimetry, the total heat loss to the compartment walls, ceiling, and floor, and the total mass and heat fluxes through the compartment door. Other measurements are described in Ref. [1] and included the soot density, the concentrations of O_2, CO_2 and CO in the hot gas layer, the compartment pressure, compartment leakage, the radiative and total heat flux at various targets in the compartment, surface and core temperatures of horizontally and vertically oriented control and power cables, and visible and infrared video records from multiple perspectives. From these measurements, it was determined that nearly 72 % of the fire energy went to heat compartment surfaces, 24 % escaped through the doorway, and 4 % went to heat the upper layer compartment gases.

KEYWORDS: CFD, compartment fire, energy balance, fire model validation

REFERENCES

[1] Hamins, A., Maranghides, A., Yang, J., Johnsson, E., Donnelly, M., Yang, J., Mulholland, G., and Anleitner, R., "Report of Test for the International Fire Model Benchmarking and Validation Exercise #3," NIST Special Publication 1013-1, Gaithersburg, MD, 2005.