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A posteriori modelling of the growth phase of Dalmarnock Fire Test One

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ABSTRACT

The challenge of *a posteriori* (i.e. after the event) modelling of a well characterized full-scale fire test using computational fluid dynamics is illustrated in this work. Test One of The Dalmarnock Fire Tests was conducted in a 3.5 m by 4.75 m by 2.5 m concrete enclosure with a real residential fuel load. It provides measured data at the highest spatial resolution available from a fire experiment to date. Numerical simulations of the growth phase have been conducted with the numerical code Fire Dynamics Simulator (FDSv4) while having full access to all the measurements. This includes description of the fuel load, compartment layout, temperature and heat flux data, and camera footage. No previous fire simulation had this large amount of data available for comparison. Simulations were compared against average and local measurements. The heat release rate is reconstructed from additional laboratory tests and upper and lower bounds for the fire growth are found. Within these bounds, the evolution of the average hot layer temperatures in time could be reproduced with 10–50% error. Worse agreement with local measurements of gas temperatures was achieved (between 20% and 200% error). Wall temperatures were predicted with less than 20% error and wall incident heat fluxes within 50–150% error. Largest discrepancy is seen close to the flames. This level of agreement with the measured data was achieved after exploratory simulations were conducted and several uncertain parameters were adjusted and readjusted while having full access to all the measurements.

1. Introduction

Modelling of compartment fires using computational fluid dynamics (CFD) has been a research topic since the introduction of computational techniques in fire science in the 1980's [1]. Only in the last decade the available computational power and knowledge of fire dynamics have grown sufficiently to carry out simulations in real-size building enclosures, using grids that are fine enough to reproduce fire-driven flows reasonably well [2]. Since then, CFD has been used extensively to model enclosure fire dynamics [3–5] both in research and in industrial applications. There are two common industrial uses of CFD. One is for design of the fire safety strategies in the built environment (which results are rarely made available for public scrutiny) and the reconstruction of accidental fires as part of forensic investigations (recent examples are the 2001 WTC [6] and the 2003 Station Nightclub [7] investigations).

The state of the art of fire modelling is such that given a fire of known size and power (evolution of the heat release rate (HRR)), CFD calculates the resulting temperature and smoke concentration fields. The fire source is therefore treated as an input into the model by means of a prescribed HRR as a function of time (e.g. [8,9]). This poses a problem in the study of accidental fires where the HRR is unknown. Predicting the evolution of the HRR (i.e., spread rate and growth pattern) instead of measuring it is among the most challenging pending issues in fire research [9,10].

Most modelling work in the literature corresponds to scenarios with simple fire sources, like pool fires or a single burning item of constant or near constant HRR. This type of scenario avoids the more complex processes of flame spread and fire growth observed in real fires. Little research has been done comparing simulations with real-scale fire tests that use realistic fuel loads. Some of most important examples using pool or crib fires are presented here. Reneke et al. [11] conducted *a posteriori* simulations of fire tests involving crib fires in a full-scale single compartment with a zone model obtaining reasonable agreement with the measured average temperatures when the measured HRR is used as an input. Miles et al. [12] obtain good results in average temperatures when performing *a posteriori* simulations of a series of fire tests involving wood cribs. Although local measurements where available, neither of these papers compared results at the field or local level. Pope et al. [8] conducted *a posteriori* simulations of the 1999–2000 BRE large compartment test series [13] using the CFD code FDS. The simulations provided reasonable agreement with the measured temperature field within the context of structural fire safety. Rinne

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