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Sensitivity Analysis of Fire Dynamics Simulation

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1 Introduction

In case of fire dynamics simulation requirements to reliable results are most often very high due to the severe consequences of erroneous results. Proper solutions require sufficient physical and numerical description combined with an adequate mesh. However, advanced models and detailed meshes are very costly in terms of manpower, storage and CPU time. At the same time determination of fire scenarios and additional input parameters may be highly uncertain. Thus, to provide reliable results applicable for sound decision support the inclusion of sensitivity analysis is crucial.

2 Materials/Methods

Sensitivity analysis of a fire dynamics simulation is performed on a benchmark case comprising a steady-state full-scale fire scenario in a domestic sized room.

The screening method of Elementary Effects (Morris method) is applied. The method comprises a number of individually randomised one-factor-at-a-time simulations where all factors are varied within their input space in a way that spans the entire input space to form an approximate global sensitivity analysis.

The fire dynamics simulations are made by the special application fire simulation CFD code FDS. The input parameters chosen for the sensitivity analysis (SA) are listed in Table 1.

Table 1. Input parameters applied for the SA.

Heat release
Fire geometry
Fire location
Fuel type
Initial and external temperatures
Opening size (door width adjusted)
Solid angles (grid size of radiation model)
Radiation model
Smagorinsky constant

The parameters are divided in physical parameters - comprising fire characteristics, room characteristics and external boundary conditions – as well as program parameters that influence the numerical solution process.

3 Results

A total of 40 CFD simulations are performed. On the basis of input and output the elementary effects are calculated and the corresponding mean value and standard deviations are used to create graphs like Figure 1.

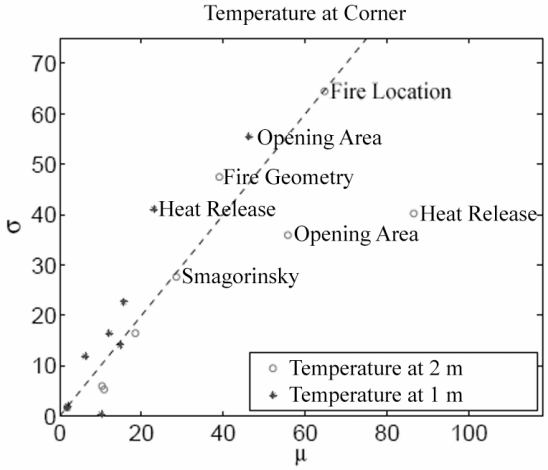

Figure 1. Sensitivity of temperature at the corner of the benchmark room to typical variation of selected input parameters.

In Figure 1the mean value μ determines if a factor is important, and the standard deviation σ is a measure of the interaction with other factors and/or nonlinear effects.

4 Conclusions

It is found that the result is highly sensitive to many input parameters. An importance ranking of the parameters is provided. Evidence seems to underline the statement that fire dynamics simulation results should never be accepted and applied in practise unless proper sensitivity analysis and uncertainty estimation have been carefully undertaken