Abstract

The application of numerical fire simulations to validate and to evaluate the propagation of fire and smoke is already a fundamental part of the preparation of fire protection or safety concepts, especially in the field of performance-based designs. Against this background, the GFPA-guideline *Ingenieurmethoden des Brandschutzes*, has been developed in the recent years, which describes and classifies the available possibilities, approaches and models as well as provides suitable support for their application. Those programs and models respectively have to provide reliable results on the one hand and have to be efficient on the other hand. Thus, it is mandatory to continuously improve and extend the available possibilities of numerical fire simulations also in the future to satisfy the rising requirements as sufficiently as possible.

There is extensive need for improvement in numerical fire simulations especially in the field of heat transfer, both between the gas phase and the solid phase and within the solid phase itself. So far, the focus of further developments has mainly been on the modelling of the gas phase as well as pyrolysis and burning processes. In contrast to this, the physical processes of both convective heat transfer, in particular in the context of special configurations such as pipes or ducts (e. g. air ventilation ducts), and multidimensional heat conduction in solids have not been sufficiently accounted for so far.

Hence, a heat transfer model for coupled processes in fire simulations was developed in the present thesis, which is able to represent the process of convective heat transfer between the gas phase and the solid phase for both horizontal and vertical plane surfaces and in particular pipe and duct flows on the one hand and the process of heat conduction within multidimensional problems on the other hand physically correct. In addition to this the model is able to reproduce corresponding results using numerical simulation. The model was optimised both physically, by considering the specific fire effects and characteristics, and numerically, by selecting adequate numerical methods, for the integrated usage within numerical fire simulations. It has a modular design, so it is suitable for an integration into current and future fire simulation codes. Additionally, a basis was established with and within this model for a later expansion with appropriate pyrolysis models. For that, an interface is provided with the embedded source term on the one hand and the required multidimensional temperature fields are determined precisely by the model on the other hand. A for the completion and demonstration concluding necessary integration of the developed heat transfer model for coupled processes into a state-of-the-art fire simulation code was exemplarily and successfully performed by means of the *Fire Dynamics Simulator* in its present and current version 5.

In summary, the state-of-the-art was expanded with the heat transfer model developed in this thesis and integrated into an internationally recognised CFD fire simulation code. Additionally, an important step was made on the way towards a fully coupled fire simulation imaginable in the future for instance for the purpose of the fire protection design of structures. Beyond that, the developed model can also make a valuable contribution in other fields, where extensions and improvements are still necessary in the future, in particular in upgrading pyrolysis models. Finally, the present possibilities in numerical fire simulations were expanded with the developed model also in such fields, where calculations in fact are performed at this stage, whereas the applicability of the present and available models or the transferability of their constituents is however questionable or even incorrect.