

ABSTRACT

A MODEL FOR FLAME SPREAD AT CABLES

Cables are fire loads and ignition sources at the same time and represent one of the most frequent fire hazards. For estimating the fire risk and planning of safety measures it is important to be able to predict fire spread at cable systems realistically. With numerical simulation models, which are more and more used in fire safety engineering, fire processes can be described more or less exactly, if the heat release rate of the burning objects is known. However, the existing models are not yet available to simulate fire spread at cables in detail. Therefore it was a goal of this work to develop a numerical model for fire spread at cables to be used together with an existing CFD (Computational Fluid Dynamics) fire simulation model. The model should be able to compute cable fires with sufficient accuracy by considering the relevant influences on the fire spread and describing the processes of the heating of the cable and the resulting pyrolysis of the insulating material.

With respect to the ignition and propagation behavior in cable fire, laboratory scale and large scale cable fire tests performed at iBMB in the past were reevaluated. In addition, own laboratory scale tests and procedure from the literature were used to derive thermo physical data, which are needed as input data for the model, e. g. thermal conductivity, specific heat, ignition temperature, effective heat of combustion and heat of gasification. The assigned procedures are examined regarding its suitability and uncertainties.

The new model for fire spread at cables, the CFS (Cable Flame Spread) model, is based on the thermoplastic pyrolysis model of the CFD code FDS4 (Fire Dynamics Simulator version 4). The FDS4 code, representing the international state of the art of the CFD room fire simulation models, was extended within three areas:

1. Whilst FDS calculates the one-dimensional heat conduction for a rectangular object independently for each side, this approach was enhanced in the CFS model into a simplified cable model. The thermal coupling between the internal side of the insulation and the metal core is described by a finite volume model, which includes not only transversal effects but also lateral (axial) heat transport along the core. Also the energy dissipation of an electric current can be considered by default of heat sources.

2. Instead of the simple one step decomposition approach for the pyrolysis of cable insulating materials, a two-step finite decomposition model was developed on the basis of the Arrhenius law. For the use as input parameters decomposition temperatures and rates are derived from thermal gravimetric investigations, and heat of gasification, heat of combustion and maximum burning rates are calculated from small scale experiments.

3. Since in most applications cables with several cores (complex cables) or cable bundles are present, approximate solutions were developed for the application of the CFS model to complex cables. Input data for the two-step decomposition model were derived from Cone calorimeter tests for different cables and assumptions for geometry-referred conversions are made.

As a first validation of the CFS model, cable fire experiments with different cable materials in vertical arrangement were recalculated. It is shown that the new CFS model describes the combustion behavior of cables more realistically, considering the individual temperature bands of the decomposition. The fire spread along cable arrangements can be predicted with certain restrictions. Since special effects of the heating of insulating materials such as melting, dropping, flowing and charring are not yet included in the model, the forecast of pyrolysis and fire spread is not yet possible in one universal deterministic model.