THE ROLE OF RADIATION IN THE INTERACTION BETWEEN A FIRE AND A POLYDISPERSE WATER MIST

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ABSTRACT

To predict the performance of fire protection spray systems, the interaction between the fire and water droplets is modelled. Such modeling requires the complete description of the spray in terms of droplet size, size distribution, and velocity.

In the present two-phase model, the gas phase is computed by solving the set of turbulence-modelled, density-weighted, averaged conservation equations for mass, momentum, energy and species, together with transport equations for the turbulence variables. The equation set is closed using the RNG k-ε (Renormalization Group theory) turbulence model with additional buoyancy-driven production/destruction. Turbulent combustion is modelled using the Eddy Break-Up-Arrhenius model. A multiphase radiative transfer equation including the contribution of soot/combustion products and water droplets is used to model radiation[1]. To capture the full polydisperse nature (without using droplet-size classes) of the spray, the model of Beck and Watkins[2] is used. In this model, a full distribution of droplet sizes is considered in a single liquid phase, the droplet size distribution being characterised by its first four moments. The liquid-phase conservation and transport equations are written for the two moments of the drop number distribution, which represent the liquid mass and the surface area. The two other moments represent the total sum of drop radius and the droplet number. The velocities to be used in the two transport equations are obtained by defining moment-average quantities and constructing further transport equations for the relevant moment average velocities. An equation for the energy of the liquid phase is required.

Governing equations for both phases are solved in an Eulerian framework employing a finite-volume method which combines the use of the high-order ULTRASHARP technique for the convective terms and ITERATIVE PISO algorithm for the treatment of the pressure-velocity coupling.

The model is applied to three-dimensional fire-water mist scenarios. The influence of water spray on radiation is studied with special emphasis on the contribution of each radiative phenomenon. Results demonstrated that the attenuation of radiation is two-fold: the radiant energy emitted by the flame is reduced, and this energy is attenuated by water droplets. The role of scattering in the attenuation of thermal radiation in fire-water mist interactions is investigated. Model predictions are compared with available experimental data.

REFERENCES

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