Finite element variational multiscale formulation for low Mach number flows coupled with radiative heat transfer

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Problems of combustion in fire scenarios are usually mathematically described by the Low Mach number approximation of Navier Stokes equations [4]. Thermal radiation has direct effects on many industrial applications, such as fires in vehicular tunnels, combustion in furnaces, gas turbine models, etc. Growing concern with high temperature processes has emphasized the need for an evaluation of the effect of radiation heat transfer.

We describe a finite element formulation for the coupling of the low Mach number model and the radiative transfer equations based on the variational multiscales method [1]. We extend the subgrid scales to the radiation intensity appearing in the energy equation.

We compare a standard ASGS formulation [3] and a complete residual based formulation additionally containing all nonlinear terms as cross- and Reynolds- stress terms.

The Radiative transfer equation is modelled by the P_N and the DOM models [2]. Both models are stabilized using the variational multiscale method.

Implementation issues, such as the linearization procedure and the coupling of the different equations in play are described.

Numerical simulations are presented for three dimensional fires in vehicular tunnels scenarios, we discuss the effect of the different stabilization techniques and radiative models.

References

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