A Hybrid Finite-Element-Finite-Volume Mixed Method for Thermal Arc Simulations

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Résumé

Over the past few decades, numerical computation has proved to be a powerful tool in understanding thermal arcs behaviour and characteristics. Most of the numerical methods in use, are often based either on finite volume or finite element approaches but very seldom on both of them. In the present work, we propose a new combined finite-element finite-volume method for stationary and unsteady schemes. The main advantage of this approach is double-fold: on one hand, the flow, energy and species equations are solved using a classical finite-volume (FV) method which enables us to express them as flux transport equations providing a robust physical meaning. On the other hand, Maxwell's equations are solved using special finite-element (FE) analysis methods which aims to directly compute the magnetic field (for stationary and unsteady schemes) without adding additional equations and imprecise boundary conditions. The reason an FE analysis is proposed resides in its ability to efficiently handle the mathematical formulation of Maxwell's equations involving (**curl**)-operators. The usual treatment of the Maxwell's equations for the arc consists in solving for the potential vector with arbitrary boundary conditions that could lead to some discrepancies and is very difficult to solve in unsteady schemes. The choice of instead of is very attractive because it allows one to write the equation for in a TADR (transient-advection-diffusion-reaction) form suitable for most FV and ordinary FE solvers. We propose two separate approaches for the FE-method: one that is only suitable for a steady-state scheme and another that could be applicable for both steady and unsteady cases. Some numerical results are also provided.

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