An Immersed Volume Method for Conjugate Heat Transfer and Turbulent Flows

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Immersed methods for Fluid Structure Interaction and Conjugate Heat Transfer are gaining popularity in many scientific and engineering applications. They are known today under different names such as the embedded boundary method, the immersed boundary method, the fictitious domain and the Cartesian method. In this work, we will present the Immersed Volume Method (IVM).

All these approaches are attractive because they simplify a number of issues in multi-domain applications in particular the transmissions of boundary conditions (i.e. heat transfer coefficients) and problems related to meshing the fluid domain and boundary layers. However they operate on non-body fitted grids which require a special interface treatment. Indeed recent developments are focusing on issues related to the immersion of a surface mesh, the detection and the intersection algorithms for the interface and finally the transmission of boundary conditions between the solid and the fluid regions.

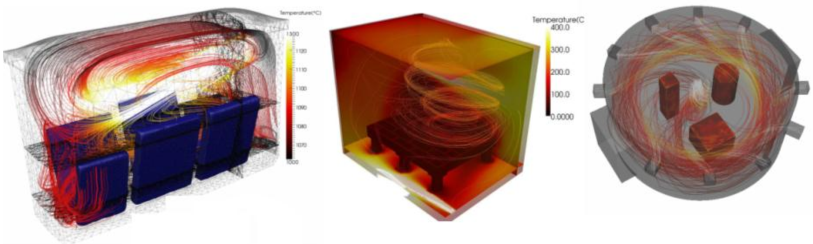

Figure 1. Streamlines and isotherms inside industrial furnaces

In this work, we will answer these questions and present stabilized finite elements methods combined with an immersed volume approach for thermal coupling between fluids (i.e. air, water) and solids (i.e. high-alloy steel). It consists in considering a single 3D grid of the domain and solving one set of equations with different thermal properties. A distance function enables to define precisely the position and the interface of any objects inside the volume and to provide homogeneous physical and thermodynamic properties. An anisotropic mesh adaptation algorithm based on the variations of the distance function is then applied to ensure an accurate capture of the discontinuities at the interface. The proposed method demonstrates the capability of the model to simulate unsteady three-dimensional heat transfers and turbulent flows with the presence of different conducting solid bodies (see figure 1).