CONJUGATE HEAT TRANSFER AND WALL REACTION IN COMPUTATIONAL FLUID DYNAMICS

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We propose a robust numerical method for the simulation of heat transfer and surface reaction in flows around complex geometries. In computational fluid dynamics (CFD), the equations of transport of the flow, or any species present in the flow, are solved in a discrete form on a mesh. Two approaches are used for the treatment of immersed solids. The first requires the generation of a mesh that conforms to the geometry of all solid surfaces, which may be prohibitively expensive for very complex geometries (mesh-conforming method). The second, and the focus of this work, modifies the transport equation by adding a force or source term, which makes the flow experience the presence of the wall (immersed boundary method). The solid surface is therefore virtual and may be simulated on non-conforming meshes. The immersed boundary method is a very elegant and efficient approach to complex geometries and its implementation in the governing equations of flow has received a lot of attention. However, little has been done to couple these virtual boundaries with agents transported by flow, such as heat or chemically reactive species. To address this gap in current computational capabilities, we have developed and validated an approach that enables the simulation of conjugate heat transfer between a flow and a solid, and surface reaction. Applications of the proposed methodology range from the biochemistry of coagulation in blood flows to the ablation of a space vehicle heat shield during atmospheric reentry.