Validation Of COMSOL Multiphysics® For Magnetohydrodynamics (MHD) Flows In Fusion Applications

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Abstract

Several commercial CFD companies have recently extended their codes to magnetohydrodynamic (MHD) flows. However, there are many computational challenges associated with MHD flows under the harsh fusion environmental conditions that require such codes to be carefully examined in a special range of flow parameters and geometries. Among the commercially available CFD tools, COMSOL Multiphysics, a finite-element solver, is one of the possible candidates to be used as a design and analysis tool in fusion cooling applications. It solves coupled 3D incompressible Navier-Stokes/Maxwell equations in a segregate manner, using the inductionless approximation. In this study, we perform various tests to address the COMSOL capability to adequately resolve LM-MHD flows in strong magnetic fields under steady and unsteady flow conditions. First, fully developed laminar MHD flows were computed and the results compared with the analytical Shercliff and Hunt solutions at high Hartmann numbers up to 15,000 for electrically conducting and insulating ducts. Second, the COMSOL capability to address developing MHD flows was addressed using the case of 3D laminar steady MHD flows in a non-uniform transverse magnetic field for which the experimental data are available. Finally, two unsteady MHD flows were computed and the results compared against available 3D numerical data: (1) MHD flow in a horizontal cavity withy volumetric heating and (2) periodic MHD flow in a conducting duct with thin electrically conducting walls. Most of the comparisons have demonstrated good qualitative and often quantitative match with the available experimental, analytical and numerical data.

Reference

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Figures used in the abstract

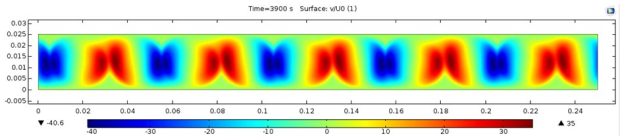

Figure 1 : MHD natural convection