DRBEM Solution to MHD Flow in Ducts With Thin Slipping Side Walls and Separated by Conducting Thick Hartmann Walls

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Abstract

In this study, the dual reciprocity boundary element method (DRBEM) solution to magnetohydrodynamic (MHD) flow of an electrically conducting fluid is given in a single and two ducts stacked in the direction of external magnetic field. The duct walls perpendicular to the applied magnetic field (Hartmann walls) are conducting thick walls whereas the horizontal walls (side walls) are insulated thin walls allowing the velocity slip. The DRBEM transforms the convection diffusion type MHD equations in the duct and Laplace equation in the thick walls to boundary integral equations which are discretized by using constant elements. The resulting DRBEM matrix-vector equations are solved as a whole with the coupled boundary conditions on the common boundaries between the fluid and the thick walls. The effects of the slip length, thickness of conducting walls and the strength of the applied magnetic field are shown on the flow and the induced magnetic field. It is found that, in the absence of slip, as Hartmann number (Ha) increases the flow is concentrated in front of the side walls in terms of two side layers, and this separation is happened for much smaller value of Ha when the thickness of the conducting walls is increased. The Hartmann layers are diminished when both the Ha and wall thickness are increased. For large Ha, the velocity magnitude drops and thus the flow is flattened especially in the core region. The continuation of induced magnetic fields to the thick walls is well observed in both co-flow and counter flow cases. When the velocity slips on the thin side walls, the flow tends to form symmetric vortices in front of the side walls showing the slip phenomenon with an increasing velocity magnitude. If the conductivity of the fluid is larger than the conductivity of the thick walls, the flow returns back to one vortex form still keeping the same order Hartmann layers. Meantime induced magnetic field closes itself inside the duct as if the Hartmann walls are insulated. The proposed numerical scheme DRBEM is capable of capturing the well known MHD flow characteristics in the ducts coupled with thick walls as well as the perturbations in the behaviors of the flow and the induced magnetic field due to the thin slip walls.

References

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