MODELLING OF THE HARTMANN LAYERS BY EFFECTIVE CORE BOUNDARY CONDITIONS

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Resolution of thin Hartmann layers, which form in the liquid metal flows at the walls crossed by high magnetic field, is a serious challenge for numerical simulation of such flows. Since the structure of Hartmann layer is very simple, there have been numerous attempts to eliminate Hartmann layers by either some kind of averaging procedure or using near-wall-type boundary conditions as in turbulent flows. The first approach works well only for the flows which are nearly uniform along the magnetic field. On the other hand, the derivation and application of near-wall-type boundary conditions is rather questionable. I will present an alternative approach to the modelling of the Hartmann layer based on the singular asymptotic expansion techniques in combination with numerical solution for the core flow including the parallel layers. This approach results in a certain reduction of the governing equations which then needs to be compensated by the so-called core boundary conditions. First, such conditions are obtained for a rectangular duct flow in terms of the induced magnetic field. These conditions are then applied to various combinations of electrical conductivities of the walls that are either parallel or perpendicular to the field. As the field strength increases, the model results are shown to approach the exact solutions including the side layer for all combinations of wall conductivities. Second, alternative conditions are obtained in terms of the electric potential and also tested on the duct flow. The latter model is not only more general but also produces more accurate results at lower magnetic fields.