MHD duct flow in the presence of a magnetic dipole

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ABSTRACT

We study a liquid metal flow in a straight duct to which the magnetic field of a magnetic dipole of varying strength is exerted. This basic configuration is of fundamental interest for Lorentz force velocimetry (LFV), where the Lorentz force opposing the relative motion of conducting medium and magnetic field is measured to determine the flow velocity. The Lorentz force acts in equal strength but opposite direction on the flow as well as on the dipole. We are interested in the dependence of the force and the distributions of induced currents and velocity on the flow rate and on strength of the magnetic field as well as on geometric parameters such as distance and position of the dipole relative to the duct.

To this end, we perform numerical simulations with finite-difference method in the limit of small magnetic Reynolds number, whereby the induced magnetic field is assumed to be small compared with the external applied field. For sufficiently high Reynolds number this configuration triggers turbulent flow patterns, similar to hydrodynamic duct or pipe flow. Then the external dipole – which is considered as an magnetic obstacle for the flow – serves as a finite amplitude pertubation to the flow. Our parametric studies show the effect of Reynolds, Hartmann and Stuart numbers on the deflection of the flow.

Furthermore we study the downstream evolution of the flow pattern and compare their shape with those from other wall-bounded flows. The variation of the distance and orientation of the dipole with respect to the duct walls allows us to tune the functional form of the magnetic obstacle and to optimize the pertubation.

REFERENCES

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