

Magnetohydrodynamic flow in rectangular ducts

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The paper presents an analysis of laminar motion of a conducting liquid in a rectangular duct under a uniform transverse magnetic field. The effects of the duct having conducting walls are investigated. Exact solutions are obtained for two cases, (i) perfectly conducting walls perpendicular to the field and thin walls of arbitrary conductivity parallel to the field, and (ii) non-conducting walls parallel to the field and thin walls of arbitrary conductivity perpendicular to the field.

The boundary layers on the walls parallel to the field are studied in case (i) and it is found that at high Hartmann number (M), large positive and negative velocities of order MV_c are induced, where V_c is the velocity of the core. It is suggested that contrary to previous assumptions the magnetic field may in some cases have a destabilizing effect on flow in ducts.

1. Introduction

The design of magnetohydrodynamic generators, pumps and accelerators requires an understanding of the flows of conducting fluids in rectangular ducts with finitely conducting walls under transverse magnetic fields. At the present time even the case of uniformly conducting incompressible laminar flow with no variation in the flow direction has not been fully analyzed. In this paper we confine ourselves to problems of this type alone. The main characteristics of such flows that need to be known are:

- (1) the volumetric flow rate q through the duct for given pressure gradient and magnetic field;
- (2) the potential difference between electrodes placed in the walls;
- (3) the stability of the flow.

Three exact solutions have been found for incompressible laminar flows in ducts with transverse magnetic fields:

- (1) rectangular ducts with non-conducting walls and the field perpendicular to one side (Shercliff 1953);
- (2) rectangular ducts with perfectly conducting walls (Chang & Lundgren 1961; Uflyand 1961);
- (3) circular pipes with non-conducting walls (e.g. Gold 1962 and Fabri & Siestrunk 1960).

Approximate methods have been developed for the physically interesting

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Magnetohydrodynamic Flow In Ducts

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