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Investigations of coupling MHD duct flows under inclined transversal magnetic fields for liquid metal blankets

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Liquid metal blankets are advanced and have many attractive features such as low operating pressure, design simplicity, and a convenient tritium breeding cycle. However, the magnetohydrodynamic (MHD) effects are a key issue remaining to be solved, one of them is the coupling MHD effect[1-3] which normally exists in liquid metal blankets. The coupling MHD effect is that the flow state in one duct will be affected significantly by the leaking electrical currents from the neighboring duct because the coupling duct wall is conductive. Previous results[4,5] indicate that MHD flow states could be modified obviously by external inclined magnetic fields for one duct flows. However, a systematic study on what is the influence of the inclined magnetic fields on the coupling MHD duct flow states is still lacking. This work aims at clarifying the influence of the inclined magnetic fields on the MHD flow states such as MHD pressure drops and velocity distributions through two coupling ducts with conducting walls.

One of the most important results[3] for the coupling MHD effect is that the pressure gradient in the coupling ducts will be several times bigger than that in one single duct if the initial flow directions in the two neighboring coupled ducts are opposite. The external magnetic fields in Reference [3] have no inclination with one pair of walls and the two-dimensional (2D) simulations are based on a fully developed modeling. The three-dimensional (3D) simulation results of this work confirm the 2D results as shown in figure 1. The 3D numerical simulations are using a self-developed code based on OpenFOAM environment. The Ha and Cw in figure 1 are the Hartmann number and the wall conductance ratio respectively. The Ha denotes the ratio of the Lorentz force to the viscous force in the fluid and the Cw represents the non-dimensional conductivity of the duct wall. The comparison results in figure 1 indicate that the 2D results agree well with the 3D results. In the case of Cw=0.01, the coupling MHD effect is significant and the pressure gradient is about 7 times bigger than that of one single duct when the inclined angle of the external magnetic field is zero, the pressure gradients decrease with the increases of the inclined angles of the external magnetic fields. In the case of Cw=0.1, the coupling MHD effect is weaker than that in the case of Cw=0.01 and the pressure gradient is about 2.4 times bigger than that of one single duct when the external magnetic field has no inclination, the pressure gradients increase firstly and then decrease with the increase of the inclined angles of the external magnetic fields. The other important result of this study is that there are reversal velocity distributions in the corners of the duct when the external magnetic field has inclination such as the inclined angles is 22.5° as shown in figure 2. The big reversal velocity distributions are harmful to the heat transfer in liquid blankets and should be considered in the future blanket design because the external magnetic fields normally have inclination with one pair of duct walls. Other 2D and 3D numerical simulation results on the influence of the external inclined magnetic fields on the MHD flow states in the two coupling ducts are also included in this paper. The above-obtained results are important and helpful for future liquid metal blanket designs, and some new observed results such as the reversal velocity distributions update the related liquid MHD knowledge.

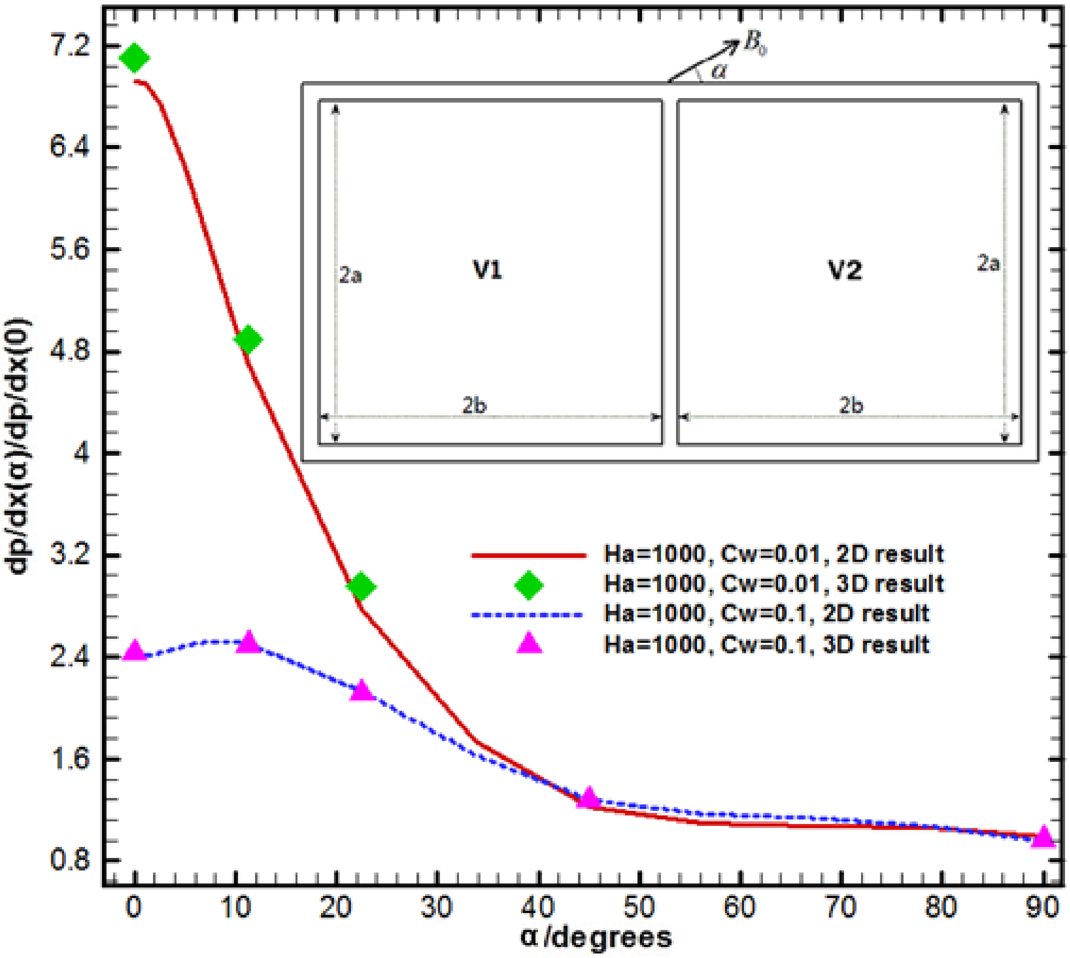
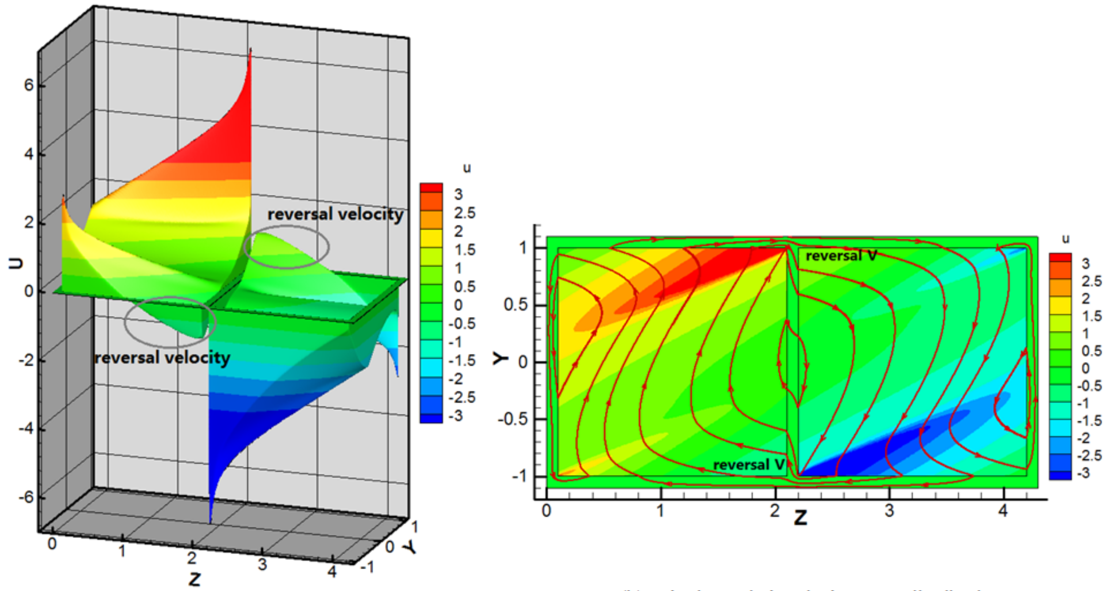


Figure 1: The relationships between the pressure gradients and the inclined angles of the external magnetic fields in the two coupling MHD duct flows at Ha = 1000 and b/a=1, the vertical coordinate represents the ratio of the pressure gradient in the coupling duct under the inclined external magnetic fields to that in one single duct under the external magnetic fields with no inclination.



(a) velocity distribution (3D view)

(b) velocity and electrical current distributions

Figure 2: The velocity and electrical current distributions in the cross-section of the two coupling ducts at Ha = 1000, Cw = 0.1, and α = 22.5°, the initial flow directions in the neighboring ducts are opposite.

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References:

(1) S. Molokov et al. J. Fluid Mech., vol. 299, pp. 73–95, Sep. 1995.

(2) Mistrangelo, C et al. Fusion Eng. Des.109–111 (2016) 1452–1457.

(3) Xiujie Zhang et al. IEEE TPS, VOL. 42, NO. 6, JUNE 2014, 1764-1769.

(4) Hua T.Q et al.1995, Fusion Eng. Des. 27 703–710.

(5) Xiujie Zhang et al. 2019, Nucl. Fusion 59 056018.

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