§18. Study on Heat Transfer Mechanism under Magnetic Field in a Liquid Blanket

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1. Objectives

In the region of transition Reynolds numbers, the increase or decrease of friction coefficients of the coolant like a Molten Salt having a low magnetic conductivity is obtained: a transition Hartmann number behavior. This behavior also leads the deterioration of heat transfer. Therefore, the thermo-fluid design of blanket under the magnetic filed fluctuation is very important. Moreover, the actual flow field is not only a smooth wall but also a concave wall. In the case, the vortex shedding and reattachment are caused, the pressure loss is caused in the flow field, and it not only influences the coefficient of friction but also the change of heat transfer. The flow behavior has been not discussed in such a complex flow field under a magnetic field. In especially, a straight square duct flow has the influence of side wall, and the secondary flow exists in the cross section. The flow fields show that drag reduction depends on the magnetic field orientation.

In the present study, DNS of channel flow with scalar field is performed and the relation between a magnetic orientation and turbulent flow statistics are considered.

2. Numerical method and boundary condition for channel flow

Our DNS code is hybrid spectral finite difference method. The periodic boundary conditions are applied to the streamwise (*x*) and the spanwise (*z*) directions. As for the wall normal direction (*y*), non-uniform mesh spacing specified by a hyperbolic tangent function is employed. The mesh numbers of 128x128x128 are used for the computational domain of 5πδ x2δx 2πδ in the spreamwise, the wall-normal, and spanwise directions. The all velocity components imposed the non-slip condition at the wall. The non-slip condition is used at the wall. A uniform magnetic field $\boldsymbol{B}_0$ defines that the magnetic orientation is parallel to the axis of the streamwise direction in Fig.1. The Neumann condition for the electrical potential is adopted on the wall. The Hartmann numbers ($Ha = \boldsymbol{B}_0 2\delta\,(\sigma/\rho\nu)^{1/2}$) based on the magnetic field $\boldsymbol{B}_0$, the kinematic viscosity ν, the electrical conductivity σ and the channel width 2δ are set to 6 and 12. The Reynolds number is 150 based on the friction velocity. The fluid flows with constant pressure gradient.

3. Results

Figure 2 shows the mean temperature. The profiles both orientations are decreased at near wall region. Figure 3 shows scalar flux, temperature fluctuation, and temperature gradient. In the wall-normal applied magnetic field, the scalar fluxes at the whole region are decreased. The wall-normal applied magnetic filed has the scalar flux lower than the spanwise applied magnetic field.

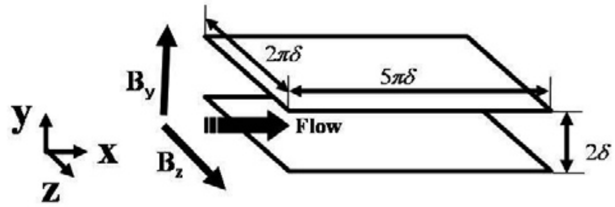

Figure 1 Computational domain

Table 1 Computational parameters

Computational region	$5\pi\delta \times 2\delta \times 2\pi\delta$ ($in\ x \times y \times z$)
Grid number	$128 \times 128 \times 128$ ($in\ x \times y \times z$)

Table 2 Flow parameters

	Re	Pr	Ha	Gr
B_0			0	0
B_y	150	0.059	6	0
B_z			12	0

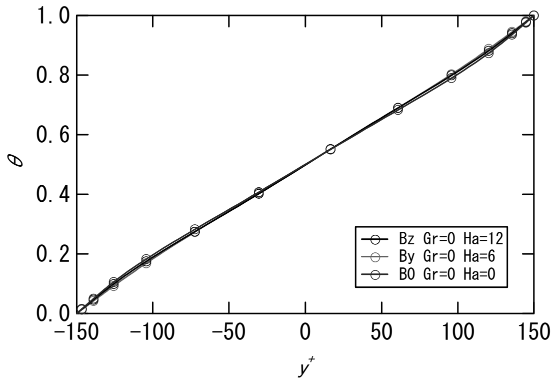

Figure 2 Mean temperature

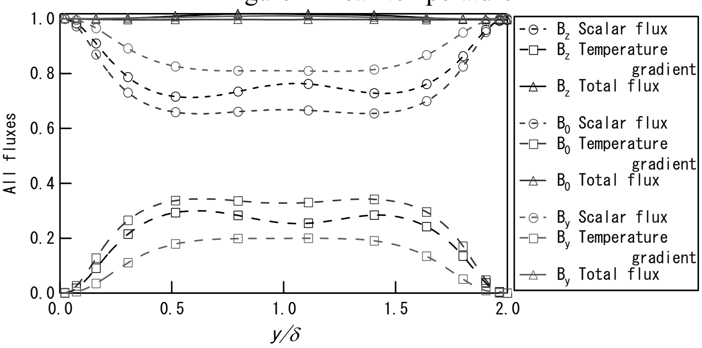

Figure 3 Scalar flux, temperature fluctuation, and temperature gradient