§19. 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.

In the present study, the objective is to develop DNS code for a straight square duct. The code is adopted for the laminar flow.

2. Numerical method and boundary condition for a straight square duct

The governing equation and the potential equation were solved in the three-dimensional coordinates. The Poisson solver is used for FFT at the streamwise direction. The laminar flow at Reynolds number 300 was set as an initial flow field. The length ratio for the vertical and horizontal of the square cross-section was assumed to be 1:1 as shown in Figure 1. The all velocity components imposed the non-slip condition at the wall. The detail flow parameter is summarized by Table 1.

3. Results

Figure 2 shows mean velocity profile at z=δ/2. The profile is parabolic; the more computational time is needed to become turbulent state. Figures 3(a)-(b) show the contour of streamwise velocity fluctuation. An initially anisotropic velocity fluctuation was changed so that the structure looks like boomerang shape; it means that the flow is transitional state from laminar to turbulent. The strong region of velocity fluctuation in Fig. 3(b) slightly moved to the wall region. Therefore, we need more computation to take fully developed turbulence. We will try to apply the magnetic field after the flow state become turbulence.

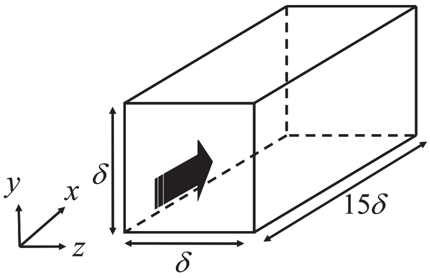


Figure 1 Computational domain.

Table 1 Computational parameters

Reynolds number	Re=300
Hartman number	Ha=0.0
Computational region	$15\delta\times\delta\times\delta\ (in\ x\times y\times z)$
Grid number	$256\times128\times128\ (in\ x\times y\times z)$

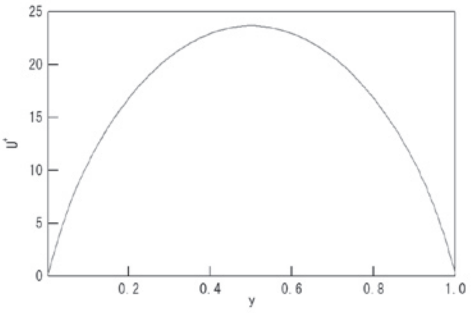
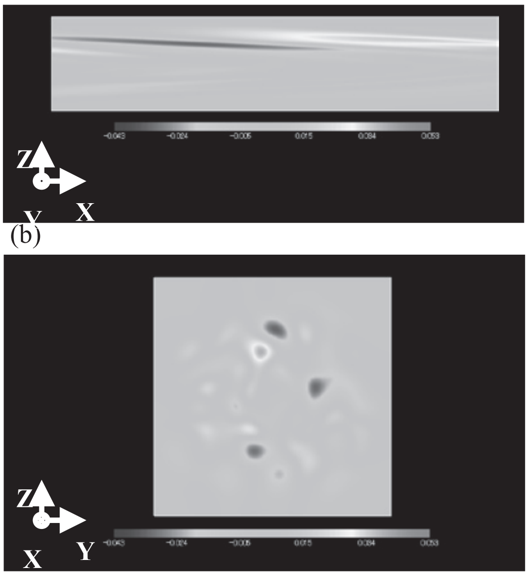


Figure 2 Mean velocity at z=δ/2

(a)



(b)

Figure 3 Velocity fluctuations: (a) Velocity fluctuation contour in x-z plane, (b) Velocity fluctuation contour in y-z plane