§19. Study on Heat Transfer Region under MHD Effect 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, namely 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 that the vortex shedding and reattachment is 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 not been discussed in such a complex flow field under a magnetic field. Therefore, it is useful to complicate the shape of the flow field in flow field calculation and to solve the temperature field at the same time, and it is important that it make comparative study of behavior under a magnetic field. In the present study, to evaluate the effect of complex geometry, laminar channel flow with back-ward facing step is carried out under a magnetic field. The difference of reattachment length near recirculation region is clearly observed when the magnetic field changed.

2. Numerical method and boundary condition for laminar flow with back-ward facing step

The governing equation and the potential equation were solved in the two dimensional coordinates. The laminar air flow in bulk Reynolds number 100 and 1000 was set as an initial entrance flow field. The height of the step and channel was assumed to be 1:1 as shown in Figure 1. 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 at the wall. The Hartmann numbers ($Ha = \boldsymbol{B}_0\delta(\sigma/\rho\nu)^{1/2}$) based on the magnetic field $\boldsymbol{B}_0$, the kinematic viscosity ν, the electrical conductivity σ and the step height δ are set to 5.0. Table 1 shows calculation parameters.

3. Results

Table 2 shows the relation between the reattachment length and the magnetic field and the Reynolds number. In any case, the reattachment length shortens when the magnetic field is imposed. Both of the ratios, when the magnetic field is impressed and when it is not so, are about 0.25. In general, the reattachment length tends to grow with an increase in the Reynolds number. Therefore, the sampling time needs the long time average to take statistical state at Re=1000. In case of turbulent flow, we will need more sampling time. Two dimensional velocity vectors are shown in Fig. 2. When the magnetic filed imposed, the reattachment length is shorter than that of non-MHD case. Therefore, firstly, it is important to predict accurately this distance when turbulence modeling is constructed with reattachment under magnetic field.

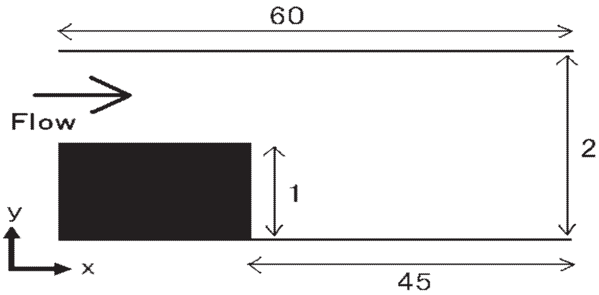


Figure 1 Computational domain.

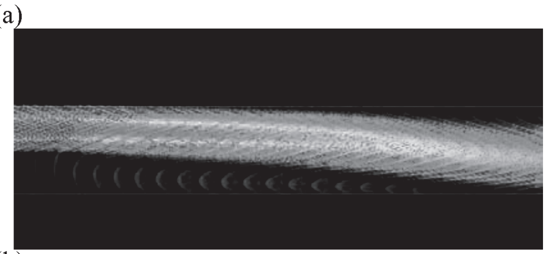
Table 1 Computational parameters

Reynolds number	Re=100,1000
Hartmann number	Ha=0, 5.0
Computational domain	60 × 2
Grid number	193 × 63
Grid resolution	$\Delta x=0.3109$ $\Delta y=0.0317$
Time increments	$\Delta T=0.0005$

Table 2 Flow parameter and reattachment length

Re	Reattachment length		Ratio
	Ha = 0	Ha = 5	
100	5.58	1.55	0.28
1000	7	1.75	0.25

(a)



(b)

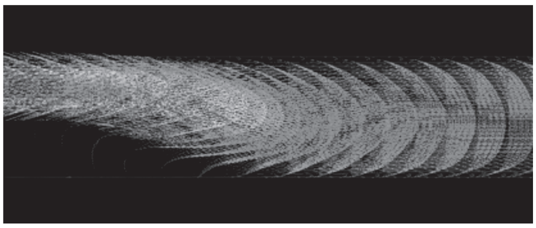


Figure 2 Two-dimensional velocity vector: (a) Ha=0, Re=1000, (b) Ha=5, Re=1000