§32. Advanced Design of the Three-surface-multilayered Channel by Optimizing Structure of the Metal Layer

Ito, S., Hashizume, H., Isshiki, D. (Tohoku Univ.), Muroga, T.

Our research group has proposed the three-surface-multi-layered channel to reduce MHD pressure drop[1] in Li/V (liquid lithium/vanadium alloy channel) blanket system. Fig. 1 shows the three-surface-multi-layered (TSML) channel in which three sides of inner channel wall have the multi-layer with insulator and thin metal layers except for the first wall. The MHD pressure drop can be reduced to be acceptable value by using an inner thin metal layer with a thickness of <0.025 mm. However, the thickness is too small to insure its structural integrity. To solve this problem, we also proposed to reinforce the inner metal layer by attaching reinforcing structures[2]. The purpose of this collaborative study is designing the TSML channel with the reinforced metal layer achieving low MHD pressure drop and high mechanical strength, and investigating a fabricating method of the metal layer.

We set two requirements to optimize the reinforcing structures. One requirement is rigidity of reinforced metal layer, which has larger rigidity than that of a 0.1-mm-thick metal layer which was successfully installed to the prototype TMSL channel.[3] Another requirement is limitation of the pressure drop, which is smaller than that with a 0.025-mm-thick metal layer. Fig. 2 shows geometry of a reinforced layer proposed in this study. We assumed that the thickness of original inner metal layer before the reinforcement is 0.02 mm and that is made of the vanadium alloy (V-4Cr-4Ti). We set reinforcing structure made of the vanadium alloy only on Hartmann wall because the pressure drop changes a little even if a side wall is reinforced completely. First, this study evaluates flexural rigidity of the reinforce layer as functions of w, h, θ (the parameters are shown in Fig. 2), then also evaluates pressure drop at a magnetic field of 1.0 T and an average velocity of 0.10 m/s depending on w, h, θ. We used commercial FEM software, COMSOL Multiphysics 4.4 for the analyses. Fig. 3 shows the design window based on two-dimensional numerical results ($\theta = 0°$). According to this figure, there exists design window surrounded with the thick black line and the thick white line. Based on three-dimensional numerical results, region of the design window becomes smaller. The detailed design window will be discussed in our future study.

We also attempted to fabricate the reinforced metal layer using spot welding, silver brazing and etching. Geometry of the reinforcing structure is corresponding to the case that w, h and θ are 2.0 mm, 0.2 mm, and 30 degree. The material of the metal layer and the reinforcing structure is stainless steel type 316L. Fig. 4 shows the fabricated reinforced metal layer by the following procedure: 1) Etching a 30-μm-thick plate of stainless steel type 316L to be 20-μm-thick except for region where the reinforcing structure will be attached by masking the region, 2) Attaching the reinforcing structure on the back face of the etched face by spot welding, 3) grinding welding mark on the etched face. The fabrication method will be improved so that the method can be applied to a longer TMSL channel in our future work.

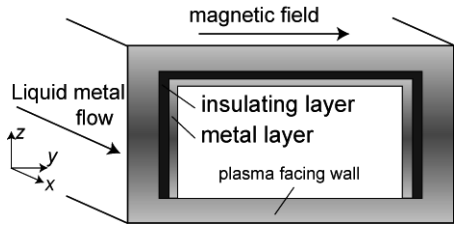

Fig. 1. Schematic illustration of thethree-surface-multi-layered channel

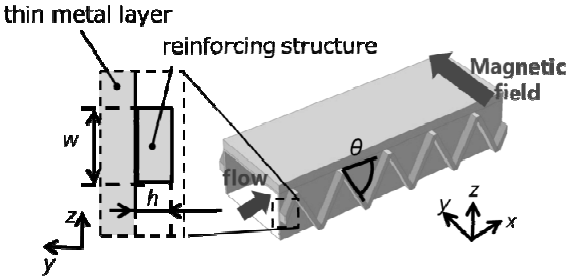

Fig. 2. Geometry of inner metal layer structure for the numerical analysis

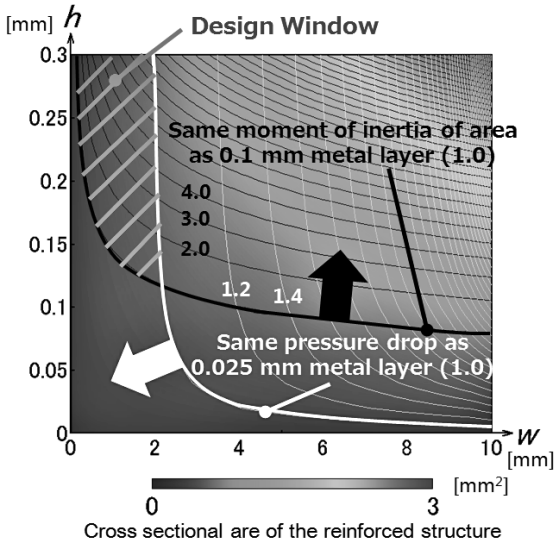

Fig. 3. Design window obtained by 2D analysis.

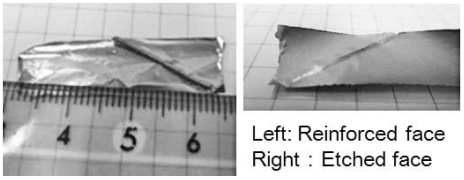

Fig. 4. Fabricated reinforced inner metal layer.

1) Hashizume, H.: Fusion Eng. Des., **81** (2006) 1431.
2) Inage, Y. et al.: Proc. NTHAS8. (2013).
3) Aoyagi, M. et al.: Proc. NTHAS8. (2013).