§10. Basic Design of Liquid Blanket with Three-Surface and Three-Layer Coating

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Reduction of MHD pressure drop is an important issue for Li-V (liquid lithium-vanadium alloy channel) blanket system. The three-surface and multi-layer coated channel shown in Fig. 1 was proposed as the solution by our research group.[1] The channel is made by inserting a thin plate of vanadium alloy coated with insulated layer onto inner surface of a vanadium alloy rectangular channel. In this study, a capability of the channel to reduce MHD pressure drop is evaluated by an experiment with a large magnetic field. Then applicability of the channel to the blanket system of a fusion reactor will be discussed based on the result. This year, experimental set-up was established and basic experiment was performed for the evaluation.

Fig. 2 shows a test section of the experimental set-up established in this year. The test section is a torus structured open channel whose inner diameter is 80 mm and outer diameter is 156 mm. A working fluid used in this experiment is melted eutectic alloy of Bi-Sn whose melting point is 138 °C. In this experiment the working fluid is heated at 150 °C. The test section is set into bore of a superconducting magnet which can generate 6T of the maximum magnetic field. The magnet can apply magnetic field vertically to the test section. At that time, circumferential driving force can be obtained by applying current in a radial direction of the channel where electrodes are set on inner and outer surface of the channel. Although the channel is open channel, the channel simulates a half region of a closed channel because boundary condition on the free surface is the same condition as symmetry condition. When the experiment is conducted, top side of the channel is covered with a silicone rubber sheet and argon gas is injected into the channel to prevent the working fluid from being oxidized. Experimental parameters are follows; Magnetic field (Maximum one is 5T); Mean flow velocity (Maximum one is 0.6m/s); Electric conductivity of wall of the channel. Pressure drop can be obtained from the applied current and the applied magnetic field because the pressure drop is the same value as the driving force. Mean flow velocity is calculated from voltage drop between the electrodes and the applied magnetic field based on principle of MHD flow meter.

Fig. 3 shows a relationship between UB and pressure drop where U is mean flow velocity and B is applied magnetic field. The result was obtained in the case that Hartmann wall is insulated wall, which corresponds to bottom side of the channel in this experiment. Solid line shown in Fig. 3 is analytical solution when flow structure is assumed as Hartmann flow through a parallel plate channel. Pressure drop increases linearly with UB both in the experimental result and in the analytical solution. However, pressure drop in the experimental result is 1.6 times larger than that in the analytical solution. In this experiment, oxide was floated and flow velocity of the oxide was lower than that of the working fluid. Therefore, an increase of pressure drop caused by friction at the free surface could be the reason of deference between the experimental result and the analytical solution.

From mentioned above, experimental set-up with a large magnetic field was established and pressure drop obtained in this experimental set-up qualitatively agreed with theoretical one. However, pressure drop in the experimental result is larger than that in the analytical solution due to the oxide. Therefore, the experimental set-up should be improved to obtain experimental data quantitatively agreeing with theoretical one. A capability of the channel to reduce MHD pressure drop will be discussed using data obtained by the improved experimental set-up and numerical analysis.

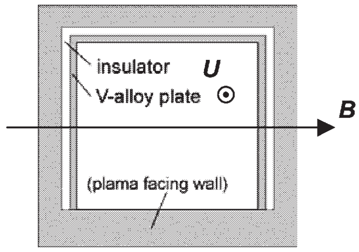

Fig. 1. three-surface and multi-layer coated channel.

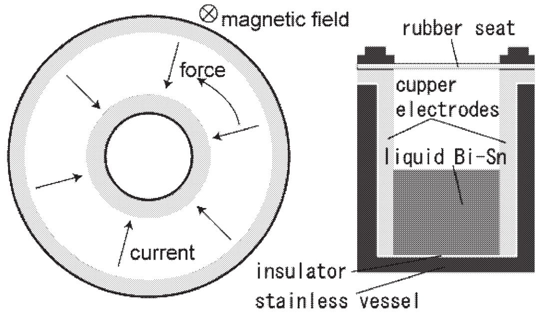

Fig. 2. Test section of experimental set-up.

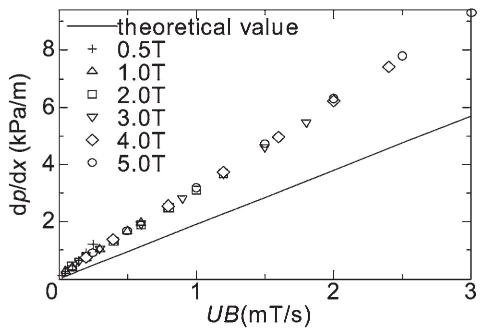

Fig. 3. Relationship between UB and pressure drop.

1) Hashizume, H.: Fusion Engineering and Design **81** (2006) 1431.