§25. Thermo-fluid Engineering Design of a Three-surface-multi-layered Channel

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Reduction of MHD pressure drop is one of the most important R&D issues in implementing Li/V (liquid lithium-vanadium alloy channel) blanket system. The three-surface and multi-layer coated channel was proposed as a solution by our research group.[1] In this study, a capability of the channel to reduce MHD pressure drop is evaluated by an experiment with a large magnetic field and by a numerical simulation. Then applicability of the channel to the blanket system of a fusion reactor is discussed based on the result. Since it has been suggested that the contact resistance affects the MHD pressure drop through the collaborative research[2], we clarified the relationship between the value of contact resistance and MHD pressure drop experimentally in this year. And then, we developed a numerical model of the contact resistance. In addition, we verified that MHD pressure drop was reduced by ceramic coated three-surface-multi-layered channel. Teflon has been used as insulator in the previous MHD experiments though Teflon is inadequate for actual fusion blanket. Therefore we need the verification of the ceramic insulator for the fusion application.

The value of contact resistance on the surface of the base stainless steel wall is evaluated by measuring the potential difference between the base wall and the side electrodes when current is applied the base plate to the both side electrodes. The pressure drop is measured by the same method as the previous collaborative research. The magnetic field and mean flow velocity are 3 T and 0.1 m/s, respectively. Thickness of the base stainless steel wall is 0.1 mm. The measurements are conducted twice at the same condition though the non-identical base plates are used. These results are named data 1 and 2, respectively. Fig. 1 illustrates the relationship between the pressure drop and contact resistance. Large value of contact resistance is obtained at first and the value decreases with time in the both measurement. It shows that the contact state changes between the fluid and stainless steel wall. In the numerical simulation, the contact resistance is simulated by a thin layer with large resistance on the base wall surface. Fig. 1 shows good agreement between the experimental and numerical results.

In order to validate the insulating performance of ceramic in MHD flow, silica (SiO_2) is coated on the cannel wall as insulator. The pressure drop is measured by the same method as the above. Parameter range in the magnetic field and the mean flow velocity are 1-5 T and 0.1-0.6 m/s, respectively. Thickness of the base wall is 0.02 mm. Fig. 2 illustrates the pressure drop characteristics. It shows that pressure drop in the ceramic coated channel is smaller than those in Teflon insulated one. As mentioned above, the effect of the contact resistance differs from one individual to the next largely. In addition, the fact that the pressure drop increases on the second day denotes the same tendency that the contact resistance decreases with time and then the pressure drop increases. Therefore the difference in the contact resistance might cause the decrease in the pressure drop in the ceramic insulated channel.

The relation between the MHD pressure drop and the contact resistance on the stainless steel wall was clarified experimentally and the similar result was obtained by the numerical simulation where the contact resistance was simulated by a thin layer with large resistance. In addition, we validated that ceramic coated three-surface-multi-layered channel did not have additional pressure drop as compared to Teflon insulated one.

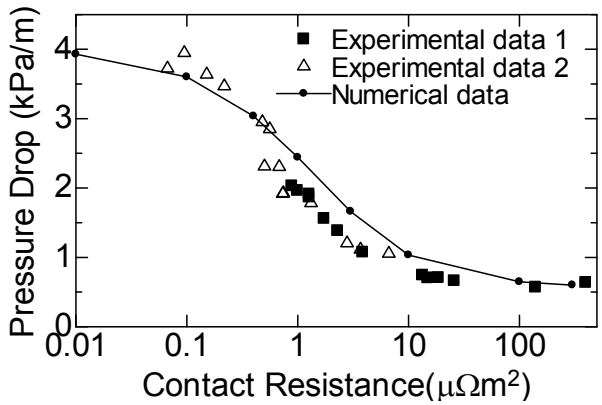

Fig. 1. Relationship between the pressure drop and contact resistance

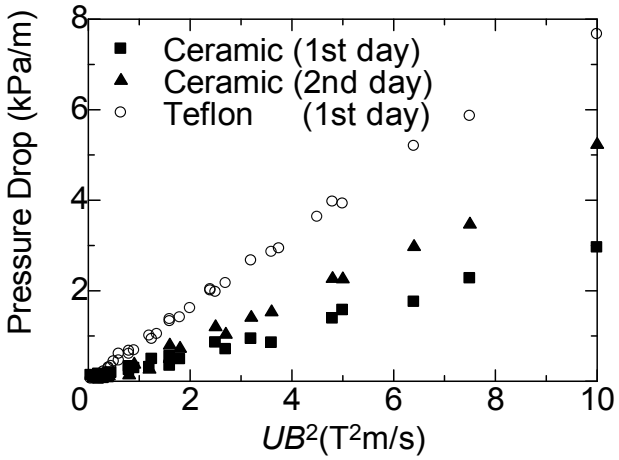

Fig. 2. Schematic view of the simulation model of the three-surface-multi-layered channel

1) Hashizume, H.: Fusion Engineering and Design **81** (2006) 1431.
2) Aoyagi, M. et al.: Fusion Engineering and Design **85** (2010) 1181.