Experimental Analysis of Soaker Hose Concept for First Wall/Divertor Application

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To allow the first wall/divertor to remove the intense radiative surface flux and to prevent it from being damaged by, creating a liquid metal free surface wall is one of the constructive goals in the fusion engineering field. Several concepts have been considered including film flow and free surface jets. However, these ideas may not be feasible ways to flow liquid metal crossing a magnetic field. The soaker hose idea was proposed to this first wall/divertor application by flowing liquid metal along the field lines or flowing toroidally. In such a concept, the fluid is introduced into the first wall by the differential pressure head, and current is applied to the liquid to create a Lorentz force to redirect the flow. Although numerical analyses have been performed for feasibility evaluations, few experiments have been carried out. The objective of this work is to analyze the effectiveness of the soaker hose concept experimentally.

In the present experiments, current added to the fluid metal can be up to 30A, while the magnetic field, which is produced by placing the two permanent magnets facing each other, is approximately 0.20T. Acrylic plastic, an electrically isolated material, is used as the hose material, and Ga-In-Sn alloy, fluid metal, is introduced into the magnetic field by static pressure head. Important parameters in this experiment are inlet velocity, the strength of the Lorentz force (which is the cross product of the magnetic field and the current density) and the fluid flow path.

Preliminary experimental results, from both vertical and horizontal hose setups, have shown clearly that the Lorentz force has acted to the liquid metal if current is added perpendicularly to the magnetic field; as seen in the previous numerical analysis. Specifically, the MHD Lorentz force has modified the shape of the flow surface and retarded the inlet flow. This retarding force has resulted in decreasing inlet velocity as the supplied current increases, or a 5% decrease in inlet velocity at a supplied current magnitude of 30 A. However, to allow the fluid to completely cover the first wall/divertor area, a stronger Lorentz force is needed to overcome the gravitational force; as already shown in the vertical setup where the fluid has been pulled together quickly by gravity rather than been pushed toroidally by MHD forces. On the contrary, in the horizontal setting, the same Lorentz force flattens the flow and directs the flow more effectively. In both settings, however, the surface tension and surface wetting play a significant role in determining flow characteristics. These are challenging problems that need to be resolved in order to put forward this concept for practical application.