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The Experimental Characterization of the Magnetic Field Effect on a Liquid Sodium Flow

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1. Introduction

A liquid sodium coolant is used for a LMR such as KALIMER and a magnetic field is generated in the electromagnetic pump or flowmeter. The magnetic field has an effect on the electrically conducting metal flow by a generation of an electromagnetic pressure drop. Therefore, in the present study, a theoretical calculation is carried out for the effect of an external magnetic field and the magnetic field is measured over the electromagnet system manufactured for the magnetohydrodynamic experiments.

2. Theoretical Analysis

Figure 1 shows the test section of the rectangular electromagnet system and Figure 2 represents the analysis model based on the uniform current density method. DC magnetic field is driven perpendicularly with the liquid sodium flow for the electromagnetic pressure drop by a magnetic field as is seen Figure 2.

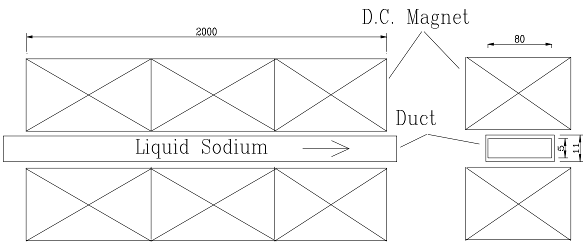

Figure 1. The sectional view of the electromagnet system.

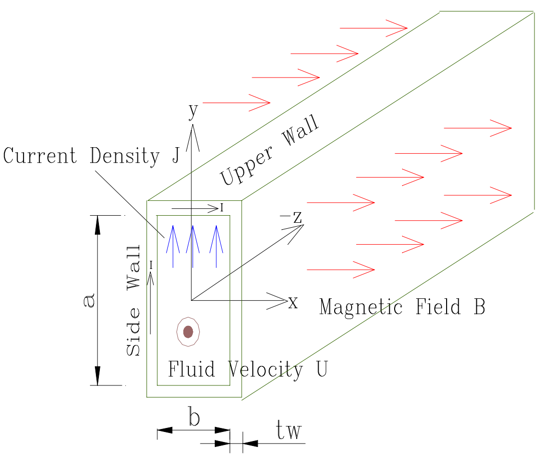

Figure 2. The 3D schematic model for an experiment on magnetic field effect.

a : The length of a side wall[m]
b : The length of an upper wall[m]
B : Magnetic flux density[T]
J : Current density[A/m^2]
U : Fluid velocity [m/sec]
t_w : The thickness of a wall[m]

On the other hand, by combining the concerned equations, the force density is as follow;

$$\Delta p = \int K_p \sigma_f U B^2 dz$$

K_p : Pressure coefficient
σ_f : Electrical conductivity of the sodium

3. The Experiment and Results

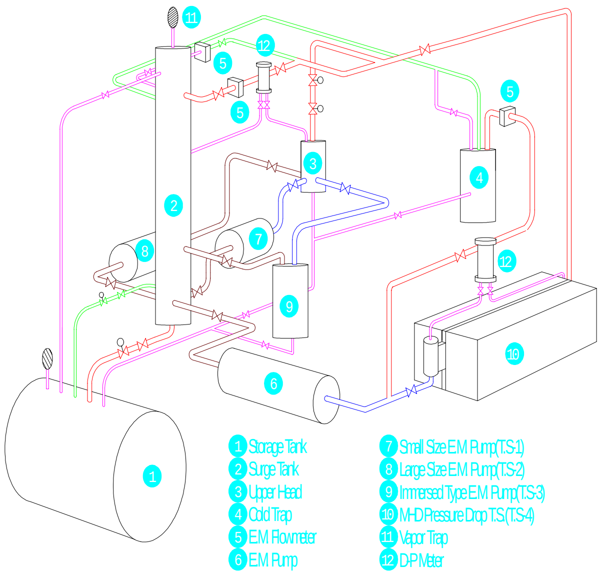

Figure 3. The MHD experimental loop with the electromagnet system for a pressure drop test.

Figure 3 shows three dimensional schematics for a pressure drop test by the magnetic field. In Figure 3, the electromagnet system consists of three electromagnets with a small gap between each electromagnet. The differential pressuremeter is seen to be equipped at both ends of the electromagnet system.

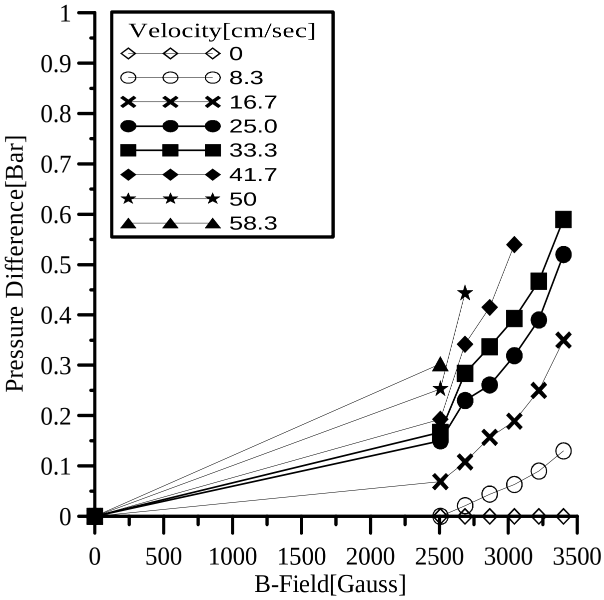

Figure 4. The pressure difference according to the varying velocity with the change of magnetic field.

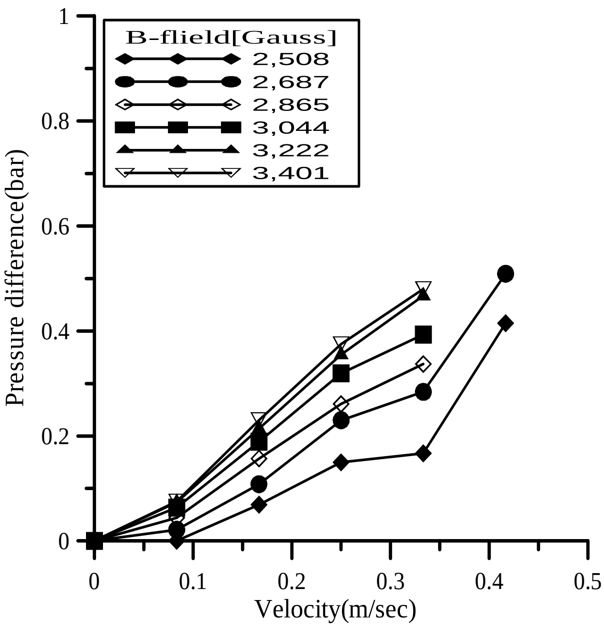

Figure 5. The pressure difference according to the varying magnetic field with the change of velocity.

In Figure 4, the measured pressure difference was plotted according to the varying velocity with the change of magnetic field when the operation temperature of the sodium is 200℃. In Figure 5, the measured pressure difference was plotted according to the varying magnetic field with the change of velocity in same temperature condition. As is seen in Figure 3 and Figure 4, the pressure difference is proportional to the flow velocity and the square of the magnetic field.

5. Conclusion

The magnetic field effect on the pressure drop was measured for a liquid sodium flow when the operational variables such as the magnetic field and flow velocity varied. In the future, the comparative analyses between prediction and experimental results will be carried out in detail through the additional experiment.

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