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# The Theoretical Investigation of the Magnetic Field Effect on a Liquid Sodium Flow

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## 1. Introduction

The liquid sodium coolant is used for LMR such as KALIMER and magnetic field is generated in the electromagnetic pump or flowmeter. The magnetic field takes an effect on the electrically conducting metal flow by the generation of the electromagnetic pressure drop. Therefore, in the present study, the theoretical calculation is carried out for an effect from the external magnetic field and the magnetic field is firstly 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 uniform current density method. DC magnetic field drives perpendicularly with liquid sodium flow for the electromagnetic pressure drop by a magnetic field as is seen Figure 2.

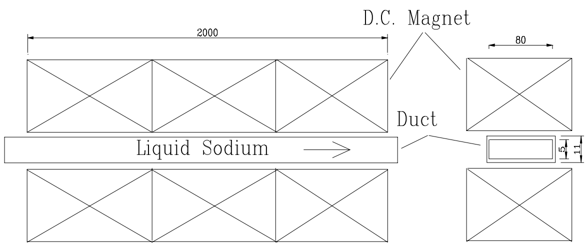


Figure 1. The sectional view of the electromagnet system.

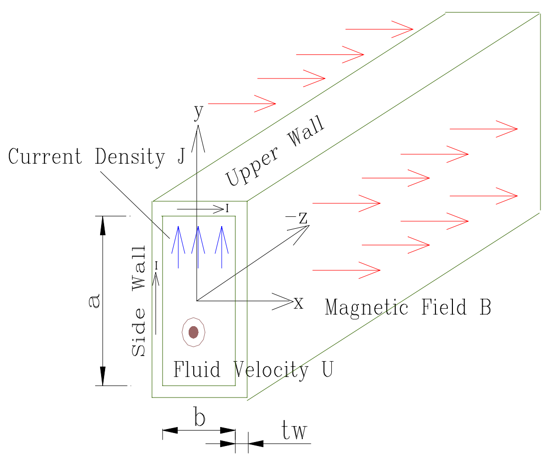


Figure 2. The 3D schematic model for an experiment on magnetic field effect.

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, combining the concerning equations, the force density is as follow;

$$\frac{Dp}{Dz} = K_p \sigma_f U B^2$$

$K_p$ : Pressure coefficient
$\sigma_f$ : Electrical conductivity of the sodium

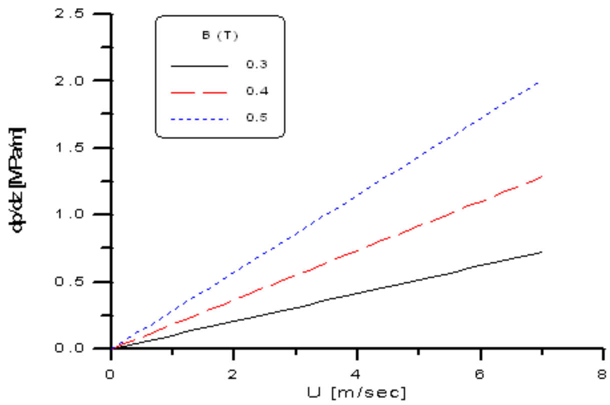


Figure 3. The force density according to the varying velocity with the change of magnetic field.

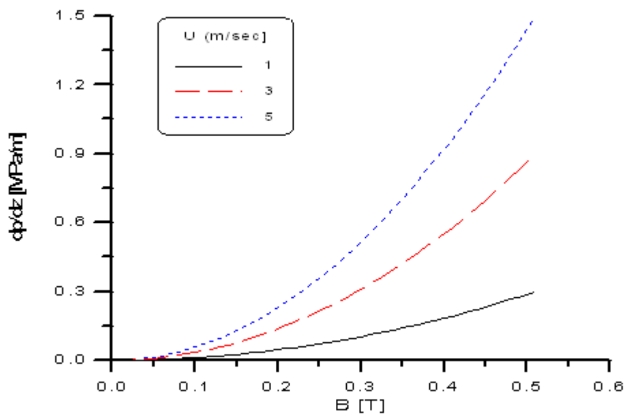


Figure 4. The force density according to the varying magnetic field with the change of velocity.

In Figure 3, the force density is plotted on the change of the average velocity with varying magnetic fields when the operation temperature of the sodium is 200℃. In figure4, the force density is plotted on the change of the magnetic field with varying average velocities in same temperature condition. As is indicated in the Equation of the force density, it is proportional to the flow velocity and the square of the magnetic field.

## 3. The Electromagnetic Field Measurements

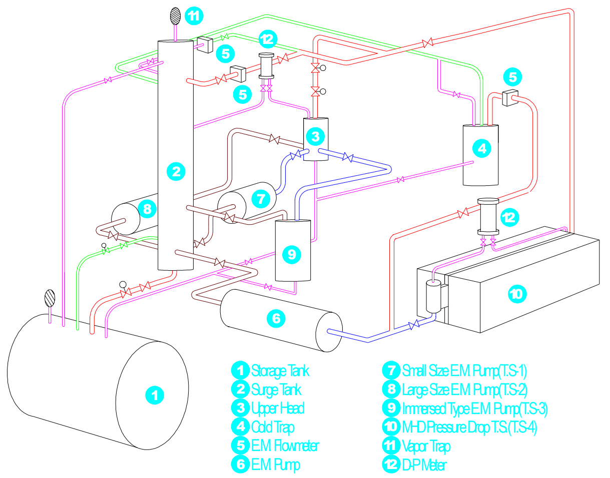


Figure 5. The MHD experimental loop with the electromagnet system for a pressure drop test.

Figure 5 shows three dimensional schematics for a pressure drop test by the magnetic field. In Figure 5, the electromagnet system consists of the 3 electromagnets with a small gap between each electromagnet. The differential pressuremeter is seen to be equipped at both ends of the electromagnet system.

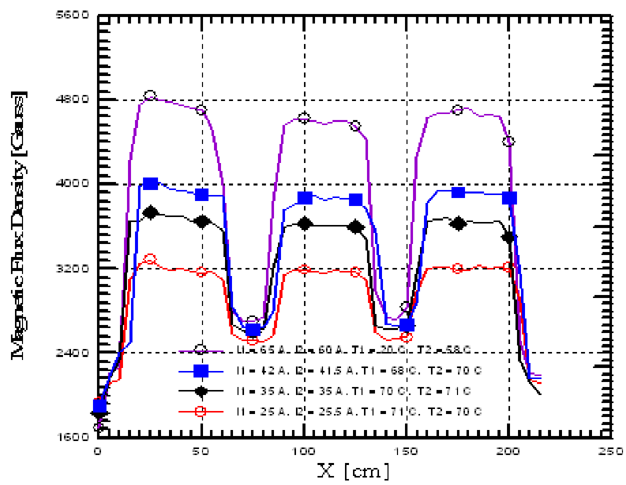


Figure 6. The magnetic field distribution in the electromagnet system.

In Figure 6, the magnetic field is almost uniform except the gap between electromagnets. Therefore, when experimental results on the pressure drop are compared with theoretical ones, the theoretical pressure drop( $\Delta p$ ) is to be calculated by solving the Equation,

$$\Delta p = \int_0^z K_p \sigma_f U B(z)^2 dz$$

where a numerical treatment may be taken.

## 4. Conclusion

The magnetic field effect on the pressure drop was investigated for the liquid sodium flow when the operational variables of magnetic field and flow velocity varied. In the future, the experimental characterization will be carried out and compared with theoretical prediction.

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