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Effect of the Type and Wire Diameter of a Wire Level Sensor in the Measurement of a Free Surface Fluctuation

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1. Introduction

A measurement of the fluctuating frequency and amplitude of the free surface in a cylindrical annular vessel where the inner vessel is simulated as an UIS of a liquid metal reactor will be carried out. Before such a measurement, the effect of the type and wire diameter of a wire level sensor in the measurement of a free surface fluctuation is investigated. Since the range of the estimated frequency is about 0.5～5 Hz, a conductivity type wire sensor is used as a level meter in order to obtain an accurate enough response. But the characteristics of this type of level sensor have not been reported in the literature so far. Owing to this reason, an experiment is carried out to find the characteristics of the level sensor before the surface fluctuation measuring experiment [1]. In the present paper the characteristics of the level sensor are described through an experiment.

2. Experiment

The wire sensor is moved vertically by the piston motion of a disk which is rotated by a DC motor instead of a free surface fluctuation in order to obtain a well defined frequency in this experiment. The moving length is 71.92mm, and the rotating frequency of the motor is controlled by an inverter. The wire sensor is immersed in the water which is contained in a small plastic vessel. The experimental range of the motor frequency in the experiment is 0.1～10Hz in order to cover the range of a free surface fluctuation in the planned experiment. An AC power with a 1 kHz frequency is supplied to the wire sensor by the power supply developed in this work.

The level sensor is an impedance type of level sensor for measuring the electrical resistance of water according to the immersed length of the wire. When two electrodes are immersed in water, the impedance is composed of the resistance of the water, the capacitance caused by a polarization of the water, and the capacitance caused by the dielectric property of the water. If the frequency of a supplied power is less than 7 MHz, the effect of the dielectric property can be insignificance [2]. If the frequency is greater than 2 kHz, the effect of a polarization of the water can be insignificant. Therefore, the impedance (Z) is described as follows in our case.

$$Z = R + \frac{1}{2\pi C_P f_P} \qquad (1)$$

where R is resistance, C_P is capacitance, and f_P is the frequency of a supplied power.

In the experiment, we used 5 kinds of wire diameter from 0.02mm to 1.2mm for the purpose of understanding the effects of a sensor diameter, and 4 kinds of wire shapes. Figures 1 and 2 show the wire sensor types used in this experiment.

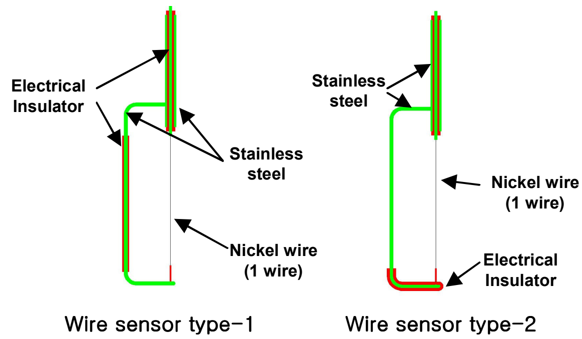

Figure 1. The shape of a wire level sensor types 1 and 2

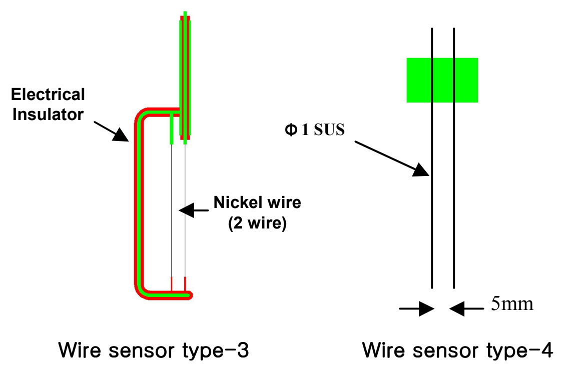

Figure 2. The shape of a wire level sensor types 3 and 4

The experimental data is collected by using the HP1413C data acquisition system and 200 data is obtained per one second during 180 seconds. The calibrations of the wire sensor are performed before and after changing the sensor.

3. Result and Discussion

The experiment is carried out by varying the oscillating frequency in the range 0.1-10 Hz with 5 different wire diameters and 4 kinds of sensor types. In the experiment, the experimental frequency follows well the ideal frequency, but the experimental amplitude decreased with an increase in the oscillating frequency. Fig. 3 shows the effects of the gap for two wires in the type-4 wire on the response of the wire sensor according to the oscillating frequency. When the gap between the center and the center of a wire is greater than 4mm, the response ratios are nearly equal in spite of the different diameters, but the value is decreased with an oscillating frequency. When the gap is less than 4mm, the gap becomes narrower, and the amplitude ratio is lowered. The figure also shows that when the gap is large, the error of the sensor which is deeply immersed in the water is higher than the error of a sensor which is slightly immersed, but when the gap becomes narrow, reversal phenomena takes place.

Although the upper and lower amplitude ratios are varying, according to the wire gap, the total amplitude ratio is nearly the same as shown in Figure 4. This phenomenon appeared in all of the oscillating frequency regions. Although the reason for a lower response when the sensor is deeply immersed in the water can be expressed literally as an increase of the electrical capacitance of the water, a detailed cause needs to be studied.

Figure 5 shows the ratio of the experimental amplitude and the ideal amplitude versus the oscillating frequency according to the wire diameters and sensor types by using our data with the exception of the data whose gap is narrower than 4mm. The ratio is exponentially decreased when the oscillating frequency is increased as shown in this figure.

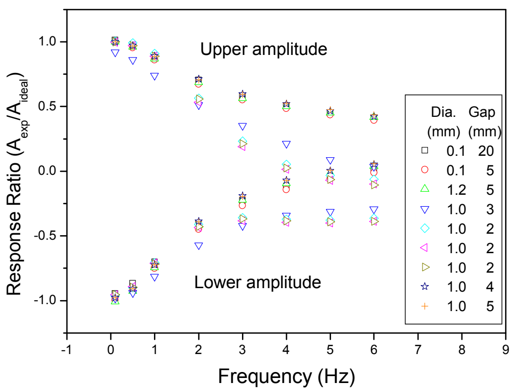

Figure 3. The effect of the gap between two wires versus the oscillating frequency in the response ratio of wire sensor

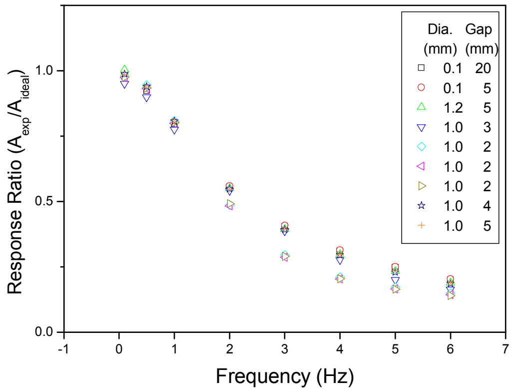

Figure 4. Comparison of the experimental response and the ideal response of the wire sensor in the wire type-4 experiment

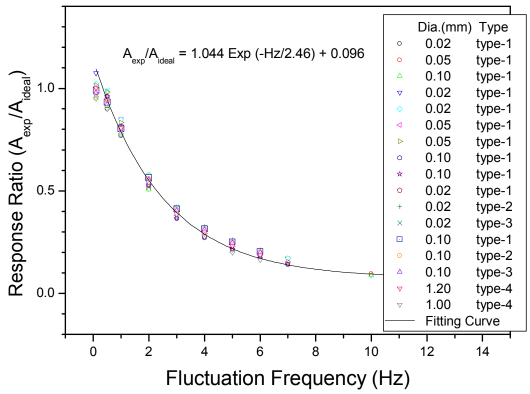

Figure 5. Response ratio of the experimental and ideal amplitude versus the oscillating frequency in the various conditions.

4. Conclusion

From the wire response experiment we found that the ratio between the experimental amplitude and the real amplitude is decreased with an increase in the oscillating frequency. But the frequency follows well that of a real situation. The response of a wire level sensor is not affected by the wire diameter and sensor type, but by the gap of the wires.

Reference

[1] H. Y. Nam et al., "Characteristics of a Wire Level Sensor in the Measurement of a Free Surface Fluctuation," KNS Autumn Meeting, Pusan, Korea, October, 2005.
[2] M. K. Jeong et al., "Development of the Impedance Void Meter," KAERI/TR-446/94, 1994.

Ackowledgement

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