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A Preliminary Design of a Wire Mesh Sensor for Measurement of Void Fraction

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1. Background

Steam explosion phenomena [1] are accompanied with a multi-dimensional and multi-phase fluid flow and heat transfer phenomena. Void fraction is one of the major parameters, which governs the premixing behavior of melt particles in water and the explosion behavior of the pre-mixed fuel. However, efforts for the development of a reliable measurement technique for void fraction are still underway, as it deals with an interaction between a melt at a very high temperature and water in a short time scale.

Hundreds of conductivity type probes installed in a test section enabled monitoring of the evolution of a melt-water interaction zone in the ECO test [2]. A technique using a dual energy X-ray system was developed to measure gas fraction, liquid fraction, and melt fraction simultaneously for a small-scale steam explosion experiment [3]. A high-energy X-ray system for monitoring multi-phase fractions is now being developed at CEA [4].

Recently a measurement of multi-phase fractions by using a wire mesh system has been introduced [5]. It has an advantage that the speed of the measurement is fast and a direct measurement is possible.

As a part of a feasibility study on a wire mesh technique for a steam explosion experiment, this paper discusses the design of the wire mesh and the results of the preliminary calibration tests.

2. Design of a Wire Mesh System

2.1 Measurement principle

Fig.1 shows a schematic view of the wire mesh grids. Two planes of wire grids are placed with a short distance from each other. The angle between the wire girds is 90^o.

Pulses of a driving voltage are supplied to the wires of the first plane (transmitter). If the pulse, given to one of the transmitter wires, arrives at a certain wire of the second plane (receiver plane), it is assumed that the crossing point between the two selected wires is occupied by the conducting phase (water). This detection is performed for all the crossing points of the wires of the two planes by means of a multiplexing circuit. In the end, the volumetric water fraction can be obtained by relating the number of crossing points occupied with water to the total number of crossing points.

In the present design, the wire mesh system consists of 16 lines of wires at each plane. The diameter of the wire is 0.5 mm and the distance between the two grid planes is 2 mm. The two layers of wires are installed in a circular frame to be fitted in a circular flow channel.

The distance between the wires in a plane is 6 mm.

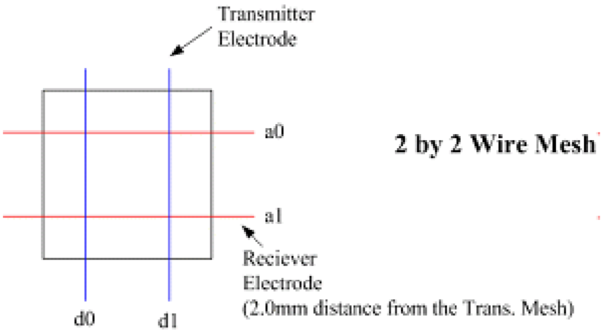

Fig. 1 Conceptual picture of wire mesh

2.2 Wire mesh sensor hardware

Fig. 2 shows a circuit of a wire mesh sensor. It is composed of a NI DAQ PCI 6259 board generating excitation pulses which control an on-off switch to produce bipolar square waves of 4.7V to distribute to 16 input channels of a wire mesh sensor, and acquisition systems for the output signals from the sensor. The acquisition systems for the output signals are a pre-amplifier, a sample and holder amplifier and an A/D converter with 16 channels to receive the signals from the sensor.

A pre-amplifier requires a build-up time to prevent a signal distortion when a signal of 32kHz is transferred.

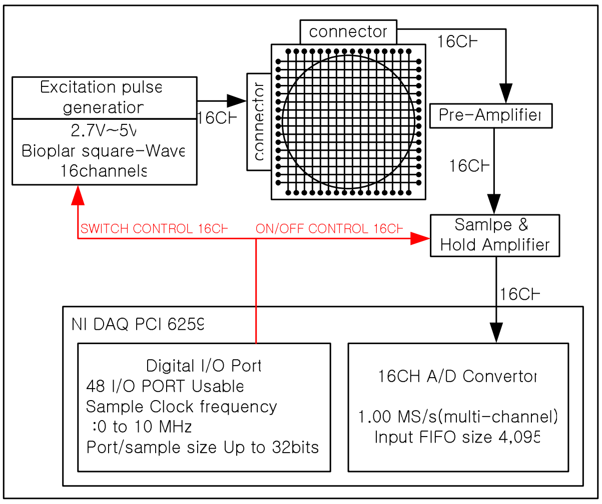

Fig. 3 Circuit of a wire mesh sensor

The input signals generated by the circuit of a wire mesh sensor are shown in Fig. 4.

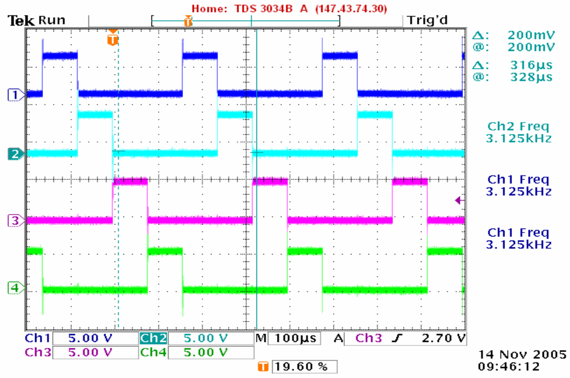

Fig.4 Input signals to a wire mesh sensor (4channel)

2.3 Wire mesh sensor software image

The software controlling a wire mesh sensor is composed of a detection mode, a result confirmation mode and a system parameter change mode.

The detection mode was designed to show the measured 16 channels in a frame at a time and to vary the output frequency from 160Hz to 40kHz for a channel. Total measuring time was optimized to be less than 50 seconds considering data file size and steam explosion time scale. The void fraction at each crossing point can be displayed by 5 different colors from 0 to 100% and the acquired data is saved on the hard disk. The detection mode is shown in Fig. 5.

The result confirmation mode enables the saved void fraction data at a required time to be displayed on the monitor.

The system parameter change mode enables the mesh numbers to be changed e.g.) from 16x16 to 32x32, and does the input voltage to be changed etc.

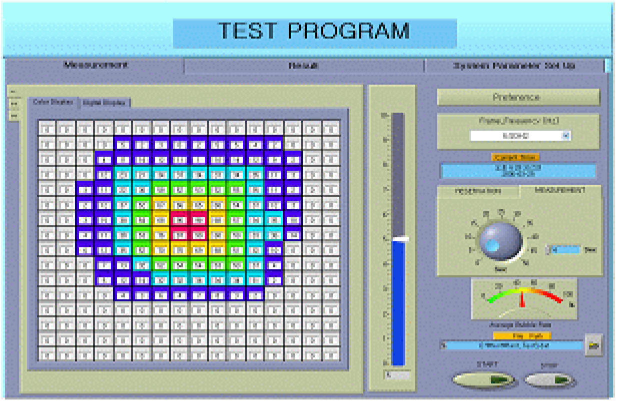

Fig. 5 Software image of a wire mesh sensor

3. Summary and Discussion

A wire mesh sensor is a very useful tool to measure void fraction which plays an important role on a steam explosion. A development of a wire mesh sensor at KAERI is at the final stage. The wire mesh sensor will be verified by applying it to a bubble column as shown in Fig. 6, compared to the void fraction data obtained from a differential pressure transmitter.

The wire mesh sensor will prove its usefulness in measurement of void fraction and then its applicability to a steam explosion experiment will provide a certain relationship between void fraction and an occurrence of a steam explosion.

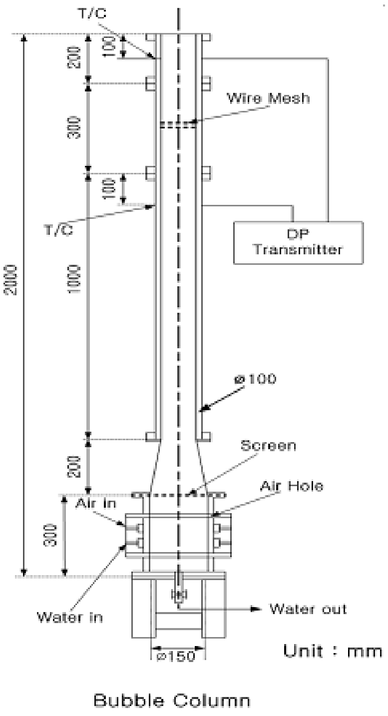

Fig.6 Schematic diagram of a bubble column

REFERENCES

[1] J. H. Song et al., Fuel Coolant Interaction Experiments in TROI Using a UO2/ZrO2 Mixture, J. H. Song et al., Nuclear Engineering and Design, Vol.222, 1-15, 2003.

[2] W. Cherdron, U. Imke, H, Jacobs, A. Kaiser, W,Schutz, ECO Steam Explosion Experiments, G00103, NUTRETH-10, Seoul, Korea, 2003

[3] E. P. Lowewen, Dual X-ray Imaging to measure phase volume fractions in a transient multiphase flow, Ph. D. Dissertation, University of Wisconsin, 1999.

[4] J. M. Bonnet, Y. Bullado, C. Journeau, P. Fouquart, P. Piluso, C. Sergeant, D. Magallon, KROTOS FCI experimental programme at CEA Cadarache, ICAPP05, Seoul, 2005

[5] H. M. Prasser, A. Bottger, J. Zschau, A new electrode-mesh tomography for gas-liquid flows, Flow Measurement and Instrumentation 9, pp.111-119, 1998.