DEVELOPMENT OF PHASED-ARRAY UVP TECHNIQUE FOR TURBULENT PIPE FLOW

*H. Takahashi¹, S. Shwin¹, A. Hamdani¹, T. Ihara² and H. Kikura¹

¹Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550 Japan
²Tokyo University of Marine Science and Technology, 2-1-6 Etchujima, Koto-ku, Tokyo 135-8533 Japan

ABSTRACT

Various measurement techniques of the velocity field of turbulent pipe flow have been developed. However, the conventional methods such as Laser Doppler Anemometry (LDA) and Particle Image Velocimetry (PIV) cannot be applied to opaque fluids and treatment of these optical systems is difficult for the monitoring use in actual plant process. Therefore, Ultrasonic Velocity Profiler (UVP) was developed by Takeda [1] for optically non-transparent liquid flows, a liquid metal flow such as mercury flow. It utilizes a pulsed echo-graphic technique of ultrasound and can measure a velocity profile on a measuring line instantaneously. In addition, UVP has a merit such as non-intrusive measurement method.

Usually, by using only one sensor, UVP method can only measure one-dimensional velocity profile. Nevertheless, UVP method can also be used for two-dimensional velocity profile (flow mapping) in channel flow. Takeda and Kikura [2] investigated velocity field of the mercury flow using UVP. Flow mapping was accomplished either by using multiple transducers, which were arranged in different positions or by using a single transducer which was moved mechanically through multiple positions and set to multiple angles. However, by using those two techniques, the measurement system becomes larger as the number of transducers increase. To overcome such problems in conventional UVP (multiple sensors and mechanical movement), an array sensor, which has multiple ultrasonic elements, can be used. Therefore, velocity vector measurement using phased array sensor had been developed by Hamdani et al. [3]. They conducted the development of the measurement system of two-dimensional velocity vector using phased array sensor. By using the array sensor, velocity profiles on multiple measurement lines can be obtained with only one sensor. In this previous study, the number elements of phased array sensor were eight only elements. Consequently, there was a limitation on measurement area.

In this study, 32 elements phased sensor has been developed to increase the measurement area. To know the performance of this measuring method, measurement of the secondary flow on turbulent swirling flow is performed. The experiment is done in horizontal pipe flow. The experimental apparatus consists of a water circulation piping system with a rotary pipe, cooling system and electromagnetic flow meter. The rotary pipe is installed upstream of the pipe. The honeycomb is inserted into the rotary pipe to generate swirl. The influence of swirl intensity on the flow structure is clarified by Phase Array UVP. Also, the applicability of this method on the flow will be discussed in detail.

REFERENCES

