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High-frame rate neutron imaging of bubble behavior in air-water two-phase flow

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Gas-liquid two-phase flow appears in nuclear power reactors and is one of the important phenomena for the safety analysis of the reactor. Especially, the transient behavior of the two-phase flow structure is very complicated and has to be understood in detail by experiments. For that purpose, flow measurement method with high temporal resolution is required. Previously, a lot of methods have been developed and applied. Neutron imaging can visualize the flow in metallic pipe and the spatial flow structure can be understood. Therefore, it is very useful tool for two-phase flow measurement. However, the improvement of the temporal resolution was not easy because of the limitation of the neutron source and the imaging system. The authors have been developed high-frame rate neutron imaging system, which consists of a high-speed camera, an optical image intensifier, a high-sensitivity lens, a scintillator and a dark box, previously. In the present study, the system was upgraded by using a high sensitive high-speed camera and an ultrahigh-sensitivity lens. As a result, the frame rate of 10,000 Hz could be achieved at B-4 neutron guide tube facility in Kyoto University Research Reactor. The current system was applied to air-water two-phase flow measurement in a circular pipe, and the bubble behavior was observed. In addition, the simultaneous measurements with high-speed X-ray radiography were carried out to compare the imaging results. The X-ray was irradiated to the test section in a direction perpendicular to the neutron beam. From these results, the possibility of the 3-D visualization of bubbles using neutron and X-ray radiographs were also investigated.

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