Onset of Gas Accumulation inside Inverse U-bend

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1. Introduction

Unpredicted gas accumulation in a fluid system, such as a safety system of nuclear power plants, have an effect into the degradation of system cooling performance [1]. The accumulative gas also can damage the elements of the fluid system. However, the mechanism how the gas accumulated in the flowing water has not been clearly studied.

The representative locations at which gases are liable to accumulate during flow are inverse U-bend, heat exchangers and check, throttle and relief valves. The characteristic of these examples is that they have locally higher elevations compared with their vicinities. The bubbles are easy to be stagnated at the elevated locations. Also, it is hard to remove the accumulative gases when they are already generated at these kinds of positions [2].

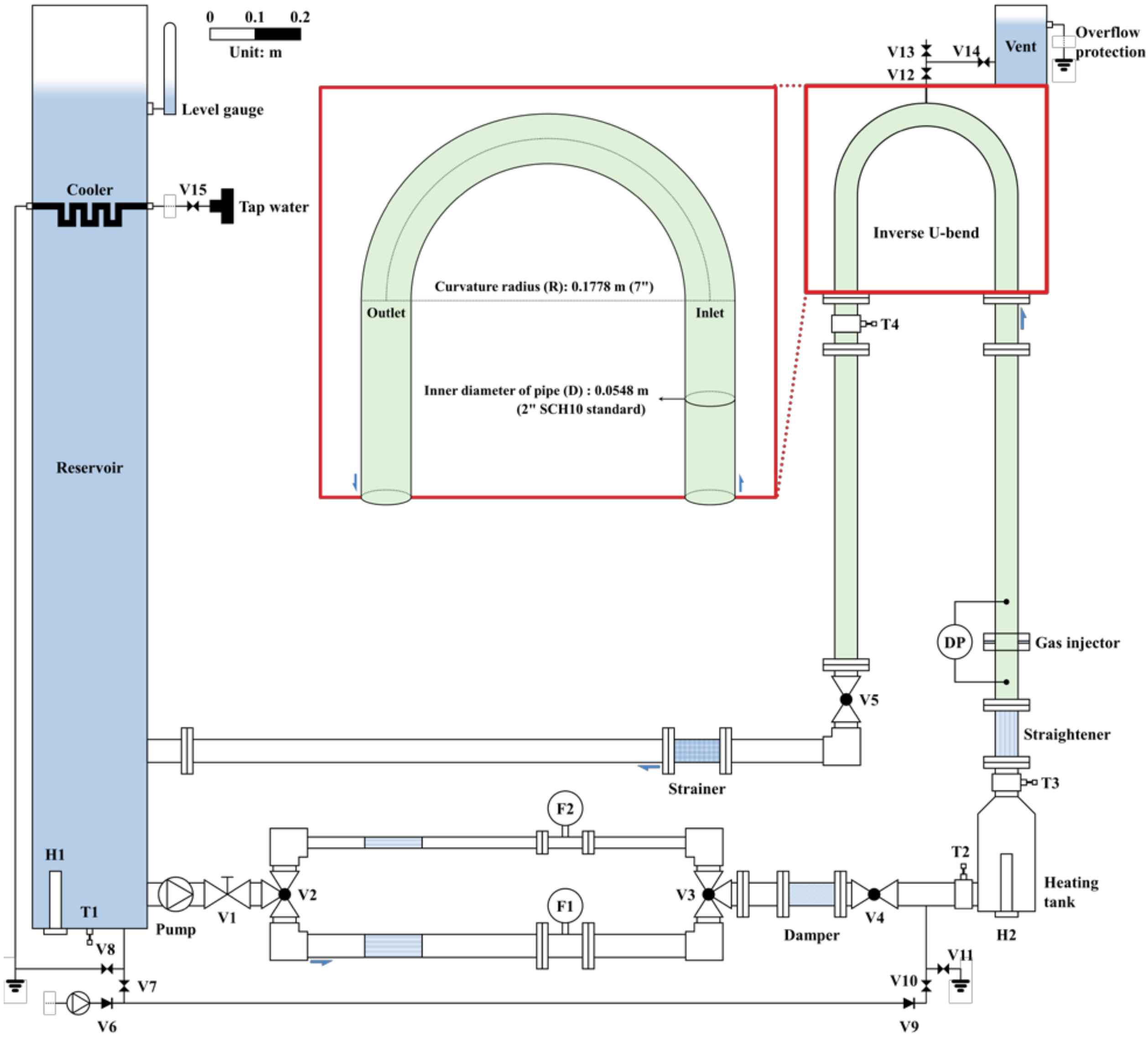

Fig. 1. Schematic diagram of experimental apparatus

Especially, the accumulative gases inside the inverse U-bend have higher possibilities to threat the entire system, as following reasons. In first, larger volume of the gas can be accumulated inside the Inverse U-bend, due to the elevated region is broader and the elevation is higher than the other potential locations [3]. Second, by increasing the flow velocity, the large volume of the accumulative gases is able to be swept away from the inverse U-bend and invade into the other component of the flowing system. When a number of accumulative gases is swept away at once, they can generate a slug and this may trigger hammering and flow-induced vibration.

In order to prevent the gas accumulation, the accumulative mechanism of non-condensable gases should be understood. In the current study, it was investigated qualitatively how the gases were began to be accumulated at the inverse U-bend using visualization images and the onset of gas accumulation was defined.

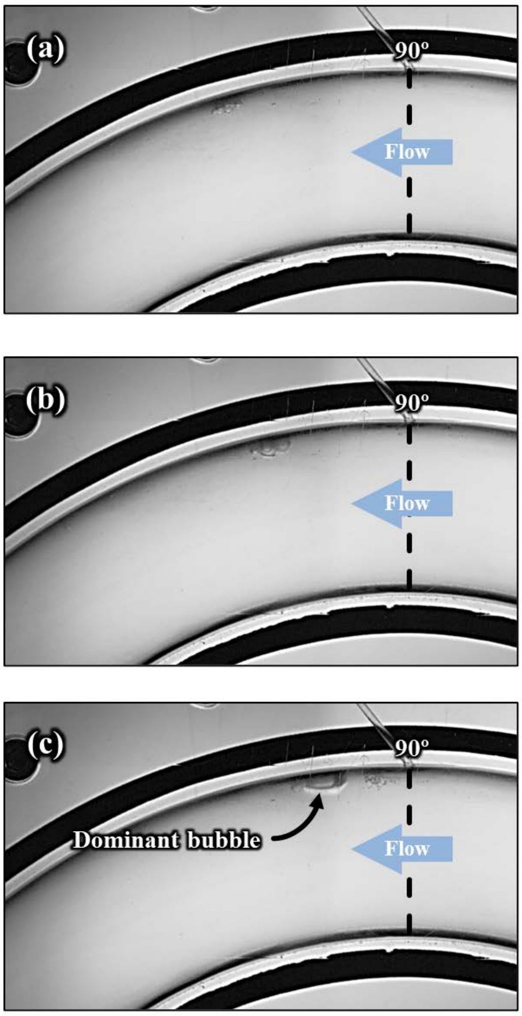

Fig. 2. Pictures for defining OGA inside the inverse U-bend: (a) a bubble cluster stagnates after the top of inverse U-bend, (b) repeated mutual mergence of bubbles, (c) the bubbles start to converge around one dominant bubble (OGA).

2. Experimental Apparatus

Fig. 1 shows a schematic diagram of the experimental apparatus built to observe the gas accumulation phenomena inside the inverse U-bend during water flows. The system consists of a water reservoir, a pump, flowmeters and a test section, i.e., the inverse U-bend.

The test section was made by transparent acrylic. The inner diameter of flow channel was about 0.055 m and the curvature of the bend was about 0.178 m. The length of the straight parts before and after the inverse U-bend were 20 times longer than the inner diameter. The demineralized water was used for the experiments. The conductivity of water was kept below then 4.9 × 10^{-4} S/m and the water was stabilized in room temperature (20-25 ℃) and atmospheric pressure (approximately 0.1 MPa) before the experiments

3. Phenomenological Results

When only a few and small-sized bubble was injected into the pipe, the bubbles only flowed with the liquid and scarcely affected by buoyancy. Therefore, the bubbles could not stagnate inside the inverse U-bend. Almost of them was swept away by the liquid flow. At a certain amount of gas injected, the gas started to be accumulated. Fig. 2. shows the visualized images of this process. The onset of gas accumulation (OGA) was defined using these visualized images. Firstly, a bubbles cluster which has similar sized bubbles started to stagnate right after the top of the inverse U-bend. Then, they merged each other. By mutual mergence in repetitive, the bubbles grew gradually into one larger dominant bubble. The point when the gas starts to accumulate around the one dominant bubble was defined as OGA.

The location of OGA changed according to the liquid velocity. As illustrated in Fig. 3. when the top of the inverse U-bend is defined at 90º, the faster the liquid velocity, the more distant the OGA location, because more abundant and larger bubbles are needed for gas accumulation under faster liquid velocity.

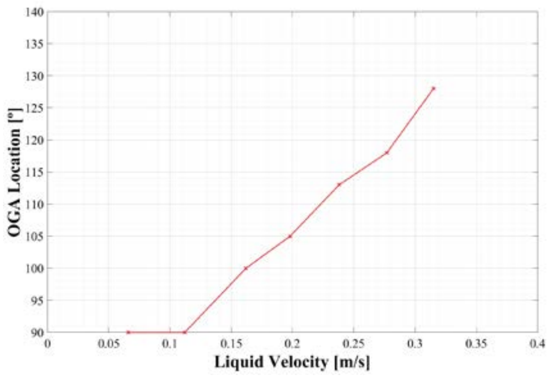

Fig.3. Variation of the OGA location according to the liquid velocity

3. Conclusions

In the present study, the gas accumulation process inside an inverse U-bend was experimentally observed and the onset of gas accumulation (OGA) was defined using visualization images. The gas accumulation mainly occurs at the point right after the top of inverse U-bend and the point becomes more distant from the top when the liquid velocity increases. This study investigated the onset of gas accumulation but the size and amount of injected gas were not specified. To overcome the limitation, the further experiments are planned.

REFERENCES

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