Experimental study of siphon breaking phenomenon in real scale reactor design

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1. Introduction

In the heat transfer system which uses the liquid fluid to remove and transport the heat, the LOCA(loss of coolant accident) could cause the big accident like as CHF accident and etc. In the research reactor, a little heat compared to real reactor is generated. So if the water level in reactor was maintained, the reactor could avoid significant accident like fuel rod melt down. To prevent the pool water level above the reactor core, all system should be located above the core. However, a component of a system can be installed below the core level due to the component purpose. The siphon breaker is the one of the method to maintain the reactor water level and is passively operated. The siphon breaking phenomena is very complicated due to the transient, turbulent two-phase flow mode, so there are no suitably available models and correlations.

In this study, the siphon breaking line is accepted and the size effect of line is investigated with experiment. Because of the complexity of phenomena, the size of experimental facility was chosen very large enough to apply in industry.

2. Experiment

In this section, the experimental facility and operation methods are described and the simple result of experiment was also contained. This experiment focus on the research reactor, so heat source is not existed. The simple fluid dynamics correlations and models were used in the progress on design of experimental facility [1]. The construction of experimental facility was led by DANE, POSTECH. All experiments are conducted on atmospheric pressure and temperature.

2.1 Experimental apparatus

Siphon breaker test experimental facility consists of upper tank, lower tank, piping system and return pump. Fig.1 shows the schematic diagram of experimental facility and Fig. 2 shows the installed picture of experimental facility. The upper tank has about 60-ton of capacity with 4m-depths and is made of steel plate. 16” main steel pipe is connected and pass through the upper tank as like Fig. 1. The end of main pipe has the

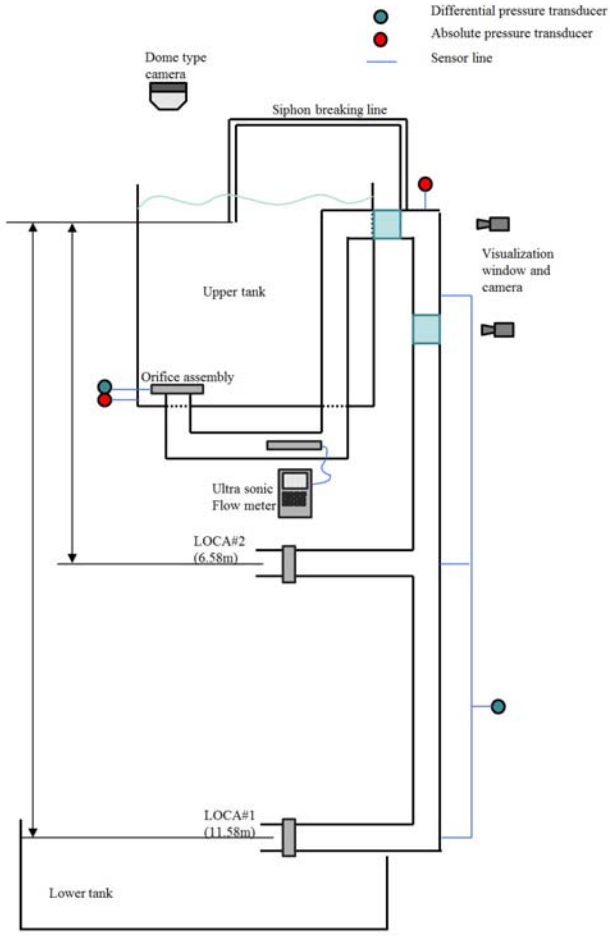

Fig. 1. The schematic diagram of experimental facility

orifice assembly which is chosen to mimic the effect of pressure difference in reactor core. Visualization windows are set on experimental facility. On the side of upper tank, the acrylic window is installed beside of orifice assembly to check whether the air is entrapped to main pipe by vortex or not. The downward part of main pipe and horizontal part of U-shape pipe also has the 500mm-length acrylic pipe to visualize the flow pattern. To observe and analyze the flow pattern, the video cameras are installed beside of both visualization windows and the dome-type camera is also installed beneath of the roof to observe the situation in upper

Fig. 2. The real constructed image of experimental facility

tank. These cameras are all-synchronized for more detailed analysis. On the lower positioned U-shape tube is used to measure flow rate by attachment of ultrasonic flow meter (UFP-20, Tokyo Keiki). The LOCA positions are two choices with different height (11.58m and 6.58m between the end of siphon breaking line and LOCA) and each LOCA has the flange to vary the exit size. The LOCA position mimics the rupture position of the pipe in real case. Each LOCA position has the butterfly-type valve and it is controlled by air compressor and electric controller. The siphon breaking line is connected by flange to the horizontal part of U-shape pipe. Additionally, the absolute pressure transducers are installed, the one is at bottom of the upper tank to measure the water level and the other is at the near the connection point between siphon breaking line and main pipe. Also, differential pressure transducers are installed, the one is for measuring orifice pressure difference and the other is for measuring the pipe pressure difference along the downward direction of main pipe. NI DAS system is used to gathering the data of all measurement.

2.2 Operation

A typical test run starts with the upper tank full of water. After the previous experiment case, the return pump operates to pull up from lower tank to the upper tank. The return pump is submersible and set in lower tank. At the LOCA #1, the pump is connected and has separated ball valve. Before the start of experiment, the additional step is conducted, the removal of air which is trapped in siphon breaking line. Vacuum pump and buffer chamber are used to remove residual air. Then data gathering and video recording are started and checked.

2.3 Experimental result

Experimental cases differ with siphon breaking line size, LOCA position, LOCA size and orifice setting. Preliminary tests are conducted with 2.5” siphon line size, two LOCA positions, 10” outlet and no-orifice. From the experimental result, the siphon phenomenon was blocked by air inflow through the siphon breaking line and the undershooting length were 330mm at LOCA#1 and 210mm at LOCA#2. This result shows the successful possibility to siphon breaking line and the decreasing trend with decreasing LOCA height. These experiments are still on-going and additional experiments will be conducted to obtain more data.

3. Conclusions

Siphon breaker facility was constructed to conduct experiment about the effect of siphon breaking line. The experimental facility was designed to test the passive operation of siphon breaking line. Some preliminary tests were conducted and show successful possibility. For parametric study, more experiments on siphon breaking line will be achieved in the future.

REFERENCES

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