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Experimental Research of Gas Accumulation according to Variation of Temperature

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1. Introduction

When gases intrude into the reactor safety system or accumulated unexpectedly, various problems may occur as follow: (1) damage to system elements including pipelines and pumps, (2) degradation of reactor fluid devices, (3) reduction in cooling performance and (4) unreliableness on result of accident analyses [1]. Since these problems are not accounted for the analyses of accidental condition, the gas accumulation have to be avoided. Gas can intrude and be accumulated in safety system due to various reasons: (1) leakage from system components, (2) cavitation due to the pressure drops and (3) separation of dissolved gas by temperature or pressure variation [2]. To deal with the gas accumulation phenomena, it is necessary to establish the principle of gas accumulation. In the present study, the separation of dissolved gas by temperature changes in the condition without flow is discussed.

2. Experimental apparatus

The experimental equipment is designed to evaluate the amount of gas created by the variations in temperature and pressure in the conditions without flow. As shown in Fig. 1, the experimental equipment consists of gas volume measuring tank (GVMT), gas accumulator and pressurizer. A band-heater is installed in the gas accumulator to control temperature. A cartridge-heater is installed in the pressurizer to control pressure condition.

When the dissolved gas is separated from the water contained in gas accumulator and GVMT, it is accumulated in GVMT. The amount of gas can be measured using the scale on the visualized wall of GVMT. The actual volume of water contained in the gas accumulator and GVMT is 5.565 L.

3. Results and discussion

3.1. Theoretical prediction

Krofta et al.(2010) show concentrations of air dissolved in water according to various temperatures and pressures as shown in Table. 1 [3].

Based on these values, the volume of accumulated gas(V_{acc}) in a specific temperature(T) and pressure(P) can be calculated as follow:

$$V_{acc} = f(C_0 - C)RV_0\frac{T}{P} \quad (1)$$

where, f denotes dissolving efficiency, C_0 denotes dissolved air concentration at 20 ºC temperature and atmospheric pressure, C denotes concentration at specific temperature and pressure condition, R denotes the gas constant for dry air (287.05 J/kg·K) and V_0 denotes initial water volume.

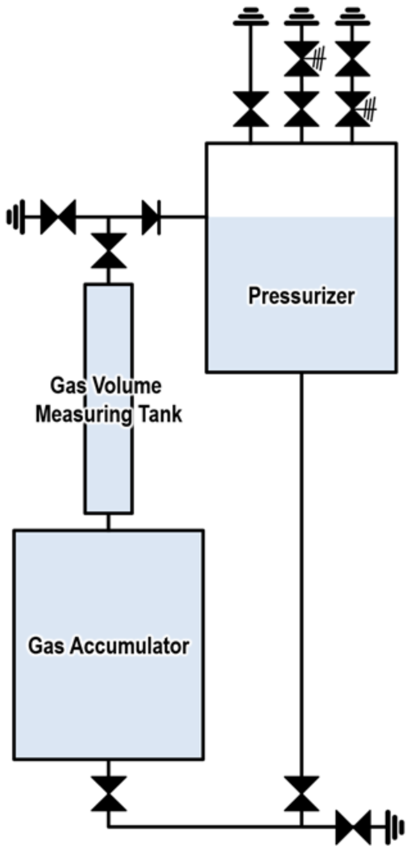

Fig. 1. Schematics of experimental apparatus.

Table. 1. Concentration of air dissolved in water. [3]

Temperature	Pressure		
	1 bar	3 bar	5 bar
20 ºC	24.25 mg/L	72.75 mg/L	121.25 mg/L
40 ºC	18.51 mg/L	55.53 mg/L	92.54 mg/L
60 ºC	15.94 mg/L	47.84 mg/L	79.71 mg/L
80 ºC	15.05 mg/L	45.15 mg/L	75.24 mg/L

Table. 2. Prediction of accumulated gas volume.

Pressure	1 bar
Inner volume	5,565 mL
Dissolving efficiency	80 %
Temperature	**Volume of accumulated gas**
20 ºC	0.000 mL
40 ºC	22.960 mL
60 ºC	35.364 mL
80 ºC	41.503 mL

In the current study, since the initial water volume is same with the volume of water in the gas accumulator and GVMT, it is possible to derive the predicted values shown as Table. 2. It is assumed that the dissolving efficiency is about 80 %, since the water used in the experiment remains stationary without any mixing process for at least one day before testing.

3.2. Experimental results

Fig. 2 shows the volume of accumulated gas when the water is heated from 20 ºC to 80 ºC. The experiment was carried out by heating the water from 20 ºC to 80 ºC under atmospheric condition. When the temperature reached 80 ºC, the temperature was maintained until dissolved gases are no longer separated.

As shown in Fig. 2, the gas accumulation did not occur immediately as changes in temperature. The expected amount of gas was observed after the high temperature was sustained for a considerable period of time. The amount of gas accumulated was approximately same as predicted.

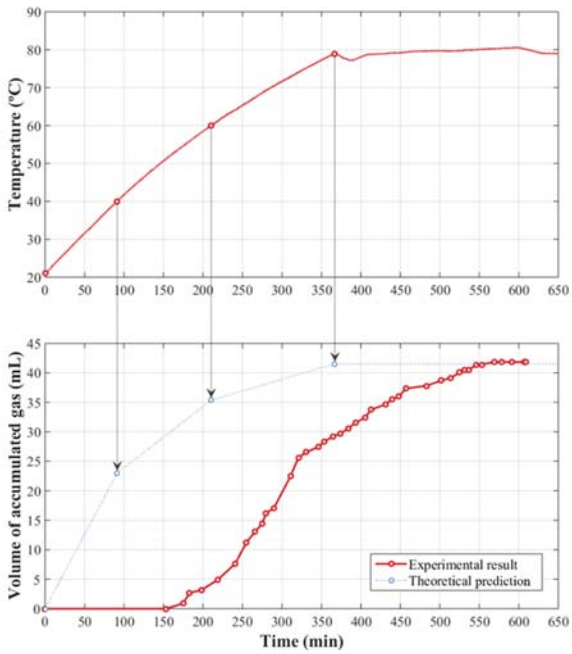

Fig. 2. Experimental result.

Table. 3. Experimental conditions.

Case number	Temperature	Pressure
Case 1	Heating	-
Case 2	Cooling	-
Case 3	-	Pressurizing
Case 4	-	Decompression
Case 5	Heating	Pressurizing
Case 6	Cooling	Pressurizing
Case 7	Heating	Decompression
Case 8	Cooling	Decompression

4. Further works

As a follow-up study, not only the temperature but the pressure variation will be taken into account. As shown in Table. 3, various experimental conditions were designed for the experiment without flow. The experiments are planned to carry out in (2) cooling, (3) pressurizing, (4) decompression and (5-8) combination conditions.

In addition, for observing the gas accumulation under the conditions of flow, the experimental equipment will be installed as shown in Fig. 3. To monitor the accumulated gas due to pressure changes, a section is included in which the pressure drops sharply using a Venturi tube. A heating section is also included to monitor the gas accumulation due to temperature changes.

5. Conclusions

The experiment quantitatively identified the process in which dissolved gases are separated from the coolant and accumulated due to temperature changes in saturated water.

Through this research and further plans, the principle of gas accumulation in accordance with the conditions of

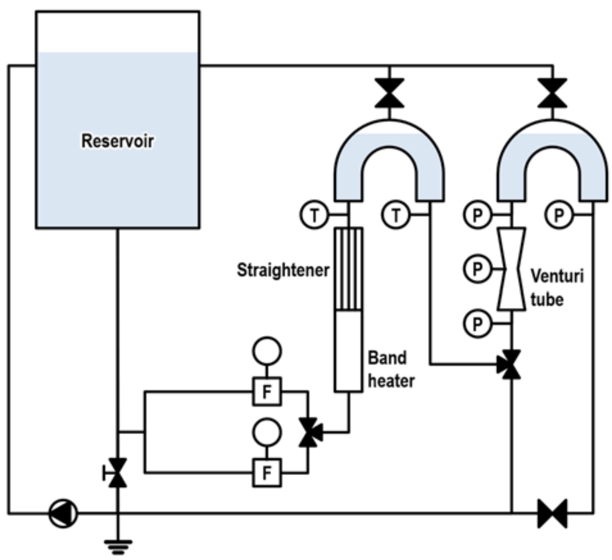

Fig. 3. Equipment concept of experiment with flow.

temperature and pressure can be established. This may contribute to the development of techniques for observing accumulated gas effectively. It also can contribute to enhancing safety of plant operation.

REFERENCE

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[3] Krofta M, Wang LK, Flotation engineering, Lenox Institute of Water Technology, Lenox, MA, Technical Manual No. Lenox/01–05–2000/368, 1st edition, 2000.