Research on fundamental technology for SCWR based on RISA (12th report, Wettability observation in capillary tubes at subcritical condition using neutron radiography)

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In order to evaluate the effectiveness of radiation-induced surface activation (RISA) to an enhancement of metal surface wettability under a subcritical condition, a new method to measure the wettability in small diameter pipes from an observation of a capillary action using neutron radiography was examined.

Keywords: SCWR, RISA, Wettability, Capillary action, Neutron radiography

1. Introduction

From a viewpoint of the importance of fundamental knowledge regarding fluid property in the thermal design and reactor safety analysis of a supercritical water reactor (SCWR), improvement of metal surface wettability due to the RISA under temperatures up to 290 ºC was evaluated in our previous report [1]. It was confirmed that the surface wettability on oxide metals after γ-ray irradiation was improved regardless of specimen type, while the changes in contact angle due to radiation was reduced at high temperatures over 250 ºC. In order to evaluate the effectiveness of the RISA under a subcritical condition with temperature over 300 ºC, we examined a new method to measure the surface wettability based on an observation of a capillary action using neutron radiography.

2. Experimental

A test section for taking the image of water in capillary pipes consisted of a test pipes, manifolds and heater blocks. Stainless-316 pipes with inner diameters of 0.5, 0.8, 1.2, 1.4 and 1.8 mm were used as test pipes. The test section was pressurized at 21 MPa using a nitrogen gas bottle and set at 320 ºC using 3 aluminum heater blocks attached on the bottom, the middle and the top parts of test section. A plunger pump introduced a distilled water into a bottom manifold connecting to the test pipes. Water levels formed in the test pipes were measured by analyzing the test section image obtained by the neutron radiography [2].

3. Results

Figure 1 shows a typical image in the test pipes obtained by the neutron radiography. The water levels in the pipes are increased due to the capillary force in the order of decreasing pipe diameter. Figure 2 shows the relationship between the pipe diameter and the relative water level difference from that in a 0.8 mm-diameter pipe. In the figure, a line indicates the value calculated with a force balance equation which took gravity and surface tension forces into account. The calculated value has a good agreement with the measured data if the contact angle between liquid and pipe wall is assumed to be 33º in the calculation. The result reveals that the proposed method is applicable in evaluating metal surface wettability under high-temperature conditions. The effectiveness of RISA under the subcritical condition will be reported in the presentation.

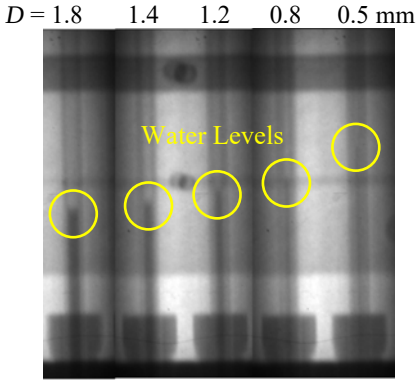

Fig. 1 Typical image in capillary pipes taken by neutron radiography

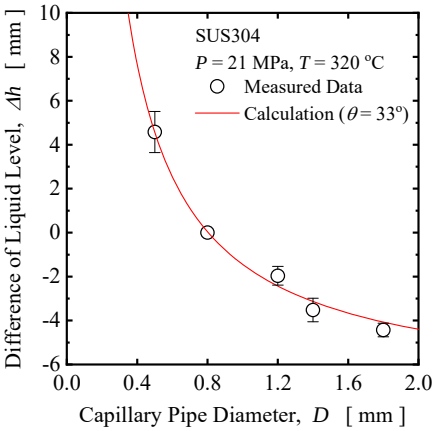

Fig. 2 Relationship between pipe diameter and water level difference

References

[1] W. Susanto, et al., 2018 Annual Meeting of AESJ / Fall Meeting, 2H15, 2018.

[2] I.S. Anderson, R. McGreevy, Z.Hassina Bilheux (Eds.), Neutron Imaging and Applications, Springer, Berlin, 2009.