Analysis of the Peak Temperature within a Sodium-Water Reaction Jet

Ji-Young Jeong, Tae-Joon Kim, Jong-Man Kim, Byung-Ho Kim
Fluid Engineering Division, Korea Atomic Energy Research Institute
150 Dukjin-dong, Yusong-Gu, Taejon, Korea, 305-353
jyjeong@kaeri.re.kr ; tjkim@kaeri.re.kr; kimjm@kaeri.re.kr; bhkim1@kaeri.re.kr
Nam-Cook Park
Chemical Engineering Division, Chonnam National University
300 Youngbong-dong, Buk-Gu, Kwangju, Korea, 500-757
ncpark@chonnam.ac.kr

1. Introduction

One of the important problems to be solved in the design and construction of a sodium cooled fast reactor is to confirm the safety and reliability of the steam generator which transfers the heat from the sodium to the water. Sodium-water reaction events may occur when material faults such as a pinhole or crack occur in the heat transfer tube wall. [1-3] The injection of a high velocity jet of water into sodium produces a violent chemical reaction with the formation of corrosive reaction products, the generation of heat, and the formation of particles and/or jets of the reactants and products moving at high velocities. When such a leak occurs, it is postulated that the wastage of a tube surface in the proximity of a reaction could be the result of a combination of both an erosion and a corrosion by the reactants and the reaction products, and that the wastage is further accelerated by the heating of a tube surface as a result of the heat generated by the sodium-water reaction. Therefore, it is very significant to determine the peak temperature within a sodium-water reaction jet from the view of designing a steam generator. [4,5]

2. Experimental

2.1 Experimental apparatus

Figure 1 shows the small leak sodium-water reaction test facility used for this study. It mainly consists of two reaction vessels, a sodium circulation circuit, sodium and a steam supply system, a sodium purification system, and a drain system. The entire loop including the reaction vessel and piping lines are filled with sodium and high pressure steam is injected into the reaction vessels. Tests were conducted in a reaction vessel (2). During the tests, any hydrogen with entrained sodium was vented from the reaction vessels to the atmosphere through a vapor trap

2.2 Experimental procedure and conditions

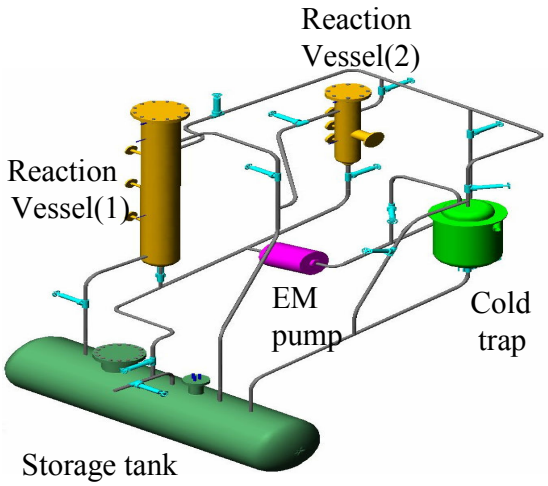

Figure 1. Experimental apparatus

Steam was injected into the sodium from a steam reservoir through an injection nozzle at a 87kg/cm^2 pressure and 300℃ temperature. The initial size of the nozzle hole which was used in the tests was 0.2mm in diameter. And the initial leak rate was 0.38g/sec H_2O. These nozzle specimens were exposed to small leaks of steam/water in a 300℃ stagnant sodium. Before opening and after closing the steam injection valve, argon gas was bubbled into the sodium through the injection nozzle in order to prevent a nozzle blockage. The injection duration was determined from the opening and closing signals of the injection valve.

3. Results and Discussion

A series of tests was conducted to determine the peak temperature within a sodium-water reaction jet. The measuring tool used for the influence range of the reaction jet in shown in Figure 2. It has twenty one thermocouples which are arranged in a concentric circle form. Measuring distance of the peak temperature within a sodium-water reaction jet was determined to be 10, 17, and 27mm from the measuring tool to consider the neighboring tube space

in a steam generator and the theoretical maximum jet flame length which was derived by Dumm of INTERATOM. [6]

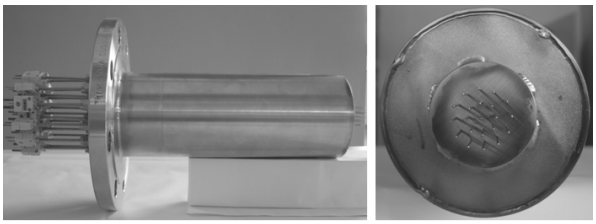

Figure 2. Measuring tool for the peak temperature within a sodium-water reaction jet

As shown in Figure 3, the peak temperature within a sodium-water reaction jet appeared at a 17mm point from the measuring tool.

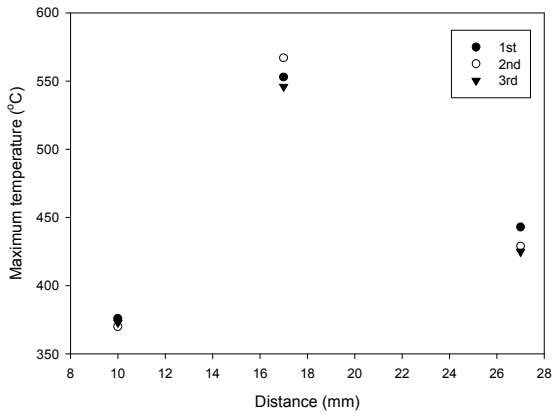

Figure 3. Peak temperature within a sodium-water reaction jet as a function of the measuring distance

This is the point which agrees with the theoretical maximum distance which is affected by a reaction jet. But it was very difficult to measure the peak temperature within a sodium-water reaction jet accurately because of the reactions which occur instantaneously on a jet flame surface with a very thin film (0.7~1mm) as shown in Figure 4.

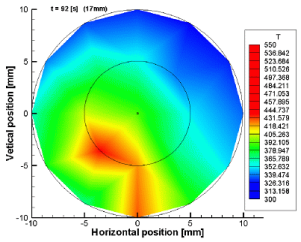

Figure 4. Axial temperature profile

3. Conclusions

A series of tests was conducted to determine the peak temperature within a sodium-water reaction jet. The peak temperature appeared at a 17mm point from the measuring tool which agrees with the maximum distance which is affected by a jet flame. The data obtained from this study will be used to prepare the design criteria and design analysis procedures for steam generators from the point of view of sodium-water reactions.

ACKNOWLEDGEMENT

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