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Self-wastage Behavior of Modified 9Cr-1Mo Steel as Heat Transfer Tube Material for a SFR SG

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1. Introduction

Sodium cooled fast reactors adopt sodium heated steam generators in a secondary sodium circuit to raise the steam to drive the turbine. In most cases these steam generators are of a shell-in tube type, with a high pressure water/steam inside the tubes and low pressure sodium on the shell-side, with a single wall tube as a barrier between these fluids. Therefore, if there is a hole or a crack in a heat transfer tube, a leakage of water/steam into the sodium may occur, resulting in a sodium-water reaction. [1-4] When such a leak occurs, there results an important phenomena, so-called "self-wastage" which may cause damage to the inside of the leakage site itself. If a steam generator is operated for some time with this condition, it is possible that it will damage the leak hole itself, which may eventually become a much larger opening. There is a danger that the resultant leak rate caused by a self-wastage might create the state of a small leak, or even an intermediate leak which would then give rise to the problems of a multi-target wastage. It has been observed in this study and others that the diameter of the nozzle hole grows to become a larger size in a very short time.[5-6] Therefore, it is very important to predict these phenomena quantitatively from the view of designing a steam generator and its leak detection systems. The objective this study is a basic investigating of the sodium-water reaction phenomena by small water/steam leaks.

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 is 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

Figure 1. Experimental apparatus

2.2 Experimental procedure and conditions

Circular type defects were used in these tests whose diameter ranged from 200~300 micrometer. These nozzle specimens were exposed to small leaks of steam/water in 300 and 340℃ stagnant sodium. Steam was injected into the sodium from a steam reservoir through an injection nozzle at a 80kg/cm^2 pressure and 300℃ temperature. And the average steam leak rates were in the range of 0.34 to 0.77g/sec H_2O before the self-enlargements. 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. Enlargement rate of the nozzle opening itself was analyzed using CAMSCOPE images.

3. Results and Discussion

Self-wastage tests were conducted by use of a small leak sodium-water reaction test facility to clarify the self-enlargement behavior of modified 9Cr-1Mo steel, as a

new steam generator tube material for the GenⅣ SFR. Figure 2 shows the result of the comparative experiment for the resistivity against a self-wastage of 2.25Cr-1Mo steel and modified 9Cr-1Mo steel which is the candidate materials for a SFR steam generator tube. Through the tests, we could confirm modified that the 9Cr-1Mo steel was more wastage-resistant than the 2.25Cr-1Mo steel.

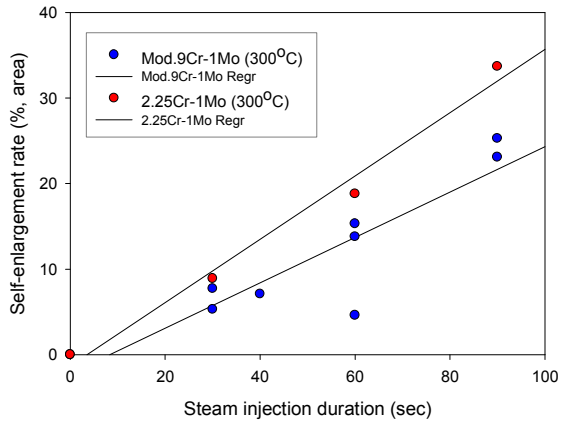

Figure 2. Enlargement rate of the nozzle opening size as a function of time

And it was also confirmed that the self-enlargement rate was apparently dependent on the sodium's temperature. (Figure 3)

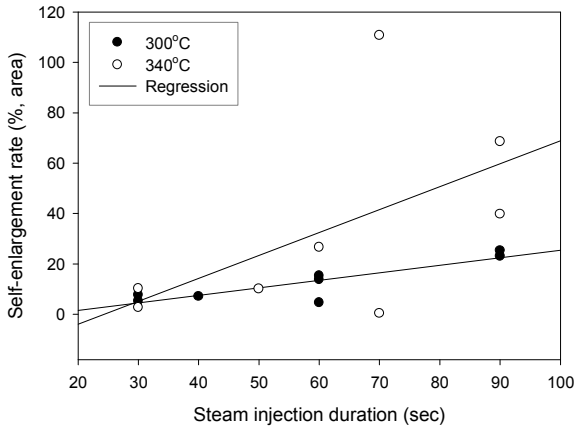

Figure 3. Effect of the sodium temperature on the enlargement rate

However, the nozzle thickness and the initial nozzle opening size were not strongly affected by those experimental parameters.

3. Conclusions

A series of tests was conducted to clarify the self-enlargement behavior of modified 9Cr-1Mo steel, as a new steam generator tube material for the GenIV SFR. Self-enlargement rate was apparently dependent on the tube materials and sodium temperature. 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.

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