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# Analysis of the Self-wastage Phenomena caused by Small Water/Steam Leaks

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## 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] When such a leak occurs, it results an important phenomena, so called "wastage" which may cause damage to or a failure of the adjacent tubes. Another type of phenomenon is a "self-wastage" which is not wastage on a wall of the adjacent tubes, but which occurs on the inside of the leakage site itself. If a steam generator is operated for some time with this condition, it is possible to damage the leak hole itself, which may eventually enlarge into 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. [4, 5] Therefore, it is very significant to predict these phenomena quantitatively from the view of designing a steam generator and its leak detection systems. [6, 7]

## 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. During the tests, any hydrogen with entrained sodium was vented from the reaction vessels to the atmosphere through a vapor trap

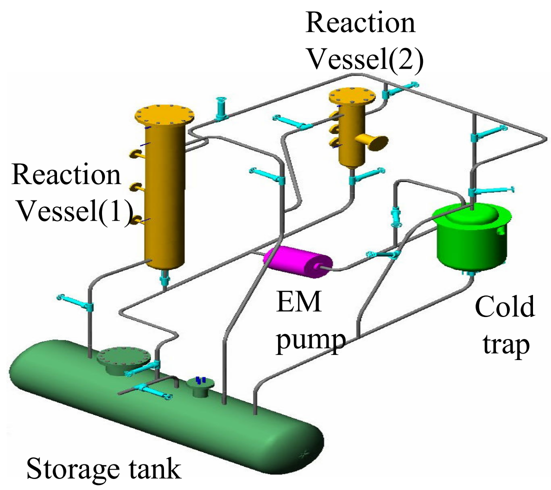


Figure 1. Experimental apparatus

### *2.2 Experimental procedure and conditions*

Steam was injected into the sodium from a steam reservoir through an injection nozzle at a 87kg/cm$^2$ pressure and 300℃ temperature. The injection nozzle had openings from 0.1 to 0.3mm in diameter. And the width, length and thickness of all the nozzles which were used in tests were 10, 10 and 3.5mm, respectively. These nozzle specimens were exposed to small leaks of steam/water in 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. 2.25Cr-1Mo steel and M.9Cr-1Mo steel were chosen for the test specimen material.

## 3. Results and Discussion

A series of tests was carried out to investigate the enlargement rate of a nozzle hole itself with time for 2.25Cr-1Mo and M.9Cr-1Mo steel. 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 $H_2O$. Enlargement rate of the nozzle hole itself was measured at 30 second intervals. As shown in Figure 2, the phenomenon where the size of the nozzle hole became larger with an increasing duration of the steam injection appeared together from the two type's of material.

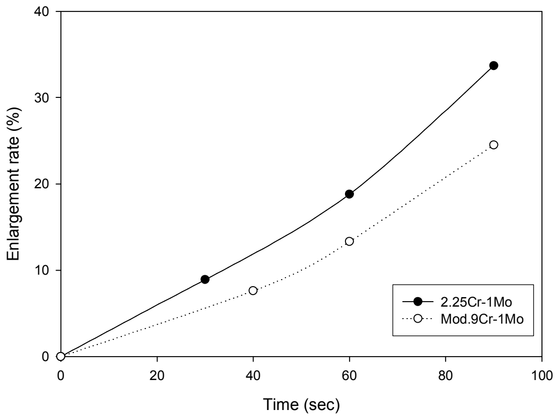


Figure 2. Enlargement rate of the nozzle hole as a function of time

The cause of it can be accounted for by a hot caustic corrosion of the metal surrounding the nozzle hole and loose grains of the base metal by the action of the steam jet. [5] This was confirmed by analyzing the nozzle hole and surface on the sodium side using SEM-EDX and CAMSCOPE. As shown in Figure 3, complicated oxide compounds are deposited onto the nozzle surface. It is assumed that they are a $(NaOH+Na_2O) \cdot Fe_xO_y$ and $(NaCrO_2+Na_2CrO_4)$ mixture.

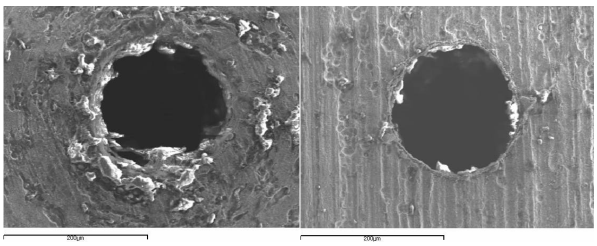

Figure 3. SEM images of the nozzle surface after the sodium-water reaction

Enlargement rate was slightly larger in the 2.25Cr-1Mo steel than in the M.9Cr-1Mo steel. Based on the cross-sectional area of a nozzle hole after a 90 second injection testing, it is estimated that the size of the nozzle hole became larger by about 1.34 times when compared with the initial value for the 2.25Cr-1Mo steel.

Post test examination showed that the nozzle hole maintained its circular shape. (Figure 4)

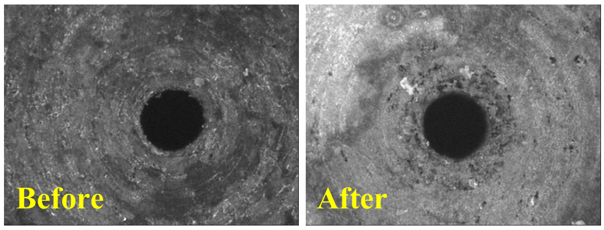


**Figure 4. CAMSCOPE images of the nozzle hole**

## 3. Conclusions

A small leak sodium-water reaction test facility was designed and constructed. And a series of tests was carried out to investigate the enlargement rate of the nozzle hole itself associated with needle-like jets of a high-pressure water/steam into the sodium side of a steam generator. 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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