Wastage Characteristics of a Modified 9Cr-1Mo Steel Tube Material for a SFR SG

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1. Introduction

The development of a sodium heated steam generator with a safety and reliability is an essential requirement from the viewpoint of the economical efficiency of a sodium cooled fast reactor. In most cases these steam generators which are in the process of development, or operating, 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, important phenomena, so-called "wastage" is the result which may cause damage to or a failure of the adjacent tubes. If a steam generator is operated for some time with this condition, it is possible that it might create an intermediate leak state which would then give rise to the problems of a multi-target wastage 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 of this study is a basic investigating of the sodium-water reaction phenomena by small water/steam leaks. For this, wastage tests for modified 9Cr-1Mo steel are being prepared.

2. Experimental

2.1 Definition of a small leak

A small leak is one in which a coherent reaction jet of a size capable of impinging on one or two heat transfer tubes is formed, causing damage to them mainly by a wastage. Small leaks are generally in the range of 0.1 to 50g/sec (0.05 to 10g/sec in Japan). [7]

2.2 Experimental apparatus

The tube materials wastage tests at KAERI were conducted in a small leak sodium-water reaction test facility-2. A schematic diagram is shown in Figure 1. It mainly consists of a reaction vessel, sodium and steam supply system, and a drain system. The reaction vessel is a 13.8-in.-diameter by 25.6-in.-long stainless steel vessel; the sodium feed line is a 1/2-in. stainless steel tube. During the tests, any hydrogen with entrained sodium was vented from the reaction vessels to the atmosphere through a vapor trap.

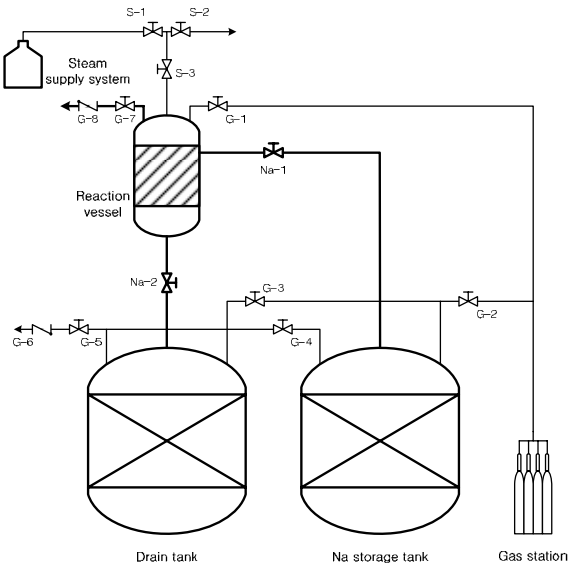

Figure 1 Experimental apparatus

2.3 Experimental procedure and conditions

Circular type defects were used in these tests whose diameter ranged from 200~400 micrometer. And the targets of an actual tube shape and size were used. Figure 2 shows the steam injection nozzle and target assembly. These assemblies were exposed to small leaks of steam in 400 and 450℃ stagnant sodium. Steam was injected to the target from a steam supply system through this assembly at a 150kg/cm^2 pressure and 350℃ temperature. Modified 9Cr-1Mo steel was chosen for the test specimen material, because this material was specified for the heat transfer tube for a KALIMER-600 steam generator. Based

on previous works, the sodium level above the steam injection point was established as variably. Because it has been proven that the effect of the sodium level on the wastage is negligible so long as the target tube is submerged in the sodium.

Figure 2 Nozzle and target assembly

3. Results and Discussion

Small leak wastage tests were conducted for modified 9Cr-1Mo steel in a small leak sodium-water reaction test facility-2. Tests were made to determine the effect on modified 9Cr-1Mo steel wastage rate of water leak rate, leak nozzle to target distance, and sodium temperature. The result for wastage rate versus leak nozzle to target distance for these tests in 400℃ stagnant sodium is shown in Figure 3. It showed that the tube spacing had a significant effect on tube material wastage rate. And also it showed that the wastage rate increased as the leak rate increased.

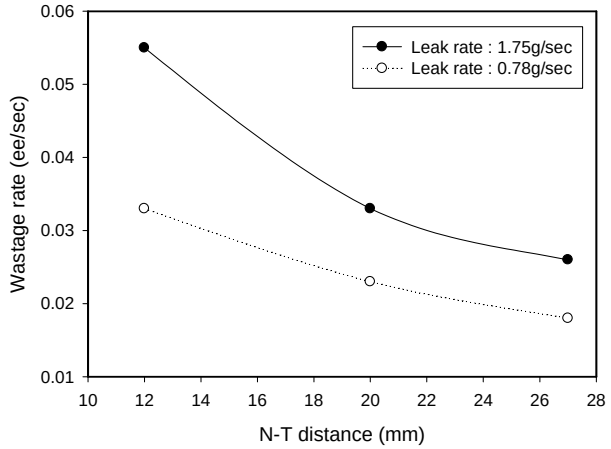

Figure 3 Relation between wastage rate and leak nozzle to target distance

Post-test examination of target tubes was performed to provide accurate data on the area, depth, and volume of the damaged zone. These examinations were carried out by Opto Mechanical Associate (OMA), Yuseong-gu, Daejeon. Measurement of the area and depth of the damaged regions was made with a ATOS 3D Digitizer which delivers three-dimensional measurement data for industrial components such as sheet metal parts, tools and dies, turbine blades, prototypes, injection molded and casted parts. A typical measurement instance is shown in Figure 4.

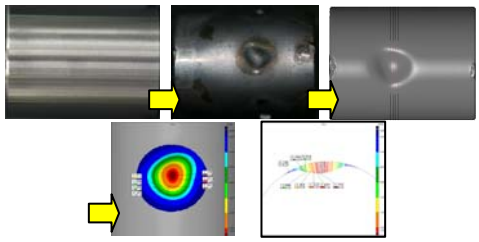

Figure 4 Post-test examination process of target tube by ATOS 3D Digitizer

3. Conclusions

A series of tests was conducted to clarify the wastage behavior of modified 9Cr-1Mo steel, as a steam generator tube material for KALIMER-600. The data obtained from this study will be used to prepare the design criteria and design analysis procedures for these steam generators from the point of view of sodium-water reactions.

ACKNOWLEDGEMENT

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REFERENCES

[1] M. Hori, Atomic Energy Review, 18, 708 (1980)
[2] NAOMICHI KANEGAE et al., Nucl. Technol., Vol. 40, 261 (1978)
[3] R. N. Newman, C. A. Smith, J. Nucl. Mater., Vol.52, 173 (1974)
[4] Harry V. Chamberlain et al., ANL-7520, 384 (1968)
[5] D. W. Sandusky, Trans. ANS, Vol.19, 106 (1974)
[6] J. R. Donati et al., Nucl. Mater., Vol.54, 217 (1974)
[7] A. M. Judd, et al., Nucl. Energy, Vol.31, 221 (1992)