Wastage-Resistant 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 will be 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 is vented from the reaction vessels to the atmosphere through a vapor trap.

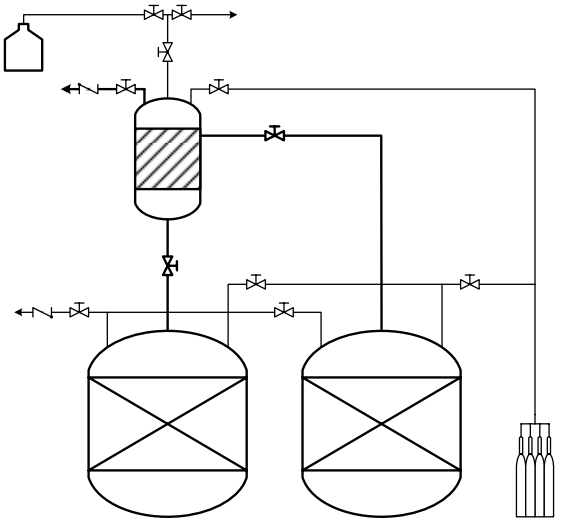

Figure 1 Experimental apparatus

2.3 Experimental procedure and conditions

Circular type defects are used in these tests whose diameter ranged from 200~400 micrometer. And targets of an actual tube shape and size are used. Figure 2 shows the steam injection nozzle and target assembly. These assemblies are exposed to small leaks of steam in 400 and 450℃ stagnant sodium. Steam is injected to the target from a steam supply system through this assembly at a 150kg/cm^2 pressure and 340℃ temperature. Modified 9Cr-1Mo steel was chosen for the test specimen material, because this material was specified for the heat transfer tube for a GenⅣ SFR steam generator.

Figure 2 Nozzle and target assembly

Based on previous works, the sodium level above the steam injection point is 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 3 shows the calculated results for the maximum length of the reaction flame jet according to the saturated steam temperature and the opening size of a leak hole.

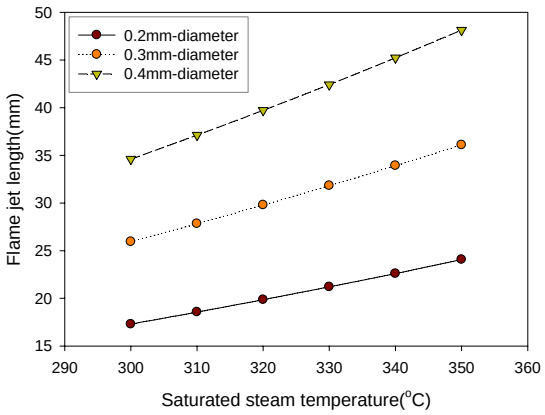

Figure 3 The relationship of the flame jet length with the saturated steam temperature, and the opening size of leak hole

And Figure 4 shows the calculated results for the steam leak rate according to the opening size of a leak hole at steam temperatures of 340 and 350℃ respectively.

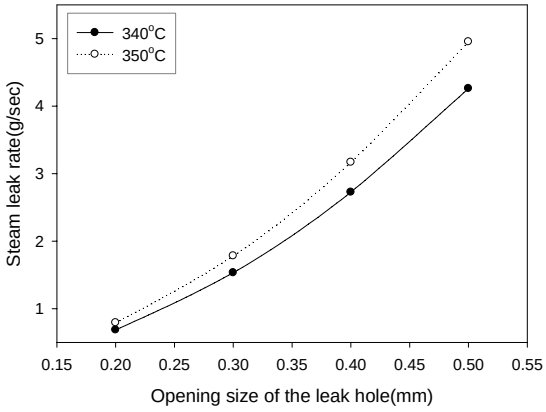

Figure 4 Steam leak rate according to the opening size of the leak hole at steam temperatures of 340 and 350℃

2.4 Work scope

The items to be established through this study are as follows.

- L/D for the maximum wastage rate
- Relation between the wastage rate and the steam injection rate
- Relation between the wastage rate and the sodium temperature
- Relation between the wastage rate and the tube wall thickness

3. Conclusions

A series of tests will be conducted to clarify the wastage behavior of a modified 9Cr-1Mo steel, as a steam generator tube material for the GenⅣ SFR. 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)