Sodium-Water Reaction Characteristics by Micro Water/Steam Leakage Experiments

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1. Introduction

Liquid Metal Fast Breeder Reactor (LMFBR) will be one of the most important power plants in the future. Liquid sodium is generally recommended as a coolant of the LMFBR, and is chemically a very reactive material. So the sodium-water reaction in the heat transfer system due to defects such as a pin-hole, breach, and a weld inferiority of the heat transfer tube, will be the most important problems from the safety aspects of the LMFBR[1,2]. If the sodium-water reaction was to occur from a micro/small water (steam) leakage, it has been observed that a micro/small water(steam) leakage to the liquid sodium can cause serious self-damage to the heat transfer material which is known as the "self-wastage" phenomenon[3]. The purposes of this study are to grasp the characteristics of the micro/small sodium-water reaction, the corrosion/erosion phenomena onto the water(steam) leakage site of the specimen, and the temperature rise onto the target surface from the micro/small water(steam)leakage occurring on the surface of the heat transfer material which is ferrite steel.

2. Experimental

The micro/small water(steam) leakage experimental apparatus mainly consists of the sodium-water reaction reactor, injector, specimen, and target, as shown in Figure.1.

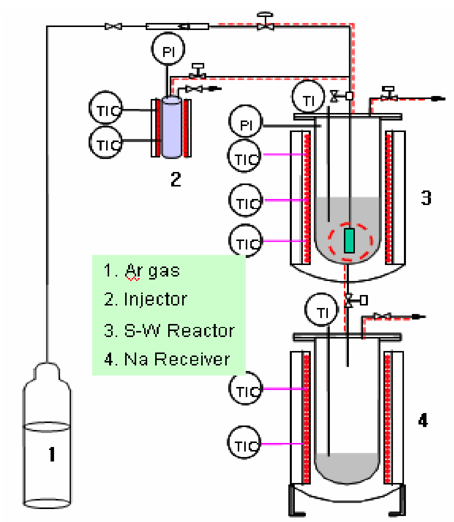

Figure.1. Experimental apparatus.

The specimen used in these micro/small water (steam) leakage experiments is 5Cr-1Mo ferrite steel. For the micro/small water(steam) leakage at a high temperature and high pressure, the specimen is manufactured to a crack-form after pressing the hole, the size is about 150㎛, prepared and fabricated by an the electric arc discharge method. Also, for the measurement of temperature rise at the target surface by the sodium-water reaction, the thermocouples are attached to the back of the target.

3. Results and Discussion

3.1 Temperature characteristics

Micro/small water(steam)leakage experiments are carried out under the following conditions;
-liquid sodium temperature: 400℃
-water quantity: 15㎖
-leaking temperature: 250℃
-sodium state: static

The temperature profile obtained at the target surface is plotted in Figure 2. The water(steam) leakage started when the temperature of the liquid sodium into the sodium-water reaction reactor reached 400℃ and the liquid water in the injector was vaporized to a high pressure vapor by an outside heating.

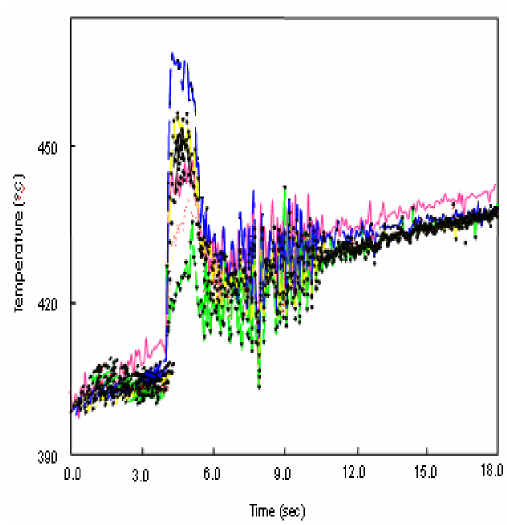

Figure.2. Temperature profile at the target surface.

The target surface temperature was rapidly and locally raised from the sodium-water reaction by a micro/small water(steam) leakage. The temperature rise at the target surface was observed to be 70~80℃ at contacting point and the temperature of the adjacent parts of the target showed about 430℃.

3.2 Corrosion characteristics

When a micro/small water(steam) leakage occurred from a crack of the specimen, a self-wastage phenomenon occurs by a corrosion and erosion by the sodium-water reaction products. In these experiments, the corrosion phenomenon of a specimen caused by the sodium-water reaction, owing to the micro/small water(steam) leakage, was confirmed with the EPMA analysis, as shown in Figure 3.

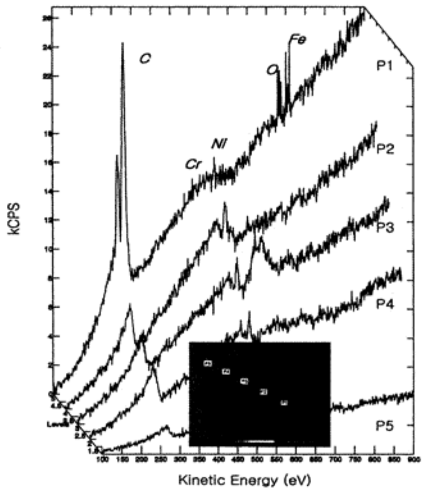

Figure.3. EPMA analysis curves.

In this figure, the kinetic energy peaks of the C, O, Fe elements appear at *ca* 300, 510, and 680~700 eV, respectively. The peak changes of these elements were much broader than those of the other elements, such as Cr, Mo, Ni and V. The compositional changes of each element in a specimen, before and after the experiment, are shown in Table 1.

Table 1 Composition changes at leak site.

	Weight %					
	Cr	Ni	Fe	Mo	V	Na
Before	6.82	0.58	89.54	1.73	1.33	-
After	5.41	1.37	86.72	-	-	6.49

4. Conclusion

In this study we observed and analyzed the corrosion phenomenon at a leakage site and the temperature rise at the target surface by a sodium-water reaction through a micro/small water(steam) leakage in a liquid sodium atmosphere. The temperature of target surface increased to about 70~80℃ by the heat of the sodium-water reaction even with a micro/small water(steam) leakage of 15 ㎖ of water. From the results of the EPMA and EDX analysis, there was a decrease of the Fe, Cr, and Ni contents, at the corrosion site of the leak specimen, but its mechanism is not fully understood. It is believed that the segregation phenomenon was due to the exothermic heat, the corrosive sodium compounds formed by the sodium-water reaction, and the deposits produced by reaction products and material matrix. .

ACKNOWLEDGEMENT

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