

The effect of NiB on the denting corrosion at the heated crevice environment

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1. Introduction

The denting of PWR steam generator tubes as a result of corrosive attack of the carbon steel support plate/tubesheet can make the mechanical deformation of the S/G tubes during operation. It has been reported that the growth of the corrosion products between tube and tube support plate/tubesheet is the one of the source to the various types of Stress Corrosion Cracking (SCC).[1-8] Denting can be occurred when brackish or seawater is used for the cooling system in the nuclear power plants. On the other hand, it has been known that oxidizers such as dissolved oxygen can create acidification at the crevice region in the case of pure-water cooling.[2] These factors regarding the denting phenomenon have been evaluated based on the concentrations of dissolved oxygen, chloride ion, temperature, pH, crevice geometry, and so on. In this work, we would investigate the effect of NiB on the denting corrosion rate.

2. Experimental procedure

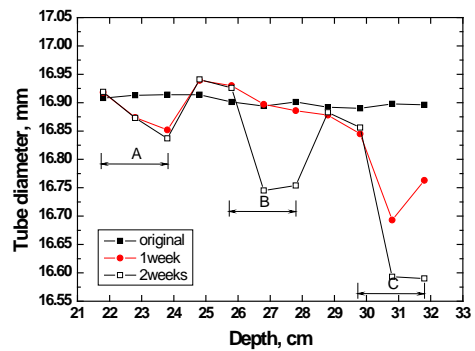
A denting autoclave design was prepared for a static autoclave system. A cartridge heater was located inside an Alloy600 tube. Before the test, the tube diameter was measured using a bore gauge. We checked the variation of the tube diameter every 1week. The inner section of the Alloy600 tube was filled with 25ml of pure water, and the outside was filled with a 1.6L solution of 35,000ppm NaCl + 0.2 M CuCl₂ at the crevice gap size test and added 4g/L NiB powder in the second test. SA508 rings were attached to the outside of the alloy600 tube. The crevice geometry was 100, 200 and 200 μm rings was supported on the Alloy600 plate at the bottom to prevent corrosion products from falling. To create a boiling state, a heat flux flow from inside to outside the tube was conducted. The temperature of the tube inside was maintained 300°C, crevice 290°C, autoclave 280°C. The images of the corrosion products were observed by Scanning Electron Microscope (SEM).

3. Results and Discussion

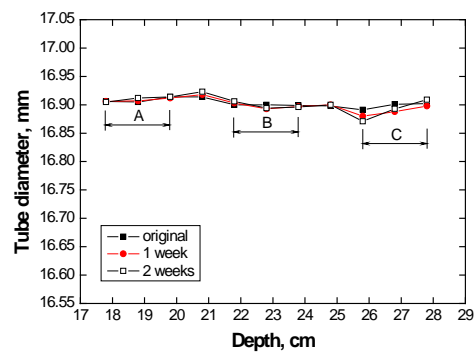
3.1 The effect of the crevice gap size

Heated crevice denting test was performed to observe the variation of the Alloy600 tube diameter. Fig. 1.

shows the decreasing of the tube diameter with increasing crevice gap size in a solution containing 35,000ppm NaCl + 0.2M CuCl₂. The mark A is the 100 μm , B is 200 μm and C is 200 μm + Alloy600 plate specimens. As a result, the denting corrosion rate was increased with the increasing of the crevice gap sizes. The test also revealed that the corrosion rate of 200 μm + Alloy600 plate crevice gap size had the fastest denting rate.



(a)



(b)

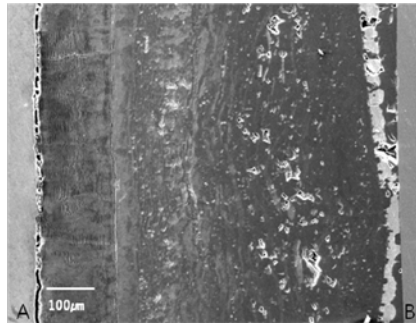
Fig. 1. Tube diameter variation with and without NiB powder in a same solution condition. (a) without NiB (b) with NiB

3.2 The effect of NiB powder on the denting behavior

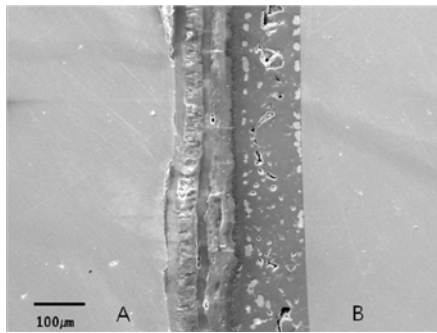
The reduction of the tube diameter was almost stopped by adding 4g/L NiB powder in the all range of crevice gap sizes. Fig. 2. shows that the corrosion products of 200 μm crevice gap size + Alloy600 plate specimen. The large corrosion products could be

observed at the specimen without addition NiB powder. On the other hand, the corrosion product of the specimen with NiB powder was narrow. The mechanism of the NiB effect is not established well. D.-J. Kim et al.[9] have reported the addition of the NiB decreased PbSCC occurrence. In this paper, NiB is easily attached than PbO on the Alloy600 surface. Therefore NiB might be attached the SA508 carbon steel, Alloy600 tube or impeding the formation of the corrosion product at the crevice.

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(a)



(b)

Fig. 2. SEM images of the corrosion product between SA508 ring(A) and Alloy600 tube(B) in a solution containing (a) 35,000ppm NaCl without NiB (b) 35,000ppm NaCl with NiB

4. Conclusions

The simulated heated crevice test was performed to measure changing of the tube diameter caused by the denting corrosion. The results showed that all the range of the tested crevice gap size (100~200 μm) specimens were decreased the diameter. But the reduction of the tube diameter was almost stopped by adding NiB powder. Therefore, NiB can be useful additive for alleviating corrosion caused by denting.

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