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Study on the effects of Ni-plating process parameters on the properties of Ni-deposit.

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1. Introduction

As the operating period of nuclear power plants(NPPs) increases, the materials used for the key components and/or facilities in nuclear power plants are deteriorated and finally failed to trip NPPs accidently and unexpectedly, resulting in huge amount of economic loss due to their maintenance and loss of plant operational efficiency. Therefore, in order to prevent or mitigate such materials degradation, the Ni-plating technique in a sulfamate solution was studied to optimize electroplating conditions. In this study, a proactive mean for the effective management such as preventing steam generator tubes from any potential corrosion damage including stress corrosion cracking occurring during operation of nuclear power plants was proposed with Ni-plating.

2. Experimental

Commercial Alloy 600 HTMA (high temperature mill annealed) was used for this study. Before Ni electroplating, the tube specimens were cleaned with acetone and then immersed in 5 vol.% H_2SO_4 to activate the specimen surfaces for deposition of a Ni strike layer. The strike layer was deposited on the ID and the OD surfaces of the tube specimens in an aqueous solution of 1.6 mol/l $NiCl_2$ + 0.6 mol/l H_3BO_3 at 40°C for about 2.5 min., then Ni-electroplating was performed in an aqueous solution of 1.39mol/l $Ni(SO_3NH_2)_2$ + 0.65mol/l H_3BO_3 at 60°C for 40 min. For electrodeposition of Ni-alloys, During the strike layer deposition and Ni electroplating, a direct current was applied between the tube specimens and a Ni anode at different current After electroplating, microstructures, thermal stability of the Ni-deposit were investigated and also its corrosion tests were performed in 40% NaOH at 315°C.

3. Methods and Results

*Microstructure **of** Ni-electroplated layers*

From the microstructure observation, the grain size of the electroplated Ni layers obtained under the conditions used in this study is submicron. And, the grain size of the Ni layer is observed to increase as the applied current density increases, which is a very effective variable to control the grain size, the mechanical property, and thus possibly the stress corrosion cracking susceptibility of the Ni electroplated layer.

Thermal stability

The Ni layer plated on the steam generator tubes should be stable at the operating temperature of NPPs for a long period of operating time. According to the test results, the hardness of the Ni layers shows to decrease relatively smoothly as the test temperature increases. But at around 350° C which is close to the operating temperature of NPPs, the hardness drops steeply, that may be assumed to be attributed to high grain size growth and/or recrystalization of the Ni Layers at around the temperature, as seen in the figure below.

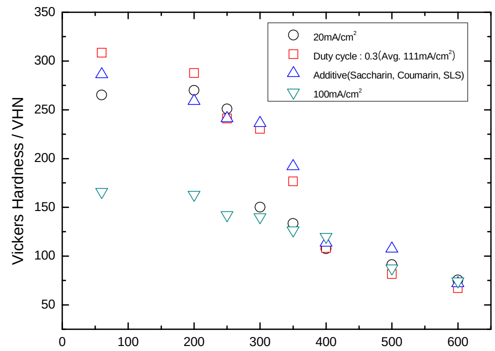

Fig. Hardness variation of Ni layers electroplated in different conditions as a function of test temperatures

. As seen in this figure, the hardness of Ni layer electroplated at an applied current density of 100 mA/cm^2 is the lowest value, which means that its grain size is largest compared to that of other Ni layers. However, at test temperature of 400° C or over, the hardness of all the Ni layers decrease and become close each other.

Corrosion test results of Ni-layer

the C-ring test results obtained from the specimens Ni-plated only on the ID tested for 7 days showed that SCC was initiated from the OD bare surface, propagated toward the ID but arrested at the interface of the Ni-layer. This means that the Ni layer plated on the Alloy 600 tube surface can prevent the propagation of secondary side ODSCC for Alloy 600 SG tube even in a strong caustic solution. In addition, the Ni layer electroplated on the tube surface was observed to prevent stress corrosion crack initiation in caustic solution, no crack was formed but only general corrosion was occurred.

4. Summary

In this study, applicability of a nickel-plating technique was investigated for a possible proactive method to prevent or mitigate SCC of PWR SG tubing. From the results of this study, it may be concluded that the Ni-plating can prevent or mitigate SCC occurring in operating SG tubes. So, this technique could become a proactive method adaptable to steam generator tubes and other key components of NPPs to prevent or mitigate corrosion damage.

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