Corrosion Test of Materials for I-S Process in Boiling Sulfuric Acid

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1. Introduction

Hydrogen is a promising secondary energy source for the next generation. Hydrogen can be used as a clean fuel in a variety of energy end-use sectors including the conversion to electricity. [1] It can be stored, and also can be transported long distance with lower loss compared to electricity.

Thermochemical water splitting process (Iodine-Sulfur Process, I-S process) is method to make an effective use of the high temperature heat for hydrogen production. [2] KAERI has started the program for developing High Temperature Gas-cooled Reactor (HTGR) for hydrogen production.

Since the IS Process uses a corrosive halogen and sulfuric acid, components materials for apparatus must be carefully selected. [3] In this study, the corrosion properties of 18 commercial materials were evaluated in boiling sulfuric acid

2. Experimental Procedure

In this study, all tests were performed in boiling sulfuric acid condition. 18 commercial materials (Fe-Cr alloys, Ni base alloys, stainless steels, ceramics, etc) were tested.

2.1 Specimens

Materials were listed in table 1. 18 materials were test in boiling sulfuric acid condition. Materials were divided to Fe-Cr, Ni base alloys and stainless steels. To perform the corrosion test, specimens were made 20mm x 20mm x 1mm plate shape with 5mm diameter circular hole for setting up.

2.2 Immersion test

The immersion tests were performed in 97% H_2SO_4 solution. The tests were performed in a pyrex glass flask with a capacity of 1L. The flask was heated on the hot plate to maintain a stable boiling condition. Evaporized sulfuric acid solution was liquidified in a reflux condenser to minimize the evaporation loss. The immersion test period was 24hours, and the test solution was not refreshed during the immersion test. The immersion period defined as the time between the moment boiling began and the moment when the heater was shut down. [3]

The weight difference before and after the immersion test was measured using an electronic balance. Before weighing specimens were washed ultrasonically in acetone for 5min.

3. Results and Discussion

Corrosion rates were measured with weight changes after immersion test, and the surfaces observation was performed for each specimen.

3.1 Corrosion rate in boiling sulfuric acid

Figure 1 shows the corrosion rate in boiling sulfuric acid condition. The corrosion rates of Fe-Cr alloys were considerably faster than other alloys. SiC had best corrosion resistance. (The corrosion rate of SiC was 0.04mm/year) The Ni-base alloys have better corrosion resistance than other alloys except alloy 600. Sanicro 28 alloy 800 had better resistance than other stainless steels.

In the test of Fe-Cr alloys, the corrosion rate was increased with decreasing Cr contents. From the test results, the corrosion rate of Fe-Cr alloys were related to the Cr. In other alloys (Ni-base alloys, stainless steels) test, the corrosion rate were not largely affected by Cr contents.

3.2 Surface observation

The cracks were found in the alloy 600 and alloy 800 surfaces. In the case of alloy 600, cracks were found in grain boundaries. From the microstructure observation, carbides were distributed in the grain boundary region and these carbides affected the grain boundary cracking.

The partial corrosion marks were found in the surfaces of stainless steels. In the case of Fe-Cr alloys, the general corrosion marks were observed in surfaces.

4. Conclusion

Immersion tests were performed to screen materials for I-S process for hydrogen production. SiC was the best resistant material in boiling sulfuric acid condition and the Ni-base alloys had good corrosion resistance. The cracks were found in the surface of alloy 600.

References

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Tabel 1. Chemical Composition of Specimens

Specimens	**Composition (wt%)**						**Density (g/cm^3)**
	Cr	**Ni**	**Fe**	**Mo**	**Al**	**Mn**	
Inco 718	17	50	33	-	-	-	8.19
Inco X 750	15	80		-	-	-	8.28
Inco 600	15.2	75	9.15	-	-	-	8.47
Inco 690	30	63	7	-	-	-	8.19
alloy X	21	52	18	9	-	-	8.22
N08	10	-	87	1	-	-	7.82
T91	9	-	87	1	-	-	7.82
316	16	11	68	3	-	-	8.00
304	18.5	9.5	70	-	-	2	8.03
alloy 800	20	31	47	-	-	-	7.94
PM2000	20	-	73	-	4.5	-	7.25
MA956	20	-	73	-	4.5	-	7.25
sus 329	26	7.5	61	3.5		1.5	8.03
sanicro 28	27	31	37	3		2	8.02
alloy 904L	20.05	24.2	50	4.25		1.46	8.13
SiC							3.21

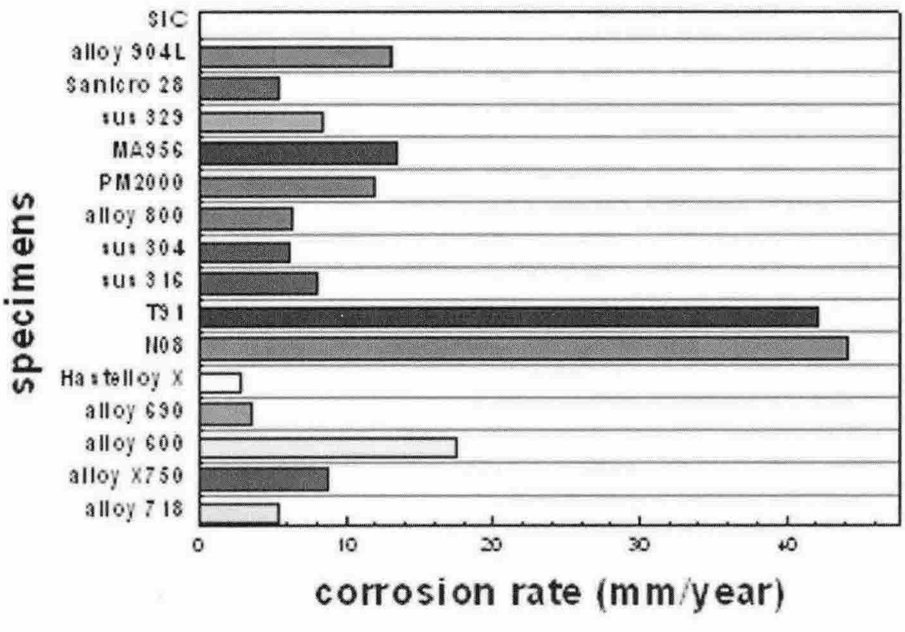

Figure 1. Corrosion rate in boiling sulfuric acid condition