Corrosion Behaviors of Nickel Bearing Materials in Molten FLiNaK and LiCl-KCl
Galvanic Corrosion of Ni based superalloys in Ni crucibles

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Corrosion tests of Ni-based alloys and stainless steels were performed in molten salts FLiNaK and LiCl-KCl at 773K for 250 hours. The mass loss of specimens was measured and the corrosion was metallurgical analysis with SEM/EDS. The test crucibles used were also analyzed to clarify the effect of galvanic corrosion according to dissimilar material system.

Keywords: molten salt, corrosion test, galvanic corrosion

1. Background and Introduction

Molten salts have preferable thermophysical features as coolants for nuclear reactors and thermal energy storage systems. However, the chemical compatibility with structural materials is one of the important issues to be addressed. The dissolution of Cr from the Ni based alloys and stainless steels in molten fluoride salt have been investigated in a previous study[1]. However, the galvanic corrosion of the Ni based alloys was not made clear so far. The purpose of the present study is to clarify the corrosion behaviors of Ni-based alloys and stainless steels in molten salts FLiNaK (46.5mol% LiF – 11.5mol% NaF – 42mol% KF) and LiCl-KCl eutectic (58mol% LiCl – 42mol% KCl).

2. Experimental Conditions

The test materials are Hastelloy-C, Inconel 600, Inconel 625, 316L austenitic stainless steel and 304 austenitic stainless steel. The chemical compositions of these materials are presented in Table 1. The specimens had a rectangular shape at the size of 15 mm × 10 mm × 0.2-0.8 mm. The specimens of Ni-based alloys (Hastelloy and Inconel) were installed in the crucibles made of Ni while the specimens of austenitic steels were installed in the crucibles made of 316L austenitic steel. Molten salts FLiNaK or LiCl-KCl of approximately 3 cc were then poured into the crucibles. The crucibles were then installed inside a vessel filled with high-purity Ar gas. The corrosion tests were performed at the temperature of 773K for 250 hours. The specimens were then taken out from the crucibles. The specimens were cleaned with water, distilled water, and acetone. The mass loss of the specimens due to corrosion was measured. The surface and cross-section of the specimens were metallurgically analyzed using SEM/EDS. The cross-sectional SEM/EDS analysis was performed on the crucible to clarify the corrosion of the crucible.

Table 1 Chemical compositions of test materials (wt%).

Specimens	Ni	Cr	Fe	Others
Hastelloy-C	Bal. (57)	15.67	6.28	Mo: 16, W: 4
Inconel 600	Bal. (72)	15.75	7.02	-
Inconel 625	Bal. (58)	21.24	4.03	Mo: 9
AISI 316L	12-15	16-18	Bal. (60)	Mo: 2, Mn: 2
AISI 304	18-20	8-11	Bal. (65)	Mn: 2

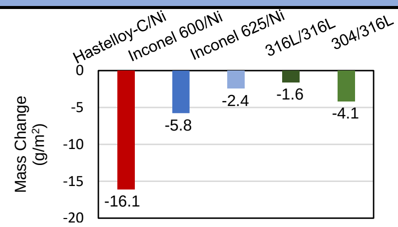

Fig. 1 Mass loss data of Ni-based alloys in Ni crucibles and austenitic steels in 316L crucibles tested in FLiNaK at 773 K.

3. Results and Discussion

Figure 1 shows the mass loss of the Hastelloy-C specimen which was immersed in molten salt FLiNaK is much larger than the other specimens. Figure 2 (b) shows the surface cross corrosion of the Hastelloy-C specimen. Its corrosion depth was three times deeper than that of the other specimens. This corrosion behavior does not agree with the previous findings where Ni-based super alloys revealed better corrosion resistance [1][2].

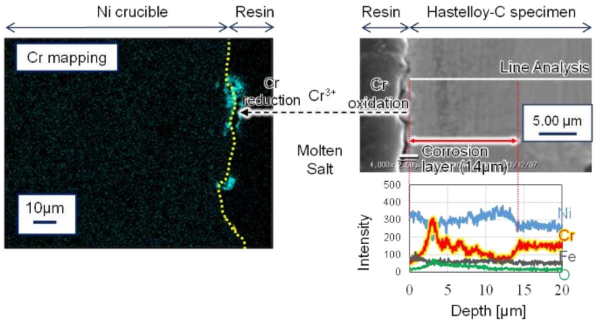

Fig. 2 Mass transfer of Cr shown through SEM/EDS images of (a) Ni crucible and (b) Hastelloy-C specimen in FLiNaK (c) EDS line analysis of Hastelloy-C specimen

The specimens of Ni-based alloy became anode and the more noble Ni-crucibles became cathode to form galvanic cell. Galvanic corrosion oxidized Cr from anode and reduced Cr ions at the cathode. This accelerated corrosion of anode. The same process did not happen to stainless steel specimens inside 316L crucibles due to the crucible and specimen materials being more similar.

The metallurgical analysis was done on the crucibles in order to find the trace of element transfer and participation through the galvanic cathode. The accumulation Cr was partially detected on the wet surface of the crucible, and this indicated the occurrence of galvanic corrosion.

4. References

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