Long-term corrosion behavior of structural materials in molten chloride salts

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1. Introduction

Molten salt reactors (MSRs) have become interested again as a potential alternative to coal-fired power plants for reducing carbon emissions. MSRs are operated at atmospheric pressure and inherently prevent severe accidents. Recently, KAERI has been focusing on MSR using chloride salts, which can hold more fuel than fluoride salts. However, several researchers have reported that chloride salts are more corrosive and the corrosion data for chloride salts is limited compared to fluoride salts [1]. Furthermore, molten salt corrosion behavior is highly depends on salt purification, galvanic corrosion, salt volume per sample surface area, crucible material and so on. However, several data did not report details on the experimental conditions.

Therefore, in this study, we will suggest the experimental procedure for molten salt corrosion testing and present the results of stainless steel 316H, alloy 625, and alloy N after NaCl-$MgCl_2$ corrosion at 650ºC for 2,000 h.

2. Materials and Experimental procedure

Three commercial alloys were used in this study: stainless steel 316H, alloy 625, and alloy N. The chemical compositions of these alloys are listed in Table 1. All alloys were fabricated into coupon-type specimens with a diameter of 10 mm and a thickness of 1 mm using electrical discharge machining. The specimens were ground with SiC #1000 papers on both sides and then ultrasonically cleaned with ethanol.

For molten salt corrosion testing, 57mol%NaCl-43mol%$MgCl_2$ was prepared in an Ar-filled glove box. To purify the salts, the mixed salt powder was heat-treated at 300°C for 24 h, then kept at 550°C for 48 h with Mg pellets. At least two specimens for each alloy were hung with an alumina rod in the individual alumina crucible to avoid galvanic corrosion. The enough purified salts were introduced into the crucibles at room temperature in the Ar-filled glove box. Finally, the crucibles were heated to 650°C in a furnace in the Ar-filled glove box and maintained at this temperature for 2,000 h. Following the corrosion testing, the salts on the specimens were carefully removed with distilled water.

Before and after the corrosion testing, all specimens were weighed using a precision scale. Metal impurities in the salts were analyzed with inductively coupled plasma optical emission spectroscopy (ICP-OES).

3. Results

Figure 1 shows the weight changes after the NaCl-$MgCl_2$ corrosion testing for 2,000h. Consistent with the observation of several researchers [2], stainless steel 316H exhibited the highest weight loss. The two Ni-base alloys, alloy 625 and alloy N, showed better corrosion resistance than the Fe-base alloy. Correspondingly, Fe and Cr contents in the salts using the corrosion testing for 316H were higher than those for alloy 625 and alloy N as shown in **Figure 2**. Interestingly, all salts after the corrosion testing showed higher Fe contents than Cr contents. Even though alloy 625 and N have lower Fe content than Cr in the alloy, more Fe content was detected in the salts. The corrosion behavior of three alloys will be discussed further in the conference using the weight changes, ICP results and additional analyses.

4. Future works

Composition [wt.%]	Ni	Fe	Cr	Mo	C	Mn	Si	Al	Ti	Others
316H	10.29	Bal.	16.82	2.12	0.049	0.59	0.57	-	-	Cu 0.22 N 0.023
Alloy 625	Bal.	3.87	21.53	8.94	0.02	0.08	0.08	0.08	0.17	Co 0.13
Alloy N	Bal.	3.66	7.66	16	0.072	0.414	0.273	0.441	-	Co 0.253

Table1. Chemical compositions of alloys used in this study

For the general information of surface morphology and phase, SEM and GI-XRD will be performed. These additional results will provide deeper insight in to the corrosion behavior of stainless steel 316H, alloy 625, and alloy N.

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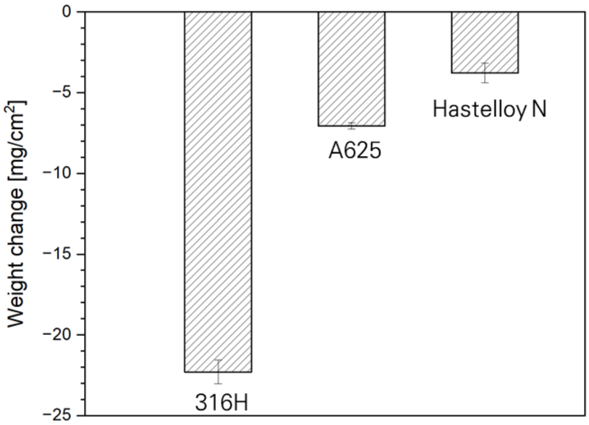

Figure 1. Weight changes of SS 316H, Alloy 625 and Alloy N after NaCl-$MgCl_2$ corrosion testing at 650°C for 2,000h

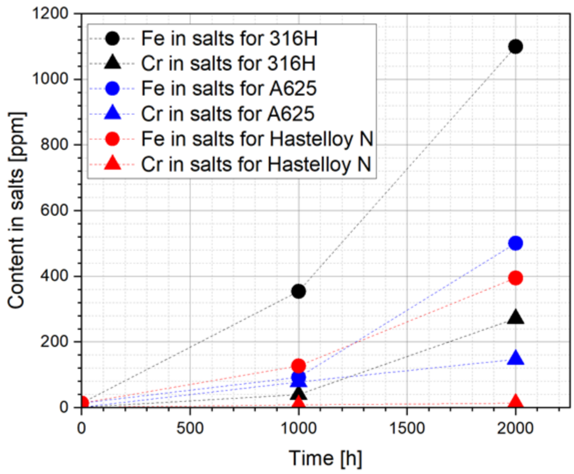

Figure 2. Fe and Cr contents in salts before and after NaCl-$MgCl_2$ corrosion testing at 650°C for 2,000h