High-Temperature Air Oxidation Behavior of Cr-based Binary Alloys

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ATF research currently focus on Cr-based coatings to protect Zr alloys. However, it is necessary to improve Cr properties via alloying. In this study, Cr alloys with Fe and Al are prepared by arc melting. Weight gains after furnace oxidation are compared, and morphology and oxides composition after air oxidation were analyzed. The oxidation resistance of the Cr-Fe and Cr-Al alloys are considered to be satisfactory.

Keywords: ATF, chromium, oxidation

1. Introduction

As a severe consequence of Fukushima Daiichi nuclear accident, the hydrogen explosions are due to the high-temperature Zr oxidation. Accident-tolerant fuel (ATF) projects currently focus on applying a Cr-based metal coating to protect the Zr alloy tubing, but modifications such as alloying of Cr may be necessary to improve Cr performance.

2. Methodology

Cr-Fe and Cr-Al alloys were fabricated via vacuum arc melting followed by thermal annealing. High-temperature oxidation behaviors in static air were studied in a furnace and measuring the weight gain. Characterization of the morphology and identification of oxides formed were analyzed using SEM-EDS and GIXRD, respectively.

3. Results and Discussion

Surface delamination and spallation were observed in some specimens at 1200°C, while samples maintained the oxide scales at 1100°C. The measured weight gains are also relatively small compared to Zr alloy oxidation and comparable to pure Cr oxidation in the literature. Characterization of the oxides identified Cr_2O_3, Fe_3O_4, Fe_2O_3, and Al_2O_3 in the specimens. GIXRD results of the samples after oxidation show the distribution of oxides as function of depth.

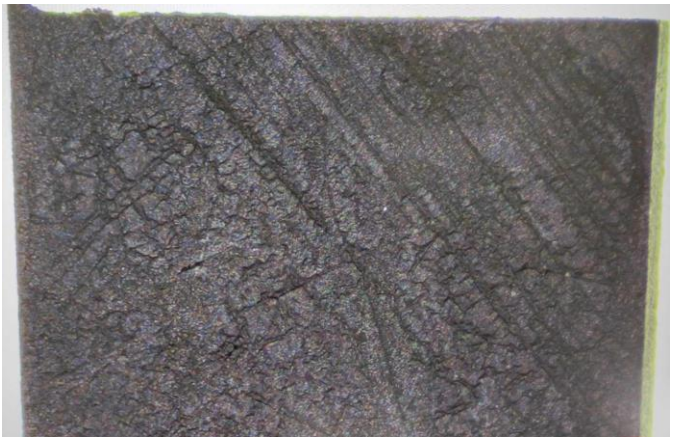

Fig 1. Cr-7Fe oxidized at 1200°C.

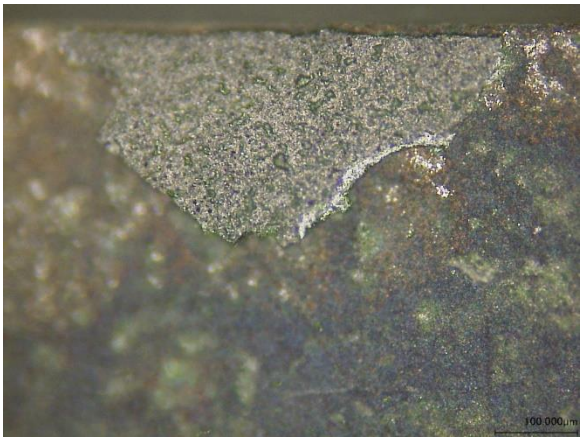

Fig 2. Cr-2Al oxidized at 1200°C

4. Conclusion

The results of high-temperature air oxidation of Cr-Fe and Cr-Al show potential improvement to pure Cr by possibly providing additional protection of the Cr_2O_3 scale for the substrate, which can be future candidates as coating. Further oxidation tests in other high-temperature atmospheres with steam are to be performed.