The Effect of Chromium on the Corrosion Behavior of Fe-Al Weld Overlay Claddings

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Introduction

The burner conditions in fossil-fueled power plants have recently been altered to comply with government clean air regulations, which have called for a reduction in the emission of hazardous NOx compounds. Altering the burner conditions has changed the furnace environment, which has led to unacceptable corrosion wastage of waterwall boiler tubes. Iron-aluminum based alloys have been studied as possible coatings due to their excellent corrosion behavior in highly sulfidizing environments[1]. Depositing the corrosion resistant Fe-Al based coatings onto the boiler tubes using weld overlays has been considered as a practical and cost effective method. Binary Fe-Al alloys have been shown to demonstrate excellent weldability at low aluminum concentrations, but above 10wt%Al they are susceptible to hydrogen cold cracking[2]. The primary objective of this research is to determine the effects of chromium on the corrosion behavior of iron aluminum alloys.

Procedure

Iron-aluminum alloys with chromium additions were cast in an argon atmosphere for corrosion testing because it was previously shown that the high temperature corrosion behavior of weld overlays could be explained by using cast alloys of equivalent composition[3]. Alloys were exposed to three corrosive environments at 500°C for 100 hours. Corrosion experiments were carried out in a high-temperature thermogravimetric (TG) balance, which measures changes in weight over time. Selected exposed samples were cracked after being submersed in liquid N_2 to obtain cracked surface images and others were cross-sectioned and polished to obtain cross-sectioned images. Scanning electron microscopy (SEM) was performed to characterize the corrosion scale morphology on exposed samples.

Results and Discussion

The high-temperature corrosion behavior of Fe-Al-Cr alloys was determined in several environments and was found to depend on the aluminum and chromium concentrations. Weight gains during 100 hours of exposure were found to generally decrease with the additions of chromium. The amount of area covered in non-protective nodules was also considered and found to depend on both the aluminum and chromium concentrations. It was found that the alloying levels required to prevent nodule formation were higher than those needed to prevent significant weight gains. Critical aluminum and chromium levels needed to prevent both rapid corrosion rates and the formation of unwanted nodules were found for the three different corrosive environments.

Conclusions

The present work focused on the high-temperature corrosion behavior of Fe-Al-Cr weld overlay coatings. It was found that a critical aluminum level was required to change the corrosion kinetics from rapid to sluggish in all of the various corrosion environments. Chromium additions were found to help reduce the corrosion rates as well as inhibit nodule growth during 100 hours of exposure. The integrity of the thin protective scale that formed on corrosion resistant alloys was considered carefully. The scale morphologies were considered in detail because it was found that kinetic data alone cannot be used to determine whether a weld is corrosion resistant or not. Critical alloying levels required for high-temperature corrosion resistance will be discussed in detail.

References

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