E. The Effect of Chromium on the Weldability and Corrosion Behavior of Fe-Al Weld

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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. Depositing corrosion resistant Fe-Al based coatings onto the boiler tubes using weld overlays has been considered as a practical and cost-effective method of addressing this issue. Binary Fe-Al alloys have been shown to demonstrate excellent weldability at low aluminum concentrations, but are susceptible to hydrogen cold cracking above 10wt%Al. Cr additions may provide a means to improve the corrosion performance while simultaneously minimizing environmental cracking due to intermetallic formation. The primary objective of this research is to determine the effects of Cr on the weldability and corrosion behavior of Fe-Al alloys.

Technical Approach

Fe-Al weld overlays with varying Cr additions were prepared with a dual wire feed GTAW system. A wide range of Cr and Al concentrations were obtained by varying the feed speed of each filler metal in order to change the weld metal dilution. The resultant weld overlay compositions were determined by electron probe microanalysis, and hydrogen cracking susceptibility was determined as a function of Cr and Al content using dye penetrant inspection. Selected compositions were also 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 N2 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 susceptibility of the Fe-Cr-Al weld overlays was found to be a strong function of the Cr and Al concentration of the overlay. Previous work showed that Al additions above 10 wt% to binary Fe-Al weld overlays were susceptible to hydrogen cracking. In this work, it was found that weld overlays with Fe-10Cr-10Al (wt%) could be deposited in the crack-free condition. Thus, the ability to prepare weld overlays with significant Cr additions provides an opportunity to improve the corrosion resistance of binary Fe-Al weld overlays The high-temperature corrosion behavior of Fe-Al-Cr alloys was determined in several environments and was also found to depend on the Al and Cr concentrations. Corrosion rates during 100 hours of exposure were found to generally decrease with the additions of Cr. Critical Al and Cr levels needed to prevent both rapid corrosion rates and the formation of unwanted nodules were found for the three different corrosive environments. The results of this work demonstrate that Fe-Cr-Al weld overlays offer potential promise as a low cost corrosion resistant coating in fossil fired boilers operating under Low NOx conditions.

Conclusions

Critical Cr and Al levels have been identified from a corrosion and weldability standpoint for the development of Fe-Cr-Al weld overlays. Cr additions up to 10 wt% were possible in Fe-10Al weld overlays and were found to help reduce the corrosion rates as well as inhibit nodule growth during 100 hours of exposure. It was found that kinetic corrosion data alone cannot be used to determine whether a weld is corrosion resistant or not.