



Experimental Evaluation of Fe-Al Claddings in High-Temperature Sulfidizing Environments

Assessment of Fe-Al claddings in aggressive reducing environments showed compositions with properties of weldability and high-temperature corrosion resistance

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ABSTRACT. The corrosion behavior of iron-aluminum alloys and their potential as protective corrosion claddings in sulfidizing environments were investigated. As-solidified castings of Fe-Al alloys with 0–20 wt-% Al were isothermally held at temperatures between 500 and 700°C for up to 100 h in a reducing atmosphere using thermogravimetric techniques. Specially tailored gases maintained partial pressures of oxygen and sulfur at each temperature ($p(\text{O}_2) = 10^{-25}$ atm, $p(\text{S}_2) = 10^{-4}$ atm). Postexposure characterization of the corrosion scales consisted of surface and cross-sectional microscopy in combination with energy-dispersive spectroscopy and electron probe microanalysis. From these results, it was found the corrosion behavior was directly related to the alloys' aluminum content. For high aluminum compositions (10 wt-% Al and above), protection was afforded due to the development of a thin, continuous alumina scale that inhibited rapid attack of the alloy. Increasing the aluminum content of the alloy was found to promote the formation and maintenance of this scale, leading to excellent corrosion behavior. For low aluminum contents (<10 wt-% Al), the ability to form and/or maintain the alumina scale was not observed. Instead, thick sulfide

phases developed either in the form of localized nodules (7.5 wt-% Al) or as a continuous surface scale (5 wt-% Al and below). Formation of these fast growing, nonadherent sulfide phases resulted in accelerated degradation of the alloy and unacceptable waste. With both good weldability and corrosion characteristics, alloys approaching 10 wt-% Al have excellent promise for providing protection as claddings in aggressive reducing environments.

Introduction

The choice of Fe-Al alloys in cladding applications requiring good corrosion resistance (e.g., waterwall structures of coal-fired boilers with low NOx burners) is attractive due to their low cost, the lack of macro- or microsegregation upon solidification during welding (Ref. 1) and better corrosion resistance compared to

conventional Ni-based and stainless steel-type compositions presently in use (Refs. 1–11). In addition, it would eliminate the brittle martensitic region that develops in the partially mixed zones of the above-mentioned austenitic alloys (Ref. 12). To date, their use is limited due to weldability issues stemming from cold cracking (Refs. 1, 13–16) and their lack of corrosion characterization in aggressive reducing environments at boiler service temperatures (typically below 700°C). In light of these facts, research was initiated to examine the sulfidation behavior of weldable Fe-Al compositions in highly aggressive reducing atmospheres. From a previous study (Ref. 1), alloys with 10 wt-% Al were identified as being readily weldable under normal field applications (Fig. 1) and had excellent corrosion behavior in moderately reducing atmospheres (Refs. 1, 13). While increasing the aluminum content has been shown to improve the corrosion resistance (Refs. 1–11), these compositions were not weldable. Some investigations (Refs. 15, 17) have cited the use of preheat and postweld heat treatments (PWHT) to relieve part of the hydrogen cracking problems, thus allowing for crack-free claddings with higher aluminum contents; however, the employment of such extensive treatments is not practical when coating large-scale structures such as utility boilers. Therefore, the objective of this work was to further characterize the corrosion behavior of weldable Fe-Al composi-

KEY WORDS

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