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Corrosion Behavior of Fe-Al-C Alloy

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Abstract

Corrosion Behavior of Fe-Al-C alloy with 1.24wt-% Al and 9.05wt-% Al have been studied. The alloys were prepared by an induction furnace under argon atmosphere. The results showed that Al combines with Fe to form FeAl precipitates in 1.24wt-% Al alloy whereas lamellar $FeAl_2$was found in 9.05wt-% Al. The results of corrosion test showed that both the alloys are more resistant in NaCl than in H_2SO_4 solution. There is indication that the form of corrosion is uniform and there is no tendency toward inter granular attack.

Keywords: Corrosion Behavior; FeAl Precipitates; Lamellar $FeAl_2$; Inter granular attack

Introduction

Fe-Al-C alloy is a good candidate for replacing some of the conventional stainless steel in several applications at moderate to high temperature[1]. Wherein, Al is used to substitute expensive alloy elements in conventional Fe-Cr-C system. Ferritic iron aluminum alloys shows ~~-~~promising physical and mechanical properties along with superior corrosion and oxidation resistance at much lower raw material cost[2].

Fe-Al alloys exhibit poor toughness. These are brittle at room temperature[3]. Addition of carbon to Fe-Al containing 8.5 to 16 wt-%Al gives higher strength[4], and better machinability[5]. It has been shown that low carbon content (0.05 and 0.1 wt-%) in Fe-9 wt-% Al leads *to* low tensile ductility[6]. Whereas, the ESR (Electro Slag Refined) ingots of Fe-10.5Al and Fe-13Al alloys containing high (0.5 and 1.0 wt-%) carbon exhibit excellent hot workability[7].

Fe-Al-C alloy is being developed for elevated temperature structural application up to 873K[8].

Aluminum plays a major role in the oxidation and corrosion resistance which is characteristic of the binary Fe-Al alloy[9]. The Fe-Al-C alloys have good corrosion resistance in a neutral environment. Its corrosion rates are comparable to that of white cast-iron in acid environments[10]. However, few data are available on the corrosion phenomena of Fe-Al alloy in acid media like H_2SO_4.

In this Study, Corrosion Behavior of Fe-9Al-0.6C alloy have been Reported.

Experimental Procedure

Thirty five kilograms of Fe-Al-C was prepared from mild steel scrap, high purity aluminum, and Mn with medium C. The alloy was prepared in an induction furnace under argon atmosphere. The chemical compositions are listed in Table 1. The ingot was cut using bimetallic band saw blade to make specimens for corrosion (14 mm in gauge diameter and 3 mm in gauge length) studies. The surface of the corrosion specimens were mechanically polished with abrasive paper up to 1200 grit, after surface finishing. The last mechanical polishing was done with 0.5 μm alumina paste. The corrosion measurements were carried out with three-electrode polarization in 0.5% NaCl and 0.05M H_2SO_4. The corrosion type and the morphology of the oxide scale were determined by optical and scanning electron microscopes (SEM). Corrosions products were examined using EDS/EDAX.

The polished section were subsequently etched with 3.3% HNO_3-3.3% CH_3COOH-0.1% HF-93.3% H_2O by volume for micro structural examination by optical microscope.

Table 1: Chemical Composition (wt-%) of the Alloys Tested

Alloys	Al	C	Mn	Si	P	S	Fe
A	1.24	0.55	0.02	0.02	0.03	0.02	Bal.
B	9.05	0.6	0.66	0.18	0.03	0.02	Bal.

Results and Discussion

The Three-electrode polarization technique was used to measure corrosion rate of the alloy. The results are shown in table 2.

Table 2: Corrosion Rate of the Fe-Al-C Alloy

Specimen	I corr(μA/cm^2)		R (mpy)	
	0.5% NaCl	0.5% H_2SO_4	0.5% NaCl	0.05 M H2SO4
Fe-1.24Al-0.55C	11.25	37.47	0.37	1.81
Fe-9.05Al-0.6C	8.96	21.62	0.35	0.74

Table 2 indicates that not only in the 0.5% NaCl but also in the 0.05 M H_2SO_4solution, the corrosion rate of Fe-1.24Al-0.55C alloy is greater than that ofFe-9.05Al-0.6C alloy. The difference of the corrosion rate is 15.99% and 59.35% respectively. This is primarily because of higher Aluminum content. A protective passive film was formed on the specimen surface at the stabilized corrosion potential. Figs 1 to 3, indicate that the oxide layer is rich in aluminum. The X-ray diffraction results show that the outer region is Al_2O_3. These corrosion rates are in either excellent or good category[11].

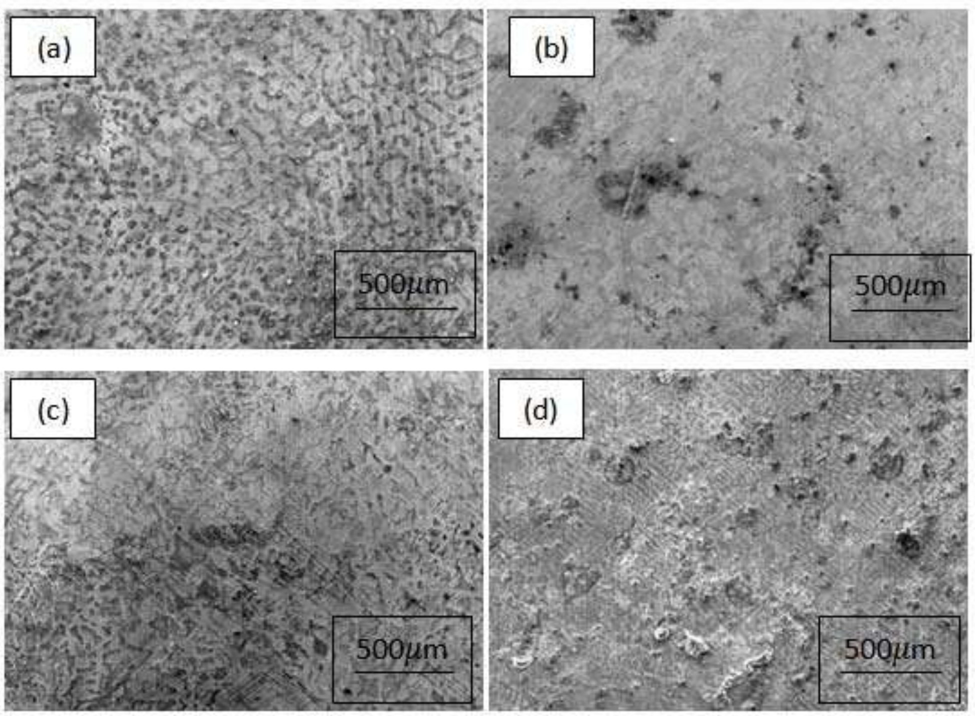

Figure 1: SEM Micrographs of as cast Fe-Al-C Alloy after Corrosion (a). Fe-1.24Al-0.55C in 0.05 M H_2SO_4 (b). Fe-1.24Al-0.55C in 0.5%NaCl c. Fe-9.05Al-0.6C in 0.05 M H_2SO_4d. Fe-9.05Al-0.6C in 0.5% NaCl

Fig 1.shows surface corroded for the alloys. Light and dark pattern microstructures seem at 1.2% Al. whereas, in the higher magnification (Fig.3) oxide pattern was very clear. SEM-EDS analysis (Fig 4-5) shows present some oxides like Al_2O_3 and FeO that are come from composition of these alloy, while Na_2O, SO_3 and Cl are from corrosion medium. The micrograph cross section of as cast Fe-Al-C alloy after corroded show that the oxide layers formed on the surface of the alloy after corrosion testing (Fig 2). It was observed that thin oxide layer formed on the surface but internal oxidation product could not be observed. The thickness of oxide layer of Fe-1.26Al-1.05C alloy could be observed in both of corrosion medium but in the Fe-9Al-0.6C alloy couldn't. These phenomena connected with corrosion rate. No inter granular attack could be observed in these conditions.

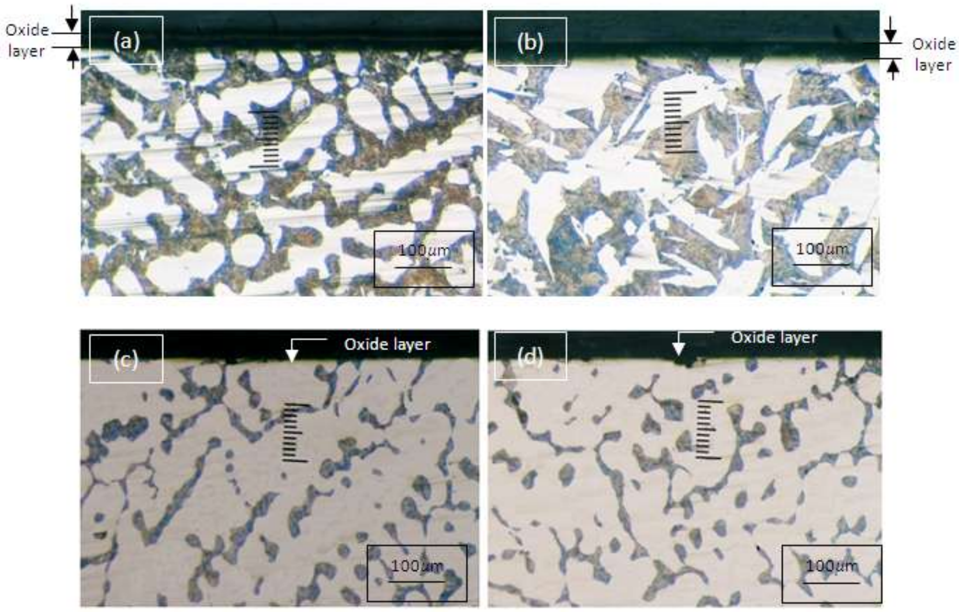

Figure 2: Metallographic cross section of as cast Fe-Al-C alloy after corrosion (a). Fe-1.24Al-0.55C in 0.05 M H_2SO_4 (b). Fe-1.24Al-0.55C in 0.5% NaCl c. Fe-9.05Al-0.6C in 0.05 M H_2SO_4d. Fe-9.05Al-0.6C in 0.5% NaCl

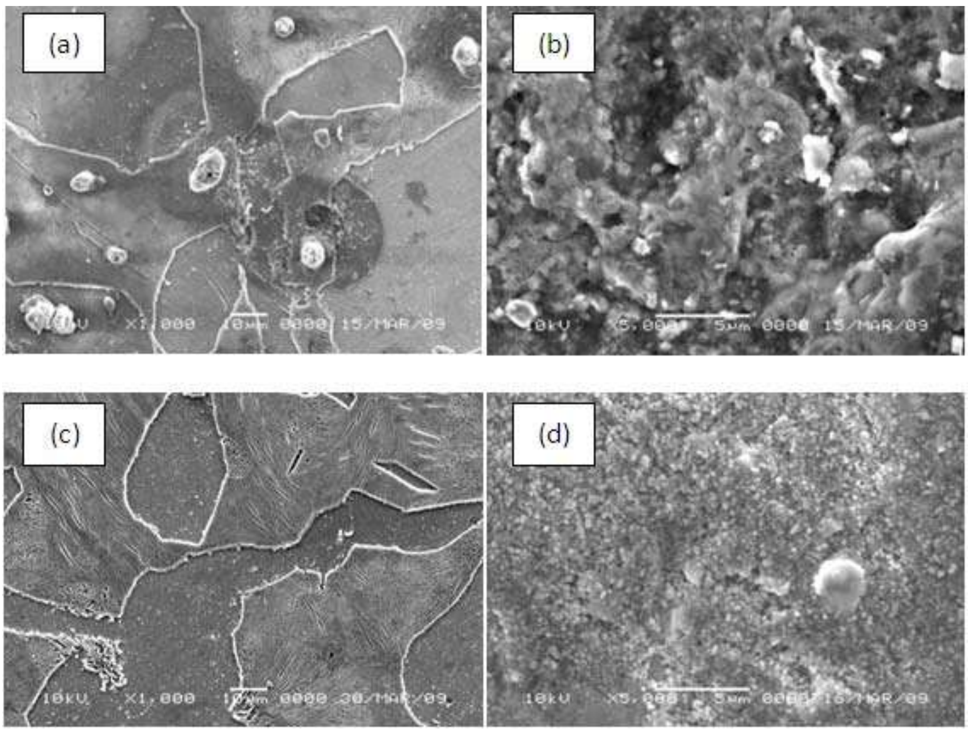

Figure 3: SEM micrographs high magnification of as cast Fe-Al-C alloy after corrosion (a). Fe-1.24Al-0.55C in 0.05 M H_2SO_4 (b). Fe-1.24Al-0.55C in NaCl c. Fe-9.05Al-0.6C in 0.05 M H_2SO_4 d. Fe-9.05Al-0.6C in NaCl

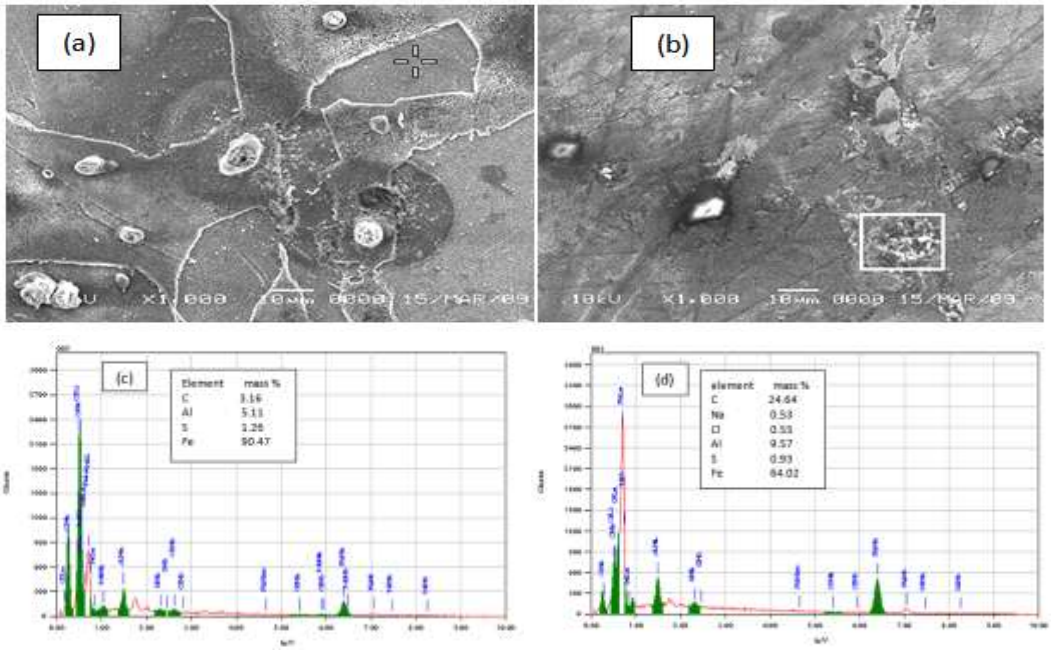

Figure 4: SEM micrographs of as cast of Fe-1.24Al-0.55Calloy after corroded (a). SE image in 0.05MH_2SO_4 0.05M (b). SE image in 0.5% NaClc. EDS result in 0.05MH_2SO_4 0.05M d. EDS result in 0.5% NaCl

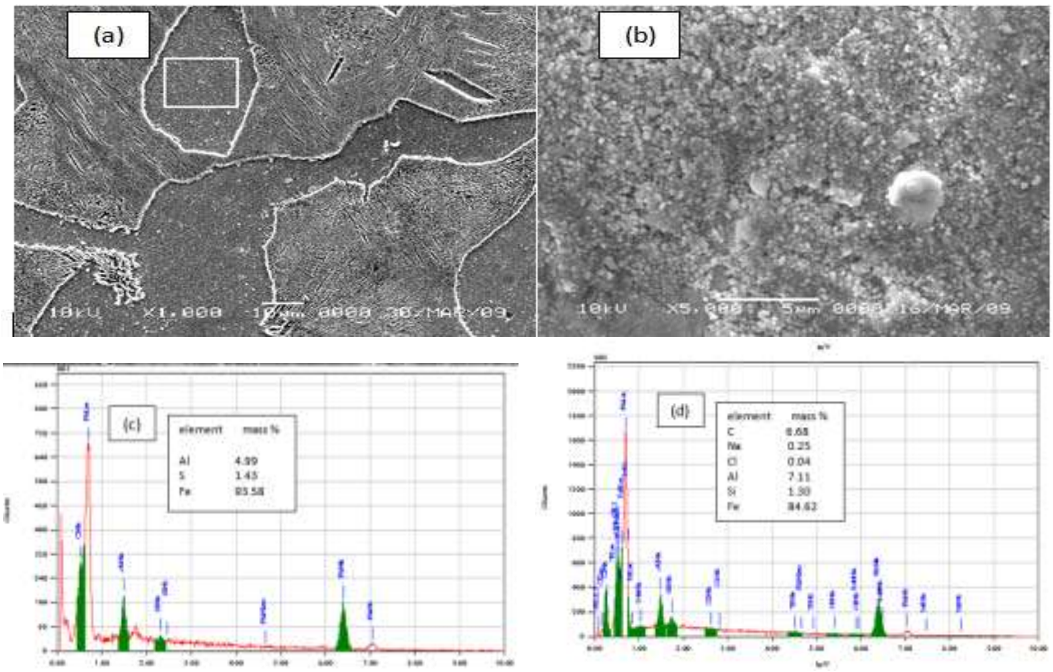

Figure 5: SEM Micrographs of as Cast of Fe-9.05Al-0.6Calloy after Corroded (a). SE image in 0.05MH_2SO_4 0.05M (b). SE image in 0.5% NaClc. EDS Result in 0.05MH_2SO_4 0.05M d. EDS result in 0.5% NaCl

Conclusions

The Fe-1.24Al-0.55C has uniformly distributed white colored Fe-Al precipitates on the darker matrix while the Fe-9.05Al-0.6C alloy has lamellar white colored$Fe\text{-}Al_2$ among a dark iron-aluminum carbide particle. General corrosion could be observed after three-electrode polarization but there is no trend toward to inter granular corrosion attack.

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