The Influence of Anneal Temperature on the Fe-8Al Plates Anti-Local Corrosive Properties


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ABSTRACT: The Fe-8wt. % Al alloy ingot was obtained by melting the pure iron and the pure aluminum together. The plates samples were prepared by cold rolling the ingots with thickness by 80%. The four samples were annealed at 850°C, 900°C, 950°C and 1000°C in air and kept for 5min before quenching. The metallographic structure, XRD pattern and local corrosion studies were employed. It is proposed that the sample was entirely re-crystallized and the crystal size was minimized and it varied from 15μm-40μm. The sample was composited by two phases which were FeAl and Fe3Al and no local corrosion was observed after sample was immersed in 5wt. % Na2SO4 12 hours.

1. INTRODUCTION

The phase diagram of the Fe-Al alloy is presented in the Figure 1. At the room temperature, when the atomic ratio of the Al is less than 10%, the two components are able to form the alpha solid solution. There are two intermetallic compounds in Fe-Al alloy namely B2 and DO3. At room temperature, when the atomic ratio of Al is 22.5%~33% the alloy structure is DO3 and the formula is Fe3Al. When the atomic ratio of Al is increased to 33%~51% it becomes B2 structure of which the formula is FeAl. Also lower bound of the B2 could be as low as to 22.5% when the temperature is higher than 540°C. FeAl and Fe3Al are considered very attractive due to good strength and corrosion resistance at high temperatures (Deevi, 1998, Liu, 1998 and Eggersmann, 2000).

A lot of researches have been done because of the unique properties of the Fe-Al alloy. Sikka et al. employed the Exo-melt technique and elevated the overheating problem during the melting process (Deevi, 1996). Zhu et al. obtained the fully dense Fe-Al at 800°C and 980MPa by using the powder metallurgy technology (Ming, 2000). Wang et al. prepared the product with 98% of theoretical density by sintering of rolled powder of Fe and Al mixture and followed by adding Ni (Wang, 2000). Kang studied the swell issue in the reactive sintering of Fe-Al and suggested that the swell and porous structures could be related to the phase changing during the sintering
as well as the fast generated heat (Kang, 2004). In this work, the Fe-8 wt. % Al plates were prepared and their micro structure, phase and anti-corrosive properties were systematically studied with Scanning electrochemical microscopy (SECM).

2. EXPERIMENTAL

The pure Fe and pure Al were melted in the vacuum induction melting furnace at 1200°C and cooled after 0.5h. The obtained ingot was forged into the plates with thickness of 4.2mm and then the plates were acid bathed at 85°C. Finally the plates were cold rolled to 0.87mm, the respective rolling ratio were 80%.

The samples rolled ratio were annealed at 850°C, 900°C, 950°C, 1000°C for 10min and then they were quenched in the water. The metallurgical structure, XRD pattern and anti-corrosive porosities were studied.

3. RESULTS AND DISCUSSION

The metallographic grading atlases are presented in the Figure 2. It can be observed that the tiny equiaxed crystals formed in the outer area but relatively bigger fiber-like crystals still existed in the inner area after the sample was annealed at 850°C. This indicates that the sample was still not entirely re-crystallized. When the annealing temperature was raised to 900°C the sample was entirely re-crystallized and the crystal size was between 15μm -40μm. The crystal sized and size
distribution further increased when the temperature increased to 950°C which ranging in 15μm - 100μm. When the temperature reached 1000°C it became even worse.

Figure 2. OM of samples treated at temperature: (a)850°C (b)900°C (c)950°C (d)1000°C.

Figure 3. XRD results of samples after treated at different temperature.

The XRD patterns are shown in the Fig 3. All the samples were composited with FeAl, Fe₃Al
and Al and there is no evidence for the existence of α-Fe. In the pattern of 900°C annealed sample only FeAl and Fe₃Al characteristic peaks could be found which indicated that the Fe and Al form alpha solid solution. All other patterns implied the appearance of Al, however the reasons for that are different regarding to the temperature. When it was at 850°C the two components could not be able to form the alpha solid solution. In the circumstances of 950°C and 1000°C because more Fe₃Al were formed after the re-crystallization and the solubility of the Al is much smaller than that in the FeAl. Thus addition pure Al crystal characteristic peaks were observed.
Figure 4. The SECM images of samples treated at temperature: (A)850°C (B)900°C (C)950°C (D)1000°C in 5%wt. Na$_2$SO$_4$ solution in different immersed time(A1 B1 C1 D1: initial stage, A2 B2 C2 D2: after 7 hours and A3 B3 C3 D3: after 12 hours).

The samples annealed at 850°C, 900°C, 950°C and 1000°C were the SECM test as performed in 5 wt. % Na$_2$SO$_4$ aqueous solution for 0h, 7h and 12h. The respective results are given in the Figure 5. Fine crystals, less and uniform impurities can improved the anti-corrosion property of materials (Skoglund, 2004 and Krasnowski, 2007). The pitting happened in the 850°C, 950°C and 1000°C annealed samples after 7h because the occurrence of the big crystals and other impurities which deteriorated the integrity of the Al$_2$O$_3$ film. However, it was not the case in the 900°C annealed sample even the time increased to 12h because of high integrity of the Al$_2$O$_3$ film.

4. CONCLUSIONS

The influence of anneal temperature on the Fe-8Al plates anticorrosive properties were studied in this work. The different processing determined the crystal structures and phase composition. By optimizing the processing parameters the optimized crystal size, size distribution and homogeneous solid solution (FeAl-Fe$_3$Al) enabled the premium anti-local corrosive properties.

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REFERENCE


