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Technical Report

Corrosion behavior of Ti–8Al–1Mo–1V alloy compared to Ti–6Al–4V

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ABSTRACT

The corrosion behavior of Ti–8Al–1Mo–1V alloy was investigated in 3.5% NaCl and 5% HCl solutions. Corrosion properties of Ti–6Al–4V alloy were also evaluated under the same conditions for comparison. It was found that both Ti–8Al–1Mo–1V and Ti–6Al–4V alloys exhibited spontaneous passivity and low corrosion current densities in 3.5% NaCl solution. The potentiodynamic polarization curves obtained in 5% HCl solution revealed an active–passive transition behavior and similar corrosion rates for the examined alloys. However, the results of the weight loss experiments under accelerated immersion conditions (5 M HCl at 35 °C) indicated that Ti–8Al–1Mo–1V alloy exhibited inferior corrosion behavior compared to Ti–6Al–4V alloy. These results were confirmed by scanning electron microscopy (SEM) analysis of the samples after immersion tests which revealed that the β phase was corroded preferentially for both alloys, but to a larger extent in the case of Ti–8Al–1Mo–1V alloy.

1. Introduction

Titanium alloys offer attractive properties such as high strength to weight ratio, high corrosion resistance, good formability and biocompatibility, and thus are widely used in many applications. These alloys are one of the most preferred materials for aerospace, biomedical, chemical and petrochemical industries [1].

Pure titanium undergoes an allotropic transformation from α phase with hexagonal closed-packed (HCP) structure to β phase with body centered cubic (BCC) structure as temperature is raised through 882 °C. With the addition of alloying elements, the β to α phase transformation temperature, or the β transus, can be raised or lowered depending on the type and concentration of alloying elements. Some elements stabilize the α phase and raise the β transus temperature, while other elements stabilize the β structure and lower the β transus. Aluminum and oxygen are among the most common α stabilizing elements, whereas vanadium, molybdenum, chromium and niobium are β stabilizing elements [2,3]. It is also worth mentioning that some elements like zirconium and tin behave neutrally at low and moderate concentrations [3]. Depending on the phases present at room temperature, titanium alloys are classified as α, $\alpha + \beta$ and β alloys.

Ti–6Al–4V is the most widely used $\alpha + \beta$ titanium alloy that contains modest quantities of both alpha stabilizer (aluminum) and beta stabilizer (vanadium) [1], although aluminum has high solid solubility in both the α and β phases. It is considered to be the “workhorse” of the titanium industry and accounts for more than half of the overall worldwide titanium usage [2]. However, there are still many unsolved questions regarding the effect of alloying components on its corrosion performance.

Titanium is generally resistance to corrosion attack in the oxidizing acidic media, but passivated titanium exhibits poor corrosion resistance in reducing acids such as hydrochloride and sulfuric acids [4]. Moreover, the constituent composition of titanium alloys is an important factor influencing their corrosion performance [4,5]. Numerous spectroscopic evaluations of oxide films formed on titanium alloys indicated that their passive layers are predominantly comprised of TiO_2 with small amounts of constituent alloying elements oxides [6]. Accordingly, the passive film formed on the Ti–6Al–4V alloy is enriched by vanadium oxides [7] that are readily soluble in aqueous solutions [6,8]. The preferential dissolution of vanadium enriched phase was observed by Atapour et al. [9] and was discussed with regard to microstructure and elemental partitioning in the Ti–6Al–4V alloy. With these considerations, vanadium as an alloying element is detrimental to the corrosion resistance and passivity of the Ti–6Al–4V, although it is necessary to stabilize the β phase. Therefore, efforts have been made to replace the vanadium with other β stabilizing alloying elements such as Mo and Nbin titanium alloys [5].

Ti–8Al–1Mo–1V is a near α titanium alloy which characterized by low density, high Young’s modulus, excellent damping capacity, good microstructure stability and fine welding and molding performance [10]. Therefore, Ti–8Al–1Mo–1V is an important material in various industries such as gas turbine and aerospace applications [11]. There were lots of works on the SCC of Ti–8Al–1Mo–1V in different solutions but data published on the static corrosion performance of this alloy is relatively scarce. Hence, the aim of this study was to investigate the corrosion behavior of Ti–8Al–1Mo–1V alloy

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