CORROSION RESISTANCE OF TITANIUM-MAGNESIUM PSEUDOALLOYS

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wear-resistant self-lubricating materials based on titanium-magnesium pseudoalloys [1] find their application in the production of frictional units operating in corrosive environments. In these composites the magnesium component acts as a solid lubricant. This article is concerned with the effect of composition of Ti-Mg pseudoalloys on their corrosion properties. Tests were carried out on infiltrated materials [2] containing from 10 to 40 vol. % of a magnesium alloy. Porous titanium skeleton were produced from PTS calcium hydride grade powder of 0.04- to 0.28-μm particle size. Infiltration was performed with IMV-3 magnesium-lithium alloy (Mg with 14%Li, 5%Zr, and 0.2% Sn).

In a laboratory study of corrosion processes weight loss measurements were made on specimens immersed for a long time (300-400 h) in a 3% NaCl solution and a 50% KOH solution at room temperature, and electrochemical characteristics were determined from anodic curves recorded potentiodynamically at a potential change rate of 3.6 V/h. Field tests were conducted on board the scientific-research ship Akademik Vernadskii during a 3.5-month voyage in tropical and subtropical climates and at a testing station near the Black Sea coast. On board the ship 30-mm-diameter, 10-mm-high specimens were mounted on a pvc panel, which was placed on an open deck. At the testing station a stand with specimens was exposed to sea air in an open space for 7 months.

Anodic curves for high-density sintered titanium IMV-3 alloy, and composites containing 23 and 37 vol.% of IMV-3 alloy are shown in Fig. 1. As would be expected, at potentials ranging from -0.18 to +1.6 V pure titanium was in a passive state. IMV-3 alloy and the titanium-magnesium pseudoalloys were found to exhibit high negative values of corrosion potential and substantial corrosion rates during anodic polarization. The polarization curves are evidence that the character of the anodic process on such a pseudoalloy is determined by the influence exerted by its magnesium component, and is unaffected by the presence of the titanium skeleton. The anodic dissolution of titanium-magnesium composites, like that of the other pseudoalloy systems (e.g., Ni-Ag [3]), is characterized by independence of electrochemical reactions. Data on the constant-potential corrosion kinetics of the materials investigated are given in Table 1. Current corrosion rates were determined for three values of potential. As the titanium skeleton under these conditions was virtually insoluble and only the magnesium component corroded, corrosion rate was assessed on the basis of the size of the part of the electrode surface occupied by magnesium. At the potentials investigated the rates of anodic dissolution were highest for pure IMV-3 alloy, slightly lower for the composite with 37 vol.% of IMV-3, and lowest for that with 23 vol. % of IMV-3. The rates of corrosion of the magnesium components in the pseudoalloys were lower than those of IMV-3 alloy, and varied with their volume content in the materials. This was borne out by data on the dissolution kinetics of the materials investigated in a 3% NaCl solution, determined by the specimen weight change method. The rates of dissolution of the magnesium phase (testing time 300 h) were 0.03 g/m²·h for the Ti + 23 vol.% IMV-3 composite and 0.15 g/m²·h for the Ti + 37 vol.% IMV composite, and were surpassed, respectively, 200 and 50 times by the rate of dissolution of pure IMV alloy (5.8 g/m²·h). In tests in a KOH solution the titanium-magnesium composites exhibited high corrosion resistance: Their rates of dissolution in the whole component concentration range did not exceed 0.03 mm/yr.

The data yielded by the laboratory studies of the corrosion resistance of the titanium-magnesium pseudoalloys are in accord with the results of the field tests in tropical and subtropical climates (Fig. 2). The corrosion resistance of titanium-magnesium pseudoalloys containing up to 25 vol.% of IMV-3 alloy was found to correspond to group II on a ten-point scale.

Thus, this investigation into the corrosion resistance and electrochemical properties of titanium-magnesium pseudoalloys under laboratory and field test conditions has shown that in a titanium-base composite containing up to 35-40 vol.% of magnesium the rate of corrosion of the magnesium phase is one or two orders lower than that of a pure magnesium alloy. The increase in the corrosion resistance of the magnesium component is apparently attributable to its impregnation with titanium to its limit of solubility [4]. To verify this hypothesis, a study was made, using a Zond electron probe microanalyzer, of the interface reaction occurring during the preparation of a titanium-magnesium pseudoalloy. Specimens of infiltrated materials are unsuitable for direct study because they give signals not only from the dissolved element but also from underlying layers. Examination were therefore carried out on model specimens prepared as follows. The magnesium alloy was melted in a solid titanium cylinder under conditions similar to those prevailing in the production of the pseudoalloys. After cooling, the cylinder was sectioned, and microsections were prepared, by electrolytic polishing, containing titanium and magnesium alloy zone separated by interfaces.

Scanning the boundary zone on the titanium side in the characteristic magnesium radiation showed that the magnesium concentration in the titanium did not exceed the limit of sensitivity of the apparatus (0.1 wt.% of magnesium). Examination of a 40- to 60-μm-thick magnesium zone adjacent to the interface revealed the presence of 2 wt.% of dissolved titanium. With increasing distance from this zone the intensity of characteristic titanium radiation diminished. Calculations of the grain sizes of the magnesium constituent in pseudoalloys of various compositions demonstrated that at magnesium alloy concentrations of up to 35-40 vol.% the width of the zone of a solid solution of titanium in the magnesium was commensurable with the size of a magnesium alloy inclusion (20-70 μm). Increasing the volume fraction of the magnesium