THESIS ABSTRACT

Stress Corrosion Characteristics of Al-5% Zn and Al-5% Cu Alloys ; Effect of Ti Addition

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ALUMINIUM alloys based on A1-Cu-Mg (2,000 series) and A1-Zn-Mg-Cu (7,000 series) compositions, though being used in high-performance aircraft structures, suffer from the disadvantage of stress corrosion cracking. Hence, methods of improving stress corrosion cracking resistance of these alloys attract great importance. Addition of small quantities of titanium (which has good corrosion resistance and high strength-to- weight ratio) to these alloys seems to be beneficial from the point of stress corrosion cracking. But the addition of titanium to the above alloys increases the complexity of the system. Also, the addition of titanium to commercial ternary/quarternary alloys (as above) is difficult by remelting process as this may result in compositional changes. Hence, to understand the effects of addition of small quantities of titanum on stress corrosion cracking from a more fundamental point of view, the stress corrosion behaviour of simple binary alloys (i. e., Al-Cu and Al-Zn, conforming to the above commercial alloys) in 1 molar aqueous solution of NaCl has been studied under various conditions of heat-treatment.

Stress corrosion behaviour was investigated using wire specimens under constant load conditions in the range of 10 to 90 per cent of tensile strengths at various temperatures in the range of room temperature to 90°C, and time-to-failure was measured as an index of stress corrosion cracking. Similar experiments were also performed on ribbon specimens under constant stress conditions (particularly at high stress levels) using a specialiy designed cam. These data have been used to determine the activation volume and activation energy for stress corrosion cracking in these alloys. The electrochemical potential measurements were also made In this experiments, and these help in distinguishing in the crack initiation and crack propagation periods.

Polarization tests were conducted under galvanostatic conditions on wire specimens under no load and constant load (at medium levels) and also on tensile specimens at a constant strain rate of 5×10^{-5} sec^{-1}. Information on change in critical current density and passivation characteristics are obtained trom these tests. To understand the effect of strian rate on stress corrosion cracking, tests were carried out on tensile specimens at constant strain rates in the range between 10^{-3} and 10^{-6} sec^{-1}. These tests revealed critical strain rate ot about 10^{-4} sec^{-1}, distinguishing between the relative importance ot stress corrosion cracking and mechanical fracture. Morphological studies carried out by metallographic techniques throw light on the effect of microstructure (and hence, heat-treatment) on the stress corrosion cracking process.

It is generally found that cold-working improves the resistance to stress corrosion in all these alloys. The process of stress corrosion in these alloys is largely controlled by stress-accelerated dissolution of the second phase, and depends on the vacancy migration at the tip of the crack. These facts are verified by the values of activation volume (15 to 111 c.c. mole^{-1}) and activation energy (0.5 to 0.9 ev.) respectively. Titanium addition to aluminium-zinc alloys decreases the activation volume, increases the activation energy, improves the grain boundary precipitation and hence, enhances the stress corrosion cracking. But its addition to aluminium-copper alloys increases the activation volume (but to a smaller extent), decreases the activation energy, favours the general precipitation, and hence, improves the stress corrosion resistance.

The experimental data show that stress corrosion in these alloys is a thermal activation process. Based on these data, an electrochemical model is proposed, wherein crack-initiation is envisaged to occur at the point of formation and stabilization of an active/passive element and crack propagation, by a cyclic process of stress-accelerated anodic dissolution and repassivation ot the crack tip. The crack initiation and propagation acquire relative importance at lower and higher stress levels respectively. Conclusion is drawn that titanium-containing aluminium-copper alloys have improved stress corrosion cracking resistance.