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Study of Stress Corrosion in Aluminum Alloys

The mechanism of the stress corrosion cracking of high-strength aluminum alloys was investigated using electrochemical, mechanical, and electron-microscopic techniques. Experiments were carried out with the commercial aluminum alloys 7075-T6 and 2219-T851 and with pure Al–4Cu. The feasibility of detecting stress corrosion damage in fabricated aluminum alloy parts by nondestructive testing was investigated using ultrasonic surface waves and eddy currents.

Strain-rate investigations of the mechanical properties of 7075-T6 alloy show marked differences between the rolling direction (RD) and short transverse direction (STD). The activation volume for dislocation movement is positive, as expected, in the STD but is negative in the RD because the effect of strain aging is larger than that due to strain rate. After allowing for this strain-aging, the activation volume in the STD is shown to be much smaller than that for the RD. This indicates greater dislocation entanglement in the STD. In the 2219-T851 alloy, the activation volume is large and positive in both directions. Although this alloy is readily corroded, it is much less susceptible to stress corrosion cracking than the 7075 alloy.

In NaCl solutions (pH 5.1) at 30°C, the steady state corrosion rate of the 7075 alloy is similar to that of Al, but the 2219 alloy corrodes more slowly, reflecting its high Cu content. Both alloys pitted, but the attack on the 2219 alloy was much more localized and severe. Hydrogen evolution on both alloys in NaCl is similar and more copious than on Al itself. In Na_2SO_4 solutions (pH 5.1) at 30°C, the alloys corroded less readily than did Al and slightly more in the STD than in the RD. No such difference was found in NaCl. No pitting was found under anodic polarization; however, extensive attack, with formation of visible oxide, was found at negative potentials.

Ultrasonic measurements of stress corrosion damage were made at 4 MHz using a $BaTiO_3$ miniature probe. Rayleigh (surface ultrasonic) wave attenuation on the alloy specimens tested was independent of surface finish up to 1.3 microns rms. Stress corrosion cracks less than 1 mil wide were detected by reflection techniques, despite considerable corrosion of the surrounding metal. These cracks were also detected with eddy currents. Both methods appear feasible for detecting stress corrosion damage on Al alloys.

Note:

Inquiries concerning this study may be directed to:

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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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