INVESTIGATION OF SCC OF HIGH STRENGTH ALUMINUM ALLOYS BY MEANS OF SLOW STRAIN RATE TEST AND CYCLIC ANODIC POLARIZATION IN COMBINATION

Monica Trueba, Independent scientist
monica.trueba@unimi.it, mokatrueba@gmail.com
Guido Russo, Università degli Studi di Milano, Italy
Stefano P. Trasatti, Università deli Studi di Milano, Italy
Sergio Lorenzi, Università deli Studi di Bergamo, Italy
Marina Cabrini, Università deli Studi di Bergamo, Italy
Antonietta Loconte, Politecnico di Milano, Italy

Key Words: SCC, Al alloys, slow strain rate, electrochemistry.

The stress corrosion cracking (SCC) behavior of high strength 7075-T6 and 2024-T3 Al alloys in NaCl solutions is investigated by means of slow strain rate test (SSRT) and cyclic anodic polarization in combination. Smooth, dog-bone shaped flat tension test specimens, having gage section areas of 40 mm^2 and 32 mm^2, respectively, and 90 mm of gage length, were machined in the longitudinal (rolling) direction from the commercial wrought sheets (Aviometal Spa). The tensile test was performed at a constant strain rate ($\dot{\varepsilon}$ = 10^{-7}, 10^{-6} or 10^{-5} s^{-1}) from a pre-load of about 5 kN until fracture. The electrochemical system consisted in non-connected two Plexiglas cylindrical cells that were fixed at the middle of the opposite surfaces of the tensile specimen (working electrode, surface area at each side of 2 cm^2). The variation of the open circuit potential (OCP) during straining was measured with respect to saturated calomel reference electrode (SCE) by connecting the two electrode system to a Gamry potentiostat. Contemporarily, the opposite surface was electrochemically perturbed by imposing consecutive cyclic anodic polarizations with open circuit potential measurements in between (OCP/polarization sequences), using an Ir-coated Ti auxiliary electrode, another SCE and a second Gamry potentiostat. At least two combined experiments for each test condition were carried out for repeatability check. Experiments with no OCP/polarization sequence during straining, and vice versa, were performed for reference purposes.
The stress-strain curves of Al 7075-T6 (Fig. 1a) show that the ultimate strength and failure strain decrease in aggressive environment as the strain rate is lowered, regardless the electrochemical perturbation, being in agreement with reported data [1]. More interestingly, quasi-periodic stress relaxation/recovery events above the elastic region in correspondence with the dissolution/repassivation cycle were detected for $\dot{\varepsilon} \leq 10^{-6}$ s^{-1} and 0.1667 mV/s of potential scan rate (n). The resolved negative spikes in the stress time derivative curve and the related polarization curves (as log | I | - t) for $\dot{\varepsilon} = 10^{-7}$ s^{-1}, 0.6 M NaCl and n = 0.1667 mV/s are reported in Figure 1b. The spike pattern along the time axe was dependent on $\dot{\varepsilon}$ and NaCl concentration. The results from ongoing combined experiments with Al 2024-T3 for verification of the above findings will be presented altogether with empirical data analysis for a quantitative insight into the environmentally assisted failure mechanisms.

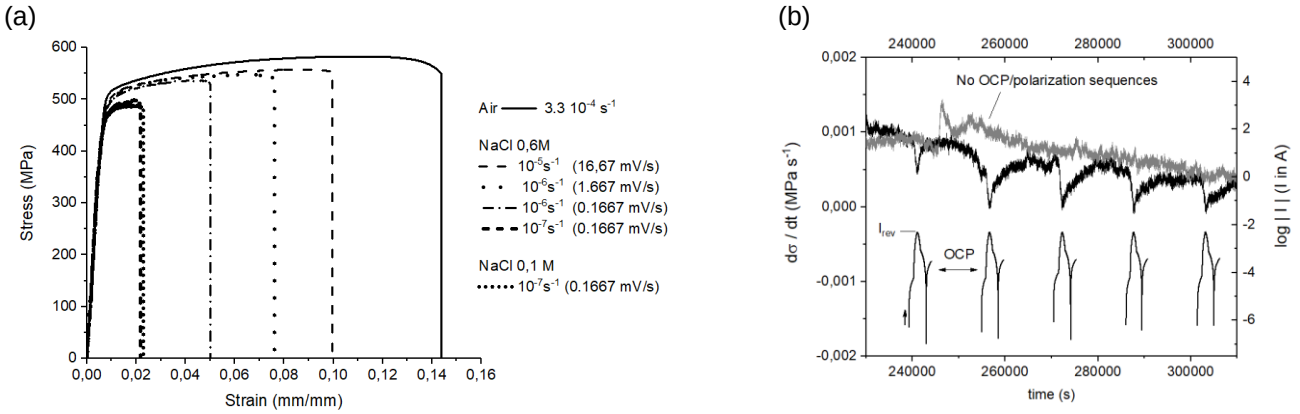

Figure 1: (a) Stress – strain curves of Al 7075-T6 in laboratory air and in NaCl solutions during consecutive OCP/polarization sequences for different $\dot{\varepsilon}$ and n; (b) Stress time derivative curves (above the elastic limit, Fig, 1a) for 0.6 M NaCl and 10^{-7} s^{-1} without and with consecutive OCP/polarization sequences (n = 0.1667 mV/s and the log |I| - time curves for the latter test condition (the arrow indicates the direction of the potential scan and I_{rev} the anodic current limit of the forward scan).

[1] R.E. Ricker, E.U. Lee, R. Taylor, C. Lei, B. Pregger, E. Lipnickas, Metall. Mater. Trans. A 44 (2013) 1353