TRANSITION FROM SMALL TO LARGE CRACKS IN TI-6AL-4V SPECIMENS

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Light alloys allow us to have light components with interesting mechanical features. Ti-6Al-4V is a bimodal titanium alloy employed in aerospace, automotive, maritime and biomedical applications. This alloy has also a good corrosion strength which can be reduced by damages on the passivating surface layer. These damages can be due to an inadequate adhesion of the surface layer, variable loads and interactions with aggressive media [1,2].

For these reasons, quasi-static and fatigue tests on Ti-6Al-4V specimens in different inert, aggressive and very aggressive environments were carried out in the past. Air, air + beeswax coating, paraffin oil, 3.5wt.% NaCl-water solution and water-methanol solutions with several percentages were investigated in order to evaluate the chemical and mechanical forces of the corrosion fatigue phenomena [3].

Stress corrosion cracking (SCC) tests on a low strength steel [4] showed that the threshold of dJ/dt decreases with decreasing deformation rate and that the electrochemical energy contribution on the crack growth is independent from the displacement rate but dependent from the electrochemical conditions at the crack tip.

As stated in [5] the crack size effect must be considered because small cracks have very high growth rate. Slow strain rate tensile and low-amplitude cyclic tests on micro-notched high strength low alloy steel specimens showed that crack growth strongly depends on the notch-tip plastic zone and hydrogen activity itself. High cycle fatigue tests with different notch shapes showed in [7] that the maximum stress and gradient increase with decreasing defect size. The stress state at the notch root is a function of the geometry. In [7] an elasto-plastic FE modelling with a multiaxial fatigue criterion and a correction for the stress gradient is also shown. Tanaka et al. [8] applied the fracture mechanics approach to fatigue crack initiation for also small notch-tip radius. In [9] micro-notched 316L steel specimens in a chloride medium gave the crack propagation rate in function of the global loading. A FE model was also developed in [9].

Micro-notched Ti-6Al-4V specimens were machined to get various notch lengths (up to about 100 μm) & tested under static & cyclic loads to obtain fracture properties, incubation times. The notches were made using Electro Discharge Machining (EDM) in order to reach various values of stress concentration factor (K_t) without notch tip plasticity.

The tests were carried out on a testing machine previously designed by the Structural Mechanics Laboratory (SM-Lab) of the University of Bergamo and now modified so that bigger specimens can be used and easier setting can be reached. During the tests an axial load was applied with a fixed increment of it every fixed time. The machine has specific grips in order to avoid unwanted bending moment on the specimens.

Test results are plotted on Kitagawa diagram to analyze the role of environment on static and cyclic applied loads. At the threshold i.e. at the endurance limit (horizontal line in Kitagawa diagram) we calculated:

$$K_{max}^{th} = \sigma_{max}^{end}(\pi a)^{\frac{1}{2}}.$$

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