Experimental study of the mechanical properties of oxygen enriched Ti alloys

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Abstract

A major limitation to the use of titanium alloys at higher operating temperatures in aircraft engines is the degradation of mechanical properties due to long-term exposure to oxygen. The high solubility and diffusion coefficient of oxygen in titanium result in the formation of a brittle layer due to the oxygen diffusion gradient under the surface. Despite the small size ($< 200\ \mu$m) of this oxygen-rich layer (ORL) relative to the dimensions of structural components, the mechanical gradient induced by oxygen diffusion can cause premature damage and subsequent failure. Most fatigue life prediction models for titanium alloys are based on simplifying assumptions and do not consider the chemical, microstructural and mechanical heterogeneities in the oxygen-affected zone.

The aim of this work is to quantify the effect of oxygen on local elastic and plastic properties through micro-scale observations. A further aim is to correlate the mechanical property gradient with changes in the mechanical behavior and fatigue life of macroscopic samples.

Micro-tensile specimens were prepared from Ti6242s, a commercial quasi-alpha alloy. Specimen were pre-oxidized at 600◦C for 3000h, resulting in an ORL extension of 100 μm. First, we measured the effect of oxygen on local properties using high-speed nanoindentation to quantify the evolution of reduced elastic modulus and hardness as a function of oxygen concentration. Second, we investigated the effect of pre-oxidation on slip localization through micro-mechanical tensile testing combined with Digital Image Correlation (DIC) and Scanning Electron Microscopy (SEM). For both investigations, the effect of grain type and crystalline orientation is discussed by correlation with EBSD (electron backscatter diffraction).

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