INFLUENCE OF THE OXIDATION IN CREEP OF TI-6Al-4V ALLOY

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The Ti-6Al-4V alloy is the most important of the titanium alloys used in engineering, combining excellent formability, weldability and a range of attractive physico-chemical properties such as good corrosion resistance and good metallurgical stability [1]. Ti-6Al-4V is currently used in aeronautic and aerospace industry mainly for applications that require resistance at high temperature such as, blades for aircraft turbines and steam turbine blades [2]. The titanium affinity by oxygen is one of main factors that limit the application of their alloys as structural materials at high temperatures. The oxidation produce a material loss through the growth of the oxide layer and the hardening by oxygen dissolution [3-4]. Notables advances have been obeserved in the development of titanium alloys with the objective of improving the specific high temperature strength and creep-resistance properties. However, the surface oxidation limits the use of these alloys in temperatures up to 600ºC [5].

The objective of this work was estimate the influence of the oxidation in the lifetime in creep of the Ti-6Al-4V alloy. The samples were analyzed by High Resolution X-Ray Diffraction, Scanning Electronic Microscopy (SEM), Atomic Force Microscopy (AFM) and microhardness test. The samples of Ti-6Al-4V were polished and treated during 24 hours at 600°C and observed the oxidation behavior in each case using argon, nitrogen and air atmospheres. The figure 1 shows microstructures obtained by SEM of one sample without treatment and one treated at 600°C in air atmosphere. In samples tested in argon and nitrogen atmospheres the microstructure were very similar to the sample no treated. The oxidation was more aggressive in air atmosphere, forming TiO_2 film in the surface, observed by High Resolution X-Ray Diffraction and the sample color was dark gray. In argon and nitrogen atmospheres the oxidation suffered by material was not detected by High Resolution X-Ray Diffraction, just color change was observed (blue in argon and yellow in nitrogen). The oxidation layer was approximately 0,81μm and its surface roughness was approximately 22 nm in the case of highest oxidation when formed TiO_2 film (figure 2). The samples microhardness was 781 HV to air atmosphere; 495 HV to nitrogen atmosphere and 393 HV to the alloy treated in argon atmosphere, showing that the oxidation brought to the microhardness increasing.

Using the Ti-6Al-4V alloy produced specimens to creep test. The specimens were tested by creep at 600ºC in argon, nitrogen and air atmospheres using 250 MPa. The figure 3 shows the creep curves obtained. When the Ti-6Al-4V was treated in argon and nitrogen atmospheres the effect the oxidation is smallest and the behavior of the creep curves shows that the lifetime increases when these atmospheres were used. Also a ductility increase (final strain) observed when these protective atmospheres were applied. Occurs a decreasing of steady state creep in function of the reduction of oxidation process, showing that for the Ti-6Al-4V alloy their lifetime is strongly affected by the atmosphere that is submitted because the oxidation suffered by the material.

Acknowledgements:

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References:

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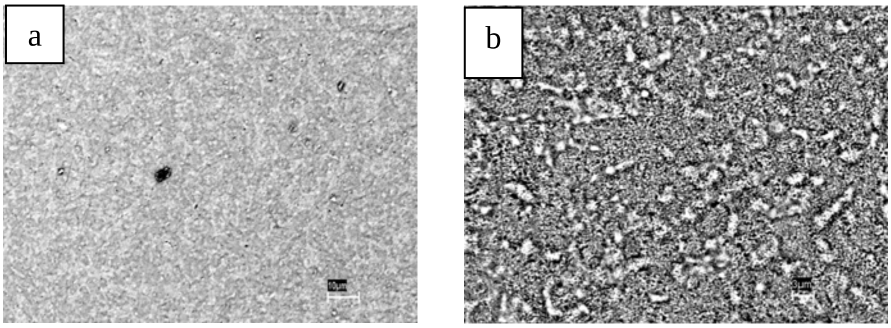

Figure 1 - Microstructures obtained by SEM of one sample without treatment (a) and one treated at 600°C in air atmosphere (b).

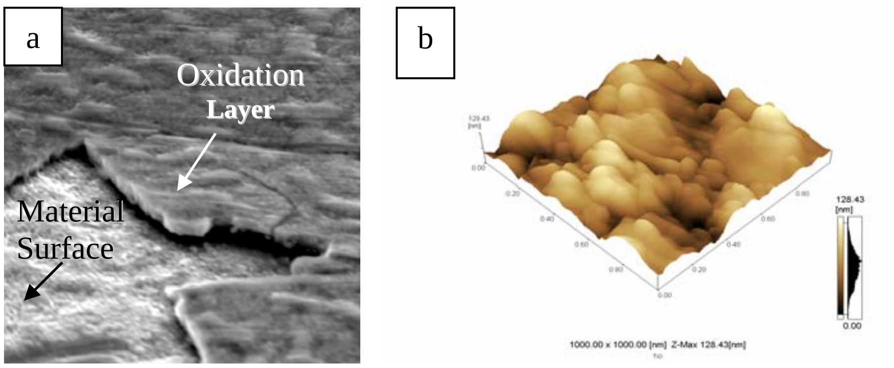

Figure 2 – Microstructure of oxidation layer by SEM (a) and surface roughness obtained by AFM (b).

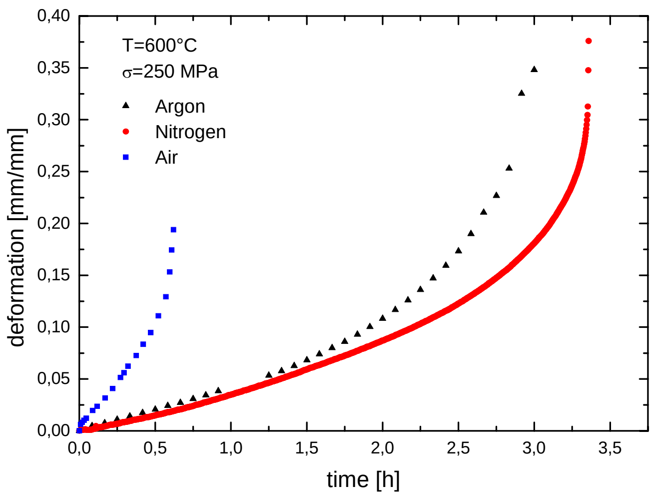

Figure 3 – Creep curves at 600°C and 250MPa obtained in argon, nitrogen and air atmospheres.