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INFLUENCE OF ANODIZING TREATMENT ON FATIGUE RESISTANCE OF TI-6AL-4V TITANIUM ALLOYS

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ABSTRACT

In this work, fatigue tests were performed on different treated specimens of Ti-6Al-4V titanium alloy and some decreases of fatigue resistance were observed. These modifications were explained thanks to surface characterization.

Keywords: titanium alloys, fatigue resistance, etching, anodizing.

INTRODUCTION

Titanium alloys are increasingly used in lots of fields like aeronautic, prosthesis or building. These pieces are often subjected to mechanical stresses and notably fatigue stress. Furthermore, anodizing treatments are commonly applied to increase surface properties like paint adhesion, osteointegration or corrosion resistance. Some recent studies on aluminium alloys demonstrated the high detrimental influence of anodizing process on the fatigue resistance. Thus, it is interesting to investigate the effect of anodizing on titanium alloys fatigue resistance.

In this work, the two main steps of this surface treatment are studied : etching and anodizing. Etching is the essential pre-treatment of anodizing. The influence of different anodizing parameters are also presented. Surface characteristics after each step are determined from fatigue resistance point of view, that is to say, morphology (roughness and local Kt), microstructure, residual stress and presence of embrittling species (hydrogen and oxygen).

RESULTS AND CONCLUSION

Fatigue tests were realized on turned (reference), etched and anodized specimens. Turned specimens were machined with a feed of 0.1mm and a cut speed of 40m/min with a new pad for each finishing cut. A part of this specimen was etched and tested in fatigue. Etching was performed on a mixture of 2w% hydrofluoric acid and 20w% nitric acid. Finally some of etched specimens were anodized with two different voltage (5V and 80V). These two different voltages induced anodic oxide film of 20nm and 200nm respectively.
Fatigue results are presented in Figure 1. Etching decreased the fatigue resistance of Ti-6Al-4V titanium alloy. The thin anodic film (anodized 5V) did not modify fatigue resistance compared to etched samples. On the contrary, thick anodic oxide film (anodized 80V) decreased slightly the fatigue resistance. To explain these modifications, some surface analyses were performed.

Surface roughness of samples was measured after each treatment. Ra and Rz were modified very slightly by etching and by anodizing. Some slight and punctual morphological

modifications were observed. These modifications appeared especially after etching and were allocated to etching pit. These punctual defaults did not increase the specimens local Kt. This is certainly due to low depth and low density of default.

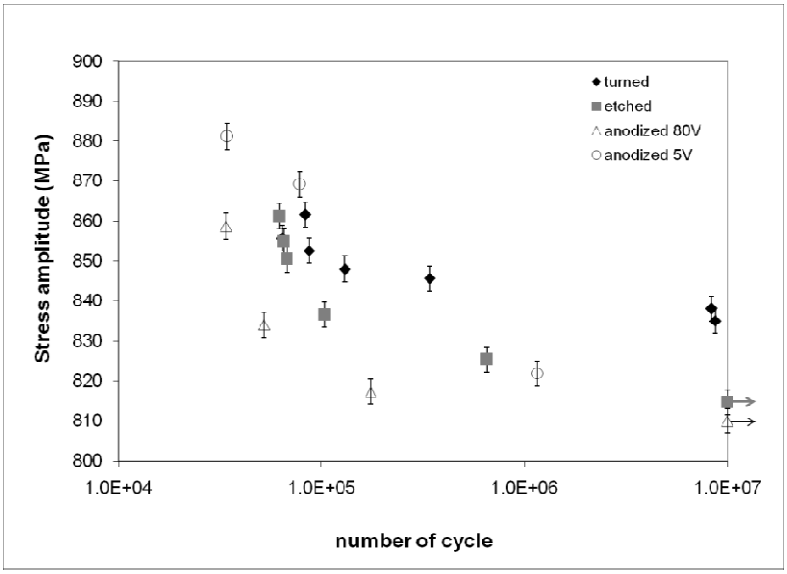

Fig. 1 - Fatigue results of turned, etched and anodized specimens

Hydrogen and oxygen profiles were observed thanks to SIMS analysis. By comparing the oxygen and hydrogen concentration in the bulk material and in the surface, it appeared that no absorption of these embrittling species was detected.

High compressive internal stresses were induced by machining. Normally etching does not add any internal stress but the top surface removal can induce some internal stress modification. In the present case, etching divided by two the initial compressive stress even if the thickness losses were low and close to 1µm. That indicated the internal stresses due to machining were mainly located at the top surface of the sample. Furthermore, this compressive internal stresses decrease certainly induced the fatigue resistance decrease. In anodized case, the compressive internal stresses also decreased to reach a value close to 0MPa. In this case, there was no material removal but the anodic oxide growth might induce some additive tensile internal stress. This modification explained the fatigue resistance deterioration.

As a conclusion, fatigue tests were performed on different kind of treated specimens and a fatigue resistance decrease associated with etching and anodizing with high voltage was observed. Thanks to surface analysis including roughness, chemical absorption and internal stress, the key surface parameter which influences fatigue resistance was determined. This parameter seems to be internal stress which is a lot impacted by etching and anodizing treatment.