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EVALUATION OF FATIGUE RESISTANCE OF TI-6AL-4V AFTER THERMAL TREATMENT

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Abstract. *The selection of a material for structural application in the aerospace industry must take into account several factors. These factors include mechanical resistance, resistance to fatigue crack propagation, and resistance to weight ratio. Titanium alloy with 6% aluminum and 4% vanadium is often used in the aerospace industry to meet the structural requirements of aircraft. There is a need to determine how this new material behaves after heat treatments, since in the industry thermal treatments are often used to enhance some of the material's characteristics. This work proposes to obtain the rotation flexion fatigue curves for different microstructures in the thermal treatment curve of the Ti-6Al-4V alloy before and after a solubilization thermal treatment, which provides different values of microhardness. The material was supplied by an aerospace company that uses this material in the form of parts stamped on the structure behind the aircraft fuselage. The material passed through the thermal treatment of solubilization and its microstructure and its microhardness were evaluated. Afterwards, it was machined to perform the fatigue tests by rotary bending, in order to acquire the tension graph by number of cycles until the rupture. Different microstructures and microhardnesses were obtained, for example the bimodal microstructure (α + β) and α-Widmanstatten with microhardness of 358.7 HV and 330.9 HV respectively. The values obtained with the flexural fatigue curves were analyzed and compared.*

Keywords: *titanium, thermal treatment, fatigue, microstructures.*

1. INTRODUCTION

The Ti-6Al-4V alloy presents the aluminium as a stabilizer of the α-phase, hexagonal compact, and the vanadium as stabilizer of the β-phase, cubic focused length. Due to these characteristics the alloy presents, equal to pure titanium, the α and β-phase at room temperature. Although the alloy has low concentrations of aluminium and vanadium, it presents a great variation in its characteristics in relation to pure titanium, such as fracture strength, hardness, microstructure and cracking propagation. The Ti-6Al-4V alloy is an allotropic transformation element at 999 ° C for β-phase. (Silva, 1998; Antunes, 1997)

Fatigue is the phenomenon of progressive failure that occurs to a material when subjected to a cyclical load for a long period until the part breaks, with a tension lower than that necessary for the fracture due to a static charge. Due to this it is of great importance to determine how the Ti-6Al-4V alloy behaves when subjected to fatigue and to quantify how the solubilization treatment influenced this event, especially in aerospace application materials. (Bauer, 2007)

2. EXPERIMENTAL PROCEDURE

The material was supplied by an aerospace company in the form of scrap derived from the shearing process in the laminated form, and annealed for the manufacture of stamped parts used behind the aircraft fuselage. The material was subjected to a metallographic analysis to determine the microstructure. It was chemically attacked by an acid solution containing 20% HF, 40% HNO_3 and 40% H_2O. It was subjected to tests to obtain the microhardness values. The specimens were machined, according to Fig. 1, in order to obtain the specimens for the rotary bending fatigue test.

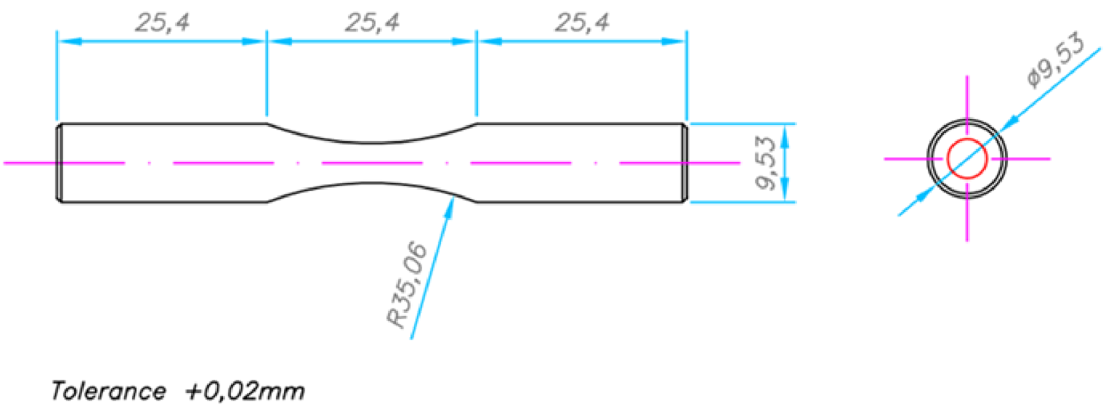

Figure 1: Technical design of the test specimen for rotating fatigue test (mm).

The fatigue tests were started by rotary bending at a tension value approximately corresponding to 85% of the tension leakage. The other points were obtained from the tensions stipulated after the end of each previous test. With the test of fatigue until the rupture was plotted the graph of the applied tension versus the number of cycles until the rupture. The same process was used for the material that went through the thermal treatment of solubilization, where it was heated for one hour to the temperature of 1100 ° C and cooled inside the oven, following the sequence of events, in order to prevent the warping of the specimen after thermal treatment.

3. RESULTS AND DISCUSSION

The bimodal microstructure (α + β), according to Fig. 2, and microhardness of 358.7 HV were obtained for the specimen as received. The microstructure α-Widmanstatten, according to Fig. 3, and microhardness of 330.9 HV was obtained in the material after the solubilization thermal treatment.

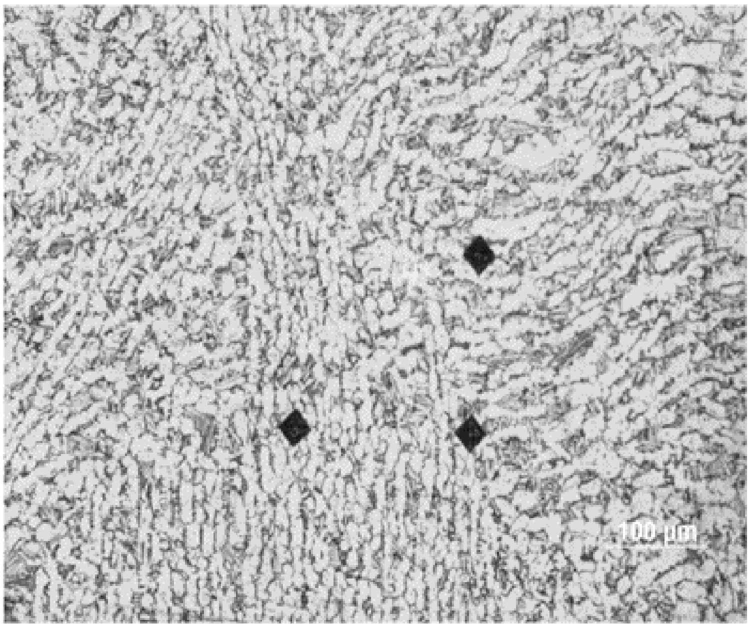

Figure 2: bimodal (α + β) microstructure of titanium alloy Ti-6Al-4V.

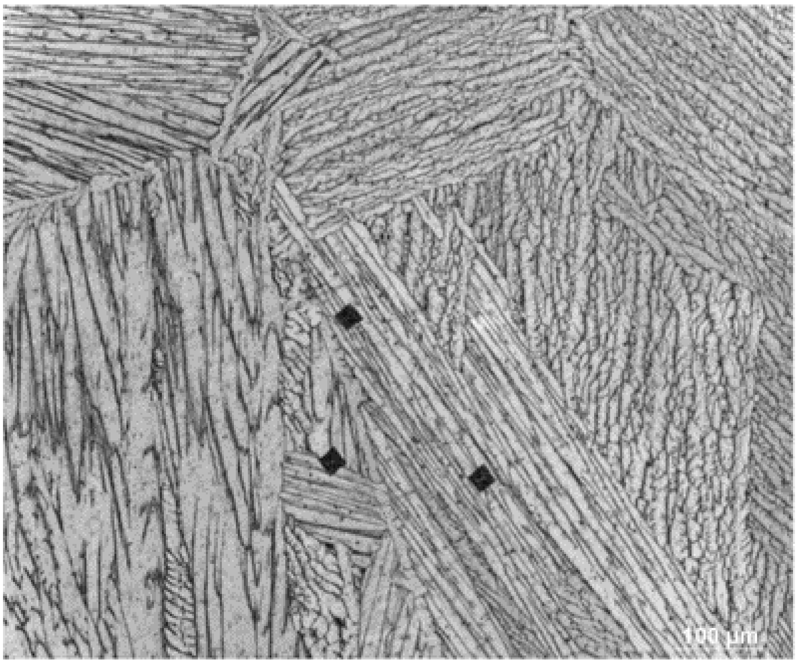

Figure 3: α-Widmanstatten microstructure of titanium alloy Ti-6Al-4V.

The graphs of the applied tension versus the number of cycles up to the break for the situation as received according to Fig. 4, and after the solubilization treatment according to Fig. 5, were plotted.

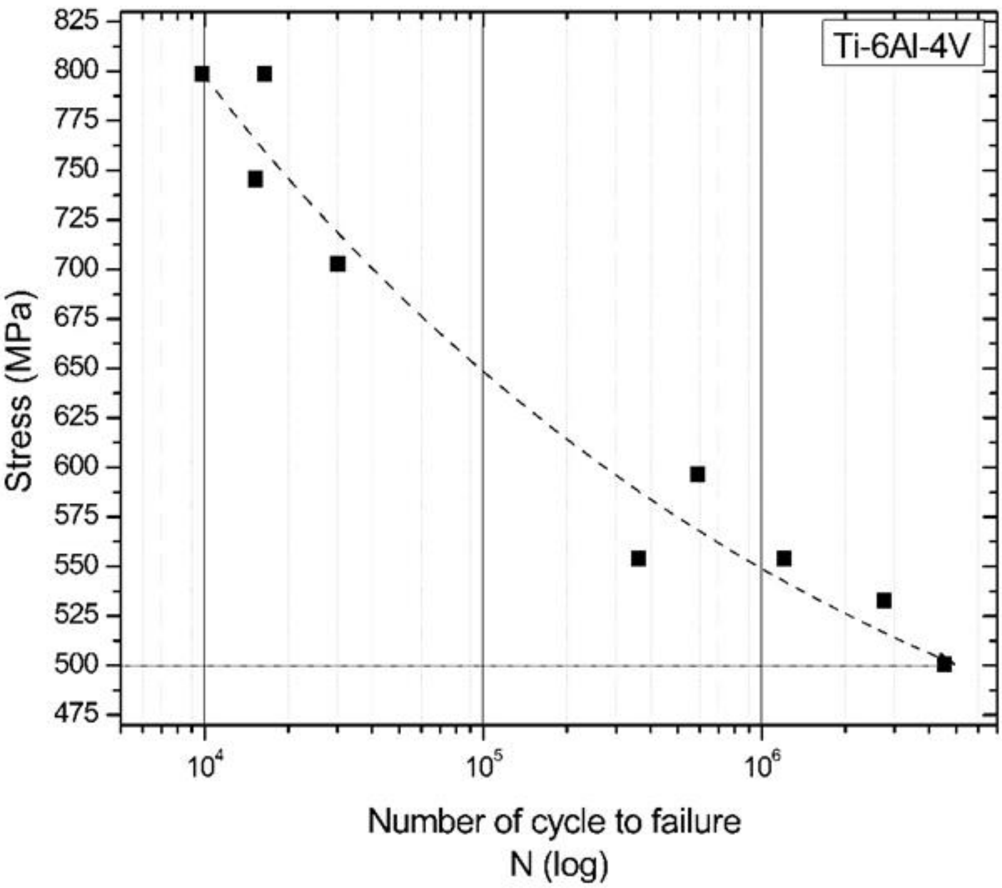

Figure 4: Curve σ x N (log) of Ti-6Al-4V without thermal treatment.

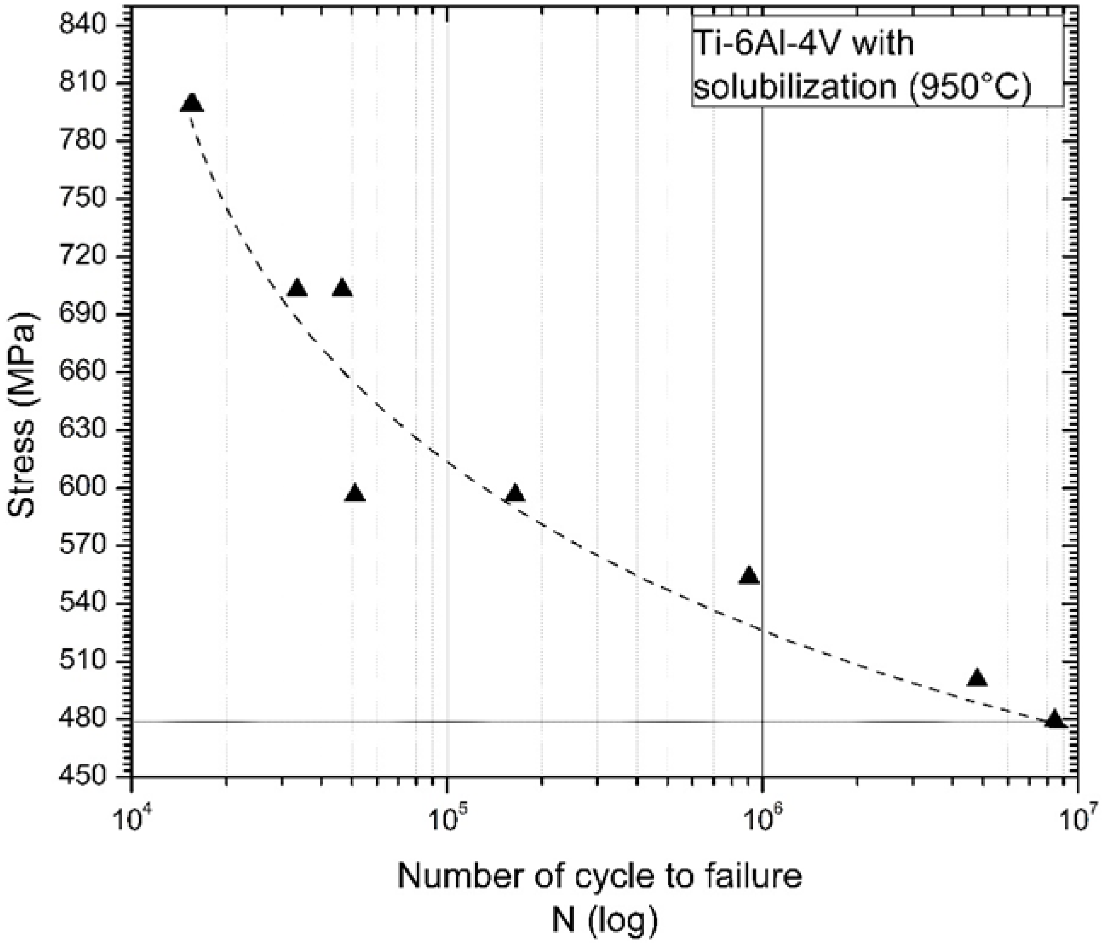

Figure 5 - Curve σ x N (log) of Ti-6Al-4V with solubilization thermal treatment.

4. CONCLUSIONS

Through the results it was possible to observe that the heat treatment influenced the microstructure, microhardness and the fatigue response by rotating bending until rupture. The solubilization treatment provided a relief in the tensions of the material causing the decrease in the microhardness value. They presented the characteristic, like several other materials, of having finite life, that is, the curve σ x N (log) tends to be a straight line. As it was considered infinite life being 5.10^6 cycles it was possible to find the value of 500MPa for both samples.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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7. RESPONSIBILITY NOTICE