COMPARATION BETWEEN PIII SUPERFICIAL TREATMENT AND CERAMIC COATING IN CREEP TEST OF Ti-6Al-4V ALLOY

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ABSTRACT

The objective of this work was evaluating the creep resistance of the Ti-6Al-4V alloy with superficial treatment of PIII superficial treatment and ceramic coating in creep test of Ti-6Al-4V alloy. It was used Ti-6Al-4V alloy as cylindrical bars under forged and annealing of 190^{o}C by 6 hours condition and cooled by air. The Ti-6Al-4V alloy after the superficial treatment of PIII and ceramic coating was submitted to creep tests at 600°C and 250 and 319 MPa under constant load mode. In the PIII treatment the samples was put in a vacuum reactor ($76x10^{-3}$ Pa) and implanted by nitrogen ions in time intervals between 15 and 120 minutes. Yttria (8 wt.%) stabilized zirconia (YSZ) with a CoNiCrAlY bond coat was atmospherically plasma sprayed on Ti-6Al-4V substrates by Sulzer Metco Type 9 MB. The obtained results suggest the ceramic coating on Ti-6Al-4V alloy improved its creep resistance.

1 – Introduction

Ti-6Al-4V alloy is one of the mostly used titanium alloys in aeronautical and biomedical applications because of its excellent combination of mechanical, toughness, corrosion resistance, and chemical stability properties [1-2].
However, the affinity by oxygen is one of main factors that limit its application as structural material at high temperatures. The high solid solubility of oxygen in titanium results in material loss and in the formation of hard and brittle layer during elevated temperature air exposure. [3]. The development of titanium alloys with the objective of improving the creep properties have been observed, although the surface oxidation limits the use of these alloys in temperatures up to 600°C [4].

In recent works was verified the increasing of the superficial properties of the alloy through the PIII nitrogen treatment [5-7] and ceramic coating [8-12]. Based on those results this work aims to evaluate the creep resistance of the Ti-6Al-4V alloy with superficial treatment of PIII superficial treatment and ceramic coating in creep test of Ti-6Al-4V alloy.

2 – Experimental

The material used in this work was obtained in Multialloy Eng. Mat. Ltda, forged and annealed at 190ºC during 6 hours and cooled in air. The samples were treated by PIII treatment at Instituto Nacional de Pesquisas Espaciais (INPE). In this treatment the samples were put in a vacuum reactor with pressure of $76x10^{-3}$ Pa and implanted by nitrogen ions during 120 minutes. The frequency used was 400 Hz, pulse of 40 μs and voltage varying between 7 and 10 kV.

Yttria (8 wt.%) stabilized zirconia (YSZ) (Metco 204B-NS) with a CoNiCrAlY bond coat (AMDRY 995C) was atmospherically plasma sprayed on Ti-6Al-4V substrates by Sulzer Metco Type 9 MB.

All the samples were submitted to creep tests at 600°C and 250 at 319 MPa under constant load mode at Instituto Tecnológico de Aeronáutica (ITA/CTA). Creep tests were realized using MAYES machines. Antares Software was used to collect the data on the elongation of the samples and the measuring of temperature in pre determined periods of time. It was used a transducer-type LVDT Schlumberger D 6.50 to obtain measures of elongation and it was used Cromel-Alumel thermocouple type AWG24 to control temperature. The creep tests were realized in accord to the standard ASTM E139 [13].

3 – Results and Discussions

Representative creep curves of Ti-6Al-4V are showed in Fig. 1.

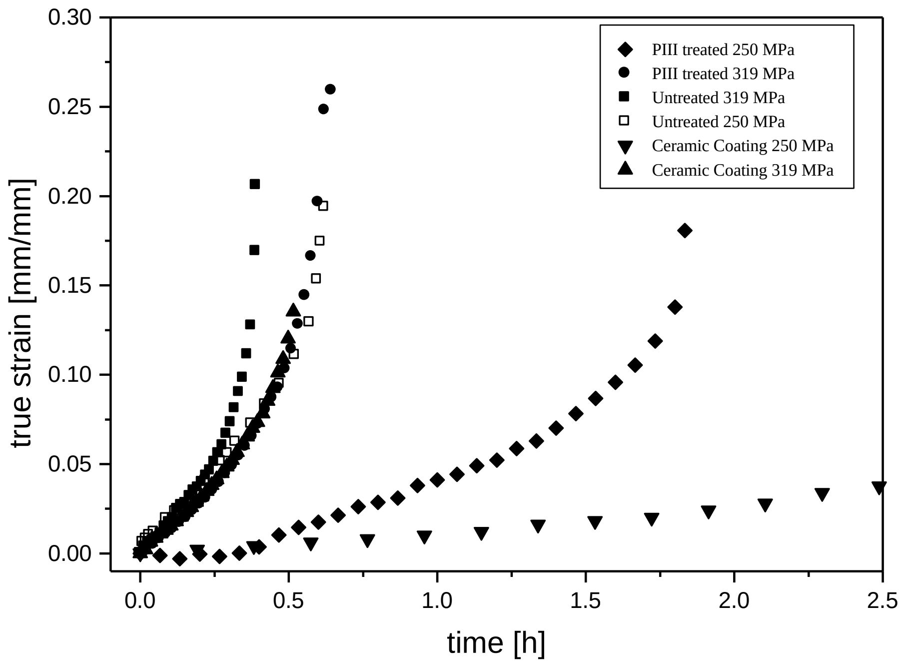

Fig.1. Typical creep curves of Ti-6Al-4V at 600ºC.

Figure 1 shows that most of the creep life of this alloy is dominated by a constant creep rate that is thought to be associated with a stable dislocation configuration due to recovery and hardening process. The higher creep resistance of Ti-6Al-4V is observed in samples with ceramic coating.

Results from the creep tests at 600°C are summarized in Table 1, which shows the values of stress (σ), primary creep time (t_p), secondary creep rate ($\dot{\varepsilon}_s$), final creep time (t_f), final strain (ε_f) and reduction of area (RA).

The reduction of the steady-state creep rate (Table 1) demonstrates that the higher creep resistance of Ti-6Al-4V is observed in samples with ceramic coating. This fact is related to the hardening superficial formed in Ti-6Al-4V alloy by the ceramic coating. It is a well known fact that hard surface and interstitial solid solutions increase the creep resistance of certain alloys. The hardening superficial during creep tests, increases rupture life. It is possible that controlled penetration of oxygen into the alloy Ti-6Al-4V could increase its creep resistance without seriously altering its ductility [14, 15].

Table 1 - Creep data at 600°C.

Treatment	**σ (MPa)**	**t_p (h)**	**$\dot{\varepsilon}_s$ (1/h)**	**t_f (h)**	**ε_f (mm/mm)**	**AR (%)**
untreated	250	0.03	0.1906	0.62	0.1938	75.83
PIII treated	250	0.27	0.0615	1.83	0.1807	29.33
Ceramic coating	250	0.38	0.0104	4.59	0.1490	71.91
untreated	319	0.01	0.5698	0.39	0.1742	62.99
PIII treated	319	0.11	0.1925	0.60	0.1964	25.67
Ceramic coating	319	0.03	0.1401	0.51	0.1353	69.75

4 – Conclusions

Constant load creep tests were conducted with Ti-6Al-4V alloy at 600°C and stress of 250 and 319MPa. When the Ti-6Al-4V with ceramic coating alloy was tested the effect of the oxidation was smaller than PIII treated alloy and the behavior of the creep curves showed that the life time was better. There was an increasing of life time. Occurred a decreasing of steady state creep in function of the reduction of oxidation process, showing that for the Ti-6Al-4V alloy their life time was strongly affected by the superficial treatment that was submitted because the oxidation suffered by the material.

5 – References

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