ACOUSTIC EMISSIONS IN TITANIUM GRADE 5 DURING UNIAXIAL FATIGUE TESTING

Claudia Barile\textsuperscript{1}, Caterina Casavola\textsuperscript{(t)}, Giovanni Pappalettera\textsuperscript{1}, Carmine Pappalettere\textsuperscript{1}

\textsuperscript{1}Dipartimento di Meccanica, Matematica e Management, Politecnico di Bari, Bari, Ita
\textsuperscript{(t)}Email: katia.casavola@poliba.it

ABSTRACT

In this paper fatigue test results are presented for titanium grade 5 specimens subjected to uniaxial loading. A couple of piezoelectric sensors was attached to the surface of the sample in order to allow real-time recording of acoustic activity occurring in the material during the test. At the same time thermographic analysis was also carried out during the experiments. Results of the fatigue behaviour of the analysed material beside the acoustic emission track and the thermal images of the sample are analysed and discussed.

Keywords: Titanium grade 5, fatigue, acoustic emission.

INTRODUCTION

Much interest appears today in studying Titanium grade 5 (Ti6Al4V). Aircraft industry, in particular, is greatly pushing towards the introduction of new materials allowing to obtain lighter structures which would lead to a reduced fuel consumption and, as a consequence, cost and emissions reduction. In this context Ti grade 5 in view of its very good strength-to-density ratio beside a significantly good corrosion resistance, can represent a good solution for many structural parts (Casavola, 2009). Nevertheless, besides these properties, it also displays an high biological compatibility; this occurrence expands the fields of application of this materials also to the biomechanics where it can be adopted, for example, for the manufacturing of prostheses. However still few data on fatigue characterization of titanium alloy are presented in literature and much more insight is required to fully understand fracture mechanisms in this material. Having this in mind, in this paper, results in terms of acoustic emission (AE) recorded during uniaxial fatigue testing of Ti grade 5 are presented. AE technique is a monitoring approach based upon the detection of acoustic waves generated inside a sample which is subjected to some thermal or mechanical loading. Possible sources of acoustic emissions can be related with crack nucleation and propagation, motion of dislocations, residual stress relaxation and so on. Monitoring the acoustic activity of the sample can give some clues about what is happening to the sample during the performed test. In this paper AE detection system was used together with thermography in order to have a comparison between the two techniques about their capability to follow the damage evolution in the sample (Barile, 2015).

MATERIALS AND METHODS

Nine samples (2000 mm x40 mm x4 mm) having two notches with 5 mm radius were tested at three different maximum stresses in sinusoidal loading conditions (R=-1) by an uniaxial Instron servo-hydraulic machine ($F_{\text{Max}}=\pm100$ KN). The detection of the acoustic waves was performed by two piezoelectric sensors Mistras Picosensor having a 250÷750 KHz bandwidth
and a 500 KHz resonance frequency. The two sensors were placed along the longitudinal line (y direction) of the sample symmetrically with respect to the line of the notches. Signal from the sensor are preamplified with a 40dB gain and then transmitted to the PC for further elaboration and for storage. For the thermographic image acquisition the sample was dark painted on one face and thermal emission was recorded in real time during the fatigue test by a NEC H2600 thermocamera having a 1240x1024 pixel CMOS camera and a FOV, at the adopted working distance, of 0.2 m x 0.15 m (horizontal x vertical).

RESULTS AND DISCUSSION

In Fig.1 results of a thermographic image and the number of acoustic events vs amplitude vs the y position along the longitudinal line connecting the two PZT sensors are displayed.

![Fig. 1 - (Left) Thermographic acquisition frame recorded during the fatigue testing; (Right) Histogram plot representing the distribution of the recorded acoustic event at a given position along the longitudinal line and with a given amplitude.](image)

It can be inferred that during the execution of the fatigue test no substantial localized increment of temperature can be observed in the specimen that could be related to damage evolution. The temperature in the lower part of the specimen appears slightly higher than in the upper part but this can be explained in view of the fact that actuation is done by the lower clamp which has, as a consequence, an higher temperature. On the other and AE activity is well detected and a peak in the number of events is found at about 50 dB of amplitude and localized about at the middle point between the sensors that is to say in correspondence of the notches. This indicates capability of the AE to follow damage evolution along the nucleation and crack propagation.

CONCLUSIONS

In the fatigue test performed on Ti grade 5 samples the acoustic emission technique has proven its capability to detect signal that can be correlated with damage evolution much time before the final rupture.

REFERENCES