FATIGUE PROPERTIES OF A GAMMA TITANIUM ALUMINIDE ALLOY

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Abstract

The fatigue properties of a Ti-48Al-2Cr-2Nb alloy obtained by electron beam melting (EBM) with a patented process has been examined by conducting high cycle fatigue tests performed at different loading ratios both at room temperature and at high temperatures, comparable to those experienced by the components during service. Some tests have been conducted in the superlong life regime well exceeding 10 million cycles, highlighting individual fatigue characteristics of the studied TiAl alloy.

Keywords gamma titanium aluminides; high cycle fatigue; fatigue crack propagation.

1. Introduction

Gamma titanium aluminide based alloys have become an important contender for high temperature structural applications in the aircraft industry to replace current nickel-based superalloys as the material of choice for low-pressure turbine blades (Winstone *et al.*, 2001; Dimiduk, 1999). The advantages achieved by the use of γ-TiAl intermetallics are principally their low density (3.9-4.2 g/cm^3 as a function of their composition), high specific yield strength, high specific stiffness, substantial resistance to oxidation and good creep properties up to high temperatures. In particular, the lower density will contribute to significant engine weight savings and reduced stresses on rotating components such as low-pressure turbine blades (Bartolotta *et al.*, 1997). Although such materials appears very promising for the turbine engine industry, optimizing the performance improvements requires more advanced approaches to accurately predict fatigue life. Therefore, there is a need to understand and address the specific fatigue properties of these materials to assure adequate reliability of these alloys in structural applications (Henaff and Gloanec, 2005). Moreover, it is difficult to obtain a component produced with γ-TiAl intermetallics with exactly the composition and microstructure desired. A further difficulty is that in the typical aeroengines applications must have an extremely low oxygen content, preferably much lower than 1500 ppm.

Electron beam melting (EBM) is a type of additive manufacturing for metal parts. It is often classified as a rapid manufacturing method. The technology manufactures parts by melting metal powder layer per layer with an electron beam in a high vacuum. Using EBM technology, the process of material production operates under high vacuum conditions, thereby reducing the risk of oxidation in the material of the final components. EBM technology for “layer by layer” productions offers several advantages with respect to other competing technologies and it is possible to operate at temperatures closer to the melting points of the intermetallic alloys (Murr *et al.*, 2010). In the EBM process, components are produced without vaporization of the powders of the initial material and the powders are made of an intermetallic alloy based on titanium and aluminium with the same chemical composition as the final intermetallic with which the components are produced.

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