Abrasive Wear of Cryogenically Treated Commercial Wrought and as-Built by Electron Beam Melting Ti-6Al-4V

CATEGORY OR KEYWORD

Category: Materials Tribology. Keywords: Titanium, cryogenic treatment, abrasive wear, additive manufacturing.

AUTHORS AND INSTITUTIONS

P. Herrera[1], E. Hernández-Nava[1], R. Thornton[2], T. Slatter[1]. [1]The University of Sheffield, Sheffield, U.K.; [2] University of Leicester, Leicester, U.K.

INTRODUCTION

The effect of deep cryogenic treatment (DCT) on wear resistance has been variously established for a number of different ferrous engineering alloys, but light alloys, such as wrought and electron beam melting (EBM) obtained Ti6AL4V, have not been investigated similarly. In this work, the abrasive wear resistance of Ti6AL4V samples obtained commercially and by EBM, were characterized. Each type of material was divided in two classes for investigative purposes, being one of those test groups in the as received condition and the other one submitted to cryogenic treatment. These materials were tested using an ASTM-G65 based 'rubber wheel' wear test apparatus and Vickers hardness measurements.

DESCRIPTION OF WORK

Ti-6Al-4V material was additively manufactured by electron beam melting using an ARCAM S12 (software v3.2), using their standard recommended settings. A layer process of 70 μm, preheating, contouring and hatching steps took place in a controlled vacuum environment at 2 x 10^{-3} mbar. Ti-6Al-4V in wrought condition was obtained from cutting plate material of 10 mm of thickness.

The samples for the abrasion test were prepared to the standard specifications as rectangular specimens of 25x76x10 mm. For EBM specimens the long direction was parallel to the build direction, which may represent an anisotropy variable, whereas the wrought product is expected to have a higher degree of isotropy. Half of each type of material was submitted to a cryogenic treatment, in which it was hold at 93 K over a period of 14 hours in a temperature-controlled chamber.

The ASTM-G65 Type A was used but with non-standard sand, albeit with similar composition and grain size. As a comparative study with all the tests performed in the same machine and parameters, the sand should not unduly influence the conclusions of the work.

Overall, titanium samples in wrought condition did not present a significant difference after abrasive wear testing as average wear volumes are similar with minimal scatter in the results. While untreated wrought Ti-6Al-4V presented a mean wear volume of 15.151± 0.245 mm^3, the cryogenically treated presented a mean wear volume of 15.205±0.401 mm^3, indicating a lack of efficacy of the DCT in this material. EBM Ti-6Al-4V however, showed a significant change in volume, losing enough material to make it not comparable to the wrought material. It is clear that the resistance of EBM obtained Ti6AL4V is very much lower than the wrought equivalent regardless of the level of DCT.

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REFERENCES

[1] Herrera P, Thornton R & Slatter T (2018) Abrasion Resistance of 304L and 316L Stainless Steel Subjected to Deep Cryogenic Treatment. STLE 2018 Extended Abstracts & Presentations (pp 96-98).