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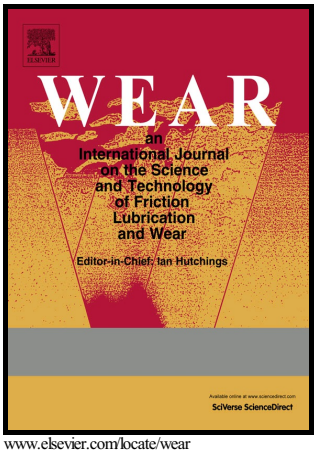

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Case study: the application of machining-conditioning to improve the wear resistance of Ti6Al4V surfaces for human hip implants

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Abstract

The purpose of this investigation was to determine the extent to which a combination of electron beam melting and specific machining procedures could improve the wear resistance of acetabular cups for hip implants. Electron Beam Melted Ti6Al4V samples, with a simplified geometry close to that of acetabular cups, were finished by machining. Wet and cryogenic machining with a different number of finishing passes were used to create different surface and sub-surface conditions. The Ti6Al4V samples were wear-tested against ASTM 1537 Co-Cr-Mo alloy using a commercial tribometer in a simulated implant environment. A change in the wear response was found as a function of the part surface topography and properties that resulted from the given machining operations. A correlation between the machining parameters and wear volume loss was assessed and discussed. Cryogenic cooling was the most promising of the evaluated machining approaches because it generated lower wear volume compared to wet conditions thanks to a hardened and more compressed surface and to the generation of a profile characterized by a reduced skewness, which revealed to be the most influencing texture parameter in enhancing the wear resistance.

Keywords: Surface, Titanium, Tribology

1. Introduction

The wear behaviour of hip implants subjected to cyclic stresses due to the human gait cycle strictly depends on their surface condition, which is usually generated during the final machining steps of the process chain. During the implant service life, wear phenomena induce the formation of wear debris that are harmful for the patient's health since they can cause osteolysis and provoke inflammatory reactions with the surrounding tissues. A reduction of wear and, consequently, of debris generation is highly desirable, especially for young and active patients [1] that have a long expectation of life. This has recently contributed to renew the interest in Metal-on-Metal (MoM) connections, composed by a Ti6Al4V acetabular cup and a CoCrMo femoral head, as an alternative to the conventionally used metal-on-PolyEthylene (PE) ones, as it was demonstrated that the former were characterized by approximately 40-100 times lower wear rate than the latter [2].

The scientific literature presents several studies addressing either the influence of the manufacturing parameters on the obtained surface characteristics, or the effect of the surface characteristics on the service life performances.