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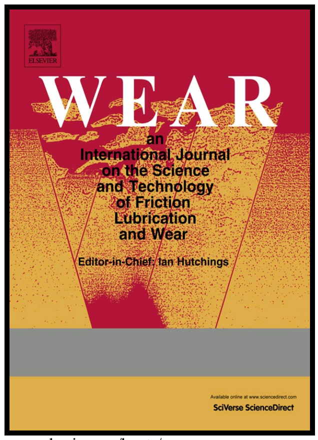

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The effect of titanium alloy chemistry on machining induced tool crater wear characteristics

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Abstract
It is widely accepted that crater wear is the primary tool wear mechanism observed in titanium alloy machining. An investigation was carried out utilising a small scale, low cost diffusion couple method to determine the effect of chemistry on tool crater wear characteristics. Using a range of commercial titanium alloys, it was found that as the β stability at RT increased, the quantity of TiC formation at the reaction interface decreased. This trend allowed for the determination of the machinability characteristics of two emerging aerospace titanium alloys: TIMETAL 407 and TIMETAL 575. The former was found to be more machinable than Ti-6Al-4V, and the latter more machinable than Ti-6Al-2Sn-4Zr-6Mo. As the chemistries of titanium alloys are directly related to the rate of tool wear, the second part of this investigation examined the effect of alloying titanium with Al, Mo, Cr and V. It was found that as the concentration of these elements in the binary titanium alloys increased, the quantity of TiC formed at the reaction interface decreased. The formation of TiC has a key role on the tool crater wear mechanism during the machining of titanium alloys.

Keywords: Machining; WC-Co; Titanium alloys; Diffusion; Tool wear mechanisms

1. Introduction

The aerospace industry has seen the new generation of civil aircraft platforms such as the Boeing 787 and Airbus A350 XWB become increasingly more reliant on carbon fibre composite fuselage, empennage and wing structures. Due to titanium's superior galvanic corrosion compatibility with carbon over that of steel or aluminium, there has been a corresponding increase in the volume of titanium required for high strength forgings and fasteners. There is an ever-increasing move to design titanium alloys with increased fatigue and ductility properties coupled with lower densities and improved machinability. This is a result of a synergy in industry to manufacture greener, more efficient engines.

Almost all titanium components are intensively machined which results in one of the costliest stages of the multi-stage manufacturing route. This is primarily due to approximately 95% of the starting material being removed as swarf [1]. The α+β alloy Ti-6Al-4V (Ti-64) remains the commonest titanium alloy used today and represents approximately 40% of the total titanium tonnage manufactured per annum. Due to the demand from end users for improved alloy performance with enhanced mechanical properties, there has been a shift in the titanium industry to develop new alloys to replace alloys such as Ti-64 in certain components. Alloys that can offer increased machinability and ductility without sacrificing high strength and fracture toughness will see lower costs achieved throughout the aerospace manufacturing supply chain. TIMETAL 407 (Ti-407) and TIMETAL 575 (Ti-575) are two new α+β titanium alloys being demonstrated as potential alloys for aerospace applications. Ti-407 has been designed to offer increased ductility, malleability and faster machining