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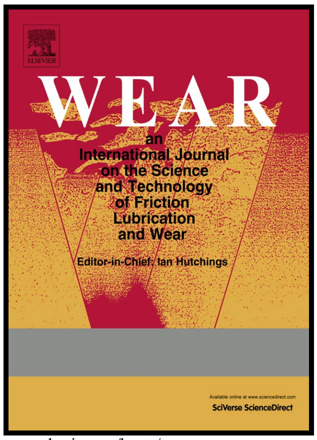

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PII: S0043-1648(17)30580-X
DOI: https://doi.org/10.1016/j.wear.2018.08.007
Reference: WEA102482

To appear in: *Wear*

Received date: 7 April 2017
Revised date: 16 July 2018
Accepted date: 9 August 2018

Cite this article as: Aline Gonçalves dos Santos, Marcio Bacci da Silva and Mark J. Jackson, Tungsten carbide micro-tool wear when micro milling UNS S32205 duplex stainless steel, *Wear,* https://doi.org/10.1016/j.wear.2018.08.007

Tungsten carbide micro-tool wear when micro milling UNS S32205 duplex stainless steel

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Abstract. *In conventional machining operations, tool wear is an important aspect of machining with many relevant discussions in the literature. However, in the micromachining process, very little is known about tool wear and wear mechanism compared to conventional machining. Some considerations for tool wear from a macro machining point-of-view may not be valid for micromachining processes because of reduced geometry of the tools and the so called size effect, which affects the kinematics of micromachining and chip formation mechanism. A small wear land on a micro-tool can eliminate half of its edges, and could double the size of the shear force at the other edges of the tool. Therefore, it is necessary to discuss the types of wear and their mechanisms for tools used in micromachining to characterize end-of-life criteria. In this sense, the main goal of this work is to analyze the evolution of wear land of a carbide micro-mill tool when cutting UNS S32205 duplex stainless steel. Experiments were performed to produce micro channels using a 3-axis CNC micro milling machine and TiN coated tungsten carbide tools with diameter 0.381 mm. Previous experiments were performed in order to choose the most appropriate cutting conditions for the evaluation of tool wear. The tools were examined before and after each experiment using a scanning electron microscope. The results show that the major forms of wear encountered during machining are nose and flank face wear, with adhesion being the most clearly observed wear mechanism. The wear land as a function of machined length showed similar behavior to macro machining operations with three defined regions of wear. Taylor's tool life equation was obtained and the resultant coefficients are similar to results from literature for macro machining operations.*

Keywords*: microcutting, tool wear, duplex stainless steel.*

1. INTRODUCTION

The demand for components with micro dimensions has grown in recent years in the most diverse fields, mainly in areas such as medical, transport, environmental and electronic components, which has required fast delivery of high or ultra precision customized components [1]. In this context, micro machining has been presented as an important tool because it is a process of high or ultra precision, which involves the manufacture of pieces that have dimensions in the order of micrometers [2].

Micro machining allows the processing of various engineering materials including titanium, brass, aluminum, platinum, iridium, plastics, ceramics, composites and stainless steels [3]. The latter are of great interest to the industry because of their high resistance to corrosion and oxidation, and these characteristics are intrinsic to the presence of certain alloying elements, especially chromium and nickel [4].

Stainless steels are classified into six main classes, namely: ferritic stainless steels, austenitic stainless steels, martensitic stainless steels, duplex stainless steels, precipitation hardening stainless steels and Mn-N substituted austenitic stainless steels [5]. Duplex stainless steels have a two-phase microstructure, ferrite and austenite, in approximately equal volume fractions, which combines many of the beneficial properties of ferritic and austenitic steels. These steels have been widely used in many industries such as petrochemical, heat exchanger, chemical tankers and architecture. Their use has rapidly increased in many applications requiring higher corrosion resistance and mechanical properties than conventional stainless steels [6,7], including small components, such as screws, nuts and lock washers.

Unlike conventional machining, the undeformed chip thickness, equivalent to the milling cut thickness, and the workpiece materials grains size are comparable to the cutting edge radius [8]. Thus, the undeformed chip thickness, for most of the time, is smaller than the radius of the cutting edge, the chip is then formed into the radius of the cutting edge, experiencing a large negative rake