ADHESIVE WEAR MECHANISMS IN DRY MACHINING AERONAUTICAL ALUMINIUM ALLOYS

D. ALLEHAUX\(^1\), S. AUGER\(^2\), A. DEVILLEZ\(^3\), G. LE COZ\(^3\),
Daniel DUDZINSKI\(^3\)

\(^1\) EADS IW, 37 boulevard de Montmorency 75781 PARIS Cedex 16, France
\(^2\) CETIM, 52 Avenue Félix Louhat, BP 80067, 60304 SENLIS Cedex
\(^3\) LPMM-Plateforme UGV – Bâtiment CIRAM – 4, Rue Augustin Fresnel – 57000 METZ

Abstract

Adhesion or adhesive wear is the main wear mechanism that operates during machining of aluminium alloys. This kind of tool wear can be produced by two different ways: firstly, adhesion wear is caused by incorporation of tool particles to the chips and (or) to the machined surface by the action of the forces developed in the tool-workpiece material interfaces. Secondly, adhesion wear is caused by the incorporation of workpiece elements to the tool faces. When these elements are removed, they may drag out tool particles causing tool wear. This last mechanism results to the formation of built-up-edge (BUE) in the tool edge region and to the formation of built-up-layer (BUL) in the tool faces.

This paper studies adhesion wear mechanisms in dry machining of an aerospace aluminium alloy, the AA 7075 (Al-Zn) alloy. Dry turning and tests were performed. Different coatings on cemented carbide tools were tested. DLC and PVD nanostructured coatings were chosen for these machining tests. Spindle and feed axis power consumption were measured for different cutting conditions. Tool wear patterns and machined surfaces quality were analysed using SEM, EDX and white light interferometry techniques. In particular, the BUE and BUL were observed and measured. In addition, chips morphology was examined.

Keywords

Dry machining, Aeronautical aluminium alloys, Coatings, Tool wear, Adhesion, Built-Up Edge, Built-Up layer

1 INTRODUCTION

In machining processes, different mechanisms can be responsible for the tool wear. Usually these mechanisms do not act separately but, their combination is multiplied synergistically [1-3]. In machining of aeronautical aluminium alloys, the adhesion wear is the main observed mechanism. The workpiece material adheres on the tool rake face in two different forms [1]. The first one involves the Built-Up-Edge (BUE) formation which corresponds to the adhesion of worked material close to the cutting edge of the tool; in the second one the worked material is poured to wider areas on the tool rake, giving rise to Built-Up-Layer (BUL). Elimination of cutting fluid increases the tool wear mechanisms and reduces the tool life.

In this work, dry turning and dry milling tests of an aeronautical aluminium alloy, AA7075, were performed to study the effects of adhesion wear on different coated carbide tools. During the machining tests, the spindle power consumption was monitored. The tool wear patterns and the machined surface quality were observed using Scanning Electron Microscopy (SEM) and white light interferometry microscopy. The BUE and BUL regions have been identified on the tool rake face, particularly after dry turning tests. The thicknesses and the affected areas by BUE and BUL were measured; they depend on the cutting conditions and on the tool coating.

2 STATE OF THE ART

2.1 BUE and BUL formation during dry machining aluminium alloys.

The papers of Carrilero et al. [1] and of Sanchez et al. [2] report on the results of studies on BUE and BUL formation mechanisms. In these works, scanning electron microscopy (SEM) was used in order to identify the effects of adhesion on dry turning of aerospace aluminium alloys, such as AA2024 and AA7050. Subsequent analysis with energy dispersive spectroscopy EDS, enabled to distinguish the characteristics between BUE and BUL formation. Short duration dry turning tests (1s and 10s) were first performed at 80 m/min with a TiN coated WC-Co inserts. The tool rake face observations have shown that an initial metal