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Parametric analysis of the Ultimate Tensile Strength in dry machining of UNS A97075 Alloy

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Abstract

Aluminium alloys (mainly 2XXX and 7XXX series) have been traditionally used in the industry in the manufacture of structural parts in aircrafts, due to their excellent ratio density-mechanical properties. Machining is commonly used in the manufacture of these parts. In addition, the actual trend is machining in dry, due to environmental and economic reasons. Under these conditions, surface integrity becomes one of the most important quality requirements applicable to machined parts. The micro and macro-geometrical properties analysis of the dry machined surface as a function of the cutting parameters is widely studied. Notwithstanding, there is a lack of research in the field dedicated to the physicochemical properties. In this paper the feed influence on the ultimate tensile strength for UNS A97075 (Al-Zn) alloy turned in dry is presented, as a first approximation to the study of the influence of the cutting parameters on this mechanical property.

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Keywords: Aluminum Alloys; UNS A97075; Dry Machining; Ultimate Tensile Strength.

1. Introduction

The sustainable manufacturing has three important core ideas: the economy, the environment and society. Nowadays, the sustainability has been mainly oriented to reduce the environment impact of the production systems, developing and promoting the noun as green production. Nevertheless, this production system sidelines the

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functionality of the products obtained [1,2].

So, it is necessary to consider the efficiency of the process in sake of the performance and add the Efficiency Tetrahedron concept: functional, energetic, environmental and economic. The four elements are interconnected with a center common element: the global efficiency [3,4].

One of the industrial sectors most involved in the change towards the application of the new concept of High Performance Manufacturing has been the Aeronautical industry. In recent years, the aeronautical production systems have been paying particular attention to clean production, even when this green production entails the assumption of a loss of economic performance, especially in highly energy-efficient contexts [5-7].

In addition, the manufacturing of aircrafts involves high safety levels. There are elements that required narrow margins of deviation in the design requirements, not only in their geometry but also in terms of physicochemical properties that mark their behavior in service [8,9].

Many of the high-demand parts are produced by machining processes like milling, turning and drilling. Aluminium and/or titanium alloys are used for strategic parts that can be structurally sensitive and are high-committed to the flight safety of the aircraft. In the particular case of aluminum alloys, which are the ones selected for the analysis presented in this paper, the increase in environmental performance has been established through the application of processes in which cutting fluids are removed (dry turning) [10-12].

These alloys have been used due to their excellent weight/physicochemical properties/cost. These materials meet the severe requirements for the strength required in structural elements of aircraft [13,14]. However, machining processes and its dry application can adversely affect the performance in service of the parts or components manufactured, decreasing the functional performance of the process, through the loss of quality or the surface integrity of the parts. [10,13,15]. The surface integrity can be defined as the properties that exhibit the surface of a material after any forming process and that are acquired and/or modified during the accomplishment of the same [16].

These surface properties can be analyzed from two points of view: geometric properties, with its micro and macro scale consideration, and physicochemical properties (Table 1), being able to improve or worsen the functional performance of the shaped element. The geometric properties have been widely studied [17-20], unlike the physicochemical properties [21,22]. Present work focus on the physicochemical characteristics, in particular in the mechanical properties, studding the influence of the feed, f, in the Ultimate Tensile Strength (UTS) of an aluminium alloy 97075 T6. This aluminum alloy is often used in the aircraft industry (7000 series, Al-Zn) along with the 2000 series (Al-Cu) [13,14].

Table 1. Levels for the evaluation of the surface integrity [16]

Geometric		Physicochemical
Microgeometric	Macrogeometric	
Surface roughness	Cylindricity	Microhardness variation
Microcraks	Concentricity	Fatigue strength
Macrocraks	Roundness	UTS
Particle adhesion	Parallelism	Residual stresses
Others	Others	Others

Almost all manufacturing processes generate residual stresses. They can be large enough to cause local creep or plastic deformation, both at the macroscopic and microscopic levels, which impacts negatively in the functional performance of the affected component. The mechanical properties considered are affected, among other circumstances, by machining processes. Changes in these properties are generally linked to the metallurgical state in which the machined part remains after the forming process. During machining, the surrounding material is elastically deformed to preserve dimensional continuity, and thus, residual stresses are created. The UTS can be significantly influenced by these stresses. The residual stresses can be defined as the stresses that remain in a material or body after a manufacturing process in the absence of external forces or thermal gradients. Different studies show that mainly the micro-geometric deviations and the residual stresses can affect other mechanical properties like fatigue and tensile strength, important parameters in this kind of workpieces [23,24]. So, this study starts with the analysis of the feed