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Experimental methodology design for fatigue behaviour analysis of turned aluminum alloys

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Abstract

Aluminum alloys are widely used in the manufacturing of structural parts in aeronautical industry. During machining the surface of machined parts suffers various alterations, not only geometric but also physicochemical changes, especially when it is done in dry. Some of these changes in surface integrity may affect their fatigue behavior. In this work, an experimental methodology to study the influence of cutting parameters on fatigue life of dry turned aluminum alloys has been proposed. It is necessary to point out that in this work only the design stage of this methodology has been exposed. Its validation and first results are left for further works.

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Keywords: Aluminum Alloys; Turning; Dry Machining; Fatigue behaviour; Fatigue test.

1. Introduction

Aluminum alloys are widely used in the manufacturing of structural parts in aeronautical industry, mainly 2000 and 7000 series, due to their high strength-density ratio. These parts are usually placed in critical areas of an aircraft, so strong quality requirements are demanded [1].

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Among the different process used in the manufacturing of these parts, machining is frequently applied. One of the most relevant quality requirements in machined parts is related to the surface integrity. When a part is machined its surface achieves new properties and characteristic compared to the initial one. These surface alterations affect not only to the geometrical properties obtained (macro and micro scale) but also to the physicochemical properties of the machined surface [2,3]. So, different levels can be taking into account to evaluate surface integrity, Table 1 [4,5].

Table 1. Levels to evaluate surface integrity.

Microgeometrical	Macrogeometrical	Physicochemical
Surface roughness	Cylindricity	Residual stress
Macrocraks	Concentricity	Micro-hardness
Microcraks	Roundness	Fatigue resistance
Surface ripples	Straightness	Corrosion resistance
Particles adhesion	Parallelism	Phase transformation
Superficial tears	Radial oscillation	Plastic deformation
(among others)	Total oscillation	Tensile strength
	(among others)	(among others)

In addition, nowadays the machining operations are usually performed in dry by environmental reasons [6]. Under these conditions surface integrity is strongly affected and the design quality requirements could be difficult to achieve [7,8].

In the particular case of aeronautical aluminum alloys, several research can be found in the literature focused on the analysis of the behaviour of geometric deviations as a function of the input variables of the machining process. However, there is a lack of research devoted to the analysis of the physicochemical properties of the machined surface (micro-hardness, residual stresses, corrosion resistance, fatigue resistance…) as a function of the cutting parameters, despite its great influence on the functionality of the machined parts [9-12].

Fatigue life is one of the most important properties to take into account in the service behaviour of structural parts in aircrafts. The fatigue life of a machined part depends strongly on its surface condition. Fatigue cracks generally start from free surfaces, where the highest loads are applied and the environmental effects are stronger (stress concentration, oxidation, loss of alloy elements, …).

On the other hand, several researches have demonstrated the strong influence of cutting parameters, mainly feed rate, on geometrical properties of aluminum alloys machined parts. So, it could be thought that mechanical properties (i.e. fatigue life) are influenced by cutting parameters [13,14]. It is necessary to highlight that this kind of analysis is strongly demanded by the industry, with the aim to improve the manufacturing performance of this parts, from a functional, economical, energetic and environmental point of view [15,16].

The necessary initial stage to start this kind of analysis is to develop an experimental methodology which allows to analyse the influence of cutting parameters on fatigue behaviour of machined parts. Thereby, in this work an experimental methodology to study the influence of cutting parameters on fatigue life of dry turned aluminum alloys has been proposed. It is necessary to emphasize that only the design stage of this methodology has been exposed in the present work, leaving for future works the validation of the results.

2. Experimental methodology

First of all, an analysis of the different standards which allow to study the fatigue behaviour of materials has been carried out. Table 2 shows the different standards taken into account.