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Influence of tool cooling on thrust forces in tapping operations of reinforced polyamide

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Abstract

The machining with compressed air cooling has been identified as an environmentally conscious process. Its good performance has been achieved in materials as titanium alloys or aluminum alloys, but composites have not been explored. This work presents a first study related to evolution of thrust forces during the tapping process in reinforced polyamide with glass fiber, in particular PA66-GF30, when the tool cooling is considered. The experimental methodology was carried out by tapping operations in plates of PA66-GF30, using a drilling center. The experimental tests were executed using compressed air cooling by means of a vortex-tube cooling, in dry. Taps are of high-speed-steel with cobalt as base material and with coating; their geometry and dimensions are M12x1.75 mm. Outcomes obtained confirm that the methodology is appropriate in the tapping process of PA66-GF30. The tool cooling provides a reduction of thrust forces, although it is conditioned by type of tap and the coating.

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Keywords: Tapping; PA66-GF30; Cooling; Force.

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1. Introduction

Recently, environmentally friendly manufacturing processes have being studied under different perspectives. It is possible to find in the academic literature, researches about the influence the tools in the consumed energy and associated CO_2 emission [1] or only focused on the required energy on the machining of materials as PEEK-GF30 [2-3], or in the analysis of machining parameters [4]. Moreover efforts have been carried out in the development and analysis of innovations processes related to the refrigeration [5-7]. In this sense, the machining with compressed air cooling has been identified by Shokrani et al. [5] as an environmentally conscious process. Its good performance has been achieved in materials as titanium alloys [6] or aluminum alloys [7].

In the machining, the forces studied frequently because they influence on the machine stability and in the process energy, and they are subjected to variations according to process conditions [8] as can be seen in tapping processes [9]. On the other hand, the composite, reinforces polyamide with glass fiber, PA66-GF30 is a material increasingly studied by its industrial use. Its behavior in machining process as turning [10] or drilling [11] has been analyzed, but not in tapping process.

Therefore, this work presents a first study related to evolution of thrust forces during the tapping process in reinforced polyamide with glass fiber, in particular PA66-GF30, when the tool cooling is considered.

2. Experimental Procedure

The experimental methodology was carried out by tapping operations in plates of PA66-GF30, using a drilling center; the main mechanical proprieties of PA66-GF30 can be seen in Table 1. The thrust forces have been measured by a Kistler piezoelectric dynamometer and captured by Dasylab software [12].

The experimental tests were executed using compressed air cooling by means of a vortex-tube cooling, in dry (see Fig. 1.a). The data has been taken at room temperature and at 15 ºC. Taps are of high-speed-steel with cobalt as base material and with coating; their geometry and dimensions are M12x1.75 mm (see Fig. 1.b and Table 2).

Table 1. Mechanical proprieties of PA66-GF30.

Proprieties	Value
Density (kg/m3)	1350
Rockwell hardness M	75
Tensile strength (MPa)	93.1
Compression strength (MPa)	124

Table 2. Characteristics of tools.

	Tool T1	Tool T2	Tool T3	Tool T4
Tool material	HSS-E	HSS-E	HSS-E	HSS-E
Coating	TiN	AlCrN	TiN	AlCrN
Number of flutes	5	5	4	4
Chamfer form	C	C	B	B
Class of Fit	6HX	6HX	6H	6H

In these tests, the cutting speed performed takes the following values, 10, 20 and 30 m/min. For each cutting speed and each tap, three tests have been carried out. Thus, the average of three forces has been considered in the posterior Section.