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INFLUENCE OF DRILL BIT DIAMETER ON DRILLING OF POLYURETHANE FOAMS

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ABSTRACT

Drilling is one of the most common processes involved in machining operations. The usual requirement is the efficient material removal. However, when it comes to the living tissues, drilling assumes greater attention to ensure a minimally invasive procedure. This work describes conventional drilling experiments performed on solid rigid polyurethane foams with similar mechanical properties to the human bone. An extensive experimental study was conducted to evaluate the effects of different drill diameters (4, 5 and 6mm) on the temperature rise and stresses generation during drilling. Different experiments were performed to assess the repeatability of the tests. Results from the experiments suggest that both drilling temperatures and stress levels increased with increase in the drill tool diameter.

Keywords: polyurethane foam, drilling, drill diameter, temperature, stress, damage.

INTRODUCTION

Drilling is a mechanical process in which a drill bit revolving on its own axis that is called the drilling axis creates a cylindrical cavity in the material by applying axial load on the rotating drill. This mechanical action between the drill and that material affects the surface properties in different aspects. It is a known fact that this process generates high mechanical efforts and high temperatures due to high contact friction between the drill bit and the base material. An excessive increase in this values can endanger the integrity of the material and the quality of the process. Nevertheless, when the drilling concepts are applied on the living tissues, the precautions for a minimally aggressive technique require augmented attention. Some problems get initiated during drilling are caused due to the mechanical and thermal damage to the surrounding of the bone in the form of micro-cracks, irregular surface topography of drilled walls and even bone necrosis (Singh et al. 2016). These damages may lead to failure of the joint and the implant. The importance of reducing the bone damage risk is becoming clearer and it is visible in the large increase of recent published works (Fernandes et al. 2015, Fernandes et al 2016, Singh et al. 2016).

The main focus of the present study is to contribute to reduce of the mechanical and thermal damage during bone drilling procedures. Therefore, the goal was to measure the influence of drill bit diameter, more precisely with regard on temperature, strains and stresses evolution. An experimental procedure was conducted on solid rigid polyurethane foam materials (Sawbones, Pacific Research Laboratories, Inc., Vashon. WA USA), as an alternative for human bone. The foams were instrumented with strain gauges to measure the level of strains on the surface during the drilling. Simultaneous, the temperature distribution on the drill bit

were measured with the thermography equipment. The overview of the experimental setup used in this study is shown in Figure 1.

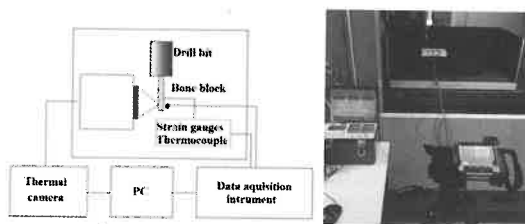


Fig. 1 - Experimental setup for measuring temperature and stresses of polyurethane foam during drilling

RESULTS AND CONCLUSIONS

Results show that the smaller drill bit diameter at constant feed-rate (75mm/min) and drill speed (600rpm) leads to a decrease in the temperature rise and stresses generation in solid rigid foam materials during drilling, as show in Fig 2 (a) and (b).

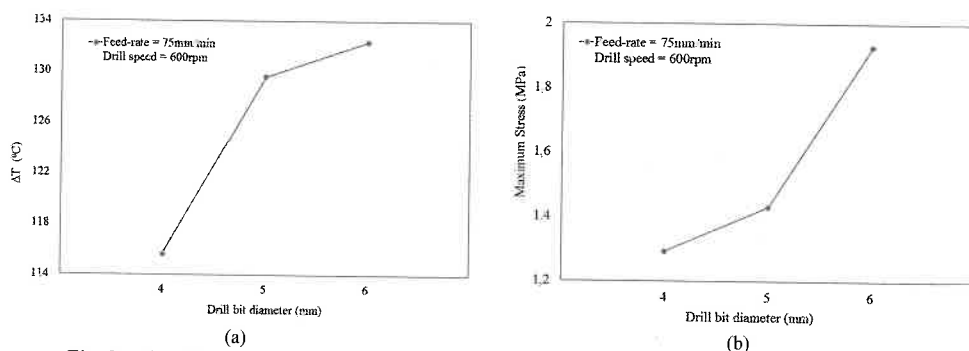


Fig. 2 - The effect of drill bit diameter on temperature variation (a) and maximum stress, σ_{zz} (b).

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