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REGULAR PAPER

Micro Drilling 3D Printed Cobalt Chromium Molybdenum for Biomedical Applications: An Experimental Study on the Tool Wear and Machinability

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Abstract
This paper presents the evaluation and observation of the drillability characteristics of cobalt chromium molybdenum (CoCrMo) produced through 3 dimensional (3D) Additive Manufacturing technologies named Selective Laser Sintering. CoCrMo is regarded as one of the advanced materials which are currently garnering popularity in both engineering and medical applications. However, this material falls under the hard-to-cut materials category due to its unique properties such as high strength, toughness, wear resistance as well as low thermal conductivity. All these tend to hinder the machinability resulting in rapid tool wear and subsequently shorter tool life. 2 mm diameter holes were drilled on a 5-axis high precision machine under flood cutting conditions with varying cutting speed and tool geometry (point angles). Drilling was conducted on a 3D printed CoCrMo ($60 \times 60 \times 4$) plate, forces and tool wears are the outputs recorded from the experiments conducted. The best combination of tool geometry and cutting speed on machining 3D CoCrMo are then identified. The best combination when micro drilling 3D printed CoCrMo is with 50 m/min and using tool B (130° point angle) drill bit. This combination generated the least thrust force and the lowest tool wear overall, 208.995 N and 0.089 mm wear respectively. The result from this study contributes to the minimization of tool wear and improvements in micro drilling efficiency by selecting appropriate machining parameters when working with CoCrMo alloys.

Keywords Cobalt chromium molybdenum · Micro drilling · 3D printed metal · Tool wear

1 Introduction

Recent years shows the increase in trend in producing miniature products and machinery which is physically smaller and cheaper. Industries in the field of electronics, aerospace, automotive and medicines are all leaning towards this movement. Most of these miniaturised parts and components are made by micromachining techniques. Within those techniques, micro drilling is one of the most fundamental machining techniques [1]. When products and machines are getting smaller, thinner and denser through time, the requirement for more lines and holes in limited space were needed. Moreover, quality of hole produced along with better tool life is the main purpose of recent research. To achieve this goal, researchers are finding ways to improve performance of micro drilling in many areas such as methods of manufacturing, materials fabrication as well as shapes and geometries of micro drill.

Generally, micro hole drilling mechanism are mainly using twist type micro drill bits. It is frequently observed that the behaviour of twist type bits is that they usually break down before they wear [2]. Technically speaking micro drill bits withstand greater load compared to its strength, slight changes in processing parameters may result in catastrophic failure. Hence, as reported by Jadhav et al. [3], the selection of tool geometry, machining parameters and cooling techniques are important in obtaining good performance in micro drilling. Important geometry factor of micro drill bit is their point angle, flute length and helix angle. Flute lengths are measured by depth of hole drilled, it's a determining

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