Additive Manufacturing of Embedded Thermocouples in WC-Co Cutting Tools for Cutting Temperature Measurement

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ABSTRACT

During machining processes, a large amount of heat is generated due to deformation of the material and friction of the chip along the surface of the tool, especially in the cutting zone. This high temperature strongly influences tribological phenomena and adhesion, tool wear, tool life, workpiece surface integrity and quality, chip formation mechanisms and contribute to the thermal deformation of the cutting tool, leading to high operating costs and reduction of the end product quality. In this sense, being able to assess the cutting temperature in real time, at various points of the cutting tool during machining processes, is of utmost importance to effectively optimize cutting parameters and the cutting fluid flow adequately, for minimizing heat generation, temperature and consequently wear, allowing to increase tool life.

This work proposes the fabrication of embedded additively manufactured type K and type N thermocouples by laser powder bed fusion for real time cutting temperature measurement. Processing parameters optimization was performed to obtain a dense and continuous thermocouple with no significant defects and the additively manufactured thermocouples were tested in comparison to a conventional thermocouple. The obtained results show that this approach is effective to produce embedded thermocouples in WC-Co cutting tools capable of measuring cutting temperature, which will allow a real time optimization of the cutting parameters, namely cutting speed, feed and depth of cut, during in-service time, thus enhancing tool performance and life.

INTRODUCTION

During machining processes, a large amount of heat is generated, being estimated that approximately 90% of the mechanical work applied to the workpiece is transformed in thermal energy, due to deformation of the material and friction of the chip along the surface of the tool, especially in the cutting zone [1,2]. This high temperature strongly influences tribological phenomena and adhesion, tool wear, tool life, workpiece surface integrity and quality, chip formation mechanisms and contribute to the thermal deformation of the cutting tool, leading to high operating costs and reduction of the end product quality [3–5]. In this sense, the ability to measure cutting temperature in real time, at various points of the cutting tool during machining processes, is of utmost importance to effectively optimize cutting parameters and the cutting