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ORIGINAL ARTICLE

Machinability study of cryogenic-ultrasonic vibration-assisted milling Inconel 718 alloy

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Abstract

A new machining method, cryogenic-ultrasonic vibration-assisted milling (CUVAM), is proposed to improve the workability of Inconel 718. This study examined the machining mechanism of CUVAM technology at different machining parameters. The cutting force, chip, tool life, workpiece surface morphology, and surface integrity after conventional machining (CM), cryogenic cooling machining (CCM), and CUVAM were compared. The experimental data showed that cryogenic assistance could effectively improve the machining environment and coefficient of friction (CoF) and improve surface integrity. On the other hand, the cutting force increases after CCM due to the low-temperature brittleness of Inconel 718, but the ultrasonic vibration assistance in CUVAM can suppress the increase in cutting force. CUVAM well combines the advantages of cryogenic assistance and ultrasonic assistance. Compared to CM, the CUVAM method can reduce the cutting force by 36.5% and have a beneficial impact on tool life. The chipping effect was more obvious. Compared to CCM, the surface roughness after CUVAM was reduced by 39.1%. The excellent machinability of the CUVAM method was verified through the combination of experiments and theory, which provides a new method for the high-quality, high-efficiency, and pollution-free machining of Inconel 718.

Keywords Inconel 718 · Cryogenic-ultrasonic vibration-assisted milling · Hybrid Machining · Cutting force

1 Introduction

Inconel 718 maintains its mechanical characteristics at temperatures beyond 700 °C and has outstanding tensile strength and corrosion resistance. This substance is widely employed in the petrochemical, nuclear, and vehicle engineering owing to its capacity to meet the strict criteria of combustion chambers and other high-temperature components in aviation turbines [1]. Contrarily, typical difficult-to-machine material Inconel 718 has a poor rate of material removal, high work hardening rate, and low heat conductivity severely limit its development potential [2, 3]. In this situation, all kinds of hybrid machining techniques have been developed to increase Inconel 718's machinability.

Usually, both conventional and non-conventional machining processes have poor surface integrity, poor machining performance, and excessive tool wear. Hybrid machining processes (HMPs) avoid or reduce the adverse effects of individual machining processes on a workpiece by combining the advantages of two or more machining processes [4]. The

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