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ORIGINAL PAPER

Effect of hybrid tri-nano flood cooling environment and shearing parameters on surface quality with tool health in helical milling of Ti6Al4V

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Abstract
Hole milling is strenuous in the Titanium Alloy grade 5. Ti6Al4V has extraordinary metallurgical properties, so it has popularity in the Aerospace, Automobile, and Ship-building industry. The lower heat absorbing ability, springiness, and chemically activeness at higher temperatures, strain hardening consensuses, poor tool life, and damaged surface texture. This is a common issue in Ti6Al4V machining allows penurious machinability. This investigation focuses on the effect of cooling strategies like a typical flood, Minimum Quantity Cooling Lubrication, and novel Hybrid Tri-nano Flood Coolant with popular cutting inserts in Hole milling. A total L9 orthogonal arrays performance quantifying in terms of the Crater, Flank wear, and Average Surface Roughness value (Ra) at a sidewall and bottom of the Hole. Analysis of Variance manifests that the Tool type and Coolant are more significant for wear control and superior surface quality in the Ti6Al4V Hole milling by balanced Lubri-Cooling. Optimum results were acquired by adapting the 65 m/min cutting speed, Axial Depth of Cut is 0.6 mm, and Hybrid Tri-nano Flood Coolant through PVD-TiAlN + TiN coated inserts. However, the Radial Depth of Cut is 45% of the tool diameter, and the Ramp angle should be 1.24° constant through the hole milling. All these shearing parameters in the hole milling of Ti6Al4V under the Helical milling Computer Aided Milling tool path revamp.

Keywords Ti6Al4V · Hole milling · Hybrid tri-nano flood coolant · Shearing parameters · Crater wear · Flank wear · Average roughness value

1 Introduction

Titanium Alloy grade 5 is the most popular super alloy in Aircraft, shipbuilding, and the Automobile industry because the material possesses less weight and has high strength, strong corrosion resistance, and dimensional stability at high temperatures. This duplex $\alpha + \beta$ superalloy does not have such excellent machinability because of its thermally excited metallurgical behaviours [1–3]. With the increment in temperature, this dual-phase alloy changes its phase HCP to BCC. Initially, beyond 500 °C, Ti6Al4V is highly chemically active, reacts with the cutting tool, and starts chemical itching. After that, beyond the range of 600–700 °C or exceeds this limit. The oxygen and nitrogen molecules in the machining environment diffused with the workpiece and hardened its surface layer.

Furthermore, above 882 °C alpha phase start transforming into the beta phase [4, 5]. It has a fine basket wave-dense lamellar structure and offers high strength. Titanium dual-phase alloy offers high strength at elevated temperatures (up to 1050 °C). It shows a hard surface by predominant plastic deformation and diffusion of upper layer molecules. After moves with very high-temperature significant thermal softening, the BUE and galling of the cutting tool degrade the machining accuracy [6–8]. Circular pocketing is a familiar shape in aircraft components. Also, the surface quality of the side wall and the bottom portion for interchangeability means higher Dimensional accuracy [9, 10]. Hole creation is carried out by conventional Drilling and the Helical milling method in the Ti6Al4V machining. However, the drilling method makes large hole-making impossible due to drill bit

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