ABSTRACT

The present thesis is an endeavour to study and improve the grindability of Ti-6Al-4V employing an advanced single-layer electroplated superabrasive cBN wheel. The thesis comprises of (i) wear mechanism of cBN wheel in high speed grinding and its effect on the surface integrity, (ii) ultrasonic assisted high speed grinding under different viscous fluids, (iii) high speed moderate depth grinding and a non-destructive method to measure the grinding-induced subsurface deformation, and (iv) FE simulation of single-grit grinding.

i) Three different grinding speeds (20, 40 & 60 m/s) were employed under both water-based and oil-based fluids to study the wear mechanism and its effect on surface integrity. It was observed that thermal shock-induced fracture has a dominant effect on wheel wear, and because of this, water-based fluid yielded 2-4 times higher radial wear than neat oil (up to 40 m/s). Due to lower radial wear, neat oil provided better surface integrity than water-based fluid.

ii) The ultrasonic assisted grinding was undertaken using fluids of different viscosity (lubricity). The high lubricious fluid provided less resistance to vibration transfer to the grinding zone, and consequently, the effective amplitude of vibration increased with an increase in fluid's lubricity. This has governed the grinding scallop formation significantly. Besides, the UAG improved (more compressive) the residual stress by 20-100%.

iii) The grinding of Ti-6Al-4V up to a high wheel speed of 90 m/s at moderate depth was attempted. The metallographic study revealed more deformation at a higher wheel speed (90 m/s) and a higher removal rate. The XRD result indicated deformation-induced texturing of the 002 basal plane of the hcp-α phase of Ti-6Al-4V. The present work also proposed a Gi-XRD based non-destructive methodology to measure subsurface deformation with only around 1.2 µm inaccuracy in measurement.

iv) The 3D single-grit simulation revealed an initial pure ploughing phase followed by dominated ploughing + cutting (pdc), and ploughing + dominated cutting (pcd). A clear transition from pure ploughing to ploughing + cutting regime (pdc + pcd) was distinctly captured. The specific grinding energy and residual stress of single-grit simulation were compared against the results of the actual grinding process.

Keywords: high speed grinding of Ti-6Al-4V; electroplated cBN wheel; finite element simulation of single-grit grinding; non-destructive technique for deformation layer.