Abstract

The grindability of advanced ceramics and CMCs employing single layer electroplated diamond wheels is investigated. The work is divided into three objectives.

i. The high-speed grinding of alumina, yttria-stabilized zirconia (YSZ) and carbon fibre reinforced silicon carbide (C/SiC) was investigated. Grinding speed up to 200 m/s was used. High grinding speed promoted ductile deformation for alumina and generated high compressive residual stresses. For YSZ, ductile deformation and high compressive residual stresses were observed. The forces during alumina and YSZ grinding followed the maximum undeformed chip thickness (h_m), whereas ground surface characteristics were controlled by grinding scallop height (S_g). For C/SiC grinding, the defects were different for different fibre orientations. For fibres orthogonal to the ground surface, the h_m controlled the defect formation and fibre-matrix delamination up to a depth of 400 µm was observed. For other two orientations (orthogonal fibres in grinding plane), S_g governed defect generation. The defects in the latter orientations remained confined only to the machined surface.

ii. The effectiveness of different grinding environments (flood cooling (FC), MQL-soluble oil (MQL-SO), MQL-neat oil (MQL-NO), MQL-alumina nano-fluid and MQL-hBN nano-fluid) during high-speed grinding of alumina and YSZ was evaluated. Grinding speed was kept fixed at 80 m/s. For alumina, MQL-NO promoted micro-cutting and generated high compressive residual stress. Contrarily, FC provided less fracture and the highest compressive residual stress for YSZ. The use of MQL nano-fluids yielded fracture for both alumina and YSZ.

iii. The mechanisms of wear of diamond grits over the electroplated diamond grinding wheels were studied during grinding of alumina and YSZ at 30 m/s and 50 m/s grinding speeds under – conventional flood cooling (CFC), MQL-SO and MQL-NO. Wheel loading was observed while grinding alumina and YSZ under CFC and MQL-SO. Indentation fatigue fracture was found to be the dominant mode of diamond grit wear during alumina grinding under wheel loading conditions. The wear of diamond grits during YSZ grinding was dominated by thermal fatigue fracture at a higher grinding speed of 50 m/s. The Raman spectroscopy revealed graphitization of some of the active diamond grits upon YSZ grinding under CFC and MQL-NO at 50 m/s.

Keywords: ceramics; Ceramic matrix composites (CMCs); grinding; minimum quantity lubrication; diamond; wear