HIGH-SPEED FACE-MILLING OF 7075-T6 ALUMINUM USING CARBIDE AND DIAMOND CUTTERS

Objective

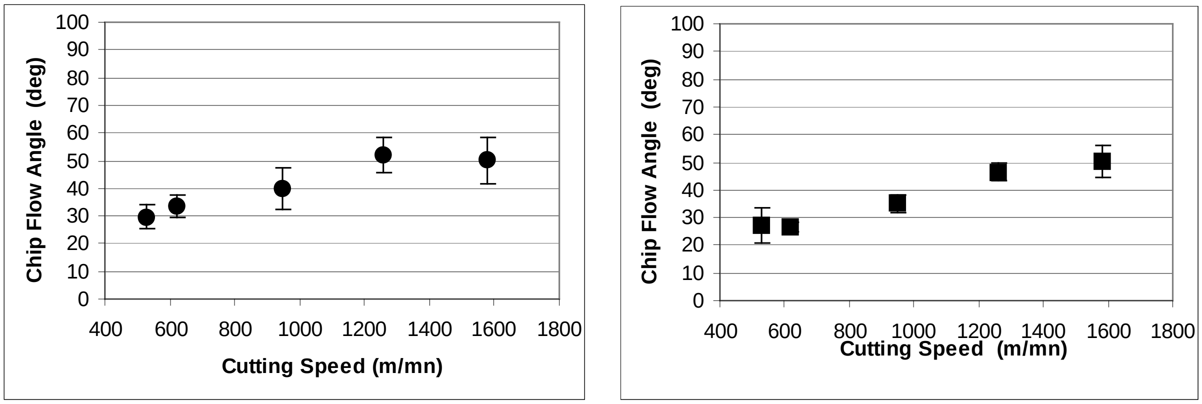
This research is concerned with the analytical and experimental study on the high-speed face milling of 7075-T6 aluminum alloys with a single insert fly-cutter. The results are analyzed in terms of cutting forces, chip morphology, and surface integrity of the workpiece machined with carbide and diamond inserts.

Approaches

- All the experiments were performed on a 100 HP variable speed high-speed milling machine. The maximum table feed and maximum spindle speed on this machine are 16.51 m/min and 10,000 rpm respectively. Face milling tests were performed by cutting blocks of aluminum 7075-T6. Uncoated carbide and diamond inserts of nose radius 0.79 mm (Kennametal SEEN 422J K313) were used in a Kennametal high velocity face milling cutter to machine the blocks. Single insert fly cutting was carried out for all the tests in this research.
- The mechanics underlying the high speed cutting process was studied based on the results predicted by certain analytical and numerical methods. The oblique machining theory was extended to three-dimensional machining cases
- Finite element modeling. In order to validate the calculated values pertaining to process mechanics, finite element simulation has been carried out for each of the cutting conditions.
- Surface integrity interrogation: X-ray diffraction for residual stress measurement, SEM for chip morphology, optical microscopy for tool wear measurement, and profilometry for surface roughness.

Results

1. High chip flow angles and chips thinner than uncut chip thickness were observed in the speed range of 610 to 1524 m/min (Fig. 1).
2. Shear stresses and shear plane temperatures, obtained by applying the extended machining theory and finite element simulation, showed nearly constant values in the high speed regime. Shear stresses of 250 ~ 300 MPa were much lower than the known ultimate tensile strength (500 ~ 550 MPa) of 7075-T6 (Fig. 2).
3. Shear localized chips were observed while face milling the aluminum alloy at higher feeds in the high-speed regime (Fig. 3).
4. Compressive residual stresses were observed from the workpiece subsurface in the range of cutting conditions considered in this research. An increase in feed is shown to leave higher compressive residual stresses in the workpiece while cutting speed and depth of cut show an opposite effect (Fig. 4).
5. Surface roughness improved with cutting speed up to 1524 m/min, beyond which it showed degradation. Increasing depth of cut is shown to slightly deteriorate surface roughness (Fig. 5).



(a) DOC=1.27 mm **(b) DOC=2.54 mm**

Figure 1: Variation chip flow angle vs. cutting speed
(Machining of AL7075 T6 by a carbide tool with feed of 0.2 mm/tooth)

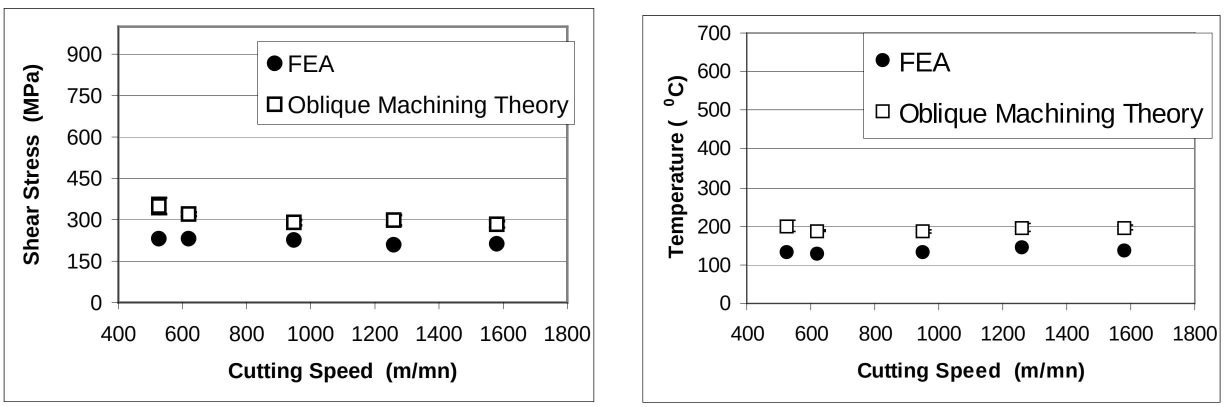


Figure 2: Average stresses and temperatures in shear plane
(Carbide tool with feed of 0.2 mm/tooth and depth of cut of 2.54 mm)

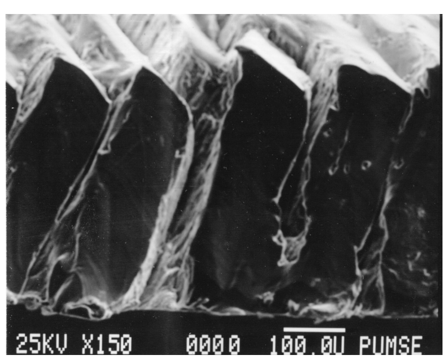
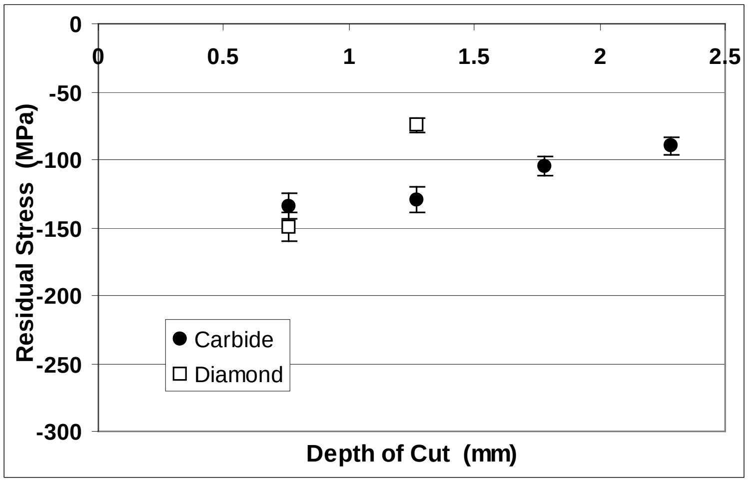


Figure 3: Segmented chips of aluminum 7075-T6
(Cutting Speed = 1250 m/min, feed= 0.38 mm & depth of cut = 1.27 mm)



(c) Speed=1372 m/min & feed=0.1 mm/tooth

(d)

Figure 4: Variation of maximum residual stress with cutting conditions

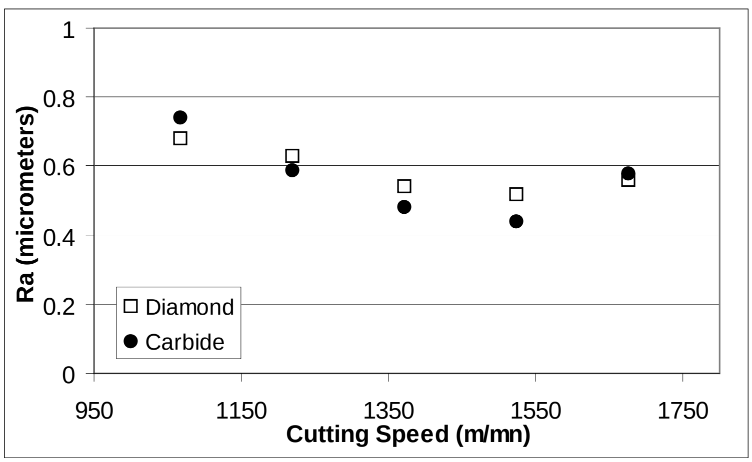


Figure 5: Variation of surface roughness vs. cutting parameters.
(Feed=0.1 mm per tooth & depth of cut=0.76 mm)