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Feasibility of improving productivity through the usage of higher axial depth of cut per pass during MQL based sustainable micro-milling

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Abstract

Mechanical micro-milling process emerged as an economic, time-efficient, and easily controllable micro-fabrication process that can be applied to a wide variety of materials. During fabrication of deeper micro-features using micro-milling process, application of larger axial depth of cut can enhance productivity by reducing the number of passes. However, machining with a larger depth of cut can degrade the machinability in several ways. The influences of the axial depth of cut during minimum quantity lubrication (MQL) [1] assisted micro-milling on Ti-6Al-4V using 500 µm diameter TiAlN-coated tungsten carbide (WC/6Co) tools are studied here.

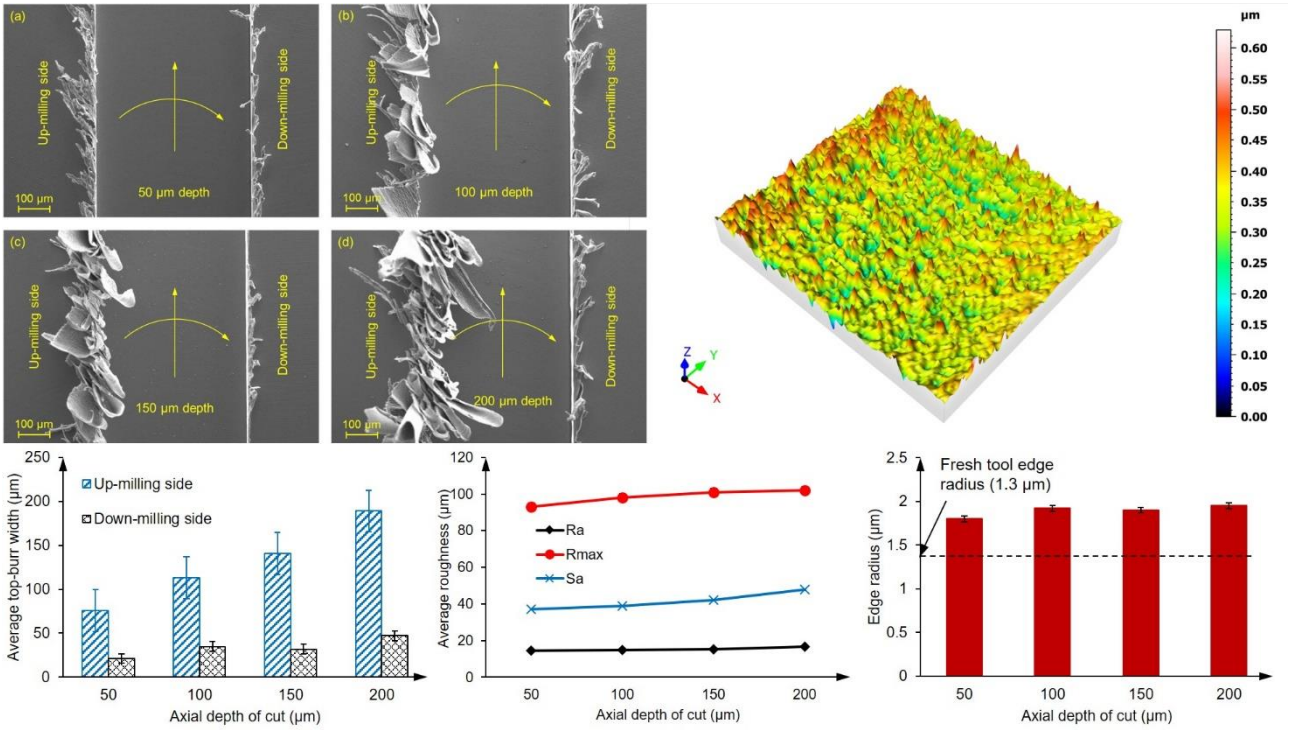

Figure 1. Effect of the axial depth of cut (50, 100, 150, and 200 µm) on top-burr size, surface roughness, and tool wear (45,000 rpm, 2.0 µm/flute)

During micro-milling with a given tool, the plastically deformed material bends in the lateral direction of the side-walls to generate top-burr. As the volume of this plastically-deformed material increases proportionally with the axial depth of cut, the top-burr size also increases (Fig. 1). An increase in the average width of the up-milling side top-burr from 76 – 189 µm is observed when axial depth is increased from 50 – 200 µm. Undesired inward flow of the burrs (bending towards the slot) is also clearly detected. Down-milling side top-burr, however, does not change perceptibly. Surface texture roughness R_a and R_{max} also change only marginally with the increase in axial depth. Significant change in the areal roughness (S_a) is also not detected. As usual, the fresh tool suffers rapid break-in wear in the initial 5.0 mm length of cut; however, the final edge radius remains more-or-less same across all the trials. Thus, it is the top-burr that predominantly limits the usage of high axial depth of cut per pass. There are several micro-scale deburring processes reported in the literature [2] that can remove burrs with negligible collateral damage. Therefore, higher axial depth can be employed during micro-milling to enhance productivity, provided that the component can be processed through a deburring technique.

References

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