Effect of Fiber-tool Contact Mode on Carbon Fiber Reinforced Plastic Milling Tool Wear

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Severe tool wear during carbon fiber reinforced plastic (CFRP) milling is one of the factors to deteriorate machining quality such as delamination and surface roughness. In CFRP machining, hard carbon fiber is removed in the form of brittle fracture. The intermittent fatigue stress and rubbing between the cutting edge and fiber during the fiber removal process cause severe tool wear. Furthermore, it was reported that the bouncing-back effect of cut fiber also accounts for a significant proportion of flank wear progress. The effect of these physical interactions between the fibers and cutting edges on tool wear depends on the cutting angle (angle between fiber orientation and the cutting direction). When the angle is over 90°, fibers tend to be fractured by bending in bundles at once. The fracture point of these fibers is below the machined surface, thereby leading to less rubbing with bouncing-back fibers and tool flank face. Therefore, relatively less tool wear area is observed when the cutting angle is over 90° compared to under 90°. In milling processes, the cutting angle varies because of tool rotation, unlike orthogonal cutting. Consequently, although all the fibers are subjected to bending, the tool wear area varies with the fiber orientation angle (angle between the fiber orientation and milling tool feed direction). However, there is a lack of studies on tool wear behavior in CFRP milling. In this study, the tool wear trend according to fiber orientation angle was investigated in CFRP milling. A simulation was developed to derive the geometrical relationship between fibers and rotating cutting edge. Based on the relationship, the number of fibers expected to slide on the tool rake and flank face were derived. Tool wear area difference was explained with the calculated tool travel distance of the region where bent fibers having contact with tool flank face.

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