ABSTRACT

Ultrasonic Vibration-assisted Machining (UVAM) leverages the intermittent cutting produced by the vibrating tool. The vibrations generated utilize a flexure hinge which deformed to amplify the deflection from the piezoelectric actuator to the tool tip. Among the various types of flexure hinges, the Notch Hinge is widely used due to its proven advantageous properties and ease of fabrication. This study employs the finite element method to analyze the influence of Notch Hinge design parameters on deformation and stress. One of the Design of Experiment methods, the full factorial design, is implemented with five levels for each parameter. The study's results indicate that a larger radius increases the tool's deformation, while thicker walls and hinges have the opposite effect. The induced stress remains minimally affected by hinge thickness but decreases significantly (≈ -30%) with a larger radius. Grey relational analysis identifies the optimal design combination in this study as having a radius of 3 mm, wall thickness of 2 mm, and hinge thickness of 16 mm. This configuration achieves a maximum tool deformation of 1.95 μm and a stress of 64.3 MPa in the simulation. These findings highlight the Notch Hinge's capability to enhance deformation and minimize stress under typical vibration conditions in UVAM operations. Each key parameter of the Notch Hinge contributes to either increasing or decreasing deformation and stress values, providing valuable insights for optimizing tool performance in precision machining applications.

Keyword: Ultrasonic Vibration-assisted Machining, Flexure hinge, Notch Hinge, Deformation, Finite Element Method