Investigation of tool-workpiece contact rate and milling force in elliptical ultrasonic vibration assisted milling

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Abstract

Elliptical ultrasonic vibration assisted milling (EUVAM) is widely used as an efficient processing method for hard-to-machining materials such as titanium alloy, superalloy, and hard-brittle materials. To uncover the mechanism of the intermittent cutting characteristics in EUVAM, the tool-workpiece contact rate model is developed by combining with the kinematic relationship between the tool edge and the workpiece in the process. According to the analysis of the contact rate model, the phenomenon that the contact rate increases rapidly with the time-varying tooth position angle in one-dimensional ultrasonic vibration assisted milling can be improved in EUVAM. In addition, considering the variation of window function and undeformed cutting thickness, a force model is established. And the experiment of EUVAM is performed to verify the model of ultrasonic milling force, and the influence of process parameters (amplitude, cutting speed, feed rate and cutting depth) on ultrasonic milling force is also analyzed.

Full Text

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Figures

$$V_c \sin \theta + 2\pi a f \cos(2\pi f t) + V_f = 0 \quad (1)$$

Figure 1

Schematic diagram of EUVAM interrupt processing characteristics

Figure 2

Curve chart of contact rate change trend

Figure 3

Undeformed cutting thickness in ultrasonic milling

Figure 4

Three-dimensional simulation results of ultrasonic milling force

Figure 5

Comparison of x-direction normal and ultrasonic milling forces

Figure 6

Elliptical ultrasonic vibration device and its calibration test

b. Schematic diagram of experiment platform

Figure 7
Ultrasonic milling force experiment platform

Figure 8

Comparison of simulation and experimental value of milling force

Figure 9

Variation trend of average milling force