Modelling for the micro-interactions of grit-workpiece in ultrasonic vibration grinding of fused silica glass

Cheng Huang[1,#], Yupeng Xiong[1], Yifan Dai[1], Silin Guo[1], Hao Hu[1], and Shanyong Chen[1]

1 Laboratory of Science and Technology on Integrated Logistics Support, College of Intelligence Science and Technology, National University of Defense Technology, Changsha, Hunan 410073, P.R of China

Corresponding Author / Email: hithuangcheng@163.com, TEL: +86-13187089709

KEYWORDS: Ultrasonic vibration side grinding, Micro-interaction effects, Stochastic distribution of grits, Cutting force

The cutting force in ultrasonic vibration side grinding (UVSG) of brittle materials is of significance for the machined quality. However, the micro-interaction mechanism between abrasive grits and workpiece remains a significant issue in terms of the research on cutting forces in the brittle material grinding due to the stochastic distribution nature of the grits. Meanwhile, these micro-interactions are further affected by ultrasonic vibration in UVSG process. Considering these issues, this paper aims at modeling the cutting force affected by the stochastically distributed grits and ultrasonic vibration to reveal the multi-scale grinding mechanics in UVSG of fused silica glass. Through modeling the stochastic grinding wheel surface and analyzing the kinematics of multi-grits, the unified motion trajectory and the instantaneous chip thickness in UVSG were enabled to derived to determine the different grit-workpiece interaction stages. With consideration of the ultrasonic vibration effects on the micro-interactions, a novel theoretical cutting force model was developed based on the analysis of force generated at three interaction stages, i.e., rubbing, plowing, and cutting stages. The numerical simulations of this model could provide the time-domain variation features of cutting forces to evaluate the fluctuations and trends of the cutting forces from multi-scales. Experimental verifications indicated that the cutting force and its fluctuations are within the acceptable error margin. Furthermore, a thorough analysis of force fluctuating situations at different ultrasonic vibration amplitudes was conducted. The analytical results indicated that an increase in ultrasonic vibration amplitude was not only beneficial to restrain the force fluctuation, but helpful to reduce the brittle fracture damages of fused silica glass.