Title: Experimental and numerical investigation of the breakage of a cutting tool with ultrasonic vibration

Authors: Chunxiang Ma, Zhibo Wang

PII: S0141-6359(17)30251-9
DOI: https://doi.org/10.1016/j.precisioneng.2017.09.011
Reference: PRE 6661

To appear in: *Precision Engineering*

Received date: 1-5-2017
Revised date: 16-9-2017
Accepted date: 19-9-2017

Please cite this article as: Ma Chunxiang, Wang Zhibo.Experimental and numerical investigation of the breakage of a cutting tool with ultrasonic vibration.*Precision Engineering* https://doi.org/10.1016/j.precisioneng.2017.09.011

[1]Experimental and numerical investigation of the breakage of a cutting tool with ultrasonic vibration

Chunxiang Ma and Zhibo Wang

School of Mechanical and Power Engineering, Shanghai Jiao Tong University, Shanghai 200240, China

*Corresponding author. Tel: 86-021-34206554; fax: 86-021-34206554.
E-mail address: cxma@sjtu.edu.cn (C. Ma)

Highlights

- breakage of the cutting tool with ultrasonic vibration is a fatigue failure and it includes three stages: micro-crack generation, the fatigue stripes spread, a rock fracture.
- The pulsating main cutting force and pulsating frictional force act periodically on the rake face of the cutting tool. This is the first reason for the fatigue failure of the cutting tool with ultrasonic vibration
- The flank of the cutting tool is alternatively subjected to the compressive stress and the tensile stress. This is the second reason for the fatigue failure of the cutting tool with ultrasonic vibration.

Abstract

In this study, first, the breakage of a cutting tool with ultrasonic vibration was investigated using a scanning electron microscope. It was concluded that the breakage of a cutting tool with ultrasonic vibration has the features of fatigue fracture; i.e. it undergoes three stages: micro-crack generation, micro-crack spreading, and brittle fracture. Second, the reasons for the breakage of the cutting tool with ultrasonic vibration were analysed theoretically. The analytical results demonstrated two reasons: one is that the pulsating main cutting force and pulsating frictional force act periodically on the rake face of the cutting tool; the other is that the flank of the cutting tool is alternatively subjected to compressive stress and tensile stress. Furthermore, the influences of the main factors on the breakage of the cutting tool with ultrasonic vibration were studied experimentally. Finally, the breakage of the cutting tool was analysed using the finite element method (FEM). FEM simulation results demonstrate that the fatigue life and fatigue safety factor of the cutting tool decrease and the fatigue damage coefficient of the cutting tool increases with the increase in the amplitudes of the pulsating loads, reciprocating frictional force, and normal force.

Keywords: *Cutting tool, Breakage, Ultrasonic vibration, Pulsating load, FEM*

1. Introduction

Since the late 1950s when Kumabe [1] applied ultrasonic vibration to a cutting tool, many scholars have