Accepted Manuscript

Dicing Wheel Wear Monitoring Technique Utilizing Edge Diffraction Effect

Seongkyul Jeon, Abolfazl Zolfaghari, ChaBum Lee

PII: S0263-2241(18)30156-8
DOI: https://doi.org/10.1016/j.measurement.2018.02.057
Reference: MEASUR 5305

To appear in: *Measurement*

Received Date: 30 May 2017
Revised Date: 25 July 2017
Accepted Date: 23 February 2018

Dicing Wheel Wear Monitoring Technique Utilizing Edge Diffraction Effect

Seongkyul Jeon, Abolfazl Zolfaghari, and ChaBum Lee*

Department of Mechanical Engineering, Tennessee Technological University
1 William L Jones Dr., Cookeville, TN, 38505, USA
Corresponding: clee@tntech.edu, Tel. +1-931-372-6169

Abstract

This paper presents a non-contact, convenient, efficient cutting tool wear monitoring technique of dicing wheel based on an edge diffraction effect. Dicing is a standard technology for fabricating components of micro-electromechanical systems, and the wear of dicing wheels may influence the components' quality with respect to cutting-surface quality and subsurface damage. Based on the edge diffraction principle that utilizes interference of transmitted wave and a diffracted wave at the wheel end, the diffraction patterns according to dicing wheel conditions were scanned, and cross-correlation was used to extract attrition and abrasive wear from the measured diffraction patterns. Attrition and abrasive wear were related with lag and similarity coefficients of cross-correlation, respectively. This measurement technique can be used for on-machine or in-process monitoring of wheel conditions or wheel radius compensation and can be included in dicing parameter optimization process.

Keywords: Dicing wheel wear; Edge diffraction; Cross-correlation; Wear monitoring

1. Introduction

Wear of cutting tools is caused by material stress and thermal change at the tool edge [1-3], which in turn depend on cutting operations such as turning, milling, drilling, dicing, and scribing as well as cutting conditions and cutting fluid [3-8]. Cutting tool wear can be classified into abrasion (sub-microscale), attrition (microscale), chipping (mesoscale), and fracture according to the damage size [3]. As the micro-nano scale wear progresses, the morphology and dimensional accuracy of the cutting tool are reduced, and the worn cutting tool has to be replaced. For precision machining, maintaining a nanoscale sharpness of the tool edge through accurate measurement of the tool wear and determining different cutting positions, which is as important as tool wear, are critical in cutting tool edge condition and affect the form error and surface quality of a machined product. Tool wear especially increases cutting force and heat generation, leading to reduced cutting stability and repeatability.

Cutting tools are typically replaced on a schedule. However, some are replaced according to the wear condition of the tool due to high costs. Currently, cutting tool conditions are inspected by machining operators both visually and off-site. However, the visual inspection method is less efficient and limited to quantitatively derived micro-nanoscale cutting tool wear detection such as morphology, wear, and chipping conditions. For more accurate results, the scanning electron microscopes (SEM), coordinate measuring machines (CMM), atomic force microscopes (AFM) and touch-triggered stylus probes (TSP) are used to measure cutting tool wear parameters [9-12]. Also, more advanced measuring techniques using white light interferometry or confocal microscopy can be applied when a nanoscale analysis is