Cutting Tool Crater Wear Measurement in Turning Using Chip Geometry and Genetic Programming

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ABSTRACT

Tool wear prediction plays an important role in industry automation for higher productivity and acceptable product quality. Therefore, in order to increase the productivity of turning process, various researches have been made recently for tool wear estimation and classification in turning process. Chip form is one of the most important factors commonly considered in evaluating the performance of machining process. On account of the effect of the progressive tool wear on the shape and geometrical features of produced chip, it is possible to predict some measurable machining outputs such as crater wear. According to experimentally performed researches, cutting speed and cutting time are two extremely effective parameters which contribute to the development of the crater wear on the tool rake face. As a result, these parameters will change the chip radius and geometry. This paper presents the development of the genetic equation for the tool wear using occurred changes in chip radius in turning process. The development of the equation combines different methods and technologies like evolutionary methods, manufacturing technology, measuring and control technology with the adequate hardware and software support. The results obtained from genetic equation and experiments showed that obtained genetic equations are correlated well with the experimental data. Furthermore, it can be used for tool wear estimation during cutting process and because of its parametric form, genetic equation enables us to analyze the effect of input parameters on the crater wear parameters.

Keywords: Chip Radius, Genetic Programming, Machining, Tool Crater Wear

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1. INTRODUCTION

Chip form and tool wear are two of the major machining performance measures that have been the subject of extensive studies over several decades.

It must be said that having the true conception of chip formation and chip movement is an essential task in the prediction of chip breakability, furthermore, geometrical features of produced chip give us valuable information about tribological phenomena in cutting zone such as tool wear, cutting zone temperature, etc.

On the other hand, tool wear and economical estimations related to tool life are among essential issues associated with machining optimization, because in automated manufacturing operations, tool must be removed from the cutting process well before it fails, otherwise the parts produced become out of the allowable tolerance (Devillez & Lwsko & Mozer, 2004). Therefore, tool wear is of great significance in manufacturing since it affects the quality of the components, tool life and machine costs.

Mechanisms responsible for tool failure are abrasive, adhesive and diffusion wear (Devillez & Lwsko & Mozer, 2004). Considering that the chip radius has a direct relation with the form of crater wear and this type of wear is formed due to adhesive and diffusion factors, it can be resulted that these factors affect chip geometry impressively.

There has been some research on tool wear estimation over the past several years, and some analytical (Dawson & Kurfess, 2005) and empirical models were proposed for the evaluation of crater depth and length, however most of them lack practical applications.

Several direct and indirect measurement techniques have been proposed for evaluating crater wear in carbide inserts. Direct methods are based upon direct measurements of the worn area of the tool using optical (Dawson & Kurfess, 2005) and vision systems (Jurkovich & Korosec & Kopac, 2005; Khalifa & Densibali & Faris, 2006). These methods have advantage of high-measuring accuracy, but cannot be easily adopted for online applications, mainly because of interruption of coolant and chips (Lister & Barrow, 1986; Tlutsy & Andrews, 1983). For this reasons, several authors have proposed indirect techniques for wear monitoring.

Various indirect methods have also been developed in which the state of the wear in different cutting operations is estimated from measurable parameters such as, the cutting forces (Choudhury & Kishore, 2000; Mori-waki, Shibasaka, & Tangjistcharoen, 2004), vibration analysis (Ramakrishna & Prasad & Kumar & Shantha, 1996), acoustic emission (Li, 2002; Telsang & Katu, 2004) and cutting temperature (Natarajan, Arun, & Periasamy, 2007) and using ultrasonic technique. However, few reliable and robust indirect methods are available for industrial use. This is mainly due to the intricacy involved in machining process and uncertainty in the correlation between the process parameters and tool wear.

In spite of the fact that numerous researches have been done in the field of chip radius and tool wear, there is a few works which has considered the effect of tool wear on the produced chip radius. Fang et al. (1993) investigated the effects of progressive tool wear on chip breakability and chip form in turning operations. The experimental results from this research showed that developing crater wear on the tool rake face acts as a chip breaking groove and so by passing time and expanding crater, chip radius will reduce.

By considering the basic nature of the various wear mechanisms that are generally observed in machining operations, it has been showed that during the progressive tool wear, some major wear parameters contribute to the variation in chip flow, chip curl and chip breakability in metal machining, typically in a turning operations. Figure 1 shows various wear features studied in mentioned research.

K. C. Ea et al. (2003) investigated tool wear mechanisms and their effects on chip curl/chip form in machining with grooved tools using equivalent tool face (ET) model. In mentioned work, a new methodology is extended to correlate chip curling when machining with progressive tool wear mechanism in grooved tools.
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