SELECTION OF OPTIMAL CUTTING CONDITIONS IN MICRO-ENDMILLING PROCESSES

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ABSTRACT
Micro-endmilling process is applied to fabricate precision mechanical parts cost-effectively. It is a complex and time-consuming job to select optimal cutting conditions with high productivity and quality. In this paper, high speed machining(HSM) experiments of heat-treated die steel (H-13, HRc 51) are studied for optimum selection of micro-ball endmilling conditions. Tool life and wear characteristics under various cutting conditions are investigated through a monitoring system. It is equipped with the machine vision and cutting force measurement systems. Optimal cutting conditions are obtained through the Taguchi method.

INTRODUCTION
The Micro-endmilling process has been widely used to produce micro components, such as micro dies and molds, micro machines, watches, bearings, etc. [1,2] Micro-endmill wear deteriorates machining accuracy and productivity, and increases cutting force. It causes tool breakage and drops productivity. By correctly measuring the wear of micro-endmills, it is possible to understand the wear characteristics and to predict the optimal change of tool life. Using the cutting force information, endmills are protected from tool breakage. To improve productivity and quality of cutting condition for maximizing material removal rate, condition monitoring linked with optimal selection of cutting conditions is indispensable.

Tool wear measurements are divided into direct and indirect methods. The indirect methods, such as cutting thrust force, torque signal and cutting temperature measurements have been used for conventional machining processes [3]. These methods deduce tool life or wear from change of measuring signals. However, it is impossible to observe the wear of complex shaped endmills by using the indirect methods. For direct methods, measurements using SEMs, confoccal microscopes, and lasers have been used. However, these measurement systems are expensive and difficult to use in the rugged work space.

It this paper, a novel machine vision system equipped with a precision servo stage is applied for wear measurement of micro-endmills directly [4,5]. Cutting force measurement system using a tool dynamometer is proposed to estimate wear during micro-endmilling processes. Micro-endmill wear is measured by the image processing and edge detection methods [6]. Gradient of cutting force signal is derived from the tool dynamometer system. Optimal cutting conditions with better tool life and MRR are obtained from the Taguchi method with the same weight values on the gradient of cutting forces and the direct wear measurement.

FIGURE 1. Experimental set up.

EXPERIMENTAL SET UP
As the high spindle speed with high accuracy is required in the micro-endmilling process, a high-precision CNC milling machine equipped with a 150,000rpm air-spindle is applied for