Development of an optimized smart tool holder using symmetrical structure for three axis cutting force measurement in diamond cutting

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KEYWORDS: Cutting, force, Smart tool holder, Symmetrical structure, Piezoelectric force sensor

Cutting force measurement is an important technique to monitor machining process in diamond cutting. This paper presents an optimized smart tool holder using symmetrical structure of a fast tool servo (FTS) for three axis cutting force measurement by utilizing six piezoelectric force sensors. The cutting force in each axis is measured by using the differential result of two sensors for eliminate influence of environment noise, bias current and temperature drift. The symmetrical structure of the tool holder is designed based on flexible hinge, and the theory model is constructed and optimized for high stiffness and low coupling. An improved algorithm that is combination of differential and dynamic accumulation method is developed for stable and accurate static force measurement. Tests are carried out to verify the effectiveness of the algorithm on improvement of stability and accuracy of output voltage and static force measurement, which demonstrates that the influence of environment noise, bias current and temperature drift can be reduced effectively. Then, the smart tool holder is integrated on a FTS for cutting experiments. By compared with commercial dynamometer, it is verified that the proposed tool holder system has excellent performance of high sensitivity and high accuracy in three axis cutting force measurement, and has capacity of identification of nanometric scale microdefects.