Design of a Long Stroke Fast Tool Servo with Application to Microstructured Surfaces Fabrication

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Abstract

Fast tool servo (FTS) is an ultra-precision machining method used to manufacture surfaces with complex microstructures and arrays. Compared to the traditional machining method, it has high efficiency and machining accuracy. The FTS is an independent tool holder system that can realise the cutting tool's high frequency reciprocating motion. This research presents a complete and systematic design method for a long stroke FTS system driven by a voice coil motor. A closed loop control system was built based on the chosen control hardware in the control system design. The control system simulation and the system identification were achieved. Different control algorithms were tested on the designed system. Most importantly, a novel hybrid control algorithm was proposed based on PID control, sliding mode control, and feedforward control. The hybrid control algorithm helped the FTS system achieve less than 1% tracking error. The rapidity, accuracy and robustness of the hybrid control algorithms were also verified.

A series of machining experiments were conducted, where the machine tool axis tracking error, the FTS system's motion profile, and the machined surface accuracy were analysed. The machinine experiments also demonstrated its capability in microstructured Surfaces Fabrication.

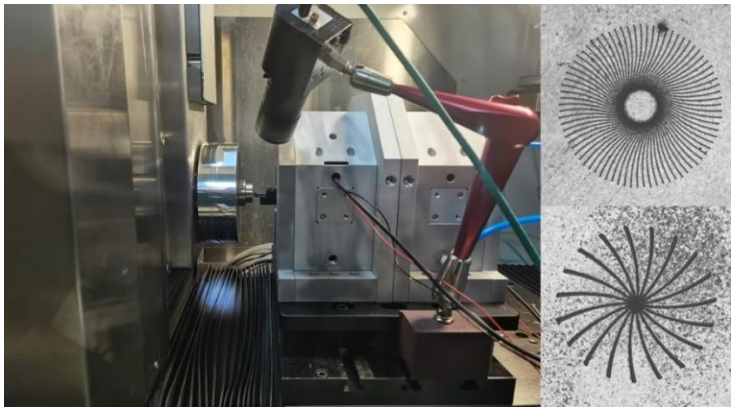

Figure 1: Designed system and machined microstructed surfaces