Parallel tool servo turning of microstructured surfaces using complementary filters

Hao Wu[1], ZeLong Jia[1], MingJun Ren[1], XinQuan Zhang[1,#] and LiMin Zhu[1]
1 State Key Laboratory of Mechanical System and Vibration, School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai 200240, P. R. China
Corresponding Author / Email: zhangxinquan@sjtu.edu.cn, TEL: +86-15802107897

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***Abstract**: Tool servo diamond turning is a promising technology in machining of microstructured surfaces. Considering that the tool trajectory of complex surfaces consists of highly mixed low-frequency and high-frequency components, conventional slow slide servo technology suffers from low efficiency or surface quality due to the limited control bandwidth. Although the ultra-precision machine tool is equipped with a fast tool servo system to compensate for the tracking error of the slow slide, the high-frequency components in the original tool trajectory could cause the nonlinear motion errors of the slow slide, which is perpendicular to the motion direction of the slow slide and cannot be compensated for by the fast stage. To address this problem, this work proposes the concept of a parallel tool servo (PTS) by incorporating a tool decomposition method into the dual-stage drive lathe. By utilizing the complementary filters, this technology decomposes the original tool trajectory into a low-frequency trajectory for the long-stroke slow slide and a high-frequency trajectory for the high-bandwidth fast stage, respectively. Such tool path decomposition method makes the servo axes of the dual-stage drive lathe work in a cooperative way, ensuring that the machine tool maintains good tracking performance. Relative to using a conventional geometry-based tool decomposition method for turning micro lens arrays, the peak-to-valley tracking error when using the proposed frequency-based PTS method decreases from 739 nm to 425 nm, and the corresponding surface quality of the machined parts has been greatly improved, which demonstrates the effectiveness and superiority of the PTS method for enhancing tracking performance of the dual-stage drive lathe in manufacturing of complex microstructured surfaces.*