A selective kinematics error model for on-machine measurement compensation

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In order to improve measurement availability for manufacturing applications, on-machine measurement (OMM) is integrated onto the machine tools. However, the inherent kinematics error will inevitably induce additional deviations onto OMM results. This paper presents a selective kinematics error model for OMM compensation. Using homogeneous transformation matrix (HTM), relationship between multi-coordinates can be established and spatially distributed single error components are consequently synthesized as a volumetric error model. For the machine tool configuration in the work, there are two kinematics error chains, as illustrated in Figure 1. One is from machine base to the machining surface, and the other is from the machine base to the DRI probe. Kinematics error modelling for multi-axis machine tools are based on multi-body system theory. Multi-body system theory offers a comprehensive description of general mechanical system utilizing lower order body topological structure.

**Framework of kinematics error compensation**

The flowchart of the proposed methodology is illustrated in Figure 2. According to the measurement task and machine tool configuration, a selective kinematics error modelling and measurement process will be carried out. The machine tool kinematics error in the scanning region is consequently mapped in order to compensate the OMM result. To validate the proposed methodology, the OMM result is compared with calibrated offline measurement result.

**Experiment and discussions**

This section proposes a simple scheme for machine tool kinematics error measurement in nanometric level, with capacitance probes (Lion Precision C8) and a flat mirror artefact. The maximum sampling frequency of capacitance probes used is up to 1 kHz and the displacement measurement resolution is 0.08 nm. Furthermore, the 2 mm spot size also automatically filters out short wavelength errors on the target surface so that the artefact surface finish will not affect the measurement. In the following part, the measurement process for X axis straightness in the Z direction EZX, C axis axial error EZC, C axis tilt error EBC, and squareness error between X axis and C axis will be respectively described.

**Conclusions**

The paper presents kinematics error modelling, measurement and compensation for on-machine surface measurement. Both theoretical and experimental work has been conducted to generate the machine tool kinematics error map for compensation of OMM results.

**Reference**
