Compensating the Thermal Displacements of a Feed Drive with Ball Screw

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Abstract

Displacements due to internal and external heat sources continue to be an important challenge when trying to increase the attainable manufacturing accuracy of machine tools. An algorithm to compensate the expansion of the spindle was developed with regard to thermal and geometric analyses, using a test stand with ball screw. It is possible to clearly reduce the thermal change of the ball screw length due to frictional heating by implementing a compensation module in the CNC control.

In experiments, a ball screw spindle was transiently heated thermally and geometrically by a cyclic traverse motion. Maximum errors of several hundred micrometre arise here if a semi-closed control is used. The goal of this investigation was to reduce the geometric errors due to a differentiated heating along the length of the spindle without using an absolute length measuring system. Figure 1 on the left shows the measured temperatures along the spindle, which was heated for four hours and then cooled for two hours by an axial movement of 300 mm at the end of the front third of the used spindle. Using the compensation algorithm, it is possible to reduce the positioning errors by approx. 85% in the heating phase or rather to a maximum error of approx. 0.04 mm even in semi-closed systems without a length measuring system (Figure 1 right).

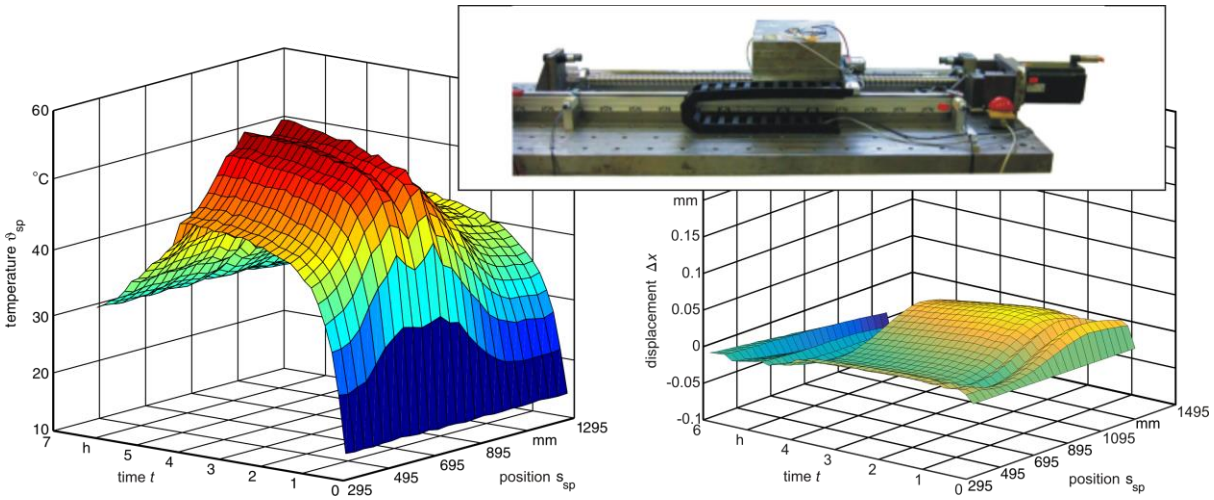

Figure 1: Measured course of temperature at the spindle position (left), displacement errors when using the compensation algorithm without length measuring system (right)