Increasing the energy efficiency of a high precision machine tool through active spindle shaft cooling control optimization

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Abstract

Machining tolerances are ever increasing in their demand, especially in high precision manufacturing. Thermal factors influencing the machine tool are a major source of errors when machining high-precision components. The main approaches towards counteracting these errors are to cool the most affected machine components and to include long warm-up times in the machining process in order to achieve a thermally steady state. These approaches are energy-intensive as well as time-consuming and therefore lead to ineffective use of production resources and increased part costs. For these reasons, consideration is being given to reducing warm-up times while using resources efficiently.

In order to achieve a short warm up time, a spindle with shaft tempering system is introduced. The state of the art is the heat dissipation of the shaft tempering medium in heat exchangers by additional unit technology with constant flow temperature and high flow rate. The proposed solution involves active control of the temperature control system and therefore acts according to the machining requirements.

The active temperature control takes different machine conditions into account and thus regulates the flow rate required to temper the shaft tempering medium without requiring additional peripherals in addition to a water cooling system. In order to validate the efficiency of the approach, a comparison between a non shaft tempered spindle, a shaft tempered spindle with passive temperature control and the proposed active control loop is undertaken. These involve measurements of the thermal saturation time of the spindle growth as well as of the energy consumption of the spindle system.

The presented method offers an improvement in spindle growth by approximately 50 % and a reduction in the thermal settling time by over 70 % while simultaneously improving the energy efficiency of the manufacturing of a component.