Investigations On Thermal Management Of A Machine Tool Spindle By Using Lamellar Heat Exchangers

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Abstract

Power losses during the operation of a machine tool spindle lead to thermally induced displacement of the TCP, consequently to process inaccuracies. In addition, high temperature can cause critical thermal loads onto spindle components in form of wear and stresses. Some present cooling concepts for high precision machining spindles are based on active cooling of the inner shaft core by circulating fluids. However, inner shaft cooling involves costly sealing techniques. For this reason, the subject of this project is to investigate alternative heat transfer mechanisms and their effects on spindle growth and critical temperatures.

This paper deals with the concept of implementing lamellar heat exchangers consisting of multiple lamellar discs into a machine tool spindle system. Inner discs are mounted onto the shaft and outer discs are integrated into the housing. Heat is transferred through the respective air gaps [Figure 1]. The main challenges result from increasing the heat transfer by simultaneously minimizing system warming due to inner friction of air. To optimize heat transfer, basic potential of lamellar heat exchangers and their limits are revealed based on fluid simulations and experimental validations. Different materials, surface structures, diameters, axial and radial air gap widths are investigated. The heat transfer coefficient, heat dissipation due to inner friction of air and heat quantity are calculated to evaluate the potential of fluid-free spindle shaft cooling.

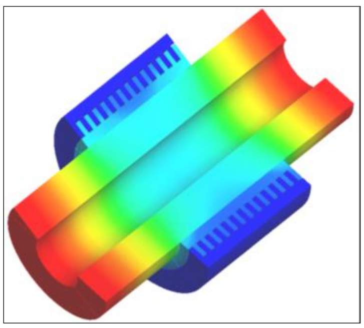

Figure 1: Shaft cooling with lamellar heat exchangers through air gaps