Mechanical property determination for cutting tool and workpiece using indentation and investigations on the boundary film formed in sliding contacts with emulsions

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Knowledge about the tribological interactions occurring between workpiece/chip and the cutting insert in lubricated turning processes is of great interest to model and to optimize the machining process. Taking the chip-tool contact as an example, the temperature at the interface can be easily over 400°C, which is usually much higher than that in lubricated contacts of machine elements. Before modeling the friction and heat partition of the contacts for a cutting process, as a primary step, it is essential to know the mechanical properties of the workpiece and cutting insert not only at room temperature but also under higher temperatures as the materials are exposed to in the cutting process.

To determine the Young's modulus and hardness of the coated carbide cutting tool and the workpiece (42CrMo4), a Hysitron TI 950 Nanoindenter with integrated heating stage was used. The measurements were performed with a Berkovich tip under room temperature, 300°C, and 400°C, respectively. It shows that the mechanical properties of the workpiece are significantly influenced by temperature, while the cutting insert does not change much till the tested temperatures.

Friction measurements have also been carried out in tribometer test, in which a ball is loaded against a steel plate in a heated lubricant tank doing reciprocating motion. The steel ball was coated in the same way as the cutting insert with AlTiN. The experiments were carried out mainly at boundary lubrication conditions in the presence of metalworking fluids. The formed boundary layer was investigated using nanoindentation. Thus it is possible to apply the determined mechanical properties of the respective partners into a simulation model for further analysis.