

Deformation of steel chips due to machining

Dr. Sabine Schwarz¹, Univ.Ass. Dipl.-Ing. Christian Baumann²

¹University Service Centre for Transmission Electron Microscopy (USTEM), TU Wien, Vienna, Austria, ²Institute of Production Engineering and Photonic Technologies, Vienna, Austria

Background incl. aims

During machining of materials, high temperatures and high pressures can occur. So, the materials are exposed to high plastic strain, high strain rates as well as high temperatures and heating rates. In order to be able to describe this, materials are examined to see how they change.

Chips that were removed by turning are very small in contrast to the remaining workpiece. They heat up so quickly that they reach more than half their melting temperature in just a few milliseconds. This in turn can significantly change the strength of the metal [1] and its resistance to the formation of chips. That's why chips were chosen to be characterized concerning their microstructure.

Precise predictions through simulations are desired and the material model for the simulations must be examined [2]. Therefore, it is essential to compare simulations with experiments and observe actual changes in the microstructure of the chips and gain knowledge of the material behavior. To this end, microstructural investigations on chips were carried out using transmission electron microscopy (TEM).

Methods

For investigating the microstructure in TEM, electron transparent Focused Ion Beam (FIB) lamellae were prepared (Fig. 1). Chemical analyses were carried out by EDX mapping. Information for determining the grain size depending on the distance to the surface (depth) was obtained by bright field and corresponding dark field images.

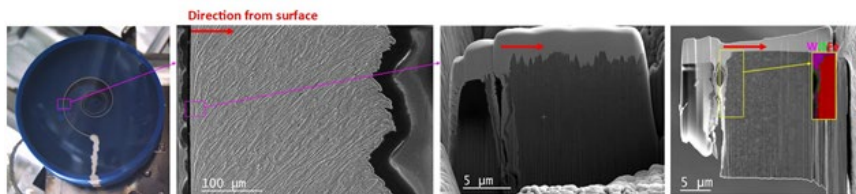
Results

Several chips were investigated regarding the change of the microstructure from the surface into the depth of the material. Different cutting speeds and different final cooling rates led to a change in grain size over the depth from the surface. The EDX mappings showed an oxide layer on the surface of each sample of the chip.

Conclusion

Microstructure characterizations are important for investigating materials and improving the associated simulations. The present investigations on the steel chips pointed out a clear difference between the change in microstructure caused by different cutting speeds and different cooling rates.

Graphic:



Keywords:

steel chips, microstructure, TEM, simulation

Reference:

- [1] Mates, S., Vax, E., Rhorer, R. and Stoudt, M. (2020), Dynamic Flow Stress Behavior of Hypo-Eutectoid Ferrite-Pearlite Steels Under Rapid Heating, *Mechanics of Materials*, <https://doi.org/10.1007/s40870-020-00241-z>
- [2] Bleicher, F., Baumann, C., Krall, S., Mates, S., Herzig, S., Alder, T. and Herzig, N. (2021), Considering the influence of heating rate, complex hardening and dynamic strain aging in AISI 1045 machining: experiments and simulations, *CIRP Annals-Manufacturing Technology*, <https://doi.org/10.1016/j.cirp.2021.04.083>