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A HYBRID APPROACH TO THE MODELLING AND SIMULATION OF GRINDING PROCESSES

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We present recent advances in the modelling and simulation of Internal Traverse Grinding, a high performance grinding process incorporating a high rate of material removal combined with a high surface quality. Due to a special grinding wheel geometry, the latter two goals are achieved in just one pass of the tool through the axisymmetric workpiece[1].

The simulation framework we are presenting generally consists of three components: Firstly, a parametric plain strain, h-adaptive finite element model capturing the material penetration of a single cBN grain on a meso scale during the machining process, cp. fig. 1, left.

Secondly, a topography analysis procedure in combination with a geometric-kinematic simulation have been developed to measure and analyse the surface topography of an actual grinding wheel and use this information to model the grinding wheel surface in the latter geometric-kinematic simulation. This enables us to exactly calculate the transient penetration history of every grain intersecting with the workpiece bulk, cf. fig. 1, right.

These results are then used in the third component of the simulation framework, namely a process scale workpiece model currently under development which captures the effects of thermomechanical loads on the workpiece undergoing material removal and thus shall enable us to predict potential unwanted phase transformations of the bulk surface as well as size and shape errors of the finished part in the near future.

For the mesoscale machining model, a thermoelastic viscoplastic constitutive material model including ductile damage and thermal softening is used to predict the thermome-

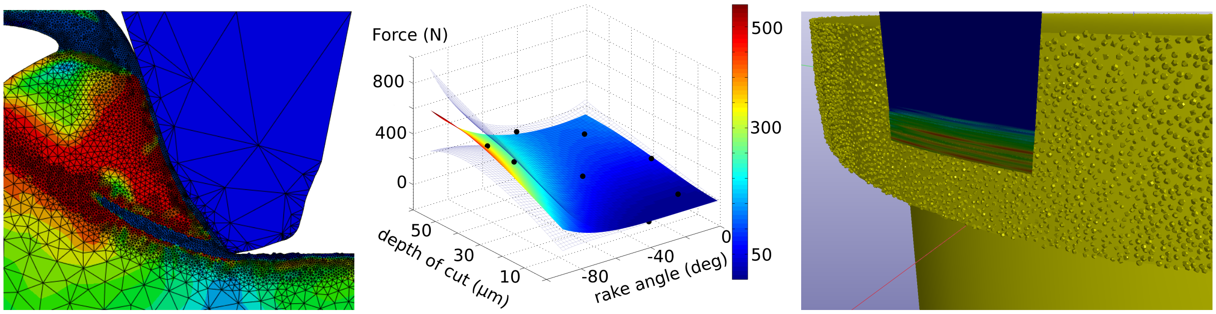

Figure 1: Von Mises contour plot of meso-scale machining simulation for a single cBN grain, showing the onset of a damage induced shear band in the primary shear zone (left). An exemplary result of the regression model for the tangential cutting force component – the sample points are printed in black (middle). Geometric-kinematic simulation showing the grinding wheel in yellow and a workpiece section that is being penetrated by the cBN grains (right).

chanical response of the workpiece bulk [2]. To overcome mesh dependence and reduce the finite element discretisation error, an h-adaptive remeshing algorithm based on a Zienkiewicz-Zhu error estimator and two additional more physically motivated refinement indicators was implemented as an extension to the commercial FE software Abaqus we are using [3]. Moreover, phase transitions shall be predicted on this meso scale as well, enabling us to make a more realistic prediction of the resulting surface integrity of the machined parts. Prove for this is given by comparison with experimental data recorded at the Institute of Machining Technology (ISF). To reduce the number of necessary numerical experiments, a regression model based on design of experiments is incorporated to approximate the induced thermal and mechanical loads on the workpiece during the process scale simulation, see fig. 1, middle.

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