DEFORM™ Application #351

Simulation of Chip Geometry

Background:

The shape and other characteristics of the chip are significant factors in automated machining. The shape of chip formation influences the ease of chip removal, surface finish, cutting force, tool temperature, insert life and the overall robustness of a machining process. The accurate prediction of chip shape in a computer simulation provides a competitive edge in the development of advanced and complex processes.

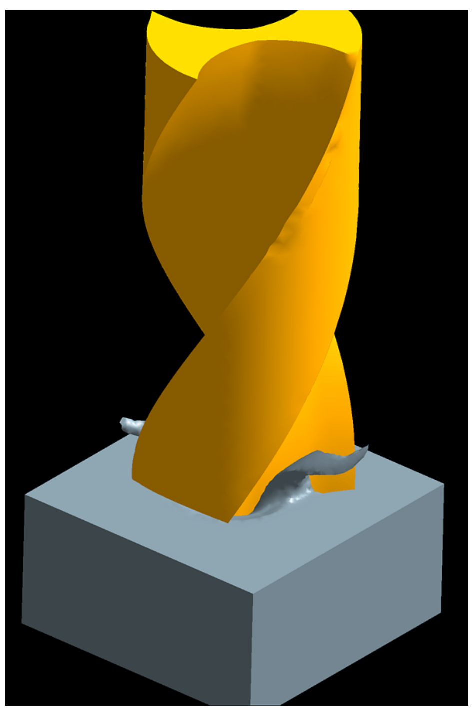
Through the past 30 years, computer technology, from CAD and solid modeling, to tool path generation, to CNC machine control has proven its value to industry. With ongoing improvements in computer and software technology, three-dimensional (3D) simulations of chip forming are now practical.

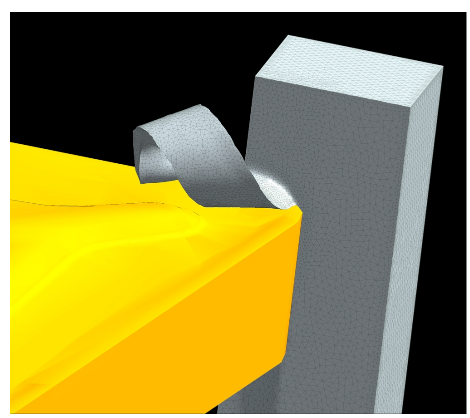
Chip Formation:

Proper selection of insert geometry, rake angle, chip breaker arrangement and cutting conditions influence chip flow and the effectiveness of chip control. The process designer must balance effective chip removal with tool temperature, wear, and cutting force. While general trends in chip behavior are reasonably well understood, the specific behavior varies from case to case. Computer simulation is one more tool which can assist in developing process parameters which allow for effective chip removal without placing undue load or thermal stress on the insert.

Researchers have shown that simulations can properly predict variations of chip curl and thickness with changes in insert geometry, depth of cut, and cutting speed. Other studies have shown reasonable agreement with cutting forces, tool stress, and temperature, all of which influence tool wear.

It is well established that the transition from smooth to serrated chips occurs as cutting speed increases, all other parameters remaining equal. Several researchers have published studies that demonstrate how computer simulation can accurately predict this transition or chip forming behavior.





An extremely advanced, robust solver and mesh generation technology is necessary for three dimensional simulation of metal removal processes such as this drill and lathe insert. Drill geometry courtesy of WZL Aachen.

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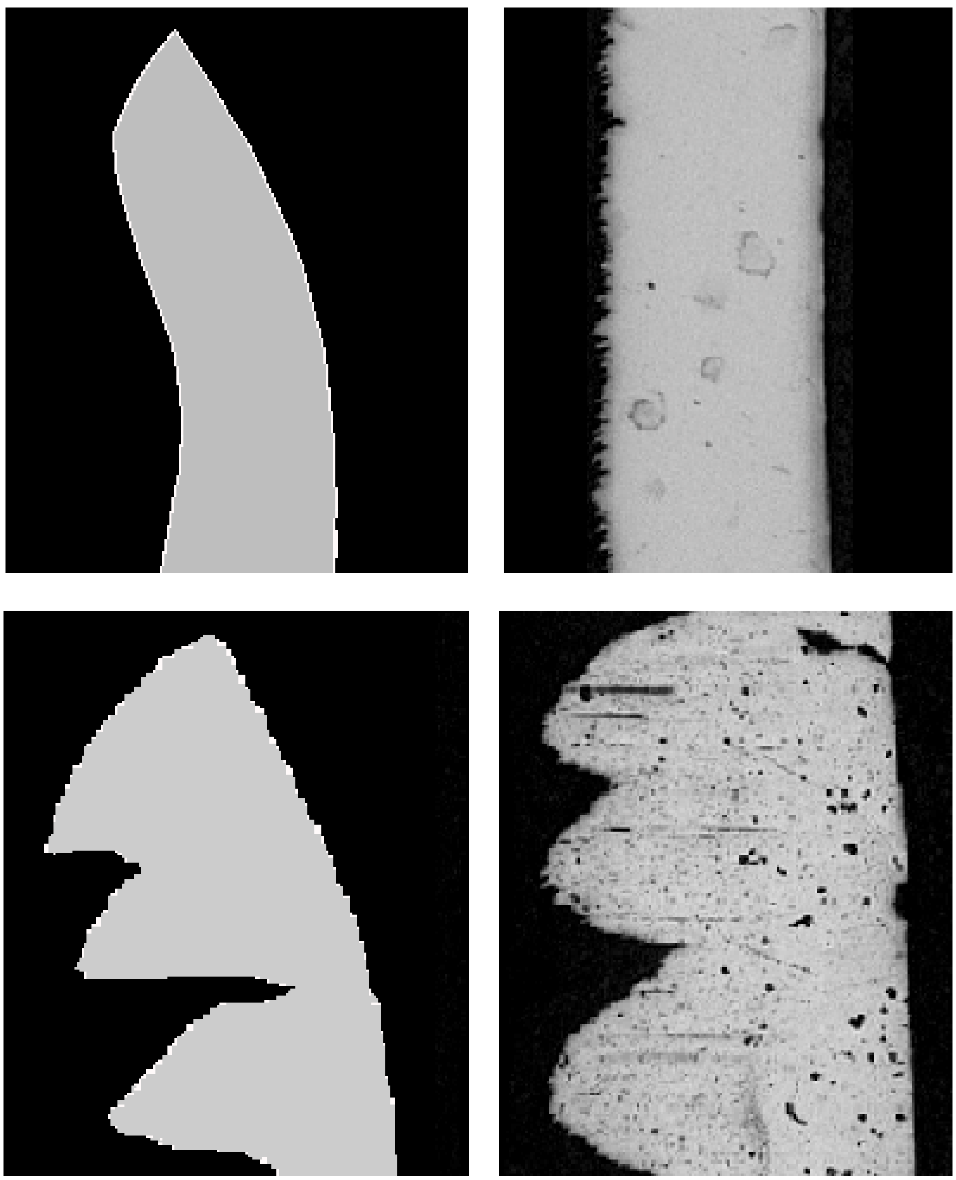
Design Environment for FORMing

3D Simulation:

Ceretti and her coworkers at the University of Brescia in Italy validated the use of 3D simulations in 1999, comparing the results of a DEFORM™-3D orthogonal turning simulation to previously validated DEFORM™-2D plane strain simulations. Subsequent simulations were conducted to replicate the oblique cutting experiments performed by Ueda at Kobe University in Japan. The simulation results correlated well with the published experimental results.

However, practical simulations require large numbers of elements to accurately represent geometry and field variables. Only with recent advances in simulation technology can simulations be run with the number of elements required for quality results in a reasonable amount of time, and without user intervention.

For example, the spiral chip shown on the front of this brochure uses 10 elements in the uncut chip thickness, giving very precise results. The drill chip has 4 or more elements in the chip thickness, also giving good resolution.



DEFORM accurately predicts the transition from a smooth chip to a serrated chip with increasing feed rate. The top image depicts a smooth continuous chip on the left, with experimental results on the right. The bottom image shows a serrated chip (simulation left - experimental right). Courtesy of E. Ceretti.

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