Winter, 2005

Volume 3, No. 1

DEFORM™ News

Events:

- The Fall DEFORM Users Group Meeting in North America was held on November 3 & 4, 2004 in Columbus, Ohio. During this meeting, SFTC staff conducted hands-on workshops to demonstrate our new capabilities. These were well received.
- The Spring DEFORM Users Group Meeting in North America is scheduled for May 10 & 11, 2005 at a site to be determined.

Training:

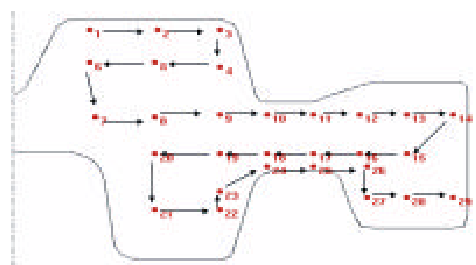
- February 22 & 23, 2005: 2D training will be conducted at SFTC in Columbus, Ohio.
- February 24 & 25, 2005: 3D training will be conducted at the SFTC office.
- April 26 & 27, 2005: 2D training will be conducted at SFTC in Columbus, Ohio.
- April 28 & 29, 2005: 3D training will be conducted at the SFTC office.
- Advanced training will be held on May 12 & 13, 2005 at the SFTC office, in conjunction with the spring DEFORM Users Group Meeting.
- The tenth annual Die Stress Analysis Workshop is scheduled on August 24 & 25, 2005 at Marquette University in Milwaukee, Wisconsin. Mark your calendars now.

Prediction of Microstructure During Hot Forging

DEFORM can be used to simulate the microstructure evolution of nickel-based alloys such as Waspaloy and IN718 during hot forging. Optimization and control of grain size is crucial to achieve a good balance of creep, strength and fatigue properties. A fine grain size is desirable for higher strength and crack resistance. A coarse grain size is preferred for improved creep resistance.

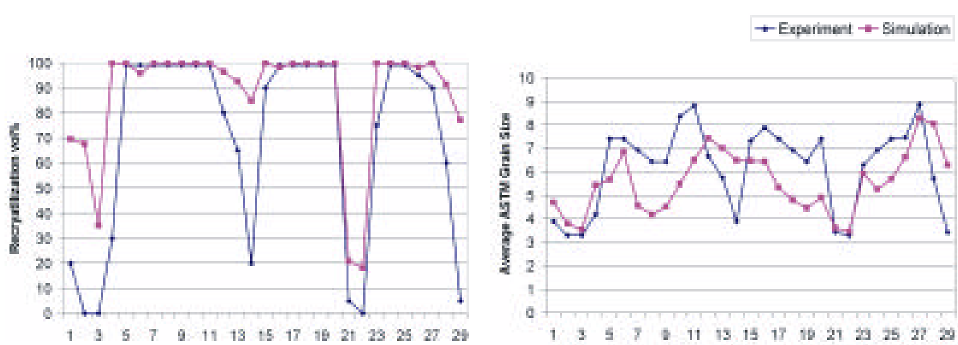
Recrystallization and grain growth models were implemented in DEFORM-HT. Three recrystallization mechanisms were considered. Dynamic recrystallization occurs during deformation when the plastic strain exceeds a critical value. Metadynamic recrystallization occurs after deformation, when the strain is greater than the critical strain. Static recrystallization occurs after deformation when the strain is less than the critical strain. Grain growth occurs when the material is heated above the recrystallization temperature. Higher temperatures and longer times increase grain growth. The volume fraction and recrystallized grain size are calculated as a function of initial grain size, strain, strain rate and temperature.

To validate the modeling approach, a Waspaloy disk was forged at Wyman Gordon using a preform with an initial grain size of ASTM 3. The simulation was performed for the entire hot-forging process, as well as final cooling to ambient temperature. Modeling predictions of the recrystallized volume fraction showed good agreement with the experimental observations. The predicted average recrystallized grain sizes showed reasonable agreement with the measured values.



Microstructure locations are shown on a Waspaloy disk cross-section.

Acknowledgements:
Development of microstructure evolution was supported by an Air Force SBIR program (Contract No. F33615-95-5238). Validation of Waspaloy disk was conducted by Wyman Gordon as part of this SBIR program.



A comparison between the experimental data and simulation result is shown. Each point represents one microstructure reading. The volume fraction of recrystallization is shown on the left. On the right, the ASTM grain size is shown.

Design Environment for FORMing

Cutting Tool Simulation

Several cutting tool manufacturers have begun using DEFORM-3D to study the behavior of cutting tool or coated carbide insert designs.

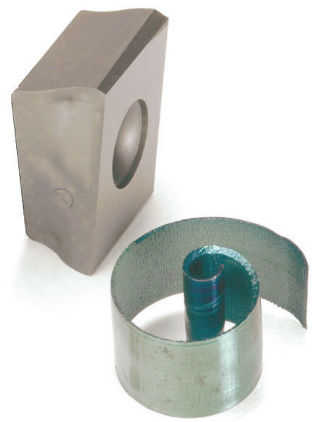
Advances in carbide manufacturing technology have allowed cutting tool manufacturers to design ever more complex shapes for optimizing chip control and cutter performance in machining processes. However, the prototype manufacturing and testing process is costly and time consuming.

This high prototyping cost makes cutting tool design an ideal application for simulation. DEFORM-3D enhancements include faster FEM solver, improved mesh generation stability and self-contact handling. These improvements benefit the DEFORM traditional forming applications and provide an ideal tool for metal cutting simulation.

Process simulation has recently been applied at Ingersoll Cutting Tool of Rockford, Illinois. According to Ingersoll Tech Center Manager Urmaze Naterwalla: "This technology helps us move away from the trial and error approach when designing a chip control feature, which may have multiple design elements and parameters. To individually build each of these design variations would be inefficient and cost prohibitive. DEFORM narrows down our band of prototypes, and conclusively points out the reasons behind improved efficiency."

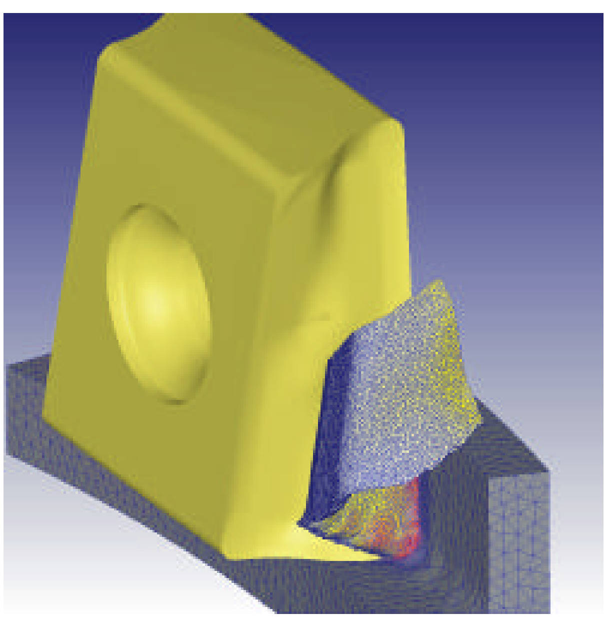
Ingersoll's new carbide S-MAX milling insert is designed to perform well in multiple cutting conditions, including face milling, slotting and end milling. The simulation result shows a desirable chip curl. This results from the chip control features on the face. The actual chip is shown below.

The simulation also predicts cutting force, insert temperature and tool stress. These are all critical factors in cutting tool design.



An Ingersoll S-MAX insert with the resultant chip is shown. The chip shape compares well with simulation results.

DEFORM is applicable to milling, turning, drilling, boring and other cutting processes. A specially designed template is available to set up basic processes, or the standard user interface can be used. Geometry can be imported from any CAD system or created within DEFORM.



The simulation of an Ingersoll S-MAX milling insert is shown with contours of temperature and the mesh.

For more information on metal cutting simulation with DEFORM, please contact your distributor or the DEFORM support staff.

Releases

DEFORM-2D version 8.1 was released in September. DEFORM-F2 was also released. This will be the replacement for DEFORM-PC. During this transition, DEFORM-PC PRO users will migrate to DEFORM-2D. DEFORM-F2 and DEFORM-2D will share version numbers and core functionalities.

Some of the key enhancements/additions made in this release for both DEFORM-2D and DEFORM-F2 are:
- Geometry is shaded on the inside to display the correct orientation.
- Geometric primitives are available.
- The centerline is shown for all axisymmetric simulations.

DEFORM-3D and DEFORM-F3 version 5.1 (beta 2), were released in late December. Some of the enhancements in this release are:
- Self-contact can now be handled during a simulation.
- The elasto-plastic model has been modified for increased robustness.
- Geometric primitives are now available in the preprocessor.
- The phase transformation kinetics models have been improved.
- Friction windows have been implemented.

Simulations graphics is being implemented to visually monitor a simulation while running. A multiple operations interface has been developed to allow the user to construct sequential operations in one preprocessing session. Multiple operations is available in DEFORM-2D and DEFORM-3D. Multiple objects can now be coupled during positioning.

For a complete list of all the improvements, please refer to the release notes in the DEFORM User Area.

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