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DEFORM™ News

Events:

- August 20 and 21, 2014: Die Stress Analysis Workshop in Columbus, OH
- November 5 and 6, 2014: DEFORM User Group meeting (tentative)

Training:

- August 12-15, 2014: DEFORM training will be conducted at the SFTC office in Columbus, OH. .
- October 7-10, 2014: DEFORM training will be conducted at the SFTC office in Columbus, OH. .
- December 9-12, 2014: DEFORM training will be conducted at the SFTC office in Columbus, OH. .

Solvers and Solution Methods

With the release of DEFORM version 11, quite a bit of attention has been focused on the new multiple operations user interface improvements. Equally important are new and improved solvers in this version.

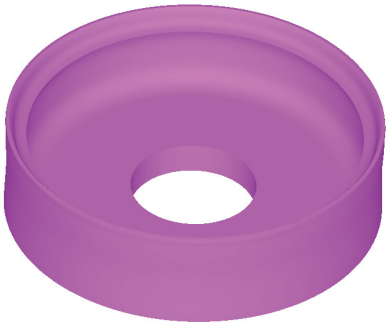
DEFORM calculates the deformation, thermal and microstructure characteristics of deforming materials. Of these, the most computationally difficult task is the deformation calculation. A single calculation is time consuming. Because the problem behavior is highly non-linear, it must be repeated hundreds or thousands of times for each simulation. SFTC is constantly exploring methods to improve computational efficiency and reduce calculation time. Part of this effort involves developing the software to take advantage of the latest in hardware technology such as multi-core systems, multiple processors, GPU's, etc.

Fundamentals

DEFORM was initially developed to simulate large deformation processes, and this remains the most popular application. For these processes, an "implicit" solver performs well. The external forces on the workpiece are assumed to be in equilibrium. DEFORM calculates the energy required for deformation and the energy applied through boundary conditions (contact, friction, prescribed velocity or force, free surfaces). Then it iterates on the velocity of each node until it finds nodal velocities that satisfy the boundary conditions with a minimum deformation energy.

With V11, DEFORM also includes a "dynamic explicit" solution method. This solver does account for inertia effects in the workpiece as well as externally applied forces.

The implicit formulation (used for most simulations) is numerically "unconditionally stable" meaning that the selection of a large time step will not cause fundamental numerical errors in the solution. Since problems are typically highly non-linear, contact and geometric updating then become the primary considerations in time step selection.



New solver technology introduced in DEFORM version 11 (right) has improved accuracy of processes like the flowforming of this cup, while dramatically reducing calculation times when compared to version 10 (left).

DEFORM™

Design Environment for FORMing

An explicit formulation, on the other hand become numerically unstable when the time step becomes too large. In practice, this places a severe limit on the time step size, meaning many more steps are required for a full solution to a large deformation problem. Material properties may be artificially manipulated to increase the allowable time step, but selection of the tuning values is not always straightforward. For this reason, implicit solutions are still preferred for the majority of bulk metal forming problems.

Both implicit and explicit formulations use matrix algebra methods to find the velocity of each node. The explicit matrix can be solved very quickly, which helps compensate for the large number of time steps required. Implicit formulation matrices require considerably more computational effort, so more development has gone into building fast, efficient solvers.

For implicit formulations, the solution behavior of the deformation model is non-linear, so solutions are iterative. Each matrix solution generates a trial for the next iteration. There are two iteration methods: "Direct" and "Newton Raphson." Depending on the problem type, one or the other may be required, or may simply give better performance.

Regardless of the solver and iteration method selected, iteration continues until the velocity field and force error norm (as displayed in the message field) fall within acceptable values as defined in the simulation controls. The results from various solutions, while very close, will not be identical. Nonetheless, all will fall within an acceptable range as defined by the convergence criteria.

Applications

Sparse matrix solvers use modified Gaussian elimination to solve matrix equations. They may not have the fastest performance in all applications, but they work in all applications, without some of the numerical issues associated with other solver types. SFTC introduced a new sparse matrix solver in version 11. It has reduced iteration times on large problems by about one-third.

Iterative solvers, as their name implies, use iterative solutions rather than elimination to find solutions to matrix equations. With a good initial guess, they are much faster than a sparse matrix solver, but are also prone to divergence with unstable processes. SFTC introduced the first interative solver in DEFORM over ten years ago. With V11, a new solver is introduced which shows performance gains and improved scalability on multi-core simulations.

The largest gains have been seen on spinning flow forming, and similar processes with spinning workpieces. In these processes, we have seen run times drop from a week or two down to a day or two. At the same time, volume control has improved significantly.

Conclusion

This article is intended to be a general overview of solver technology and improvements in V11. For specific details, check the technical notes in the user area at www.deform.com.

DEFORM Version 11.0 and 11.0.1 Releases

DEFORM V11.0 was released in February, and DEFORM V11.0.1 was released in June, 2014.

V11.0 includes DEFORM Multiple Operations (MO) user interface (new GUI) which will, over time, replace the version 10 user interface.

DEFORM 2D/3D GUI is maintained, and will be for the near term.

A new DOE/Optimization Module with powerful post-processing and data analysis tools has been released.

A multi-blow simulation tool for hammer forging was released in V11.0 (2D) and V11.0.1(3D) with adaptive reheat and stopping controls.

License Manager Version 3.0.4 was released with V11.0. Version 3.0.5 was released with V11.0.1, with enhanced troubleshooting. Both LM V3.0.4 and V3.0.5 support all versions of DEFORM.

A new Material Suite module is available to assist with formatting material data for use with DEFORM.

Many sophisticated new material models are now available:

- crystal plasticity
- mesoscale microstructure
- improved handling of precipitation hardening alloys
- grain boundary mobility models for recrystallization and grain growth
- flow stress as a function of grain size

Scientific Forming Technologies Corporation
2545 Farmers Drive
Suite 200
Columbus, OH 43235
Tel: (614) 451-8330
Fax: (614) 451-8325
www.deform.com