Summer, 2004

Volume 2, No. 3

DEFORM™ News

Events:

- The Fall DEFORM Users Group Meeting in North America will tentatively be held on November 3 & 4, 2004 at a location to be determined. Contact us for more information.

Training:

- August 24 & 25, 2004: 2D training will be conducted at SFTC in Columbus, Ohio.
- August 26 & 27, 2004: 3D training will be conducted at the SFTC office.
- The 9th annual Die Stress Analysis Workshop will be held on August 18 & 19 at Marquette University in Milwaukee, Wisconsin. Brochures have been circulated. For more information, please contact John Walters at:
  (614) 451-8330 X-117 or
  jwalters@deform.com.
- Advanced training will be held during the first week of November in conjunction with the fall DEFORM Users Group Meeting.

Design Environment for FORMing

Inverse Calculations

Accurate material and processing condition data is required for accurate simulation results. For some processes, such as cold forming, suitable data can be obtained with a compression test. For other processes, such as heat treatment, critical process parameters are more difficult to obtain.

Convection heat transfer coefficient during quenching is one parameter that is difficult to obtain analytically or experimentally, but which has a significant influence on the process. The coefficients vary with location and orientation on the part. Cooling rate is proportional to the heat transfer coefficient, which influences material microstructure and residual stress distribution.

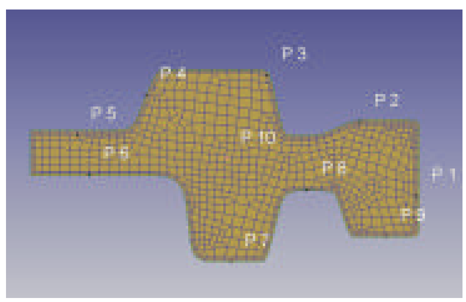


Figure 1: A turbine disk model is shown with an FEM mesh. The points represent thermocouples with experimental data.

The standard approach for obtaining this data is to place thermocouples in a part and measure temperature vs. time curves as the part is quenched. The process is simulated, and the convection coefficients are adjusted until the time-temperature curves in the simulation match those from the thermocouple data. The process is performed manually, or through the use of an external program.

After the heat transfer coefficient curves have been generated, they can be used for regions with corresponding positions and orientations on similar parts for a given quench environment.

As part of the DARPA Accelerated Insertion of Materials Initiative, SFTC successfully transitioned an improved process for

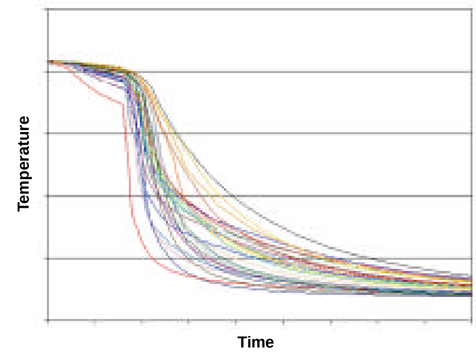


Figure 2: Experimental temperature vs. time curves are shown for each thermocouple during a quenching operation following a transfer in air.

determining heat transfer coefficients using an inverse heat transfer analysis. This method can simplify the process of obtaining calibrated convection coefficient curves from thermocouple data. The DEFORM optimization routine is then used to find the best fit convection coefficient curves for the given data.

A sample case was studied to validate the process. A part was instrumented with 29 thermocouples, and temperature measurements were made during air transfer and oil quenching.

The first simulation is run with estimated convection coefficients. The resulting temperature vs. time curve is shown in Figure 3. Note the discrepancy between the simulation and experimental data.

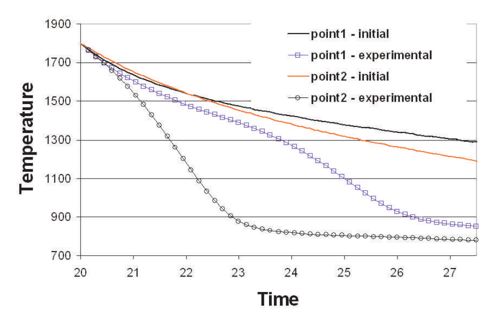


Figure 3: Temperature vs. time curves are shown using the estimated coefficients.

The data is modified and the simulations repeated until the error between the experimental and simulated values is

(over)

(continued)

minimized. Figure 4 shows simulation results after optimization. Figure 5 shows the initial and optimized convection coefficient curves.

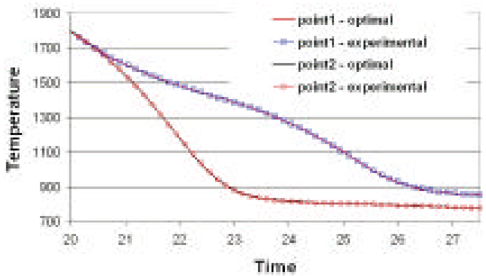


Figure 4: Using the optimized coefficients, the temperature vs. time curves matched the experimental data.

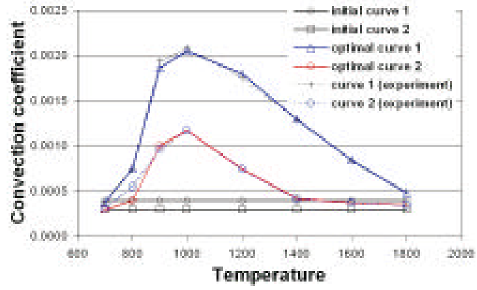
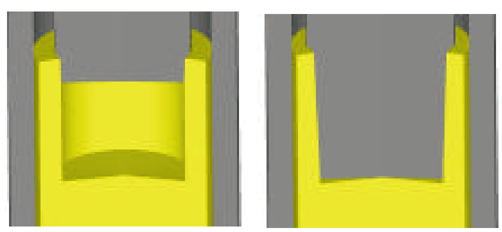


Figure 5: Initial and optimized convection coeffieient curves are shown for two sample points.

Trapped Gas

Trapped air and lube can result in an unfill that can not be overcome by an increased forming load. Venting and preform design modifications are often the only solution. DEFORM-2D version 8.0 can include the influence of trapped air using the compressibility calculated by the perfect gas law.

$$PV = NRT$$

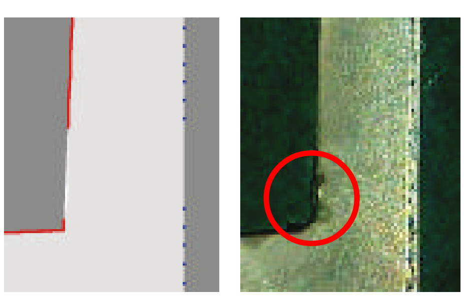


The start (left) and finish (right) of a cold forming operation is shown.

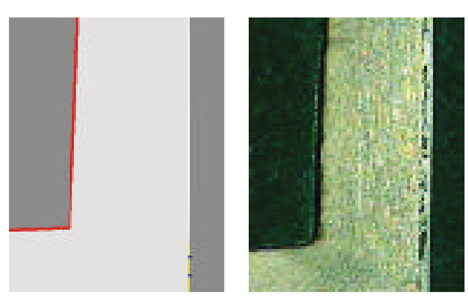
The law states that pressure (P) times volume (V) of a gas is constant at a constant temperature (T). As the volume of air is decreased during a forming operation, the increase in pressure is inversely proportional.

In the enclosed example, a tapered punch trapped a significant volume of air at the start of a cold forming operation. This air volume was compressed throughout the stroke, ultimately resulting in an unfill. Die contact is shown in the image (lower left) with an underfill at the punch corner. Good correlation is shown with the actual part. A vented part was tested by drilling a hole through the side of the part. The simulation depicted improved die fill.

In the case of lubricants, glass, steam or water, the compressibility is far less than exhibited with air. Further enhancements will be planned to account for these effects. Contact technical support at SFTC if you are planning to test this new capability.



The DEFORM simulation (left) depicts underfill without venting. Die contact is shown as a red line. The underfill on the actual part is shown on the right. Note the subtle void at the corner of the punch (red circle).



The DEFORM simulation shown on the left depicts die fill when the die was vented. Good die contact is shown as a red line. A section of the filled part is shown on the right.

Upcoming Releases

DEFORM Users will continue to see a significant number of developments throughout 2004.

DEFORM-F3 was released on April 1, 2004. This system provides an efficient and easy to use GUI optimized for forming processes. The FEM engine and AMG are common with DEFORM-3D. DEFORM-3D users will have access to DEFORM-F3.

DEFORM-2D version 8.1 is planned for release this summer. At the same time, we will release DEFORM-F2, which will replace DEFORM-PC. As part of this transition, DEFORM-PC PRO users will migrate to DEFORM-2D. DEFORM-F2 shares all core functions with DEFORM-2D. The GUI is similar to DEFORM-F3.

DEFORM-3D and DEFORM-F3 version 5.1 is planned for release in the summer.

During the past year, SFTC has developed a ring rolling program. The FEM engine is in the final stages of development and integration. Initial speed tests have been astonishing. A prototype of the preprocessor has been developed and tested.

An application server has been developed, which allows 3D simulations to be set up on a desktop and simulated on a remote fast computer. The development and initial testing has been completed and will be available in the next release. A simulation queue and a floating license are required to activate this new capability.

A new structure and GUI has been developed for multiple operations. SFTC staff demonstrated this at the spring Users Group Meeting. We encourage our users to test this capability and offer your feedback.

Additional work on optimization will be available in the form of inverse heat transfer coefficient and 2D preform design capabilities. Steady state development using ALE will be the foundation of a shape rolling system that is planned for late 2004. Some capabilities will be included in the next 3D release.

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