Spring, 2005

Volume 3, No. 2

DEFORM™ News

Events:

- The Spring DEFORM Users Group Meeting in North America will be held on May 10 & 11, 2005 at the Cherry Valley Lodge in Newark, Ohio (near Columbus).
- SFTC staff will participate in the Cold Forming 101 workshop in conjunction with the IFFI in Rosemont, IL on June 5 & 6, 2005. Contact us for more information.

Training:

- 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.

DEFORM™

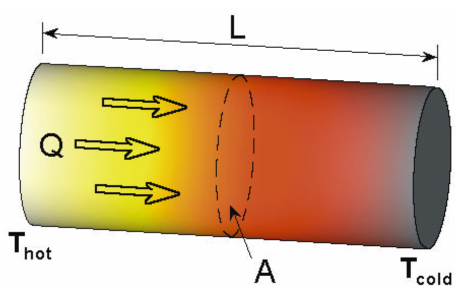
Design Environment for FORMing

Heat Transfer Modeling

The three modes of heat transfer are conduction, convection and radiation. DEFORM incorporates all three of these heat transfer models.

Conduction is the transfer of heat through a solid material or from one material to another by direct contact. Fourier's law states that heat energy will flow from the region of high temperature to the region of low temperature within a body. The rate of heat flow, $\mathbf{Q}_{cond}$, can be expressed as:

$$Q_{cond} = \frac{k\,A\left(T_{hot} - T_{cold}\right)}{L}$$



where A is the cross-sectional area and L is the distance through which heat is conducted. The amount of heat transferred by conduction is directly proportional to the temperature gradient and the thermal conductivity of the material. Higher thermal conductivity results in more heat flow.

Convection is the transfer of heat through a liquid or gas by the actual movement of the fluid. Convective heat transfer is described by Newton's law of cooling which states that the rate of heat flow, $\mathbf{Q}_{conv}$, can be expressed by:

$$Q_{conv} = h\,A\left(T_{surface} - T_{fluid}\right)$$

where h is the convection heat transfer coefficient and A is the object's exposed area. This heat is directly proportional to the convection heat transfer coefficient and the temperature gradient between the part and the fluid.

Radiation is the transfer of heat by the emission of electromagnetic waves, which carry energy away from the emitting object. The Stefan-Boltzmann equation states that the rate of heat flow, Q_{rad}, between a body at temperature T_{surf} and an environment at temperature T_{env} can be expressed by:

$$Q_{rad} = \sigma\,\varepsilon\,A\,F_{1\text{-}2}\left(T_{surf}^{\;4} - T_{env}^{4}\right)$$

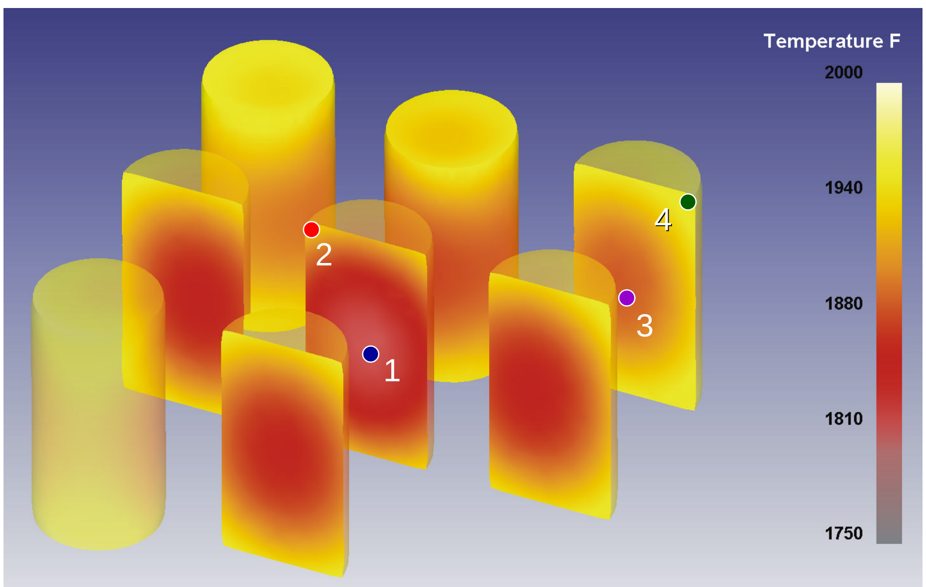
where is σ the Stefan-Boltzmann constant, ε is the emissivity of the surface, A is the body's surface area and $F_{1\text{-}2}$ is the view factor. The heat flow due to radiation is proportional to the fourth power of the temperature gradient between the surface of the part and the environment.

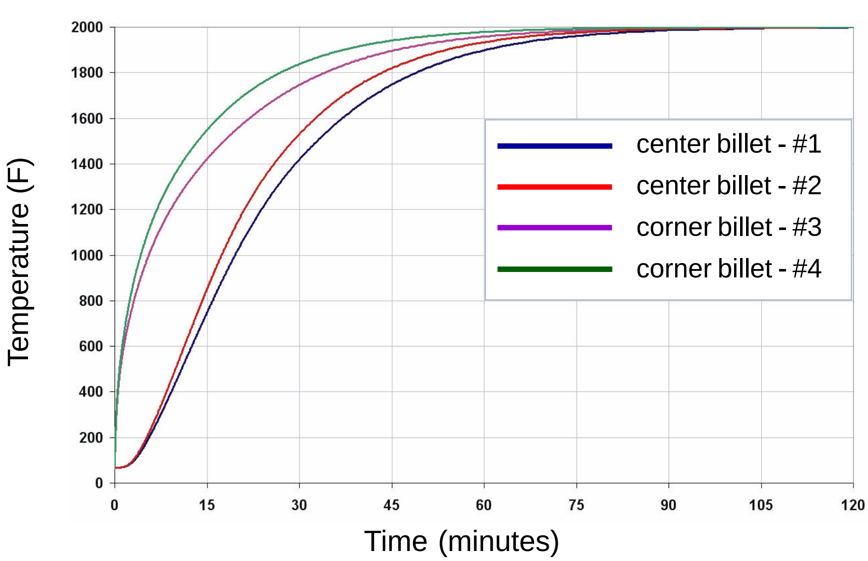
Radiant heat energy emitted by a body depends on the emissivity of the body's surface. This emissivity depends on the material type and the surface condition, with values ranging from 0 to 1. For example, the emissivity of a black body (absorbs all energy incident upon it) is 1.0. The emissivity of aluminum is typically 0.1, with other metals ranging from 0.3 to 0.7. When multiple objects are involved, the radiant heat transfer depends on geometry, temperature and part location. Radiation heat transfer is proportional to the view factor, $F_{1\text{-}2}$. Modeling radiation with view factor is required to achieve accurate simulation results for high temperature processes.

Convection is the dominant mode of heat transfer between an object and the environment below 1000°F. At high temperatures (>2000°F), radiation dominates heat transfer with the environment and convection is essentially a second order effect. Between 1000°F and 2000°F, convection and radiation are both influential.

Recent developments have included the option of view factor calculations in DEFORM. Previously, a simplified black body radiation model was used to reduce computation time.

The influence of view factor is shown in the example below. Nine billets were modeled during heating in a 2000°F furnace. The billets were loaded in 3 rows, as shown. From the predicted temperature distribution, the effect of the view factor can be seen. The center billet was heated at a slower rate due to shadowing from the surrounding objects. If view factor had been disabled, all of the billets would have shown the same result.





A DEFORM model of nine billets being heated is shown above. The shadowing effect of the center billet is captured with the view factor. Time to temperature is shown below. The center billet heats at a slower rate, as expected. High energy cost justifies modeling the heating processes.

Releases

DEFORM-2D and DEFORM-F2 version 8.2 will be released this spring. DEFORM-2D and DEFORM-F2 will share FEM engine, AMG mesh generation and other key components. 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.
- Large geometry files with multiple boundaries can be imported.

DEFORM-3D and DEFORM-F3 version 5.1 will also be released this spring. 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.
- Stability has been improved during simulation and mesh generation.
- Conforming coupling contact has been implemented for multiple deforming body simulations.
- A movement preview has been added.

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

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

Scientific Forming Technologies Corporation
5038 Reed Road
Columbus, Ohio
43220-2514
Tel: (614) 451-8330
Fax: (614) 451-8325
www.deform.com
email: sales@deform.com