Winter, 2019

Volume 17, No. 1

DEFORM News

Training:

- April 16-19, 2019: DEFORM training will be conducted at the SFTC office in Columbus, Ohio.
- June 18-21, 2019: DEFORM training will be conducted at the SFTC office in Columbus, Ohio.
- August 13-16, 2019: DEFORM training will be conducted at the SFTC office in Columbus, Ohio.

Events:

- March 20-21, 2019: Wilde Analysis Ltd. and SFTC will present at the Fifth International Symposium on Linear Friction Welding at TWI Ltd. in Cambridge, UK.
- May 21-23, 2019: SFTC will exhibit at Forge Fair 2019 (Booth 212) in Cleveland, OH. Forge Fair is North America's largest forging industry event.
- August 20-21, 2019: The annual Die Stress Workshop will be hosted by SFTC, in conjunction with Marquette University, in Columbus, Ohio.
- August 22, 2019: A one-day training (focused on die stress modeling in DEFORM) will be conducted following the workshop.

Design Environment for FORMing

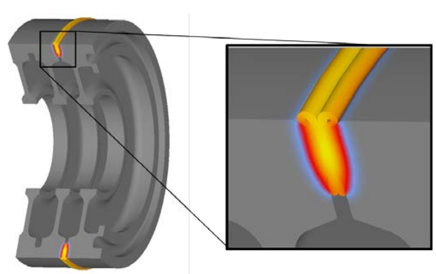
Solid-State Welding

Solid-state welding is a class of welding processes where bodies are joined without melting the base material or the addition of filler material. These operations can produce strong joints in lightweight alloys or dissimilar metals. They are thus popular joining methods in the aerospace and automotive industries.

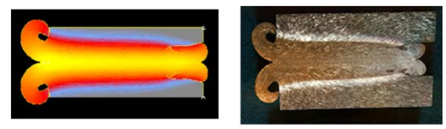
The DEFORM® system provides leading tools to model, analyze and optimize a variety of solid-state welding applications. Some of these simulation tools are quite mature, while others represent the "state of the art" in process modeling technology.

Inertia Welding

The most mature application is inertia welding, where one object is fixed while another is attached to a rotating flywheel. The objects are brought into contact and put under pressure. Frictional heat is generated at the rubbing interface, causing plastic deformation and flashing. As work occurs, flywheel rotation slows and its inertial energy decays to zero. Load is maintained, after the rotating part comes to a stop, to complete the forged bond.



The quality of the weld joint is dictated by the applied axial pressure, initial flywheel RPM and energy, interface temperature, upset distance, flash and residual stress. DEFORM models allow users to optimize these process parameters, for a desired response, on the computer. New shapes, sizes and materials can thus be evaluated with less trial and error.



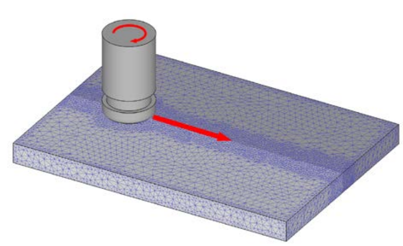
PREDICTED ACTUAL

Inertia welding cases has been modeled with DEFORM-2D for 20 years. GE and SFTC presented two validation examples at NUMIFORM 2001. One case involved titanium aircraft engine disks (shown) and the other studied compressor spool stages of dissimilar materials.

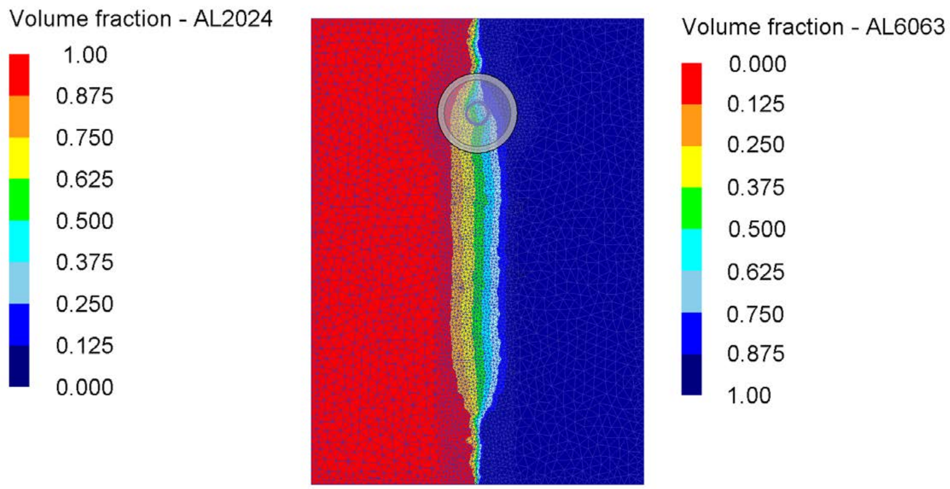
Simulation results successfully matched upset distance as a function of time, flash thickness and flash shape to within 10% of experimental measurements. Temperature predictions and the observed heat affected zone also compared well. The 2.5D torsion model even predicted the rotational speed during the process based on the instantaneous energy of the flywheel.

Friction Stir Welding

Over the years, DEFORM has also been popular for simulating friction stir welding (FSW). In the process, two objects are first clamped against each other. Next, a non-consumable tool plunges into the joint. The tool rotates, which elevates the temperature of the material due to friction and deformation. The tool moves along the joint, progressively heating and mechanically mixing the softened materials. This produces a joint with high weld strength.



Understanding the thermomechanical behavior of this process is critical. DEFORM models have been used to predict metal flow, accumulated strain, temperature, defects and loads in the process. Advanced analyses have revealed material mixing behavior (below) and resulting microstructure.

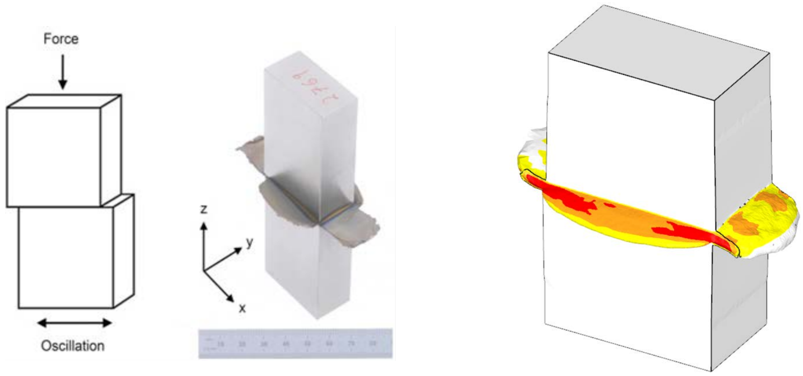


Applications of DEFORM to FSW, using the default implicit Lagrangian method, were first published as early as 2001 (2D) and 2006 (3D). An Arbitrary Lagrangian-Eularian (ALE) based method for solving FSW models was recently introduced in V11.2. Both methods allow users to evaluate the impact of material type, plate thickness, tool design, plunge depth, rotational speed and feed rate on the final welded joint.

Linear Friction Welding

Linear friction welding (LFW) shares many similarities to inertia welding. One object is fixed and another moves against it, all while undergoing an applied normal pressure loading. In LFW, the moving object linearly oscillates back and forth at a high rate. Frictional heating causes the materials to soften flash and forge together. Oscillation stops, load is held and the final welded joint is formed according to a predefined program schedule.

LFW is of particular interest in aerospace applications like welded turbine engine blisks. Notable process parameters include the material type, oscillation frequency, oscillation amplitude, friction pressure, forging pressure and material consumption rate.



Ref. (left): McAndrew AR., "Modelling of Ti-6Al-4V linear friction welds", PhD Thesis. Cranfield University; 2015

An efficient 2.5D LFW modeling capability was introduced in DEFORM-2D V11.2. It is a practical solution for simulating thermomechanical behavior in LFW processes. Its 2D plane strain model is defined normal to the oscillation direction, with a coupled solution for out-of-plane movement. 3D LFW modeling tools are also being developed. They allow full 3D prediction of deformation, heating and flash formation (above). This has also spurred new advancements in remeshing and contact behavior capabilities.

Releases

DEFORM V11.3 enhancements and new features include:

Enhancements

- Forming Express (3D) target volume
- Improved report generator
- MO user variable initialization
- Operation "Open task folder"
- Thermal property scheduling
- Step Editor magnifier on/off
- Operation copy/paste numbering
- DB merging
- Friction window preview
- Copy object
- STL 3D window import
- Custom total strain plots
- Enhanced velocity plotting
- "Diff step" options
- Report backward point tracking
- Cooling curve graph
- Cylindrical point tracking graph
- View back
- State variable default plot type
- State variable default color bar type
- Viewport settings
- PIP windows/graphing
- 2D contact area calculation
- Slicing improvements
- Discrete DOE iterations
- Spring/sliding die DOE variable
- Forming Express error checking
- Material Suite additions
- License/queue server improvements
- IMI 834 material data
- Titanium material data updates
- New lab exercises
- New license manager
- DEFORM Service Control update

The complete list of the new features can be found in the V11.3 release notes. Release notes are included with the software installation and available on the DEFORM User Area.

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