Modules

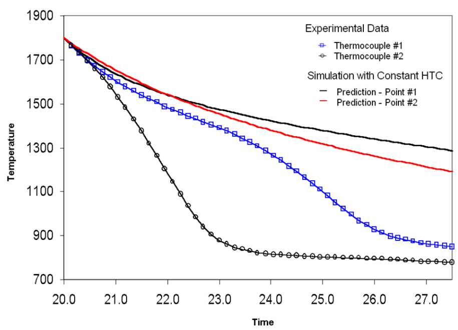
The **Doe / Optimization** module is an exciting capability based on the multiple operations environment, released in V11. Design of Experiments (DOE) is a systematic method of studying the influence of process or design changes on a defined output. DOE allows users to setup a baseline model, with multiple operations, and very efficiently run that same case, with controlled variation. Variables include geometry, process conditions and a wide range of other data. Once a DOE study has been established, dozens or hundreds of models are created and run with little user intervention.

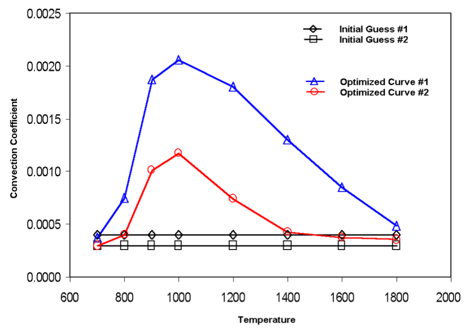
Optimization is a form of DOE study, where a control program adjusts the sampling to seek an optimum solution within a given design space. Sensitivity based optimization has been available in DEFORM for over a decade, and the ability to integrate with DOE is a significant enhancement.

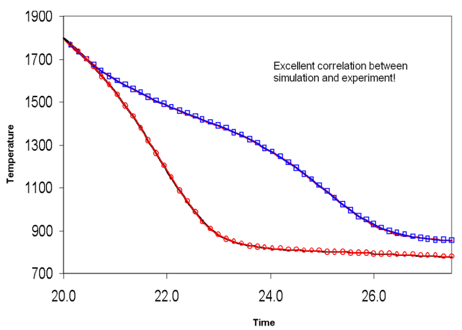
In many cases, DOE will be used to study a wide range of design space. It is quite easy to set up a second DOE in a smaller design space (subset) to better understand local surface response. Once an area is well understood, the system allows very efficient setup of an optimization run to find the numerical optimum in that space.

An automated data mining and formatting capability allows users to study the result of their study in the form of response surfaces, response plots, tornado charts, tables, histograms and others. A special postprocessor (DOE POST) allows the user to interrogate the study, while individual simulations can be opened with the existing DEFORM postprocessors.

Inverse Heat Transfer Coefficient (HTC): Accurate definition of local heat transfer coefficients as a function of temperature is required to accurately model transient thermal processes. DEFORM provides an optimization-based inverse module that extracts heat transfer coefficients from experimental thermocouple data. This user-friendly module guides the user through data preparation and post processing. Modeling results include a set of heat transfer coefficients and temperature validation plots.







Time vs. temperature is shown for two locations when quenching a nickel alloy disk (top left). The mismatch between predicted and actual temperature is the result of using a constant heat transfer coefficient, that does not match reality.

The initial (constant) heat transfer coefficients are compared to the final values, as a function of temperature and location (top right). DEFORM uses optimization techniques to accurately match the experimental data.

The final simulation, using updated HTC values, accurately matches the experimental data (bottom left).

DOE / Optimization

- DOE / Optimization uses the morphing capabilities of the Geometry Tool to morph 3D geometry.
- Simulations can be run in parallel, if more than one FEM engine is available on the DOE computer.
- DOE simulations are run on one computer, where the DOE license resides.
- FEM engines must have a simulation queue to be used in a DOE environment.
- Each DOE / Optimization license will simulate one DOE or Optimization study.

Inverse HTC

- The Inverse HTC (2D) module runs in conjunction with DEFORM-2D.
- DEFORM-2D license with a simulation queue to be used with the Inverse HTC module for 2D simulations.
- The Inverse HTC (3D) module runs in conjunction with DEFORM-3D.
- DEFORM-3D license with a simulation queue to be used with the Inverse HTC module for 3D simulations.

DEFORM™

Design Environment for FORMing

Geometry Tool

- The Geometry Tool is a stand-alone module.
- Inputs include STL, IGES and STEP.
- Capabilities include geometry repair, translation from IGES/STEP to STL and boolean operations.

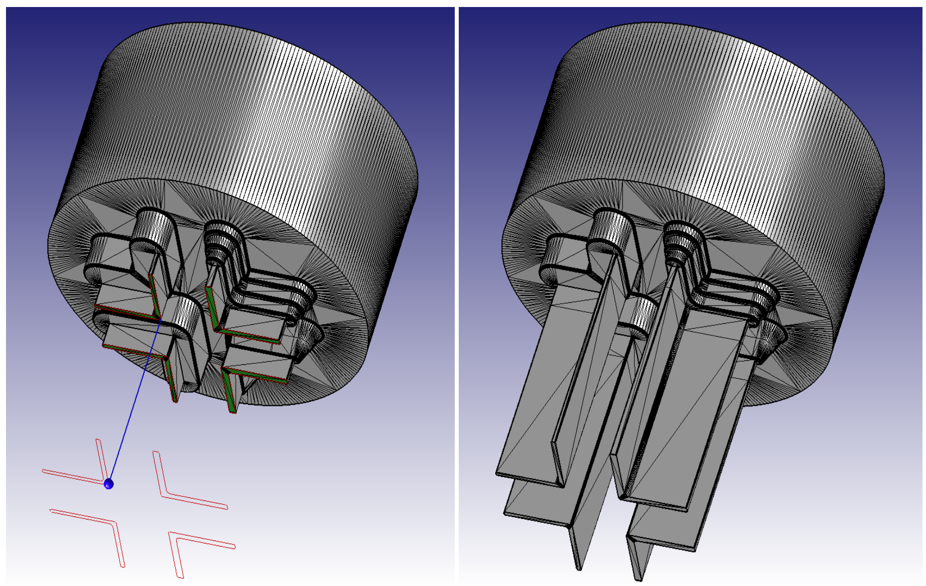
Material Suite

- CA models are integrated with DEFORM-2D and the Microstructure Module as a postprocessing function.
- DEFORM-2D and/or DEFORM-3D with the Microstructure Module are required to run material models.
- Third party strength prediction software, ANSYS and DARWIN are not included.

A **Geometry Tool** is available to supplement the capabilities of CAD systems. While most CAD packages produce water-tight STL models with no folds, cracks or illegal polygons, this is not always the case. The Geometry Tool is capable of automatically repairing a wide range of illegal STL geometry. For severe cases, a user can detect and repair geometry interactively.

The Geometry Tool also allows users to make modifications to geometries at the STL level. Surfaces can easily be offset or extruded, as shown below where the extrudates of a steady-state extrusion workpiece were elongated. Boolean operations can be used to combine objects or subtract one geometry from another. Trimming functionality allows users to cut a geometry based on a contour drawn around a part - very useful for trimming flash off of a part between operations. Other operations such as mirroring and slicing are also available.

In addition to working on STL files, the Geometry Tool can also import IGES and STEP files.



The **Material Suite** is a series of utilities to enhance DEFORM's capability in microstructure, mechanical properties and part performance.

To assist a user in data preparation, TTT calculation, flow stress data and JMAK model data preparation have been developed. The TTT calculation computes Time-Temperature-Transformation curves based on the chemical composition of carbon, alloys and stainless steels. The flow stress utility assists in the conversion of compression test data to commonly used flow stress constitutive equations, including curve fitting. The time and effort to develop JMAK models from experimental data has been significantly reduced. Inverse methods have been deployed to compute JMAK model constants for grain growth and recrystallization equations from experimental test data.

The strength model provides a link to third party yield and ultimate tensile strength predictions, based on neural network methods. Product performance can be predicted through link with DARWIN. DEFORM simulation results of the process can be input to a DARWIN life prediction model using Siesta files. An export to ANSYS for lifing is also included.

Cellular Automata (CA) models for predicting grain morphology, grain size evolution due to recrystallization and grain growth kinetics are implemented.

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