Modules

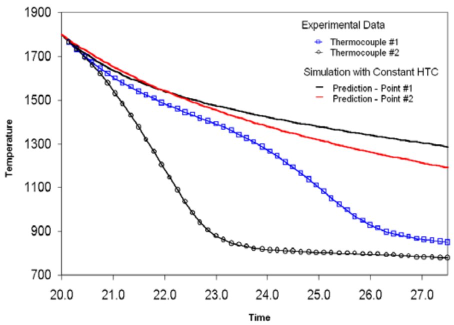
The DOE / Optimization Module adds exciting capabilities to the DEFORM multiple operations environment. Design of experiments (DOE) is a systematic method of studying the influence of process or design changes on a defined output. DOE allows users to take a baseline multiple operation model and efficiently rerun it with controlled variations. Variables include geometry, process conditions, material data and a wide range of other information. Once a DOE study has been established, dozens or hundreds of models are created and run with little user intervention.

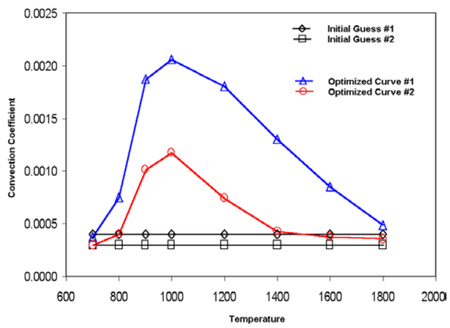
Optimization is a form of DOE study, where a control program adjusts the sampling to seek an optimum solution within a given design space. Sensitivity based optimization has been available in DEFORM for over a decade. The ability to integrate with DOE is a significant enhancement.

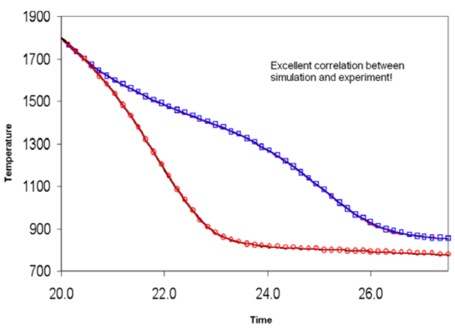
In many cases, DOE will be used to study a wide design space. It is quite easy to set up a second DOE in a smaller design space (subset) to better understand local surface response. Once an area is well understood, the system allows very efficient setup of an optimization run to find the numerical optimum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

An automated data mining and formatting capability allows users to examine the result of their study using statistical tools. Tools include response surfaces, response plots, tornado charts, tables, histograms and more. A special post-processor (DOE POST) allows the user to interrogate the study, while individual simulations can be opened with the existing DEFORM post-processors.

Accurate definition of local heat transfer coefficients, as a function of temperature, is required to properly model transient thermal processes. DEFORM provides an optimization-based Inverse Heat Transfer Coefficient (HTC) Module that extracts heat transfer coefficients from experimental thermocouple data. This easy-to-use 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.

These heat transfer coefficients are compared to the final values, which are 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 geometry may be varied via morphing, discrete input or parametric CAD coupling.
- DOE simulations can be run in parallel, if more than one FEM engine is available on the computer.
- DOE simulations run on one or, when the license allows, across multiple computers.
- FEM engines must have a simulation queue to be used in a DOE study.
- Each DOE / Optimization license will allow one DOE or Optimization study at a time.

Inverse HTC

- The Inverse HTC (2D) module runs in conjunction with DEFORM-2D.
- DEFORM-2D and simulation queue licenses are prerequisites.
- The Inverse HTC (3D) module runs in conjunction with DEFORM-3D.
- DEFORM-3D and simulation queue licenses are prerequisites.

DEFORM®
Design Environment for FORMing

Geometry Tool

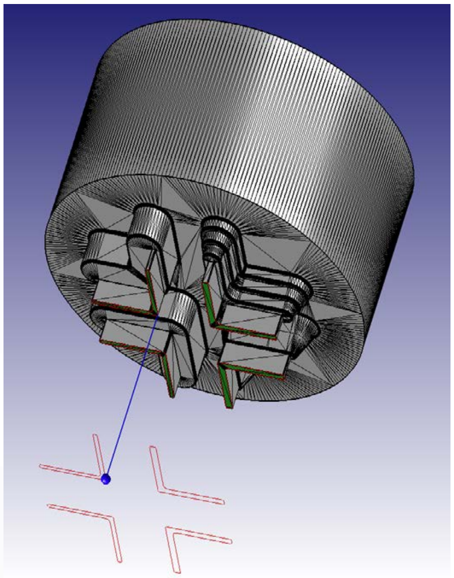
- Geometry Tool is a stand-alone module.
- Inputs include STL, IGES and STEP.
- Capabilities include geometry repair, translation from IGES/STEP to STL and boolean operations.

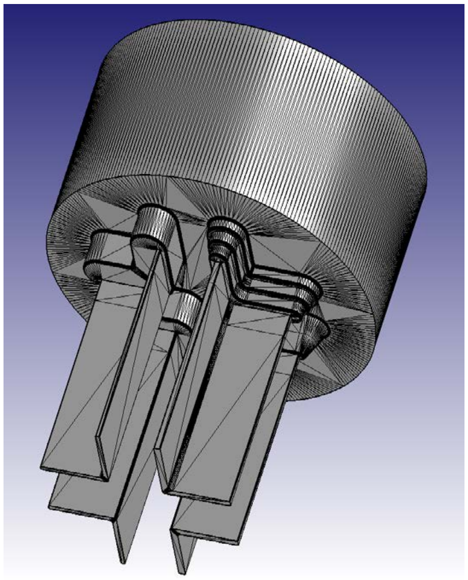
Material Suite

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

Geometry Tool is available to supplement the capabilities of CAD systems. Most CAD packages produce water-tight STL models suitable for DEFORM. Those that do not may produce models with folds, cracks or illegal polygons. Geometry Tool has the capability to automatically repair a wide range of illegal STL geometry. For severe cases, a user can detect and correct geometry interactively. Geometry Tool also imports 3D IGES and STEP files, converting the geometry to STL format.

Geometry Tool allows users to modify 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 will combine objects or subtract one geometry from another. Trimming functionality allows users to cut a geometry based on a contour drawn around a part. This is very useful for trimming flash off of a part between operations. Mirroring, slicing and other operations are also available.





Material Suite is a series of utilities that enhance the capability of DEFORM in micro-structure, mechanical properties and part performance modeling. It includes tools that significantly reduce the time and effort required to develop material models, and also allows for advanced material modeling and strength prediction studies.

The included TTT, flow stress and JMAK data preparation tools simplify material characterization tasks. The TTT tool computes Time-Temperature-Transformation curves based on the chemical composition of carbon, alloy and stainless steels. The flow stress utility converts compression test data to flow stress constitutive equations through curve fitting. Fitting methods also compute JMAK model constants for grain growth and recrystallization equations from experimental data.

Material Suite includes features that connect with external software. The strength model provides links to third-party yield and ultimate tensile strength predictions, based on neural network methods. DEFORM results can also be output to a DARWIN life prediction model using SIESTA files. Finally, the ANSYS export interface bridges the gap between manufacturing simulation and structural fatigue and in-service analyses.

A variety of advanced microstructure modeling and representation tools are provided. Cellular Automata (CA) models predict grain morphology and grain size evolution due to recrystallization and grain growth kinetics. Monte Carlo probabilistic modeling statistically quantifies processing and material variation in thermomechanical operations. Crystal plasticity models calculate texture evolution with deformation. Representative volume element (RVE) modeling links macro-scale component simulations to micro-scale response. RVE models have application in void closure, porous material density and defect evolution prediction.

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