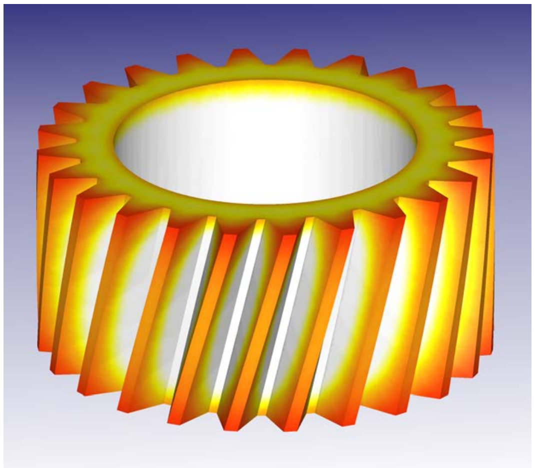
DEFORM-HT

DEFORM™-HT is a powerful stand-alone finite element modeling system for simulating heat treatment processes. The system predicts thermal, mechanical and metallurgical responses of parts during heat treatment. Heat treat distortion, quench cracking and residual stresses can be predicted. The system can also provide information on phase transformation and phase volume fraction.

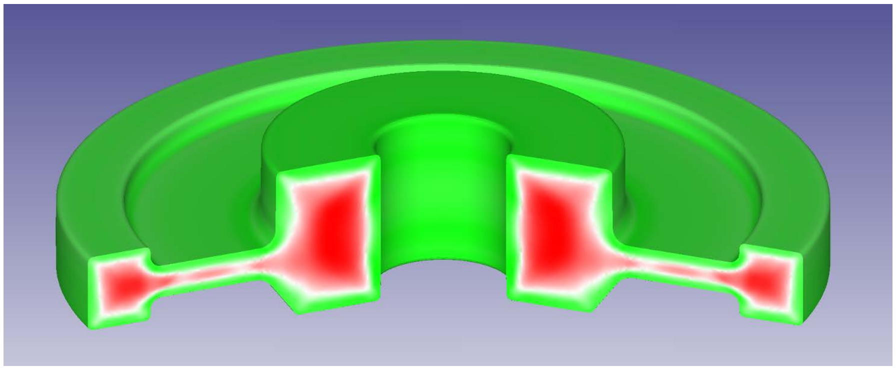
A variety of materials, ranging from carbon steel and aluminum to titanium and nickel-based alloys, can be modeled. Typical heat treatment processes include:

- normalizing	- austenizing	- carburizing	- solution treatments
- quenching	- tempering	- aging	- stress relieving



DEFORM-HT can analyze diffusion processes such as carburization, which provides a prediction of case depth. Phase transformation may be modeled using volume fractions. A high martensitic phase volume fraction (red) is shown on the gear at left. Residual stress response during and after heat treatment processes can also be predicted. Modeling of residual stress is important, since the stress field may significantly impact subsequent machining distortion and the life of a component in service. DEFORM is also capable of simulating stress relaxation and aging.

This powerful modeling tool provides critical information about the process variables required to control and optimize heat treatment processes. It provides the ability to visualize the microstructure, temperature and stress during heat treatment. This is simply not possible with experiments. It is possible to conduct sensitivity analysis without the time and cost of physical trials. DEFORM-HT is a tool that enables users to achieve an optimum balance of mechanical properties, while avoiding quench cracks and minimizing heat treat distortion and residual stresses.



In the disk shown above, the red areas represent tensile residual hoop stress after heat treatment. The green areas are compressive. Stresses in the turbine disk (shown above) were optimized without sacrificing mechanical properties by adjusting the cooling rate during quenching.

Product Specifications

- DEFORM-HT is a stand-alone system to simulate heat treatment processes. DEFORM-HT2 uses a two-dimensional model for axisymmetric or plane strain applications. DEFORM-HT3 is used for complex three-dimensional applications.
- Model outputs include evolution of temperature, residual stress, distortion, phase volume fraction, case depth and hardness.
- Heat transfer, phase transformation and diffusion modules are coupled in an integrated simulation environment.
- A mixture rule is used to define various phase properties as a function of temperature and primary alloying element.
- Volume change due to phase transformation is accounted for in the model.
- Popular creep models are implemented to simulate the stress relaxation process.
- Induction and resistance heating capabilities are included with DEFORM-HT.

DEFORM®

Design Environment for FORMing

Microstructure Module

Licensing Options

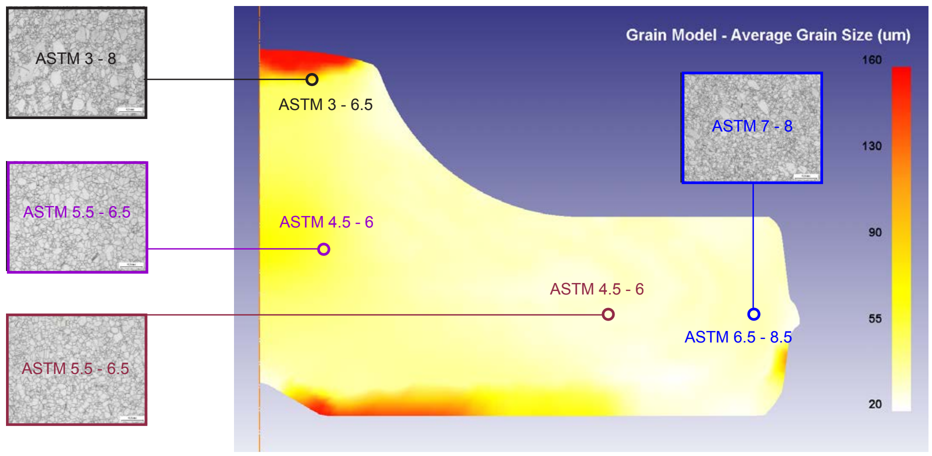
- The Microstructure Module can be added to a DEFORM-2D or DEFORM-3D license to enable microstructure evolution during thermo-mechanical processing.

Product Specifications

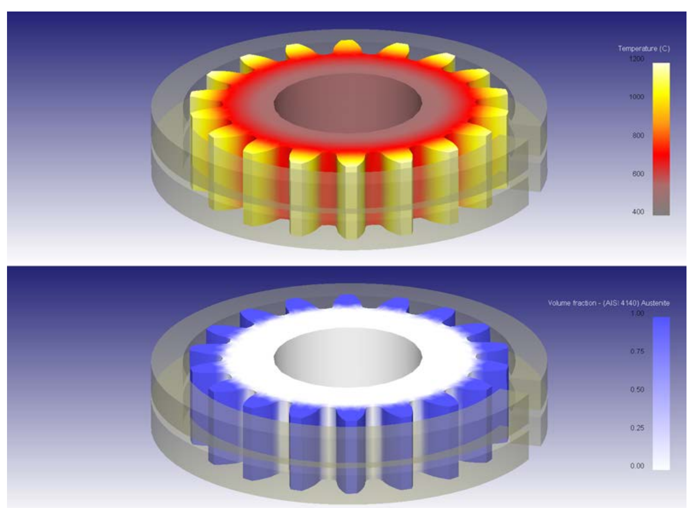
- Model outputs for the Microstructure Module include grain size, percentage recrystallization and phase volume fraction. rain orientation, percipitate size and texture.
- Standard DEFORM-HT outputs such as distortion and residual stress are also available.

The Microstructure Module expands the capabilities of DEFORM-2D and DEFORM-3D to include a wide range of microstructure and mechanical property information. Two approaches for modeling microstructure evolution during thermo-mechanical processing are implemented in DEFORM.

The Johnson-Mehl-Avrami (JMAK) is an empirical method. JMAK models are used to predict average grain size and percent recrystallization throughout a part. This method has been used in aerospace industry to predict grain size in nickel-based superalloys for years. Dynamic, metadynamic, static recrystallization kinetics and grain growth are modeled. JMAK microstructure model data are available within DEFORM for a variety of materials.



This example, courtesy of Carmel Forge, demonstrates excellent correlation between the model and a production Waspaloy turbine disk forging.



DEFORM also makes it possible to simulate phase transformations in steels. This allows for the prediction of phase, hardness, strength, residual stress and distortion. For example, the spur gear shown above underwent induction heat treatment to yield harder teeth. Induction coils were rotated around the gear to produce uniform heating around the gear circumference. The gear teeth transformed to austenite during heating and subsequently transformed to martensite upon cooling in a quench process.

Microstructure modeling is used to predict residual stress and a range of mechanical properties. Scientific Forming Technologies Corp. is the leader in the development and application of microstructure modeling for research and industrial applications.

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