DEFORM™ Application #150

Cogging Simulation

The Process:

Cogging, or open die forging, is a process used to convert a cast ingot into a forged billet. The material is locally compressed between two dies which "bite" their way along the length of the ingot. As a result, the cross section is reduced and the length increases. In addition, thermo-mechanical processing (TMP: plastic deformation at high temperature) breaks down the coarse, cast grains and provides a fine grained, recrystallized micro-structure. Cogging is used in the supply of aerospace billet, which is subsequently cut up and forged into critical rotating components, such as turbine disks.

A typical cogging schedule contains a number of heats - a single heat is where the ingot is taken from the furnace, subjected to a number of cogging passes and returned to the furnace. Each heat contains maybe 4 or more cogging passes with ingot rotations in-between. Each forging pass contains several small bites, with the dies generally operating from one end of the billet to the other.

Simulating Cogging:

Simulating cogging in a conventional manner would involve manually setting up each operation as a discrete simulation. In just a single heat, the engineer would be faced with the following deformation (D) and heat transfer (H) simulations:

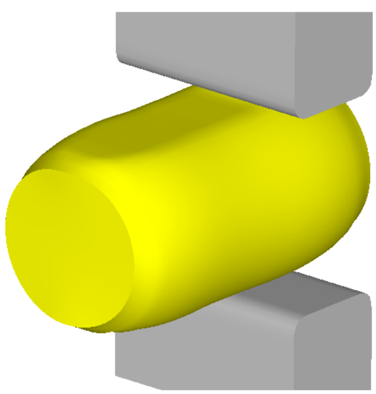
- Transfer ingot from furnace to forge (H)
- Orient ingot for first pass (H)
- Position ingot in dies for first bite (H)
- Take first bite (D)
- Reposition ingot in dies (H)
- Take next bite (D) …(repeat until end of pass)

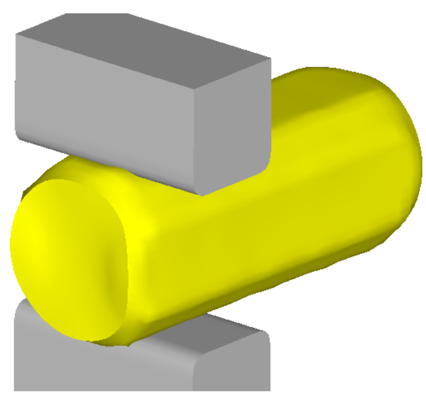
Between passes there would be an additional heat transfer simulation. After the final pass, the ingot would be reheated in the furnace.

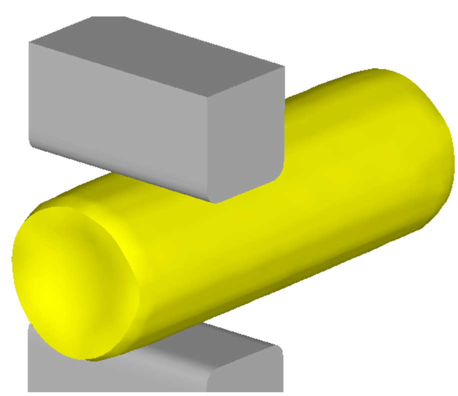
In a single heat of 16 passes, the analyst could be faced with performing nearly 300 back to back simulations. It is easy to understand the magnitude of this task.

The DEFORM™ Solution:

The DEFORM™ System contains a special pre-processor that enables the engineer to set up the complete cogging schedule in one session. Standard industry billet, die and manipulator shapes are included and the CAD interface allows additional geometry input. Process inputs include number of heats, number of passes, rotation information, bite size and time between bites/passes. Depending on it's complexity, the cogging simulation may take a number of hours to run, but setting up will only take a fraction of the time.







The three figures show the start (above), mid-process (upper right) and later (lower right) stages in the 16-pass cogging of alloy 718. The ingot was initially upset, cogged in octagonal then bi-octagonal configurations.

DEFORM™

Design Environment for FORMing

Industrial Application:

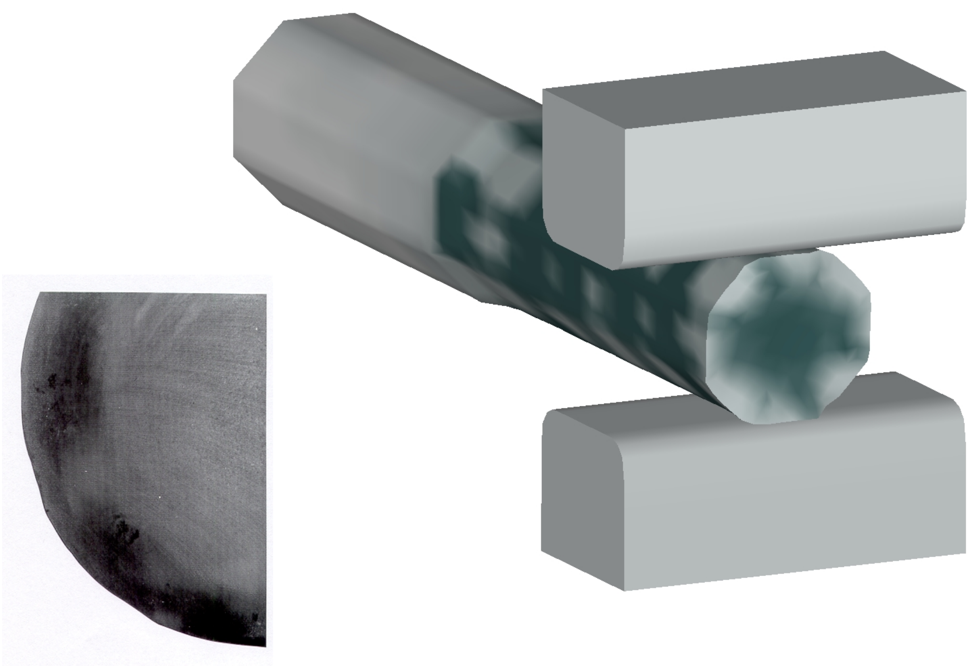
Forging a large diameter turbine disk to meet today's requirements necessitates the use of a fine-grained billet of a corresponding large diameter. If the cast ingot diameter is only marginally larger than the required billet size, upsetting is initiallycarried out. This increases the diameter, reduces the length and the deformation provides thermo-mechanical processing which recrystallizes the microstructure. Subsequent cogging reduces the diameter to its original size and provides further thermo-mechanical processing.

As part of an aerospace material supply project, DEFORM™ was used to analyze a single heat upset/ cogging schedule.

After upsetting, alloy 718 was cogged for 16 passes, in octagonal and bi-octagonal configuration, to produce a rough round billet of original diameter. The upset-cogging cycle may be repeated numerous times to achieve the specified microstructure in a large diameter billet.

The Opportunity:

DEFORM™ provides the process designer with an efficient method of obtaining critical microstructure information. Simulation has been proven in assisting engineers to develop optimized processes by trial and error on the computer. Optimizing processes results in greater yields which means significant cost savings. Improved process control is possible through the improved understanding and subsequent control of the most important process parameters.



The final stage of cogging in a four-pass heat showing contours of grain size in billet (right). Darker shading represents finer grains. Note the eight pockets of coarse, un-recrystallized grains on the periphery.

The actual cogged billet slice after macro etching (left) shows dark peripheral areas (coarse un-recrystallised grains) that correlate well with the prediction.

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