DEFORM™ Application #108

Multiple Operation Hot Forging

Background:

A metal forming process may consist of a large number of stages. A hot forming operation, for example, can exceed half a dozen individual steps, where the flow characteristics of each step will depend on the final geometry and temperature history from the previous stages. As preform design is based on the inter-relationships between these steps, a practical simulation will typically be required to consider the entire process. If intervening heat transfer stages are also considered, a complete analysis may easily consist of over twenty successive simulations.

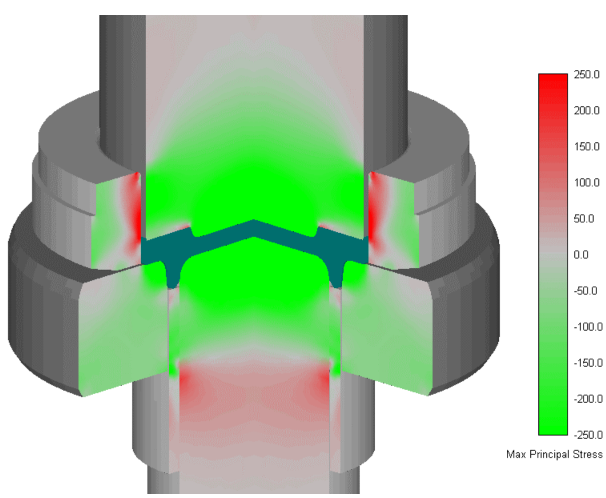
This example demonstrates how the complete thermal cycle of the work-piece material can be simulated using the multiple operation capabilities in DEFORM™, including the analysis of die stresses. If desired, the complete production sequence can be set-up by the user in one pre-processing session. This can include forced billet heating from the heater, temperature loss to the environment during transfer operations, heat transfer to tooling, press characteristics and friction between the die and workpiece.

Industrial Example:

A forging is produced flashless at UEF Automotive on a Hatebur AMP50, at a rate of 55 parts per minute. The starting material is bar stock. Automatic transfer grippers move the workpiece through three forging stations and a final piercing station. Accurate prediction of material flow, die fill and press load are critical parameters for acceptable tool life and high product quality.

Die Stress Analysis:

One of the objectives of the simulation was to investigate the stresses induced in the dies during forging. Prior experience has shown a tendency of die failure around the punch nose in the third forging station.



Maximum principal stress distribution is shown in the tools at the end of Station 3.

Consequently, this operation was simulated with elastically deforming dies to predict both the stress distributions and deflections during forming. In the plot below, the maximum principal stress distribution predicted in the tools is shown. Compressive regions are shown in green and tensile areas in red. These stresses are generated by a combination of forging pressure and high thermal

(to be continued)

Design Environment for FORMing

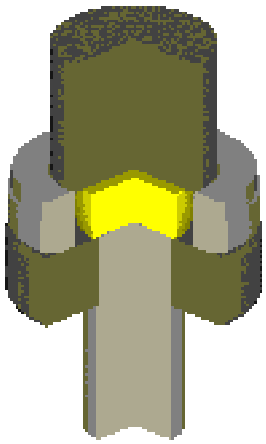
(continued)

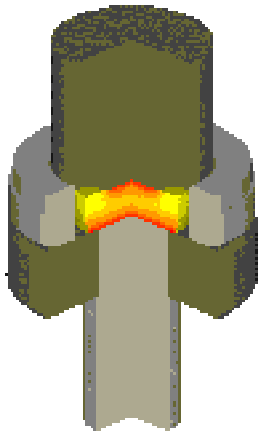
gradients at the surface of the dies. An area of tensile stress, in red, can be seen at the punch nose radius, which indicates a potential fracture mechanism.

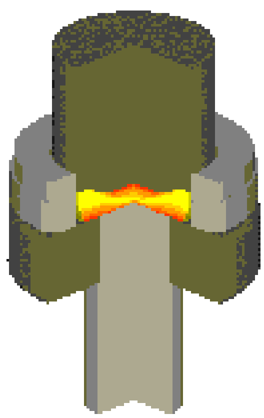
Multiple Operation Forming Simulation:

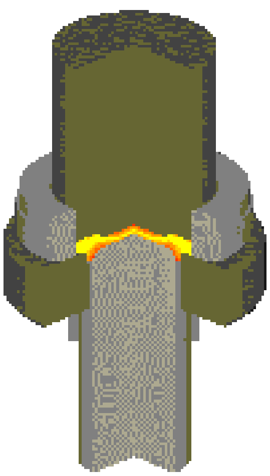
The entire process was set up in one session, using material data from the DEFORM™ database, and was run a number of times with different initial billet temperatures and friction coefficients. The die movement control applied depends on the type of press machinery being simulated.

For example, the Hatebur mechanical press at UEF has a distinct velocity profile that is dependent on the forging stroke. This was taken into account by the simulation model. The temperature contours in the workpiece and dies predicted by the simulation are shown. It can be seen that there is significant chilling at the interfaces between the punch and ejector pin and the workpiece. The final stage involves the simulation of the piercing operation, where the material is allowed to 'tear' once it exceeds a user-defined level of the damage criterion.

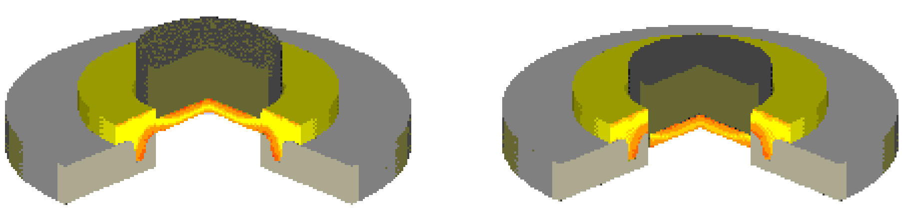








Simulation results (contours of temperature) are shown for billet positioned in dies (upper left), die chill prior to forming (top center), blocker (top right) and finish forging (left).



Contours of temperature are snow before and after piercing operation. Note the separation of the slug from the forging (right).

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