DEFORM™ Application #120

Suspension Lug Platter

A typical forged platter and trimmed part.
Threads are applied to the part by the customer.

Background:

Hammer forging is a complex process. Platter forgings with multiple parts add to the complexity due to axial volume variations. Multiple die cavities are common in hammer forgings. A typical progression might include descaling, rolling, blocking and finishing. The hammer operator moves the part from one cavity to the next, and any variation in his placement or rotation of the part can have a significant impact on the final part quality.

Modern Forge, formerly Delfasco Forge, is located in Hurst, Texas and produces various types and sizes of suspension lugs for the United States government. These lugs are the components that attach the bombs to the airplane bomb rack. The lugs described in this study are forged on a hammer, with three lugs to a platter.

Forging Process:

The forging process of this suspension lug platter included:
- induction heating,
- multiple blow roll (with rotations),
- several blocking blows and
- finish forging.

The three cavities were cut into a single die block.

Delfasco experienced quality problems associated with this forging process. The lugs exhibited defects that were detected during a magnetic particle inspection. Variations in part thickness were observed and the rate of die wear was excessive. This was considered a difficult process, and was limited to only a few operators.

Initial Analysis:

The production forging process was modeled as a non-isothermal simulation using DEFORM-3D. Each individual hammer blow was analyzed, as well as the dwells between hits. For each hammer blow, the mass, energy and efficiency were used as input to the simulation. Each blow finished when the hammer energy was depleted. When the initial analysis was completed, the simulated shape matched the physical samples provided by Delfasco. It was observed during the simulations that slight variations in positioning caused noticeable differences in the intermediate and final forging shape. This matched the production behavior.

Redesign strategy:

Goals were established for this redesign that included:
- reduction in scrap and rework,
- lower rate of die wear, and
- a more robust process.

It was clear that the roll operation and location in the blocker die were areas with the most opportunity for improvement. Small variations in location and rotation were the difference between a good part and scrap. One constraint was that the blocker design could not be modified.

With the simulation results in hand, the team decided to add an intermediate cavity between the roll and blocker operation. The number of roll blows would be minimized. This 'buster' cavity would enhance the transition from the billet to the blocker. Manual and computer generated buster designs were discussed and simulated as potential process improvements. The preform designs were evaluated

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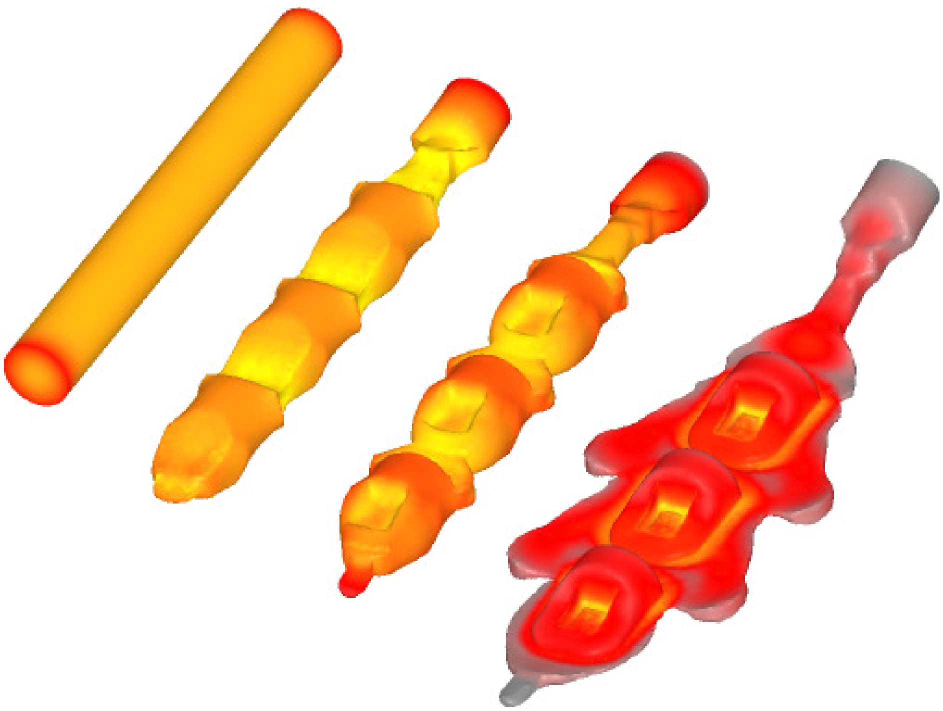
Design Environment for FORMing

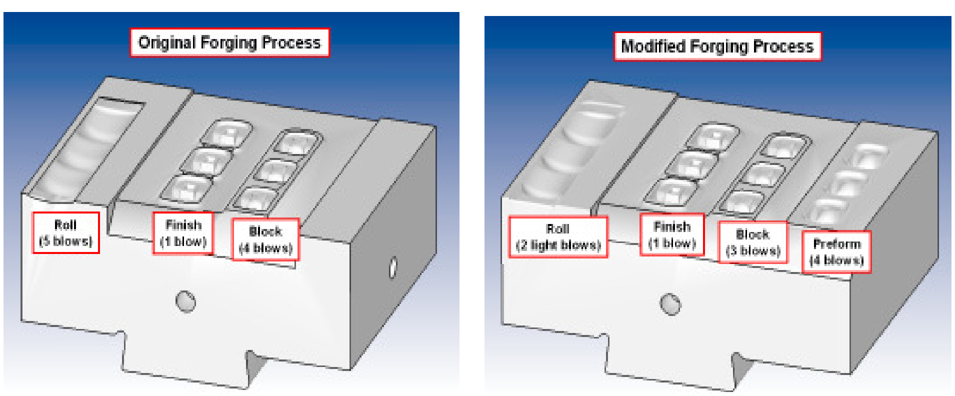


The thermal profile in the forging is shown at various points in the process.

based on die fill, defect formation, flash formation and energy requirements. The final design included two hits in the roll operation, primarily for descaling purposes. The buster cavity was optimized to minimize energy without adding defects or process complexities. This modified process resulted in better control in the initial stages of deformation, resulting in a more robust process.

Throughout the process redesign, simulation was used to test concepts prior to production trials. In the redesigned process, part location in each station was considered. Total deformation energy was calculated to estimate the number of blows required and provide a relative measurement of process efficiency. The dies were designed by Delfasco and New Die staff, while the DEFORM-3D simulations were run at SFTC within the PRO-FAST Project.

When the final shop trials were run, energy levels and blow patterns were recorded. This information was used in DEFORM-3D to simulate the modified forging process. Again, the shape of the simulated suspension lug platter matched closely with the samples provided by Delfasco.



The original and modified forging processes are compared above.

Further Discussion:

Hot forged platters of parts produced on hammers using multiple die cavities are extremely complex to design and optimize. This lug set was no exception. While this type of process has relied on craftsmanship in the past, inconsistent processes often resulted that were very operator dependent. The manufacturing problems were all observed in the computer simulation.

The new process contributed to a scrap reduction from 8% to 3.4% after 17,000 forgings. The new process was more efficient, with fewer hammer blows, allowing Delfasco staff to lower forging temperature. This resulted in an improved surface finish with a minimal penalty in die wear.

Acknowledgements:

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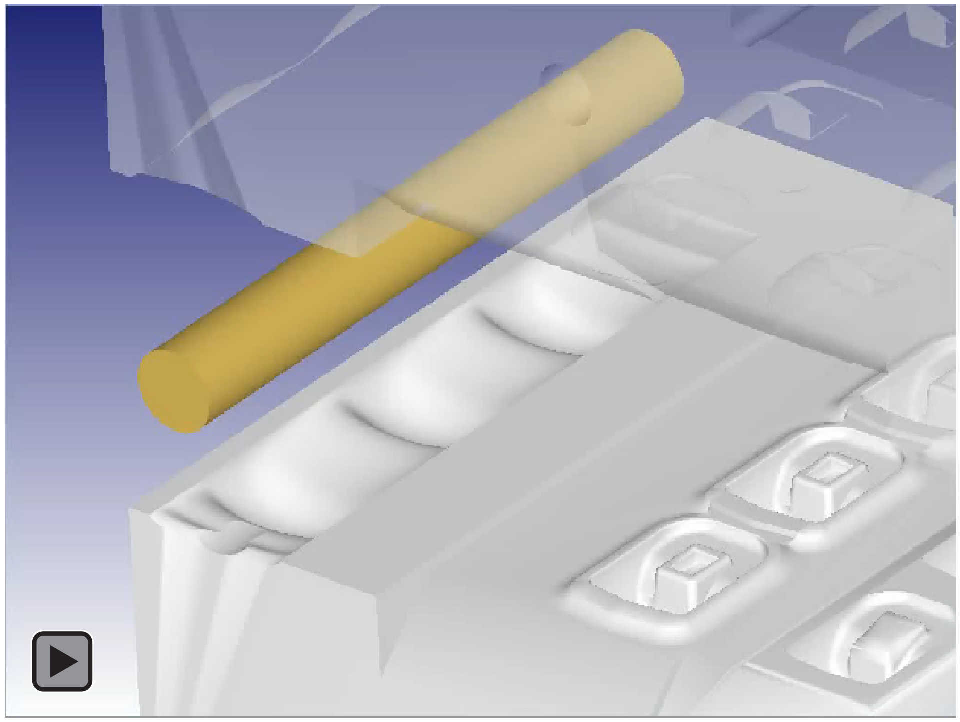
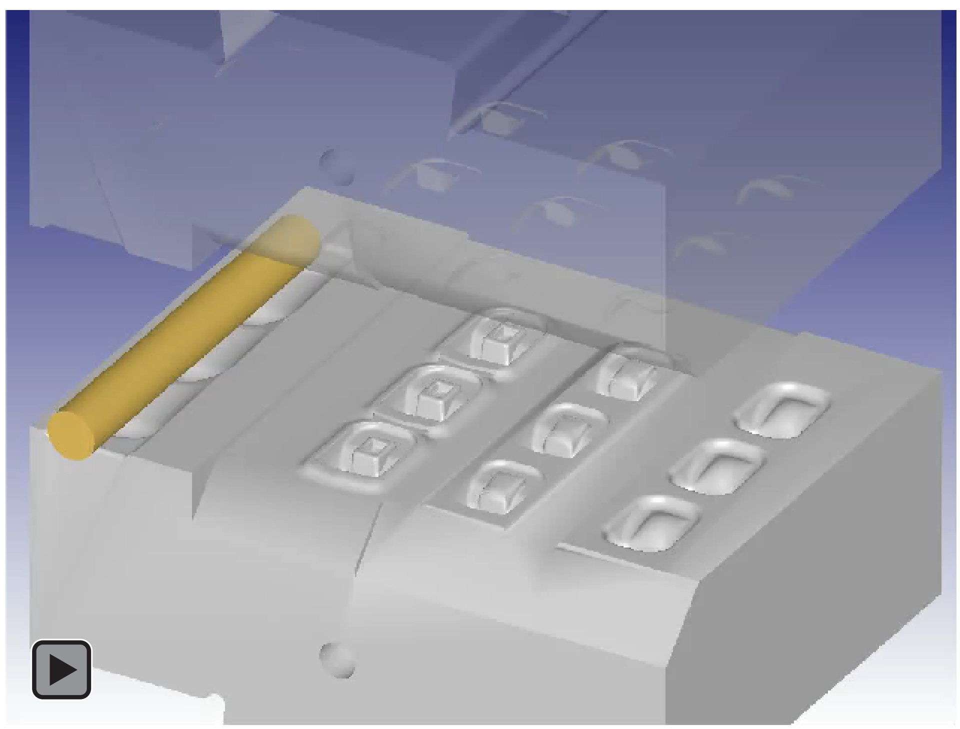
Scientific Forming Technologies Corporation
2545 Farmers Drive
Suite 200
Columbus, OH 43235
Tel: (614) 451-8330
Fax: (614) 451-8325
www.deform.com



The original forging process utilized roll, block and finish operations. Positioning variations had a significant impact on final forged shape.



The addition of a bust cavity made the modified forging process more robust.

Design Environment for FORMing

***Adobe® Reader® X** required to play animations*