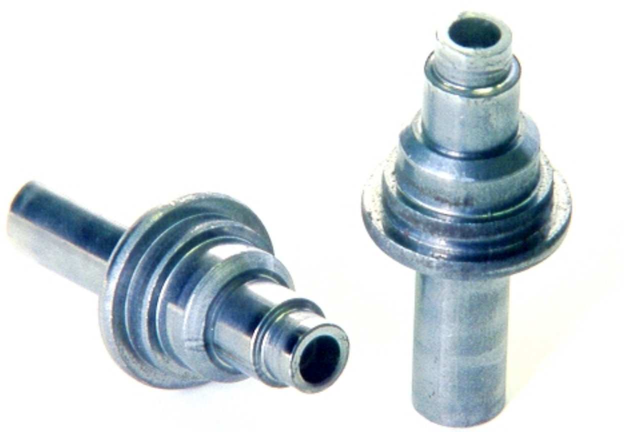
DEFORM™ Application #104

Stepped Pin - Load & Corner Fill

Traditional Design:

A wide range of cold-formed product are being economically manufactured with complex geometry and tight tolerances at very high production rates. The expectations from cold forming today place the burden on designers to develop optimum processes at a reasonable load with a limited number of operations.

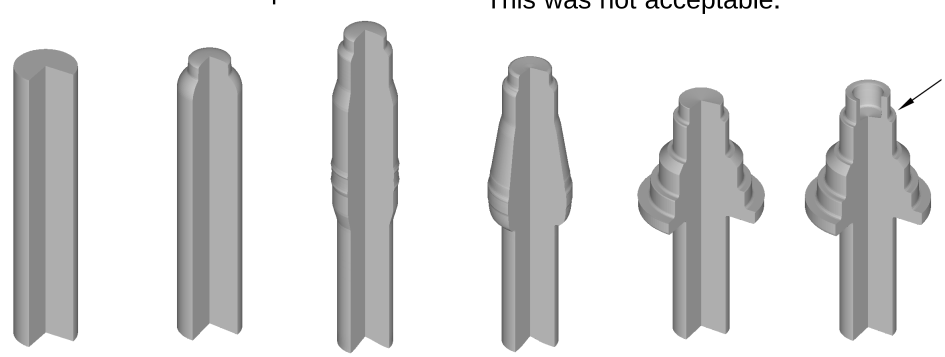


photograph of stepped pin

A traditional design would involve a preform with a conical shape, somewhat like the stepped features in the finished part. This cone would have less detail, but resemble a 'smoothed out' version of the final part.

The concept used to develop the progression design is based on distributing material in one station in a manner such that it easily fills the die details in the subsequent operation without forming a defect. One limit which must be considered is forming load. Given adequate force and strong enough tools, most shapes can somehow be formed, even if brute force is the design principal.

The designer in this case, had reason to suspect that the conventional approach would not yield the optimum design in this process. Process simulation was run using DEFORM™ to study the die fill and load requirements. The designer's suspicions were confirmed. The simulation allowed the designer to study the load at various forming steps and compare design alternatives for both die fill and load. The outside corner of the smallest step is the most difficult feature to fill using this process. At a load of 100 tons, the feature was underfilled. In fact, the corner only filled after the load was increased to 125 tons and flashing had started at the major diameter. This was not acceptable.



The typical progression for this type of part includes (left to right) two extrusion operations followed by a cone upset, final heading to form steps and piercing with a sliding die to form the bore. The arrow (right image) shows the area of underfill.

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Design Environment for FORMing

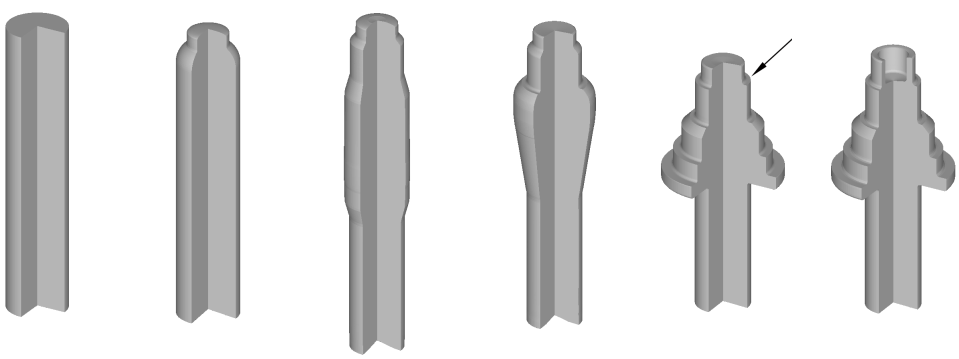
Inverted Cone Design:

A redesigned progression was developed and confirmed using DEFORM™ to quantify the results prior to making dies.

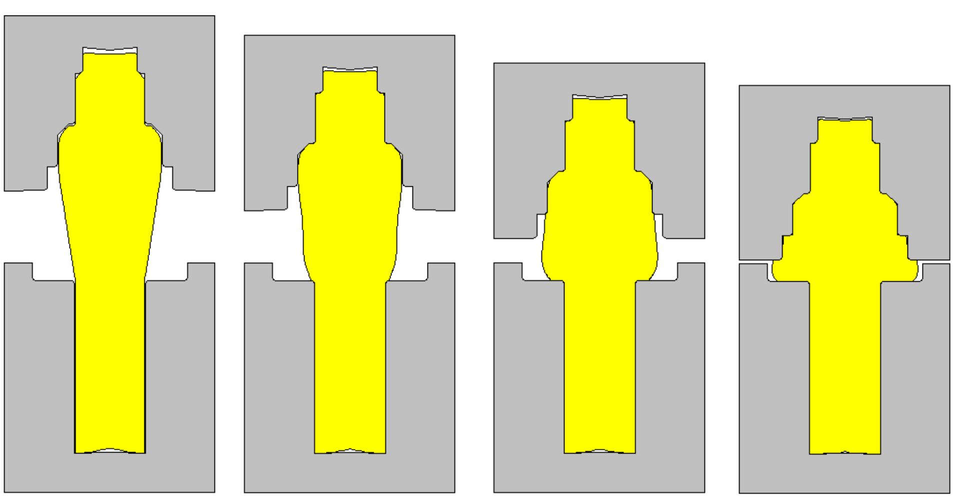
The inverted cone shape places more material furthest from the larger diameter, allowing the smaller details to fill first. This shape resulted in a lower load to fill the critical small step corner and a more robust process. In fact, the redesigned process filled the corner with 5% lower loads than were observed on the traditional design with underfill. Of course, this will have a significant influence on die life as well as product quality.

Acknowledgment:

This case study was presented by the National Machinery Company at the SME Cold Forming Conference in Troy, Michigan in March, 1999. It was also published in Fastener Technology International in the December 1999/January 2000 issue.



The redesigned progression (left to right) was similar to the original design, except that the cone was inverted. The critical corner was filled early in the heading operation. The arrow shows the sharp corner.



Note how the inverted cone fills the details from the top down. The smaller features, which were harder to fill using the original design, are filled first. At the conclusion of this operation, the critical step corners are sharp.

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