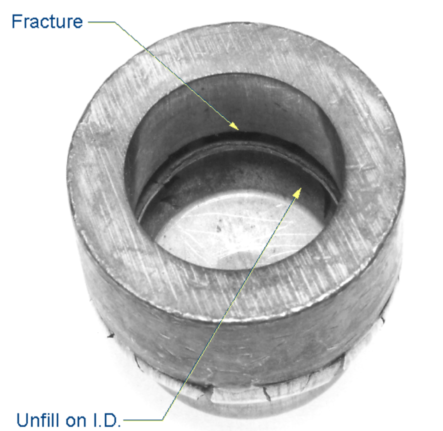
DEFORM™ Application #251

Ductile Fracture During Cold Forming

The Problem:

During an initial trial of a cylindrical cold-formed automotive part, the manufacturer observed a severe fracture originating in the inside diameter of the part after the second operation. There was also a die unfill in the area of the fracture. It was clear that this process required more than fine-tuning.

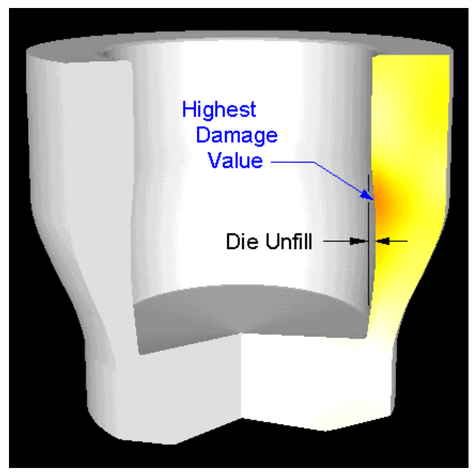


Note the severe fracture (dark area) and die unfill (below dark area) on the inside diameter of the part.

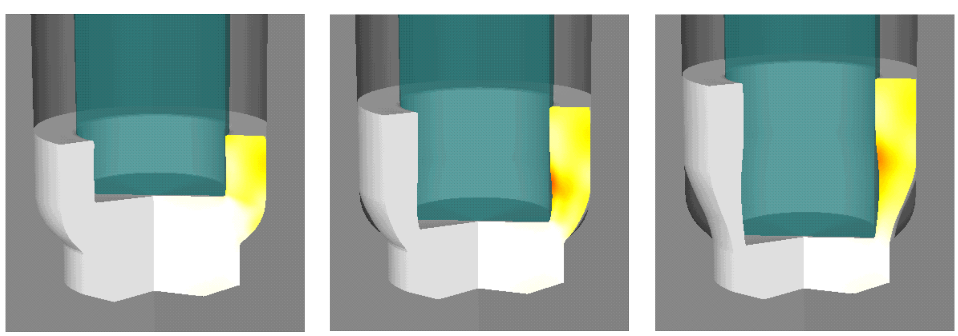
Fracture of the workpiece is a frequent subject of concern during large deformation cold and warm forming processes. Damage factor, as suggested by Cockcroft and Latham, can be used to predict fracture in cold forming operations. A number of Damage factors have been investigated by researchers, with the Cockcroft-Latham Damage Factor demonstrating good correlation with experimental data when the fracture occurs in a predominately tensile state of stress.

The Analysis:

A DEFORM™ simulation of this 1020 steel part revealed that the Damage Factor was highest in the area of the fracture, as was expected. The die unfill was also clearly observed. Process simulation was used to better understand the root cause of the defects observed. The unfill in the inside diameter is best shown in an animated sequence as the outside corner of the punch approaches the minor diameter of the die. Material is 'pinched' as this gap is continually closed. This defect is related to the volume distribution during forming.



The analysis predicted the defects on the production part. The highest damage value is shown in red. This was the region with the fracture.



Note the formation of the unfill on inside diameter as the corner of the punch approaches the minor diameter of the die during the second operation.

DEFORM™
Design Environment for FORMing

The Solution:

As an integral part of the redesign process, subsequent analysis revealed that the damage factor could be reduced significantly by changing the contour on the outside diameter. The changes involved blending fillets on the major and minor diameters with a smoother transition. Subsequent operations were used to coin the contour that is desired on the finish part. Analysis was used in conjunction with shop trials to eliminate the fracture and die unfill in this part. In order to manufacture this part, redesigned progressions were developed with the objective of eliminating both defects.

Each design concept was tested using DEFORM™ to ensure that the existing defects were removed without resulting in new problems. Volume was redistributed in each operation to eliminate the underfill on the inside diameter. The damage factor was reduced to a level where fracture was eliminated. DEFORM™ provided quantitative information on the behavior of each re-design concept. The subsequent shop trial involved a revised intermediate contour on the outside diameter. Process simulation, in conjunction with creative design, resulted in a product without unfill or fracture. This was accomplished without expensive and time-consuming shop trials.

After redesign, the product is shown at a late stage in the process. Note the straight inside diameter and the lack of fractures and underfills.

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