DEFORM™ Application #204

Die Insert Redesign

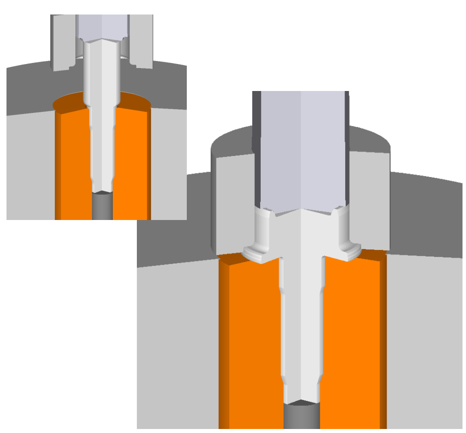
Background and Problem:

A hex-head flange screw blank was being formed on a traditional 4-die progressive header. The fourth station's die insert was only averaging about 40,000 parts to failure. The company decided that they wanted to move this part to a much faster forming machine, but at the higher speed, the poor tool life would become much more prohibitive, since more frequent stops would be required to change the inserts. This provided incentive for the die design to be refined to take advantage of the faster forming equipment. The first step in optimizing the die design was to establish the root cause of the insert failure.

hex head flange screw blank

Analysis:

DEFORM™ was used to simulate the forming of the hex-head flange screw blank. The forming pressure was subsequently used to predict the stress and deflection of the die components. To effectively study the insert, it is necessary to include the interaction of the die case and shrink fit. The original assembly consisted of a one-piece die insert and a die case.



The first (upper-left) and last (lower-right) step of the fourth station forming operation is shown.

The load for this operation is in line with expectations. The highest load occurs at the end of the stroke while . the flange fills out. This results in the highest pressure on the die assembly

DEFORM™ was used to perform a subsequent die stress analysis at the step where the highest load was observed.

A review of the stresses on the insert indicated a tensile stress. Tensile stresses exist in a component when the maximum principal stress is positive. A negative maximum principal stress only exists when no tensile stress exists, or all principal stresses are compressive.

Examples of actual die insert fracture. Note the compound fracture direction, with visible fracture propogation in the axial and radial directions.

Tungsten carbide die inserts, such as the one being analyzed, exhibit excellent compressive strength. Tensile stress, on the other hand, commonly results in a fatigue failure. Tolerance to tensile stress improves with increased cobalt content at the expense of wear resistance. The high tensile stress on the inside of the insert resulted in the fatigue failure. The stress components were analyzed to assist in the redesign process. Analysis revealed tensile stresses in both the axial and hoop directions. This was consistent with the die fracture surface.

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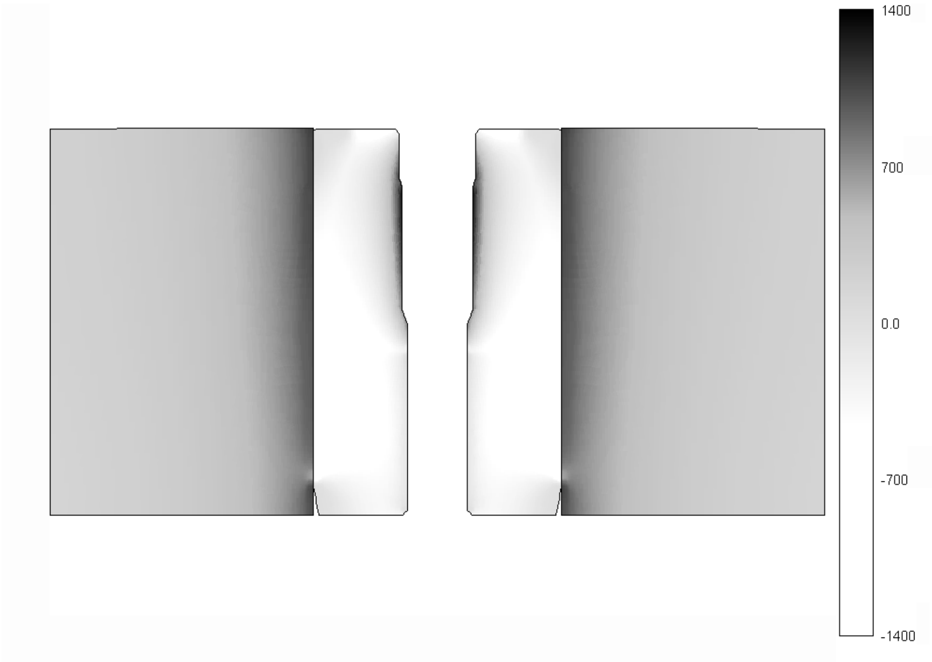
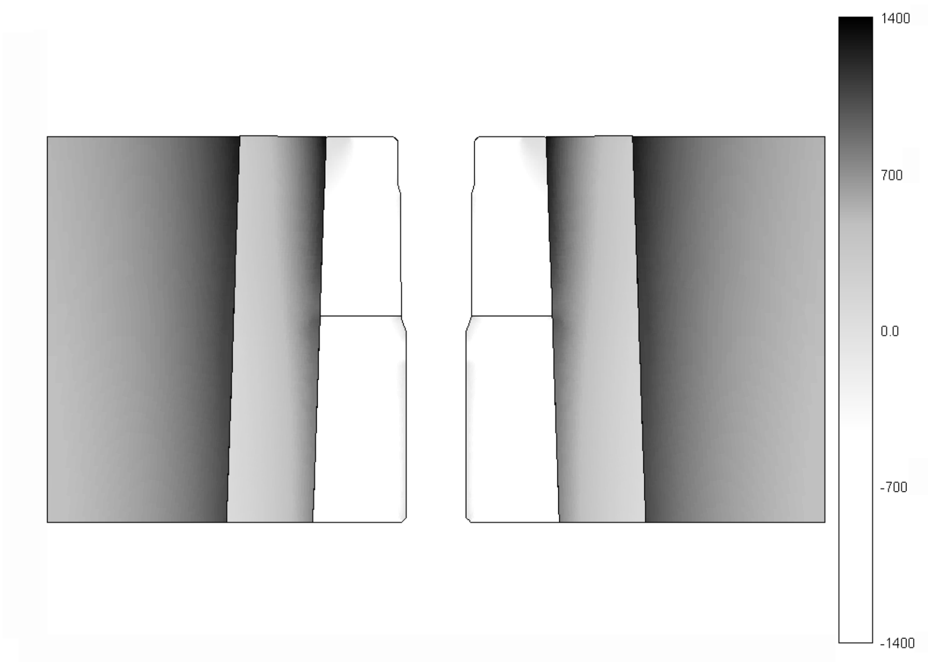
Design Environment for FORMing



Contours of maximum principal stress are shown on the original design. The dark areas represent a tensile stress and the light areas a compressive state. Note the tensile stress on the ID of the die insert.



Contours of maximum principal stress are shown on the re-designed assembly. Note that the die inserts are under a compressive stress state (light color).

Redesign:

To reduce the amount of tensile stress in the die insert, a new die configuration was designed. This utilized split inserts at the lower shoulder and an intermediate sleeve. Utilizing the two-ring design resulted in a lower hoop stress component. Splitting the insert into two pieces eliminated the axial stress concentration. Additionally, the tapered sleeves resulted in an easier die assembly.

The objective of the redesign was to minimize the tensile stress in the die inserts, while the effective stress in the die case and sleeve remain below the yield strength of the material being used. The reported improvement in die life at the time of publication was in excess of 400,000 parts. Subsequent information indicated a life of over 1,000,000 pieces without a failure!

Acknowledgements:

This case study was presented at the SME Cold Forming Conference in Detroit, Michigan in March, 1998 by the National Machinery Company. The case was subsequently published in Fastener Technology International, Leo Monroe, December 1999/January 2000, Initial Publications, pp. 40 – 42.

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