Edge fracture in hole extrusion and flanging, Part II

How shaving can reduce fracture in collar forming

BY ADVAITH NARAYANAN, DAVID DIAZ-INFANTE, AND DR. TAYLAN ALTAN

Editor's Note: Part I appeared in the July/August 2018 issue and discussed the effect of process variables in blanking (piercing).

Two-stage blanking, also known as shaving, can be used to improve edge stretchability. With this method, the operator blanks an initial hole of a smaller diameter than the desired hole. Then a larger hole is blanked with the desired dimensions before collar forming.

Shaving has been shown in research and practical experience to reduce edge fracture in collar forming (see **Figure 1**). Variables that affect this operation are the punch/die clearances (u1, u2) and the blanking offset (z).

Effect of Strain Hardening/ Hardness

In blanking and shearing operations, very high strains develop near the sheared edge after cutting. This means the material is significantly strain-hardened, leaving little room for additional stretching during subsequent operations, especially when blanking advanced high-strength steels (AHSS).

Recent studies conducted at Technical University of Munich (TUM) concluded that hardness near the sheared edge, or shear-affected zone (see **Figure 2**), is directly correlated to edge fracture during collar forming. Researchers observed that the shaving leads to lower strain hardening than in single-stage blanking.

To investigate how local hardening in blanking affects edge fracture in collar forming, researchers evaluated the edge stretchability achieved for different blanking clearances (u_1, u_2) and cutting offsets (z) using the hole expansion ratio (λ). A higher λ value indicates better edge stretchability in collar forming. λ is determined by:

$$\lambda\ (\text{in } \%) = \frac{D-d}{d} \times 100$$

Where:

D = Diameter of punch during collar forming

d = Diameter of blanked hole before collar forming

At TUM, researchers performed collar forming tests on CP-W 800 cold-rolled steel, 4 millimeters thick. The first series of tests used a 50-mm-diameter hole, blanked at various punch-die clearances between 5 and 30 percent of the sheet thickness. The maximum hole expansion ratio (λ) that could be achieved was about 5 percent. As a comparison, collar forming using a machined (milled) hole

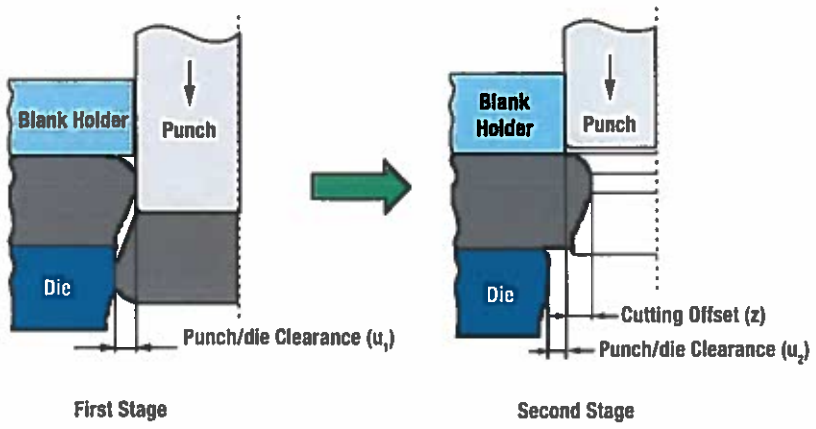

Figure 1

Shaving, or two-stage blanking, has been shown to reduce edge fracture in collar forming.

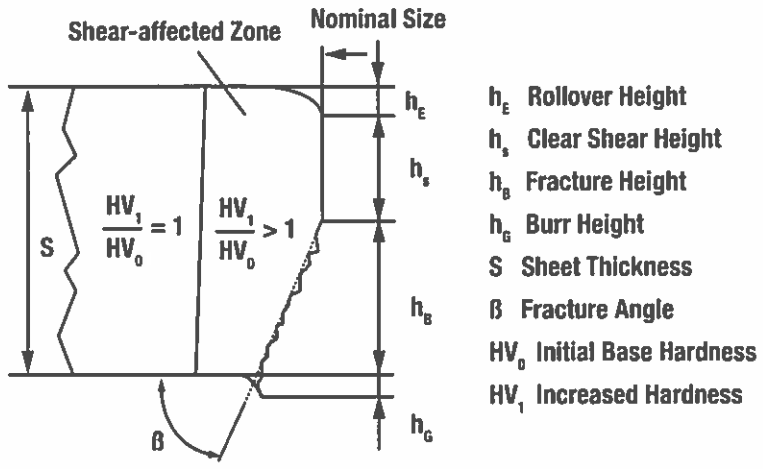

Figure 2

Recent studies conducted at Technical University of Munich concluded that hardness near the sheared edge, or shear-affected zone, is directly correlated to edge fracture during collar forming.

could yield a hole expansion ratio of nearly 90 percent.

Additional tests used punch/die clearances of 10 and 15 percent in two consecutive shaving operations respectively. The second operation used cutting offset values (z) of 2, 3, and 4 mm. The results indicated that the selected shaving-tool geometries could produce a hole expansion ratio (λ) up to 40 percent.

These results clearly show that, for certain AHSS, shaving may be a useful technique to reduce or postpone the probability of edge fracture in collar forming. Obviously, additional studies may be needed to investigate the quantitative selection of shaving conditions for other AHSS material and thicknesses.

Estimating Tool Dimensions to Reduce Edge Fracture

To replicate the experimental results obtained at TUM, researchers at The Ohio State University's Center for Precision Forming conducted finite element (FE) simulations on different AHSS of varying thicknesses. Their goal was to estimate the tool dimensions for shaving that would reduce edge fracture in collar forming.

Figure 3 shows the schematic of the collar forming operation that underwent FE simulations. The distribution of strains generated in single-stage blanking and shaving, using the FE method, is shown in Figure 4. The strain values, obtained as a function of distance from the blanked edge, are shown in **Figures 5** and 6 at two different locations in the thickness of the blank. These results also show, as did the studies conducted at TUM, that shaving leads to a relatively softer blanked edge and reduces the probability of edge fracture in a collar extrusion.

The strains, estimated in collar forming with and without a secondary shaving operation, are shown in **Figure 7**. The strains at the edge of the formed collar obtained in both cases show that shaving reduces the strains and consequently the chances of potential fracture.

It is necessary to predict at what edge strain or edge thinning level that fracture may occur. Studies are in progress to determine a relationship among strain hardening, edge thinning, and the probability of fracture for different AHSS and thicknesses. SJ

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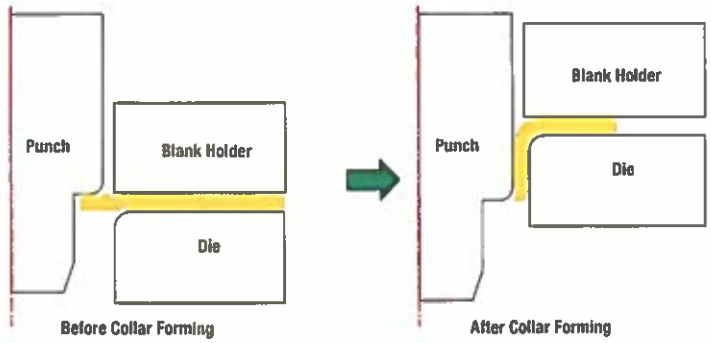

Figure 3

This shows a schematic of the collar forming operation that underwent finite element simulations.

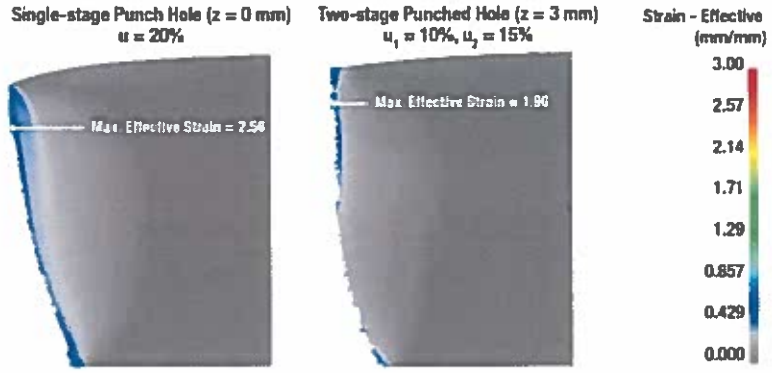

Figure 4

Shown here are strains generated at the edge after single-stage punching and two-stage shaving of a 50-mm-diameter hole from FE simulations.

Point	Distance from Blanked Edge (mm)
1 or 8	0
2 or 9	0.05
3 or 10	0.1
4 or 11	0.15
5 or 12	0.25
6 or 13	0.5
7 or 14	0.75

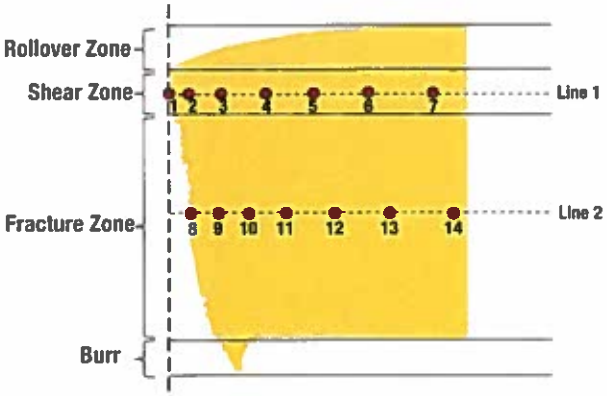

Figure 5

The strain values, obtained in function of distance from the blanked edge, are plotted from FE simulations.

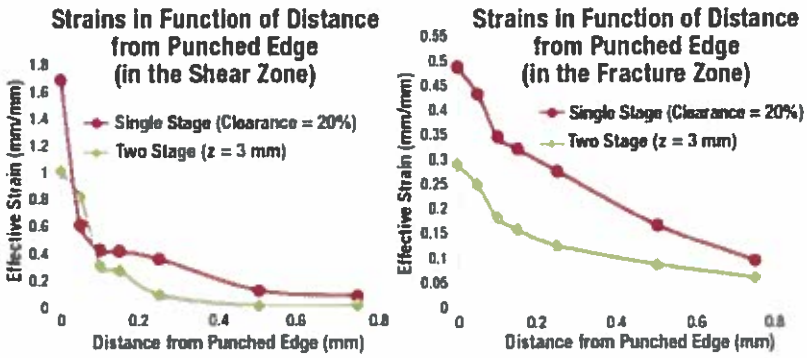

Figure 6

Strain values as a function of distance from the blanked edge are plotted at two different locations in the thickness of the blank, using single-stage punching and shaving.

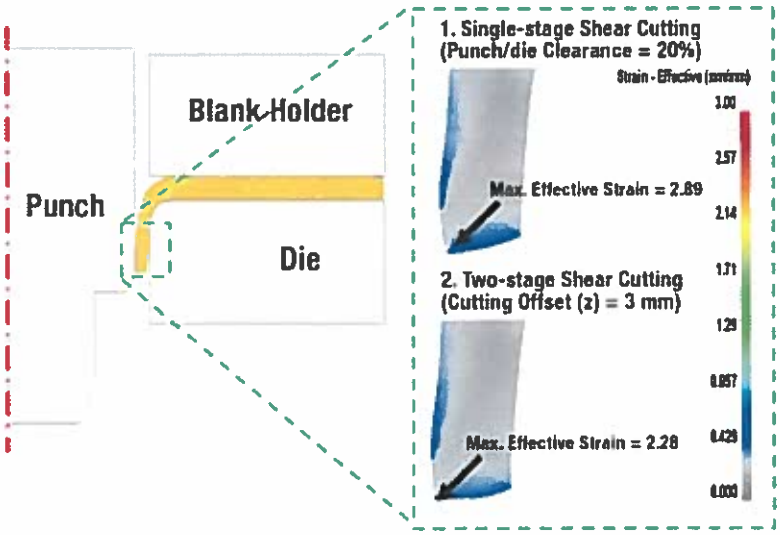

Figure 7

Strains are estimated here after collar forming for single-stage blanking (punch-die clearance = 20 percent) and shaving (cutting offset z = 3 mm).

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Reference

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