The following serialized technical article documents an independent test by United States Steel (USS) on improving the quality of the shear edge and its corresponding impact on edge stretchability on Advanced High Strength Steel (AHSS). Through a series of tests utilizing different shear angles and punch to die clearances, USS was able to document the delays which occur on the edges of the pierced hole and increase the edge stretchability during forming. This independent testing corroborates the internal testing Dayton Progress has performed and reinforces the clearance recommendations by Dayton.

**An Innovative Shearing Process for AHSS Edge Stretchability Improvements–Part 2**

by Hua-Chu Shih (Michael) & Ming F. Shi
United States Steel Corporation

**Developed Bevel Shear Hole Piercing Test**

A computer-controlled beveled shear hole piercing process for AHSS was developed by Shih et al. [8]. The experimental setup is shown in Figure 1. A general-purpose punch die set is inverted and mounted to the computer-controlled hydraulic press. The punch diameter (Pd) is fixed at 10.0 mm and various dies with different inside diameters (Dd) can be used to achieve different die clearances (CL). The punch face was specially fabricated to different beveled angles at 3, 6, 9, 12, 18, and 24 degrees. The punch load and displacement in the vertical direction can be recorded by the load cell and Linear Variable Differential Transformer (LVDT) during the entire shearing process.

![Figure 1. Schematic illustration of hole piercing die set](image)

**Edge Fracture Test–Hole Expansion Test**

The previous study [8] showed that the optimal shearing condition for piercing and shearing AHSS was the combination of a beveling angle between 3 and 6 degrees, 15% die clearance, and the shearing direction parallel to the material rolling direction. This optimal shearing condition and setup improved the hole expansion ratio by up to 60% over the conventional flat punching process of the same test materials. To further investigate and validate these findings, different grades of AHSS with different thicknesses were selected for the first part of this study. Different shearing speeds were also conducted on the beveled shear hole piercing test to investigate their effects on edge stretchability. Eight commercially produced galvanneal sheet steels with different thicknesses were included in this study. The mechanical properties for those materials are given in Table 1.

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**Reader Reply**

This month’s Tool-Tip is an answer to a question submitted by a subscriber.

**Question:** I’m piercing a 6.5mm hole in HSLA 550MPa 6.35mm material and getting an undesirable burr. How do I reduce the burr?

**Answer:** Due to the combination of HSLA 550 MPA material and a thickness of 6.35mm, the clearance should be in the range of 14% to 17% per side to reduce the generation of the burr. Dayton’s PS4 Tuff Punch would be an ideal application your piercing operation, helping to reduce the impact stresses. Adding a conical shear on the point tip at an angle of 7 degrees will also help to reduce load on the punch tip. To assist in increasing your productivity, consider using ZeronPlus™ or XNA to provide abrasive wear resistance and lubricity to the punch.

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Click here for more information.
Table 1. Mechanical properties of tested steels

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<th>Material</th>
<th>Thickness (mm)</th>
<th>Yield Strength (MPa)</th>
<th>Tensile Strength (MPa)</th>
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</tr>
</tbody>
</table>

Table 1. Mechanical properties of tested steels

The hole expansion test, as shown in Figure 2, is used to evaluate the edge stretchability and flangeability of sheet metal. A detailed description of the hole expansion test can be found in publications [2, 9]. A conical punch was used in this study and a minimum of three replicates were tested for each test condition. All of the specimens were tested with the burr up condition [2] in the hole expansion test.

![Figure 2. Schematic diagram of the hole expansion test](image)

The hole expansion ratio (HER) is calculated based on the initial and final diameters of the hole:

\[ \text{HER} = \frac{(D - d)}{d} \times 100\% \]

where D represents the diameter of the expanded hole and d represents the initial diameter of the punched hole.

Continued in our next issue...

References


