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 3

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Effects of Hole Punching Clearance

The hole expansion test was conducted on the specimen with a hole pierced with a 6 degree beveling angle in the longitudinal shearing direction. Different die clearances were selected for DP600 with thicknesses of 1.0 mm, 1.5 mm and 2 mm. The hole expansion ratio (HER) is presented in Figure 3. It is shown from Figure 3 that the largest average HER is generated when the hole is pierced at around 15% and 16% die clearance. Similar experiments were also conducted on DP980 steel with two different thicknesses at 1.2 mm and 2 mm. As shown in Figure 4, the same trend is observed and the largest average HER is generated using a shearing clearance between 15% and 17% regardless of the material thickness and grade. Those experimental data are consistent with the findings in a previous study [8].

![Figure 3. Variations of HER with die clearance for different thickness (dp600)](image_url)
Optimal shearing conditions (6 degree bevel angle, 15% die clearance, longitudinal shearing direction) along with the conventional flat punch shearing at the same die clearance were used in piercing holes for different materials. The letter F represents the conventional flat punch shearing condition and 6L represents the optimal shearing condition as shown in Figure 5. Results show that the HER is inversely proportional to the strength of AHSS and the optimal shearing condition results in a significant improvement in the HER over the conventional shearing condition, ranging between 23% improvement (2.0 mm DP600) and 62% improvement (1.0 mm DP780) in the HER.
Effects of Shearing Speeds

Two different shearing speeds, 1 mm/sec and 25.4 mm/sec, were used for both optimal and conventional shearing conditions. The comparison of the HER between two different shearing speeds for all 8 different materials and thicknesses is shown in Figure 6. While small differences are observed between the two shearing speeds, the trends are not consistent. Overall, it appears that shearing speed has little effect on HER. However, the optimal shearing condition would always generate a higher HER than the conventional shearing condition on all tested materials and thicknesses regardless of the shearing speed.

Figure 6. The HER at different shearing speeds for all tested materials and thicknesses

The comparison in the peak load between the low and high speed shearing conditions is shown in Figure 7 for three different thicknesses of DP600. It is shown that the load difference between different shearing speeds is very small, which is further evidence that shearing speed is not significant in the range examined. However, the peak load using the optimal shearing condition is 55% and 36% lower than the conventional shearing condition for 1 mm DP600 and 2 mm DP600, respectively. The lower shear load should result in energy cost savings and tool life improvement.

Figure 7. Comparison of peak load between different shearing speeds

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References


