Examining edge cracking in hole flanging of AHSS

Part III: The effects of punch speed, material, and tool wear

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This article is the third in a series of four and discusses the significance of modeling the blanking process and the influence of punch speed, sheet materials, and tool wear on the sheared edge quality.

Blanking is one of the most common methods used to produce holes or cutouts. Process parameters and tool settings in blanking can affect the part edge quality. There is a need to establish a reliable model of blanking before stretchability analysis with hole flanging. The ultimate aim is to be able to quantify how deep a flange can be achieved without fracture for a given blanked edge quality.

Effects of Punch Speed and Sheet Material

Experiments were conducted at the Center for Precision Forming (CPF) at The Ohio State University using different sheet materials (low-carbon steel, high-strength steel, aluminum, and copper), punch-die clearances of 3 percent to 25 percent of sheet thickness, and punch speeds of 0.5 feet per second to 12 FPS.[1] Results showed that punch speeds higher than 6 FPS could improve the edge quality, resulting in a larger shear zone, smaller burr, smaller rollover, and smaller depth of crack penetration.

It also was found that the edge quality improvement depends on the sheet material. The dimensions of sheared edges in blanking of various sheet materials at low and high speeds are shown in **Figure 1**.

Differences in part edge geometries are more distinct for steels than for copper and aluminum. Because copper and aluminum have much higher thermal conductivity than steel, heat generated when blanking these materials dissipates much more quickly. Temperature rise at high punch speeds is smaller than that encountered in blanking steel. Thus, the edge geometries obtained in blanking copper and aluminum are similar at low and high punch speeds. The part edge quality is more sensitive to punch-die clearance than to punch speed and sheet material.

If FE modeling of blanking is to take into account the effect of punch speed, the material properties must be available at high strain rates and temperatures. Preliminary simulations indicated that with a conventional blanking speed of 0.5 FPS, the strain rate can go up to 2,100 s^{-1}, while the temperature near the sheared edge may be as high as 250 degrees Celsius. Strain rates and temperatures obtained in high-speed blanking could be even higher.

Shear Zone Length and Burr Height for Various Materials				
Material (Sheet Thickness)	**Thermal Conductivity (W/m °K)**	**Cutting Speed (FPS)**	**Shear Zone Length (%)**	**Burr Height (0.001 in.)**
Low-Carbon Steel (1020) (0.032")	50	0.5	75	2.8
		12	80	1.2
High-Strength Steel (50-XF) (0.054")	50	0.5	40	1.8
		12	56	1.8
Aluminum (2011-T3) (0.041")	221	0.5	46	0.7
		12	46	0.75
Copper (110) (0.016")	350-370	0.5	70	0.6
		12	90	0.6

Figure 1

These sheared edge geometries were obtained by blanking various materials. The shear zone length is given in percentage of sheet thickness.[1]

Effects of Tool Wear

In addition to process parameters, tool wear can change the actual punch-die clearance and the tool edge geometry. This might lead to inconsistency in the part edge quality. **Figure 2** shows the schematic of the worn blanking tool.

The results given in **Figure 3** show that the radial wear length on the punch (*a*) can increase up to 0.03 millimeter (3 percent of the sheet thickness = 1 mm) when blanking 40,000 stainless steel sheets (AISI 304) using 5 percent punch-die clearance. Thus, the punch-die clearance increases from 5 percent to approximately 8 percent after blanking 40,000 parts.

Figure 3 also shows that a smaller punch-die clearance causes more tool wear because the deformation is highly localized, generating high stresses and high temperatures. This condition accelerates tool wear. Experimental results show that when the tool is worn out, the rollover, the burr height, and the depth of crack penetration of the sheared edge increase when using a small punch-die clearance of 5 percent. However, these values, which charac-

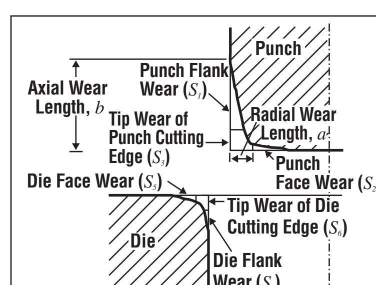

Figure 2

This schematic illustration shows the geometry of the worn blanking tool.[2]

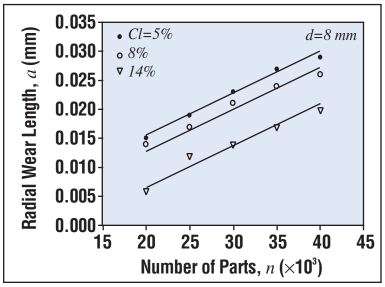

Figure 3

Here, radial wear length is a function of the number of parts for blanking AISI 304 (8-mm punch diameter with 1-mm sheet thickness) at the punch-die clearances of 5 percent, 8 percent, and 14 percent.[2]

terize the shape of the blanked edge, decrease when using a large clearance of 14 percent.

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Notes

1. *J. Breitling, M. Gruenbaum, and T. Altan, "Influence of high cutting speeds on the quality of blanked parts," ERC/NSM-S-96-19, Engineering Research Center for Net Shape Manufacturing, The Ohio State University, 1996.*

2. *J.J. Hernandez, P. Franco, M. Estrems, and F. Faura, "Modelling and experimental analysis of the effects of tool wear on form errors in stainless steel blanking,"* Journal of Materials Processing Technology, *Vol. 180 (2006), pp. 143–150.*