Lightweighting in the automotive industry using sheet metal forming, Part II
Optimization of process parameters

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The key to achieving weight reduction in a given part or assembly is not just to choose lightweight and high-strength materials, but also to develop advanced forming methods. Therefore, research and development in stamping aims to optimize the process parameters that increase productivity and improve product quality, including lubrication, die design (draw beads and use of spacers), and the selection of press ram speed variation (dwell, restriking during a single stroke) and blank holder force (BHF).

Lubrication and Coefficient of Friction (COF)

The higher strength of advanced high-strength steel (AHSS) generates high surface pressure and heat at the sheet-die interface (see Figures 1 and 2) in just a single stroke. Production operations, depending on part and press size, can generate 10 to 40 or more strokes per minute (SPM), and die surface temperatures can increase during the first 10 to 20 strokes.

Therefore, to perform adequately, lubricants used in forming high-strength material must have appropriate temperature and pressure additives. The cup draw test commonly is used to evaluate a lubricant to ensure it will perform as required.

Use of Servo-drive Presses

Servo-drive presses offer higher SPM than mechanical presses of similar size and capacity. They also offer infinitely variable ram speed within the limits of the dynamics of a given press, as well as dwell and restriking at the bottom dead center (BDC).

Assuming dies with sliding components can function at a stroke rate that is 50 to 100 percent higher than a comparable mechanical press, electromechanical servo-drive presses offer:

• Precise ram position and velocity control during the stroke, which simplifies setup, prevents noise and shock during workpiece contact and upstroke, improves formability for reducing the ram velocity during drawing and blanking, and reduces reverse tonnage in blanking.

• Adjustable stroke length, which provides flexibility so that drawing and blanking can occur in the same press with increased SPM. The press also can be run in pendulum motion mode.

• Synchronization of ram position and velocity with automatic (or robotic) part transfer, which in turn increases SPM.

Using finite element analysis, CPF estimated temperatures for a single stroke of deep drawing a round cup made of 1.24-mm-thick DP590. Punch diameter: 152.4 mm; blank diameter: 304.8 mm; punch velocity: 40 mm/second; BHF: 300 kN.

Figure 1

Figure 2

Shown is the predicted rise in temperature in degrees C during a single stroke of deep drawing a 1.2-mm-thick DP980 part (470 by 300 mm) in a 300-ton AIDA servo press with CNC hydraulic cushion.
• Rapid down- and upstroke for higher part production per minute than a mechanical press of comparable capacity while reducing ram speed during deformation.
• Energy savings, since there is no continuously driven flywheel.
• Dwell anywhere in the stroke (mainly at BDC) and restriking capacity (which allows reduced, controllable springback).
• Availability of maximum motor torque (press load) during the entire stroke, depending on press linkage design.

Use of CNC Hydraulic Cushions

At The Ohio State University’s Center for Precision Forming (CPF), an ongoing study is evaluating the formability of AHSS and Al 5182-0 using an asymmetrical die set and a 300-ton AIDA servo press with a CNC hydraulic cushion. The effect of the variable forming speed, variable BHF, and cushion pre-acceleration on material formability, as well as reduction of fracturing and wrinkling, are being investigated. Figure 3 shows the press output for the BHF and ram speed used in the tests.

As an example, Figure 4 shows the actual formed part at 75-millimeter draw depth and the simulation results of drawing Al 5182-0. The degree of thinning at the critical corner area of the drawn part is shown in Figure 5. This figure also illustrates how the COF and the source of the flow stress data (tensile or bulge) affected the simulation results. As shown, the simulation results obtained using the bulge test data were closer to experimental thinning measurements.

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Figure 3
Variable ram speed and BHF were used in forming of AHSS and Al 5182-0 with a 300-ton AIDA servo press.

Figure 4
An aluminum panel formed by a 300-ton AIDA servo-drive press is compared to simulation results for the same operation.

Figure 5
Measured and predicted thinning at the critical corner of the drawn part are compared here. Material: Al 5182-0; thickness: 1.2 mm; BHF: 150 kN; COF: 0.1 and 0.12; draw depth: 75 mm; ram speed: 310 to 0 mm/second.