Lightweighting in Automotive Industry Using Sheet Metal Forming, Part II - Optimization of Process Parameters

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To achieve weight reduction, in addition to selecting light weight and high strength materials, it is necessary to develop advanced forming methods. Thus, R&D in stamping also aims to optimize the process parameters that increase productivity and improve product quality. These parameters include, lubrication, die design (draw beads and/or use of spacers) and, as much as possible, the selection of press ram speed variation (dwell, restriking during a single stroke) and cushion pressure (or Blank Holder Force) in function of press speed.

Lubrication and Coefficient of Friction (COF)

Evaluation of lubricants using the Cup Draw Test (CDT) is well-known and was discussed in earlier R&D Updates*, published in the Stamping Journal (for example Jan/Feb issue, 2015, p. 10). Due to higher strength of AHSS large surface pressures and temperatures are generated at the sheet /die interface, as seen in Figures 1 and 2 for only a single stroke. In production operations, depending upon part and press size, 10 to 40 or more strokes/min. may be used. As a result, die surface temperatures may 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.

Use of Servo-Drive Presses

Servo-drive presses offer higher productivity, i.e. strokes per minute, compared to similar size and capacity of mechanical presses. In addition, the servo drive offers (a) infinitely variable ram speed, within the limits of the dynamics of a given press, and (b) dwell and restriking at the Bottom Dead Center (BDC). The performance and application of servo-drive presses was discussed in earlier "R&D Update" articles, published in Stamping Journal (for example: Stamping Journal, Nov/Dec., 2012, p. 12).

In addition to considerable (50 to 100%) increase in stroking rate (strokes per minute – SPM)), assuming dies with sliding components can function at increased SPM, the electro-mechanical servo drive presses offer the following capabilities:

a) Precise ram position and velocity control, during the stroke which allows for (i) easier set up, (ii) preventing noise and shock when contacting the workpiece and during upstroke, (iii) improved formability for reducing the ram velocity during part deformation, i.e. drawing or blanking, (iv) reduction of reverse tonnage in blanking.

b) Adjustable stroke length (TDC-BDC). (This provides flexibility so that in the same press drawing and blanking can be conducted with increased stroke/min. Also, the press can be run in pendulum motion mode).

c) Ram position/velocity can be synchronized with automatic (or robotic) part transfer. Thus, strokes/min can be increased.

d) Part/min produced is larger than in mechanical presses of comparable capacity because of rapid down and up stroke, while reducing ram speed during deformation.

e) Savings in energy, since there is no flywheel which is driven continuously.

f) Possibility of dwell anywhere in the stroke and mainly at BDC and re-striking capacity (this allows reduction in and control of springback).
g) Max motor torque (press load) may be available during the entire stroke, depending on press linkage design.

**Use of CNC Hydraulic Cushions**

At CPF, a study is ongoing to evaluate the formability of the AHSS and Al 5182-O using a nonsymmetrical die set and 300 ton Aida servo press with a CNC hydraulic cushion. The effect of the variable forming speed, variable blank holder force, and cushion pre-acceleration on formability of the material and reducing the possibility of the fracture and wrinkle are investigated. Figure 3 shows the press output for the blank holder force and ram speed used in the tests.

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

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**FE (Finite Element) Simulation of cup drawing**  
*Temperature distribution at the final drawn cup*

*Figure 1: Temperatures estimated using Finite Element Analysis in a single stroke drop drawing a round cup (punch diameter: 152.4 mm, blank diameter 304.8 mm, punch velocity: 40 mm/sec, blank holder force 300 kn) form DP590 (1.24 mm thick)*
Figure 2: Prediction of temperature rise (in degree C) during deep drawing (single stroke) of 1.2 mm thick DP980 (part size is about 470 mm x 300 mm) in a 300 ton Aida Servo Press with CNC hydraulic cushion.

Figure 3: Variable ram speed and blank holder force used in forming of AHSS and AL5182-O using 300 ton AIDA servo press.

Figure 4: Aluminum panel formed by 300 ton Aida servo drive press and simulation results of the same operation.
Figure 5: Comparison of measured and predicted thinning at the critical corner of the drawn part (Material: Al 5182-O, thickness = 1.2 mm, BHF = 150 ton, COF = 0.1 and 0.12, Draw Depth = 75 mm, Ram speed = 310 to 0 mm/s)