

"Fundamentals and Applications of Deep Drawing, Part I: Deep drawing with and without draw beads"

by

Advaith Narayanan, David Diaz Infante, and Taylan Altan

Editor's Note: Part I of this two-part series on deep drawing discusses the use of draw beads and spacers, or stand offs as well as drawing in progressive dies without the use of draw beads. Part II that will appear in July/August issue will discuss the effect of process variables in deep drawing of Advanced High Strength Steels using Finite Element Simulation.

In Deep Drawing, a flat blank is constrained by a blankholder while the central portion of the sheet is pushed into a die opening with a punch to draw the metal into the desired shape without causing wrinkles or splits in the drawn part. Large parts, such as automotive doors and hoods are drawn using draw beads and spacers or stand-offs, to control metal flow into the die cavity, as seen in Figures 1 and 2.

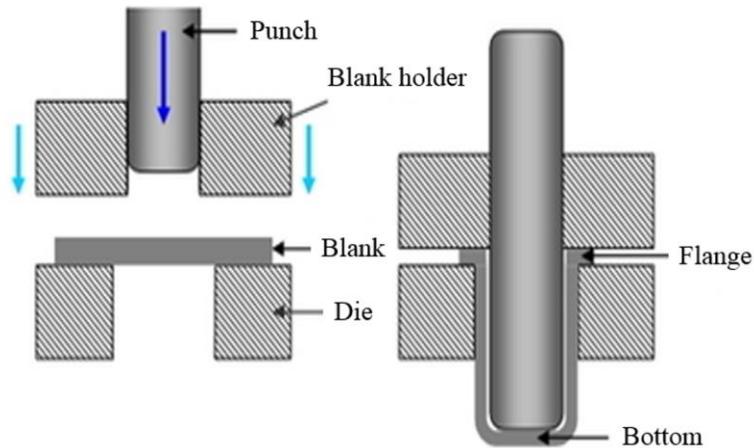
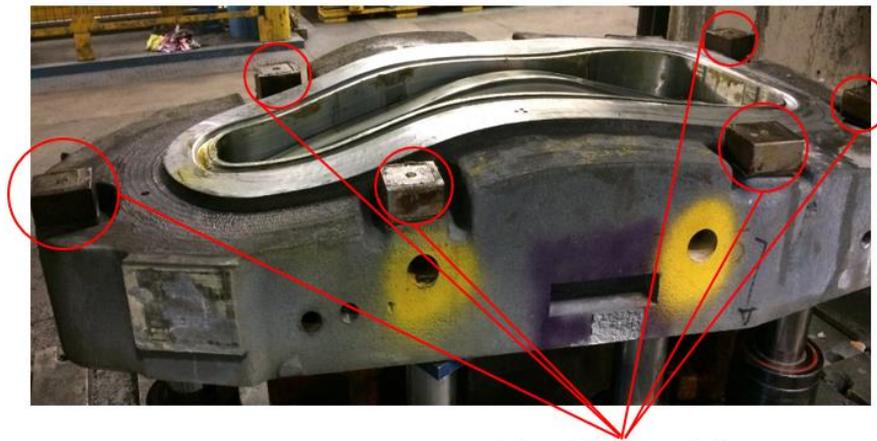


Figure 1 – Schematic Illustration of Deep Drawing a “Round Cup” (without draw beads)



Spacers/Distance blocks/ Stand offs

Figure 2 – Example of the lower half of a large automotive die that uses draw beads and spacers (also called distance block or stand-offs or kiss blocks). (Courtesy: Superior Cam)

The Use of Spacers and Draw Beads (or Stand-Offs)

Spacers, that are usually 10 or 15% of the blank thickness, are used to assure that the die halves close in a “parallel” fashion. Thus, it is hoped to compensate for elastic deformations that may occur in the dies and/or the press bed. Shims increase or decrease the height of spacers during the try-outs or in production, to assure appropriate metal flow and to eliminate wrinkles, at desired location in the die.

By restraining the metal flow, draw beads reduce the required amount of Blank Holder Force (BHF), Figure 3, that is usually exerted by an air cushion, nitrogen cylinders, or a hydraulic cushion. Different configurations of commonly used draw beads are seen in Figure 4. The design, i.e. the dimensions of the draw bead, depends on the sheet material strength and thickness, and press capacity. When using draw beads, it is sufficient to provide a BHF that keeps the die and spacers in contact throughout the forming operation, Figure 3.

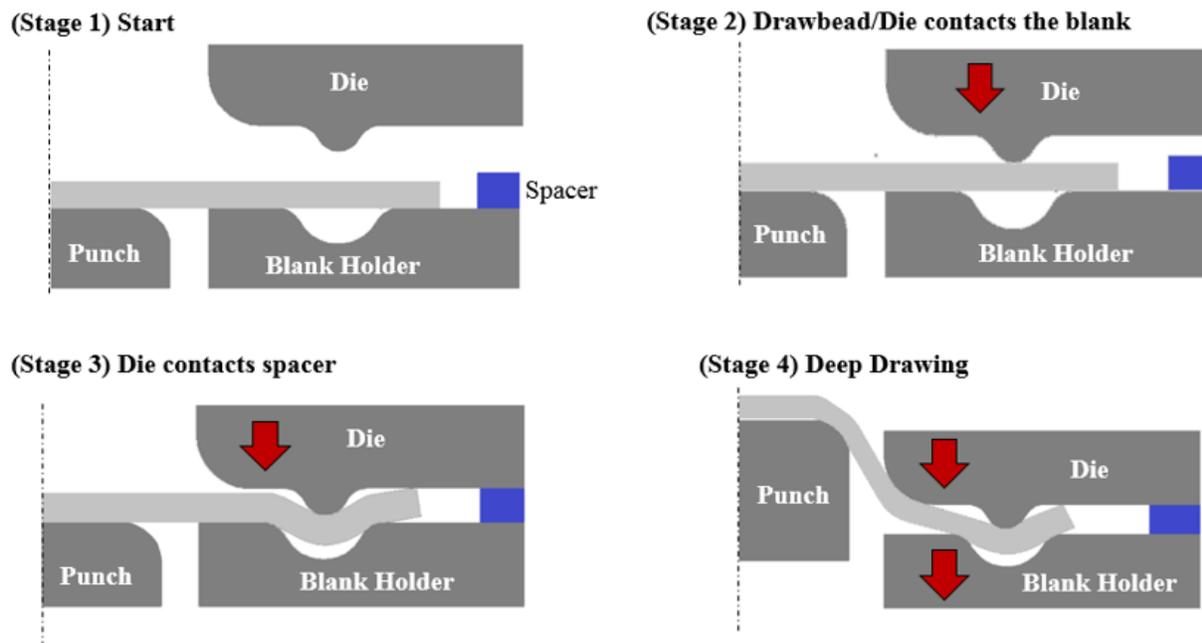


Figure 3 – Schematic illustration of metal flow in deep drawing with a draw bead and spacer (the spacer height is usually about 10 to 15% more than the sheet thickness)

When spacers are used, the die and blank holder are pressed against the spacers. At the start of the stroke, the blank is free to flow into the die cavity with the relative movement of the punch against the die. As deformation and punch stroke proceed, the edges of the blank become thicker at the die corners and some minor wrinkling may occur in the flange region. The blank thickness and wrinkle height increase but cannot exceed the clearance between the die and blank holder, provided by the spacers, if the BHF is sufficiently large. At this stage in drawing, the blank holder controls the material flow. The force exerted by the deforming blank upon the die and blank holder increases while the contact among the die, blank holder and spacers is maintained.

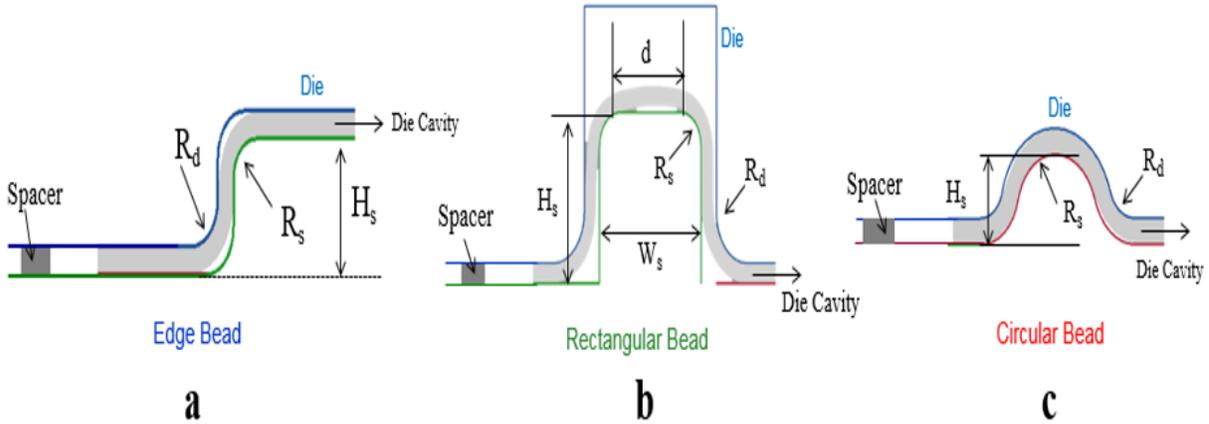


Figure 4 - Schematics of (a) edge bead, (b) rectangular bead and (c) circular bead, used in deep drawing. R_s = Bead Radius, R_d = Die Groove Radius, H_s = Bead Penetration, W_s = Bead Width

The heights and locations of the spacers are usually determined during tryout through several trial-and-error stampings. Recently, Audi developed an “intelligent” tool – a laser sensor that measures the flange draw-in, Figure 5. A control algorithm and a small servo motor activate an adjustable spacer to the optimal value. This so-called “Intelligent Tool” is now used in production at Audi, as discussed in an earlier article [1].

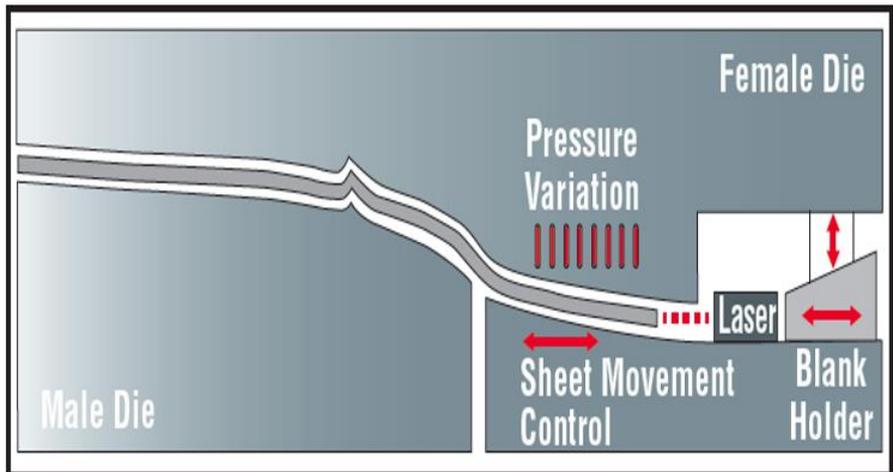


Figure 5 – The “Intelligent Tool” for stamping (with spacers). The laser sensor detects the flow of the material, then a servo motor activates the wedge so that the height of the spacer between die and blank holder is increased or decreased (between 2 consecutive strokes).
(Courtesy: Audi)

Drawing without draw beads

Deep drawing without draw beads and spacers are used in producing small to medium size parts, using transfer or progressive dies. Progressive dies perform a series of operations at several stations during each press stroke. Thus, the workpiece is shaped as the strip moves through the die and the partially formed parts are transported by the strip, as seen in Figure 6.

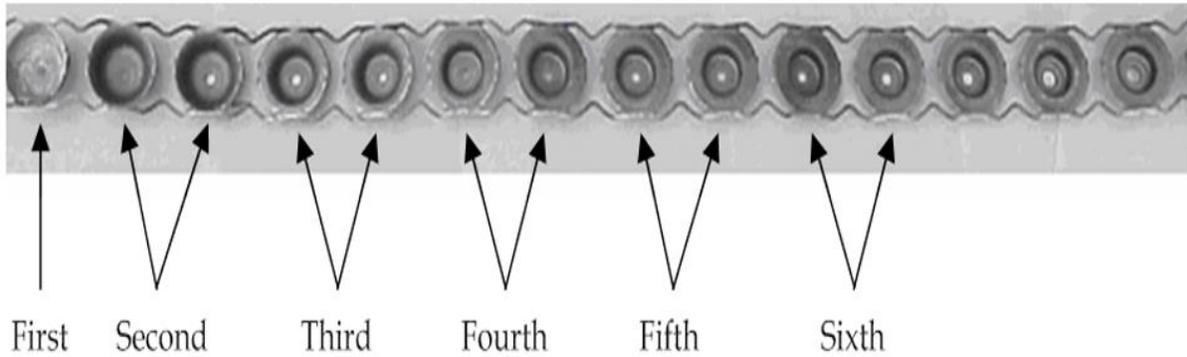


Figure 6 – Example of a progressive die: forming sequence from left to right – forming stages are indicated with an arrow. (Courtesy: PAX Machine Works Inc.)

Progressive and transfer die design, i.e. the determination of the number of stations needed and the die geometry for each station), relies heavily on past experience and several prototyping runs and by using tables or hand books [2]. In this type of stamping, there are no draw beads. Thus, the control of metal flow from the flange into the die cavity is controlled by the pressure applied on the flange of the die, usually with mechanical or elastomer springs, or nitrogen cylinders. The optimization of the blank shape is important in all stamping operations, conducted with or without draw beads. An example, illustrating the importance of optimized blank shape, is shown in Figure 7. The “optimum” blank shape can be determined with process simulation, using conventional codes, such as PAM-STAMP, for example.

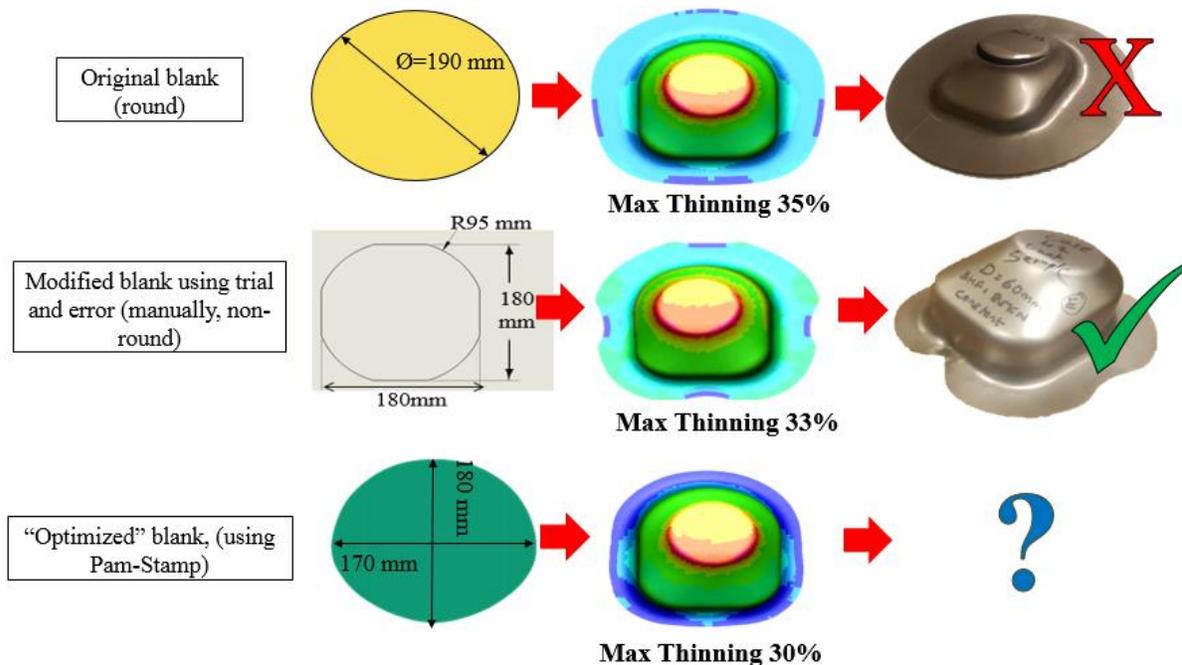


Figure 7 – Figure 7: Example part, illustrating the effect of blank shape upon the achievable draw depth. Part size approximately (80 mm x 100 mm), draw depth in experiments is 60 mm. (Courtesy: Hyson Metal Forming Solutions).

Advait Narayanan and David Diaz Infante are graduate students and Dr. Taylan Altan is professor emeritus and director of the Center for Precision Forming (CPF), at The Ohio State University, 339 Baker Systems, 1971 Neil Ave., Columbus, OH 43210, 614-292-5063, <https://cpf.osu.edu>

References

- [1] Fallahiarezoodar, A., et al., "Controlling material flow in drawing operation", Stamping Journal, March/April 2017, P. 16
- [2] Hedrick A., "How to Perform a Draw Reduction", Stamping Journal, January/February 2019, P. 14