Processes for hydroforming sheet metal

Part II: Sheet hydroforming with a punch

Editor's Note: This article is Part II of a three-part series that discusses various sheet hydroforming processes. Part I, which appeared in the February issue, discussed sheet hydroforming with a die only (SHF-D). Part II reviews sheet hydroforming with a punch (SHF-P). Part III, which will appear in the April issue, will discuss optimizing parts hydroformed with a die and with a punch.

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In sheet hydroforming with a punch (SHF-P), the female die used in conventional stamping is replaced by a pressure pot. The sheet is deep-drawn to form over the punch surface, against a counter-pressure in the pressure pot generated by a pressurizing fluid (see Figure 1). The operator can actively pressurize the fluid by an external pump, or he can allow pressure to generate passively during the forward stroke of the punch by controlling the pressure with a relief valve that allows some fluid to escape as the punch and the sheet are pushed into the pot.

In SHF-P friction at the punch-sheet interface prevents the deforming sheet from sliding over the punch surface. Thus, the stretching that occurs in conventional deep drawing is reduced or eliminated, resulting in a more uniform wall thickness and increased deep drawability. In this way, SHF-P can reduce the number of stamping operations commonly required in forming complex parts. Figure 2 shows how SHF-P is combined with regular stamping to form parts with protrusions.

SHF-P, Conventional Stamping Differences

Compared with conventional stamping, SHF-P: [1,2]

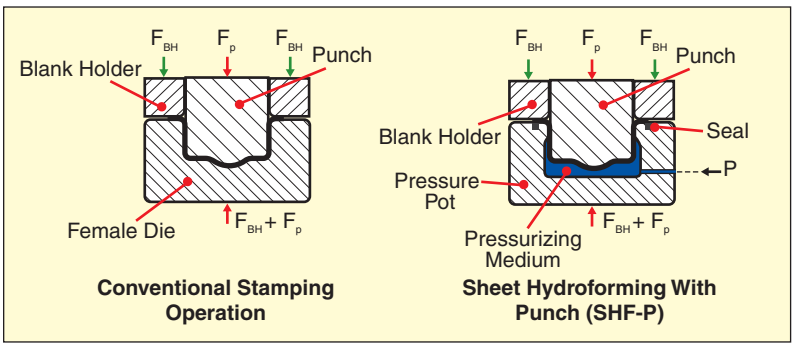

Figure 1

In the SHF-P process, a conventional female die is replaced by a pressure pot. Deeper parts with a uniform wall thickness can be formed by SHF-P rather than by conventional stamping. [F_{BH}: Blank holder force, F_p: Punch force]

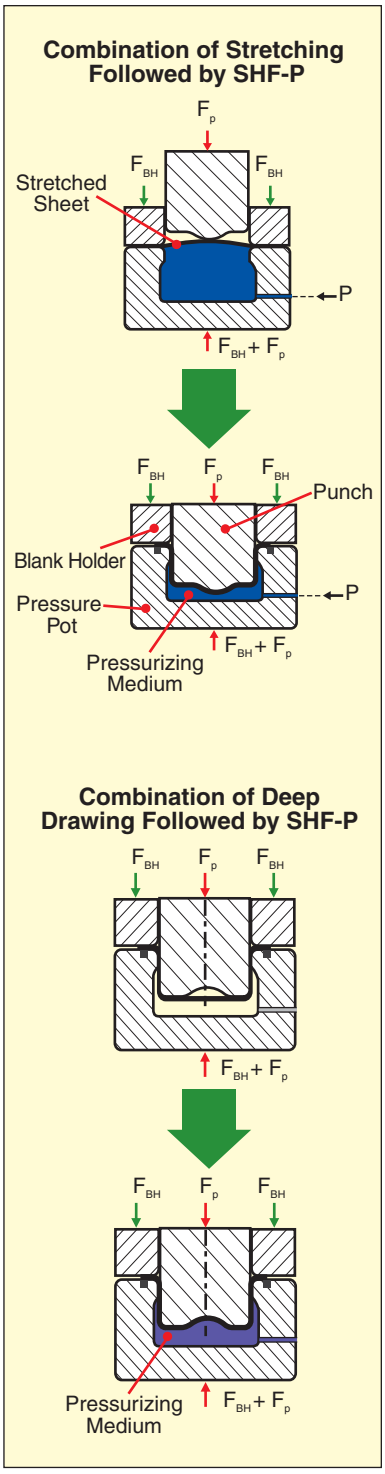

Figure 2

A combination of SHF-P, stretching, and conventional deep drawing can form parts with protrusions in a small number of forming operations.
Source: Siegert et al.

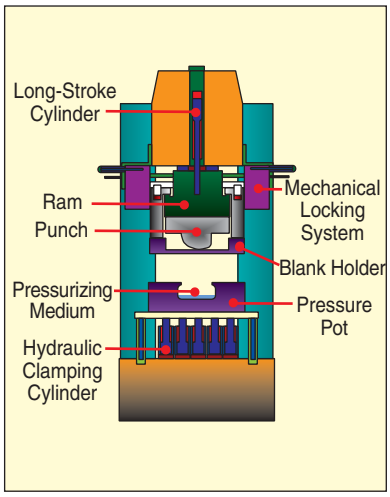

Figure 3

On SHF-P presses, the top die is moved up and down using a long-stroke cylinder that requires a small volume of hydraulic fluid at low pressure.
Source: K. Schnupp and M. Kerschner, "Presses for Hydromechanical Drawing of Panels for Automobiles," *Hydroforming of Tubes , Extrusions and Sheet Metals*, ed. K. Siegert, Vol. 3 (2003), pp. 409-421.

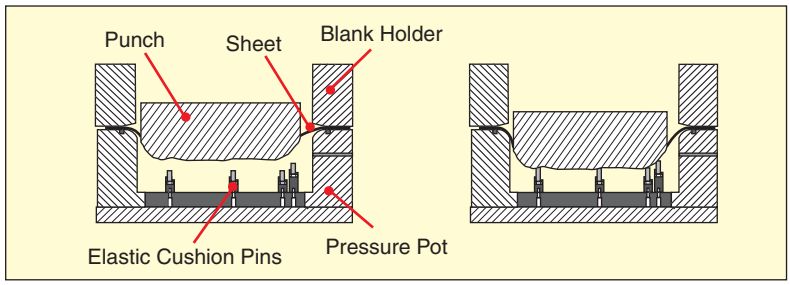

Figure 4

In SHF-P, a pressure pot with elastic cushion pins helps form sharp corners. Elastic cushion pins in the pressure pot help to reduce required press capacity.
Source: D. Stremme, H. Cherek, and R. Kolleck, "Manufacturing of Large-Size Outer Panels Using Active Hydromechanical Sheet Metal Forming," *Hydroforming of Tubes, Extrusions and Sheet Metals*, ed. K. Siegert, Vol. 2 (2001), pp. 249-258.

•Eliminates the need for a female die, thus lowering tool costs.

•Often allows forming of complex parts in one operation, thereby reducing the number of required die sets and operations.

•Requires a longer cycle time per operation—about 60 to 80 seconds versus a few seconds in conventional stamping.

SHF-P is practical for producing parts in relatively low production quantities. For example, several outer panels of General Motors' new-model Solstice® are produced by SHF-P in Amino's plant in St. Thomas, Ont., because the anticipated volume for this car is 20,000 to 30,000 units per year.

SHF-P Press

Several press manufacturers, such as Schuler, Amino, and Schnupp, build presses for SHF-P with short cycle times (see Figure 3). On these presses, the top die is moved up and down using a long-stroke cylinder that requires a small volume of hydraulic fluid at low pressure. The ram is indexed at the bottom dead center position using mechanical locks, which eliminate the need for a high-pressure hydraulic system on the top die.

Short-stroke hydraulic clamping cylinders mounted in the press bed are activated during SHF-P to apply the press force required to counteract the force generated by the pot pressure.[3]

Tool Design for SHF-P

The tool design concept for SHF-P is similar to that for regular stamping. The punch and blank holder are specifically designed for the part shape, while the pressure pot, designed to withstand high pressure, remains common for all parts.

Also, the pressure pot and sheet interface must be sealed to prevent leakage of the pressurizing fluid during the process. The pot pressure required to form a part completely depends on the smallest corner or fillet radius that exists in the part. Thus, parts with sharp corners or fillets require a press with very high capacity, resulting in a larger investment.

Figure 4 illustrates a tool design in which elastic cushion pins are mounted in the pressure pot. Toward the end of the SHF-P process, the sharp corners are formed mechanically by these pins rather than by the pot pressure. Thus, sharp corners can be formed mechanically and do not require large pot pressures. ST

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Notes

1. T. Maki, "Current Status of Fluid Forming in the Automotive Industry," Hydroforming of Tubes, Extrusions and Sheet Metals, *ed. K. Siegert, Vol. 3 (2003), pp. 25-44.*

2. K. Siegert, A. Schwager, R. Rieger, and M. Haussermann, "New Press Concept for Hydroforming," Hydroforming of Tubes, Extrusions and Sheet Metals, *ed. K. Siegert, Vol. 1 (1999), pp. 123–138.*

3. Ibid.

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