Processes for hydroforming sheet metal

Part I: Sheet hydroforming with a die

Editor's Note: This article is Part I of a three-part series that discusses various sheet hydroforming processes. Part II, to appear in the March issue, 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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Metal forming using liquid media, or hydroforming, is broadly classified into sheet and tube hydroforming (see Figure 1). Sheet hydroforming is further classified into sheet hydroforming with a punch (SHF-P) and sheet hydroforming with a die (SHF-D), depending on whether a male (punch) or a female (die) tool will be used to form the part. SHF-D is further classified into hydroforming of single blanks and double blanks, depending on the number of blanks being used in the forming process.

SHF-D Process Description

The forming operation in SHF-D has two phases (see Figure 2).

In phase I, a free-forming operation, the sheet bulges freely in the die cavity until it contacts the die surface. Free bulging ensures uniform deformation in the sheet, which improves the dent resistance of the hydroformed part compared with conventional stamped parts.

Free bulging also reduces the tendency for sheet tearing caused by localized deformation. However, after a large portion of the sheet leans against the die wall, the flow of sheet metal is restricted because of friction at the sheet-die interface.

Phase II involves calibrating the sheet against the die cavity to obtain the final desired shape when a high fluid pressure is required. The amount of this fluid pressure depends on the sheet material and thickness, part complexity, and the smallest corner radius that exists in the die geometry.

Successful application of SHF-D requires careful consideration of all aspects of the sheet hydroforming system, namely:

- Quality of incoming sheet.
- Die-workpiece interface (friction and lubrication).
- Tool design for efficient application of blank holder force to prevent leakage.
- Relationship between the internal fluid pressure and blank holder force (loading path).
- Press and tooling.
- Dimensions and properties of the hydroformed part.

Horizontal Press for SHF-D. The Institute of Forming Technology and Lightweight Construction (LFU), University of Dortmund, Germany, in cooperation with Siempelkamp Pressen Systeme (SPS), Germany, has built a 10,000-ton (100-meganewton) press for hydroforming large components (see Figure 3).

The press operates horizontally, so it has a relatively inexpensive, compact design; does not require a heavy foundation; and provides a short stroke to reduce cycle time. The horizontal design also allows for easy draining of pressurizing fluid, but it needs horizontal feeding of the part. The press frame is cast and prestressed by wire winding to withstand

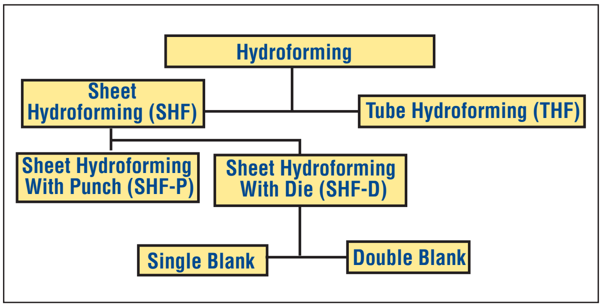

Figure 1

Hydroforming can form from sheet blanks as well as welded (steel) or extruded (aluminum) tubes. The process is used to produce many products for the automotive, household, and aerospace industries.
Source: D. Schmoeckel, C. Hielscher, and R. Huber, "Metal Forming of Tubes and Sheets With Liquid and Other Flexible Media," *Annals of CIRP,* Vol. 48/2 (1999), pp. 1-20.

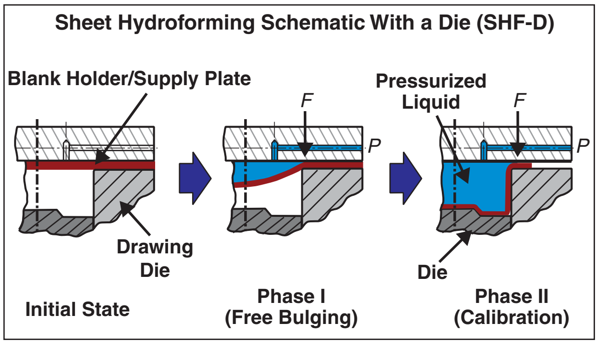

Figure 2

Initially the sheet is deformed freely (phase I) until it leans against the die surface, then calibration (phase II) begins.
Source: M. Kleiner and W. Homberg, "New 100,000kN Press for Sheet Metal Hydroforming," *Hydroforming of Tubes, Extrusions and Sheet Metals*, ed. K. Siegert, Vol. 2 (2001), pp. 351 - 362.

the dynamic loads that are generated during forming.

During hydroforming a large volume of fluid at relatively low pressure is required during phase I (free bulging), and a small amount of fluid at high pressure is required in phase II for calibration. Hydraulic systems in the press are designed to provide two different pressure levels—low pressure of 315 bars and high pressure of 2,000 bars—to reduce the cost and cycle time and make the design more compact.[1]

Double-blank Sheet Hydroforming

Two flat or preshaped sheets that can have different thicknesses and shapes and either welded or unwelded edges constitute the input material for the double-blank sheet hydroforming process.

The double blank is placed in the tool, which has both upper and lower dies with the shapes to be formed (see Figure 4). The blank is held at the edges, and the pressurizing medium is introduced between the sheets. The sheets are formed by fluid pressure against the top and bottom dies to obtain the desired part shapes.

Double-blank sheet hydroforming can be used as an alternative to sheet hydroforming with a die, because in both methods the sheet metal is forced against the die by the liquid medium. However, in double-blank sheet hydroforming, two parts can be produced in one production cycle, which increases productivity. This process potentially allows the forming of two different materials and/or two different sheet thicknesses in one production cycle.

Double-blank sheet hydroforming is still in the development stage, but it has the potential to be practical for the production of relatively small batches of parts.

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Note

1. *M. Kleiner and W. Homberg, "New 100,000kN Press for Sheet Metal Hydroforming,"* Hydroforming of Tubes, Extrusions and Sheet Metals, *ed. K. Siegert, Vol. 2 (2001), pp. 351 - 362.*

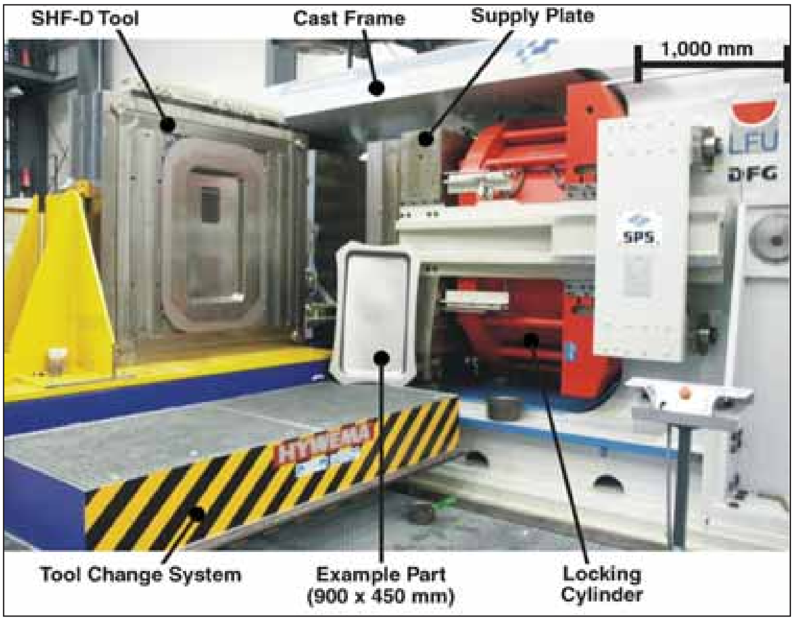

Figure 3

A horizontal press for SHF-D at LFU, University of Dortmund, has a maximum load capacity of 10,000 tons and provides a maximum forming pressure of 2,000 bars. Source: Kleiner and Homberg.

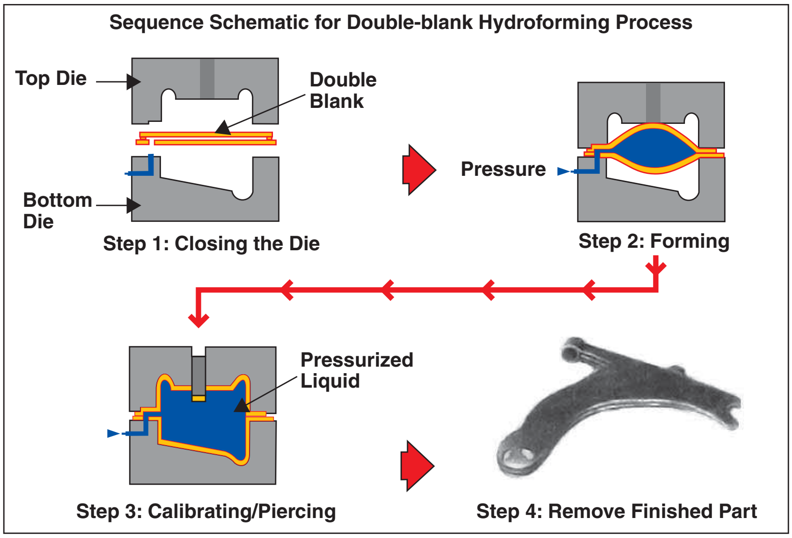

Figure 4

Source: A. Birkert, J. Neubert, and T. Gruszka, "Parallel Plate Hydroforming," *Hydroforming of Tubes, Extrusions and Sheet Metals,* ed. K. Siegert, Vol. 2 (1999), pp. 283-296.