Processes for hydroforming sheet metal

Part III: SHF-P and SHF-D case studies

Editor's Note: This article is Part III 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, which appeared in the March issue, reviewed sheet hydroforming with a punch (SHF-P).

This column was prepared by Ajay Yadav of the Engineering Research Center for Net Shape Manufacturing (ERC/NSM), The Ohio State University, Professor Taylan Altan, director.

The previous two columns discussed process details, presses, and tool design for sheet hydroforming with a die (SHF-D) and sheet hydroforming with a punch (SHF-P). To use SHF-P or SHF-D successfully, it's important to understand key process parameters such as blank holder force versus time and pot pressure versus time.

Incorrect process parameters can lead to excessive sheet stretching (fracture) or wrinkling and leakage of the pressurizing medium during the hydroforming process. The ERC/NSM has developed numerical optimization software that, when coupled with the finite element software PAMSTAMP 2000®, determines the optimal blank holder force and pot pressure versus time.

These optimized process parameters help minimize part thinning, wrinkling, and leakage of the pressurizing medium. This column describes optimization case studies for SHF-P and SHF-D operations conducted at the ERC/NSM. Another SHF-D case study was published in the April 2005 issue (p. 38).

SHF-D Case Study

The ERC/NSM is working in cooperation with the University of Dortmund (IUL), Germany, to optimize the SHF-D process for a rectangular part formed using a multipoint cushion system with a segmented blank holder. This cushion system allows different blank holder forces (BHF) to be applied at 10 different locations around the rectangular blank. Blank holder force also can be varied by time in each of these locations.

Four possible ways to apply BHF during hydroforming with a multipoint cushion system are:

1. BHF constant in space and time.
2. BHF variable in space and constant in time.
3. BHF variable in time and constant in space.
4. BHF variable in space and time.

Optimal values for all four possible blank holder force application modes to form a rectangular part were estimated.

Experiments for optimized process parameters are presently being conducted. Figure 1 shows the optimized pot pressure and blank holder force profiles varying in time and space. Figure 2 shows thinning distribution for optimal blank holder force compared with existing blank holder force used at the University of Dortmund.

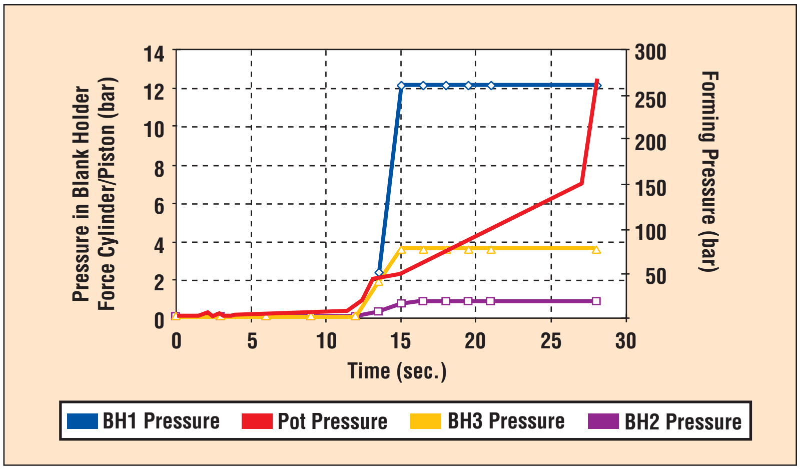

Figure 1

Varying the BHF at different locations controls material flow locally from the flange into the die cavity.
Source: V. Vavilikolane and T. Altan, "Estimation of Optimum Process Parameters to Form a Rectangular Part Geometry by Sheet Hydroforming With Die (SHF-D) Process Using Finite Element Method," Master's Thesis, The Ohio State University, Columbus, Ohio, 2005.

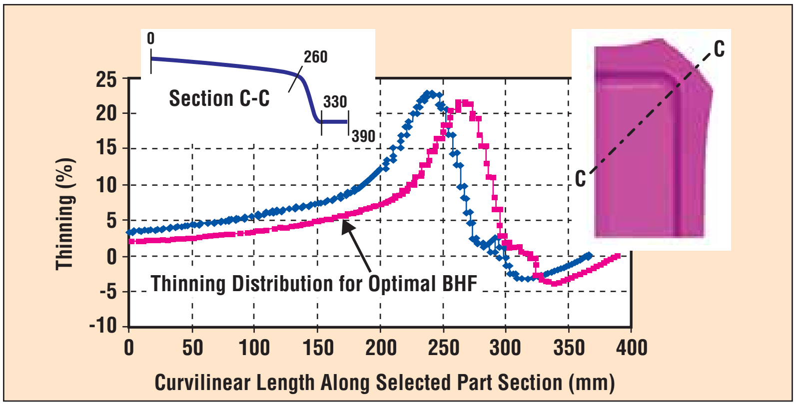

Figure 2

Optimized BHF shows improved thinning distribution in the part. A maximum thinning of 22 percent is observed at the die corner.
Source: Vavilikolane and Altan, "Estimation of Optimum Process Parameters."

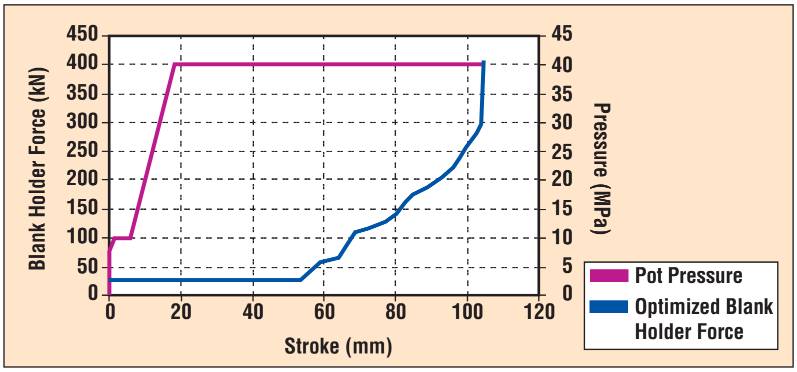

Figure 3

The optimum BHF versus the time curve is predicted using numerical optimization techniques coupled with FEM. Source: M. Braedel, H. Palaniswamy, and T. Altan, "Estimation of the Optimal Blank Holder Force and Forming Pressure Trajectory for Sheet Hydroforming Process With Punch," ERC/NSM-05-R-21, ERC/NSM, The Ohio State University, Columbus, Ohio, 2005.

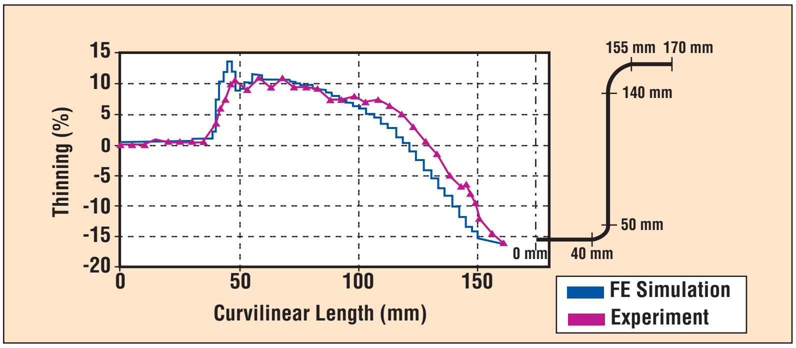

Figure 4

A match in part thinning between FE prediction and experimental measurements for optimal BHF validates FE predictions.
Source: Braedel, Palaniswamy, and Altan, "Estimation of the Optimal Blank Holder Force."

SHF-P Case Study

Analysis and optimization studies of the SHF-P process for a 90-mm-diameter round cup were conducted in cooperation with Schnupp Hydraulik, Germany. Pot pressure was limited to a maximum value of 40 MPa because of machine capacity limitations. **Figure 3** shows the optimized blank holder force profile path for hydroforming the round cup from AKDQ steel to a depth of 105 mm in a single forming operation.

Blank holder force was increased at the end of the forming process to restrain material flow and prevent excessive flange thickening, which can result in flange wrinkles and leakage Using this optimal BHF profile, Schnupp Hydraulik successfully hydroformed the round cup.

A comparison of part thinning from an experiment and FE predictions is shown in **Figure 4**. A similar optimization study and experimental validation are presently being conducted for SHF-P of a part with a conical geometry.

Taylan Altan is a professor and director of the Engineering Research Center for Net Shape Manufacturing, 339 Baker Systems, 1971 Neil Ave., Columbus, OH 43210-1271, 614-292-9267, fax 614-292-7219, www.ercnsm.org. The ERC/NSM conducts research and development; educates students; and organizes workshops, tutorials, and conferences for the industry in stamping, tube hydroforming, forging, and machining.

Write 6 on reply card