Evaluating lubricants for stamping galvannealed steels, Part II

The deep-drawing test

BY SOUMYA SUBRAMONIAN AND TAYLAN ALTAN

Editor's Note: This article is Part II of a two-part series that discusses the evaluation of lubricants for stamping galvannealed steels. Part I, which appeared in the July/August issue, discussed the strip drawing test.

Lubrication is one of the important parameters that can improve part quality in stamping. This is very evident when stamping galvannealed (GA) steel, which is difficult to deep-draw because of its hard surface coating. Better lubrication can increase the forming process window and reduce the scrap rate.

The Center for Precision Forming at The Ohio State University, in cooperation with Honda of America Manufacturing Inc., conducted a detailed study and evaluation of 21 different lubricants, some already in use at Honda's North American and international plants. Twelve lubricants that performed well in strip drawing tests were tested using the deep-draw test.

Test Principles

In deep drawing, the most severe friction takes place at the flange area. The lubrication condition in this flange area influences the thinning and failure in the side wall of a drawn cup. It also affects the draw-in length. As the blank holder pressure increases, the frictional stress also increases.

Therefore, lubricants can be evaluated in the deep-drawing test by measuring the maximum applicable blank holder force (BHF) without failure in the cup wall and by measuring the perimeter of the cups formed using different lubricants at the same BHF. Lubricants that could be used at higher BHFs are said to have performed better. For the same BHF, lubricants that yielded cups with a lower flange perimeter are said to have performed better.

Experimental Setup

The draw ratio (blank diameter to punch diameter) was selected to be 2.0. The drawing depth was selected to be 3.15 inch to leave some flange area for measuring the draw-in length and the flange perimeter. Round blanks of 270D/GA 12 in. in diameter and 0.029 in. thick were drawn in a 160-ton hydraulic press (see **Figure 1**).

Finite element (FE) simulations were conducted to determine the range of applicable BHFs to draw the cup. A maximum thinning of 28 percent of initial sheet thickness in the simulation was used to determine the highest applicable BHF. FE simulations showed a BHF of 20 to 30 tons to be suitable for drawing cups.

The lubricants were applied using a draw-down bar and pipette to 1.5 (±0.3) gm/m^2, emulating the lubrication conditions in stamping plants

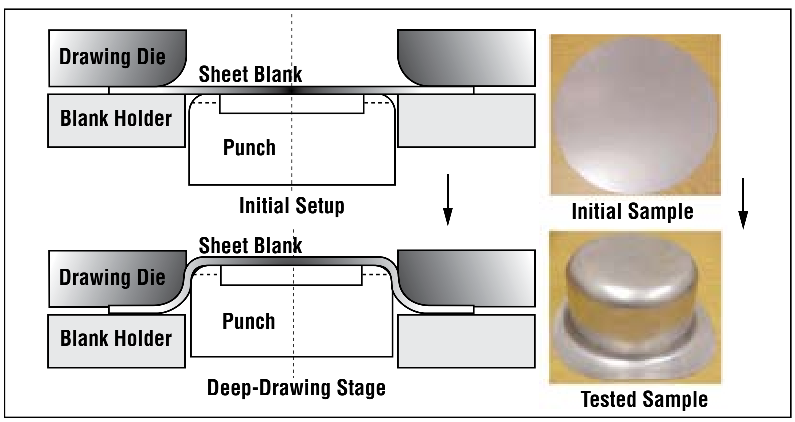

Figure 1

In the deep-draw test, round blanks of 270D/GA 12 in. in diameter and 0.029 in. thick were drawn in a 160-ton hydraulic press.

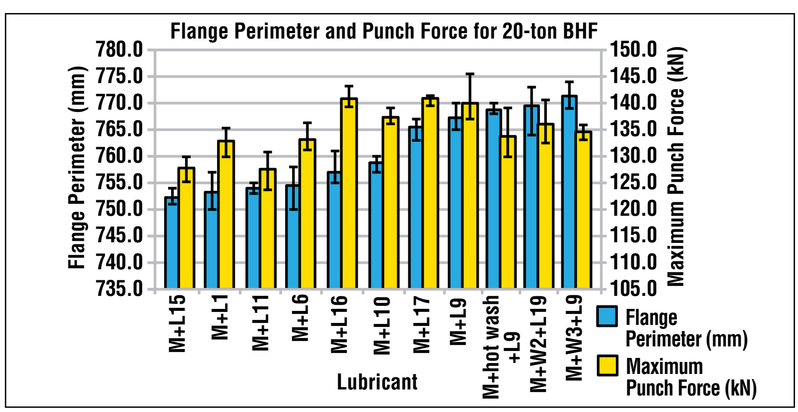

Figure 2

Flange perimeter and punch force were recorded for 11 lubrication conditions at 20 tons of BHF (M+L18 failed). Note that the Y axis on the graph does not start from 0. The error bands show maximum 7 percent deviation.

that use 0.6 to 0.8 gm/m^2 of lubricant on the sheet blanks. Cups were drawn to the same height (79.5 ±0.3 mm), and the flange perimeter was measured in each case.

The lower the flange perimeter, the lower the side wall thinning and the better the material flow. This implies that the lubricant is good and the coefficient of friction is low. Cups were drawn at 20, 22, and 24 tons of BHF.

Experimental Results

Figures 2, 3, and 4 show the results of the deep-draw tests in terms of flange perimeters for different lubrication conditions. "M" indicates the presence of mill oil on the steel sheets, and "L" stands for lubricant. Lubricants L6 and L15 performed the best among the lubricants tested.

FE Simulations

FE simulations were carried out with PAM-STAMP software to predict the coefficient of friction (CoF) at the tool-blank interface. The FEA results for 20-ton BHF are seen in **Figure 5**. Similar results were obtained for 22- and 24-ton BHF also. The perimeter of the flange obtained at the end of stroke in the simulation is compared to the perimeter of the flange obtained in the experiment and is used to determine the CoF from the simulation. From Figure 5, M+L15 has a CoF of 0.09, while M+L9 has a CoF of 0.1 at 20-ton BHF.

Results

Two lubricants stood out as best among the ones tested in this study. In general, water-based and synthetic lubricants performed better than petroleum-based lubricants. FE simulations revealed that the CoF decreases with an increase in BHF for the same lubrication condition. Variation in CoF can be observed with variation in lubrication conditions.

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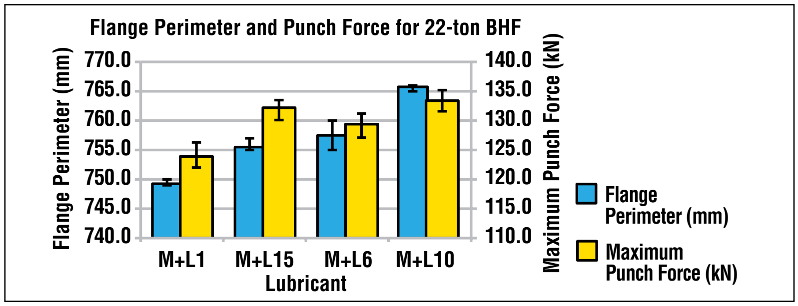

Figure 3

Flange perimeter and punch force were recorded for four lubrication conditions at 22 tons of BHF (the rest failed). Note that the Y axis on the graph does not start from 0. The error bands show maximum 3 percent deviation.

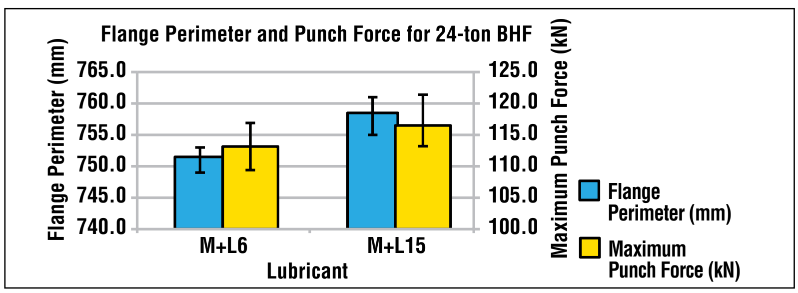

Figure 4

Flange perimeter and punch force were recorded for two lubrication conditions at 24 tons of BHF (L1 and L10 failed). Note that the Y axis on the graph does not start from 0. The error bands show maximum 7 percent deviation.

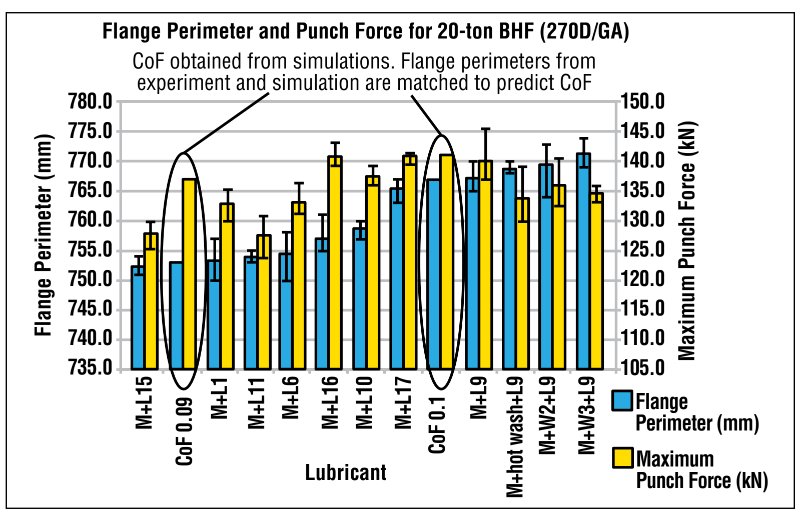

Figure 5

This comparison of flange perimeters obtained from simulation and experiments predicts the coefficient of friction for 270D/GA to be 20 tons of BHF.