Lubrication and galling in stamping of galvanized AHSS

Part III: B-pillar simulations and the strip drawing test (SDT)

Editor's Note: This article is Part III of a three-part series discussing a study of lubrication and galling in forming of zinc-coated advanced high-strength steels (AHSS). Parts I and II, which appeared in the January/February and March issues, covered the twist-compression test (TCT) for preliminary evaluation of galling conditions and the deep-drawing test for evaluation of lubricants.

B-Pillar Simulations

Forming of galvanized AHSS involves higher contact pressures at the tool-workpiece interface compared to forming mild steel. Under these severe interface conditions, improper selection of lubricants, tool materials, and tool coatings can result in high scrap rates and galling in stamping production.

In our study, a program investigated by ULSAB-AVC (Ultra-light Steel Auto Body—Advanced Vehicle Concepts), finite element (FE) simulations of B-pillar forming were conducted to determine the critical contact pressures at the die-workpiece interface that can cause lubricant failure and galling in forming AHSS parts.

Commercial software, PAM-STAMP 2G, was used to simulate the forming of a B-pillar from TRIP 600 steel. **Figure 1** shows the FE model with tool and initial sheet blank geometries.

The contact pressure on the side wall of the part was predicted to be about 200 MPa (29 KSI) and the maximum pressure was predicted to be 400 MPa (58 KSI) at the sharp die corner (see **Figure 2**). Where the maximum contact pressure is large, galling can occur on die surfaces, so it is important to emulate these critical pressure conditions in laboratory tribotests to study the lubricant performance and galling behavior in forming AHSS.

Strip Drawing Test

The SDT was developed to evaluate stamping lubricants, die materials, and coatings by emulating channel bending and deep-drawing operations for the higher grades of AHSS (DP 600/780, TRIP 780, and DP 980) (see **Figure 3**). With preliminary FE simulations of the SDT, four different die radii—0.2, 0.31, 0.39, and 0.47 inch—were determined to change the contact pressure from about 110 to 260 MPa (about 16 to 38 KSI) without any necking of the 14-in.-long, 1-in.-wide strip.

The die insert (DC53, supplied by International Mold Steel) was made to have four different radii (see Figure 3). In addition, the insert was designed to adjust freely to specific die-punch clearances that determined the ironing ratio of the strip. In SDT, two die inserts were used, and the final deformed specimen had a U shape.

Test Results

The SDT was used to evaluate the performance of several stamping lubricants on uncoated and PVD-coated dies. Two different zinc coatings—galvannealed (GA) and galvanized (GI)—were used on the same grade of AHSS (DP 590/600) strip material. The uncoated and

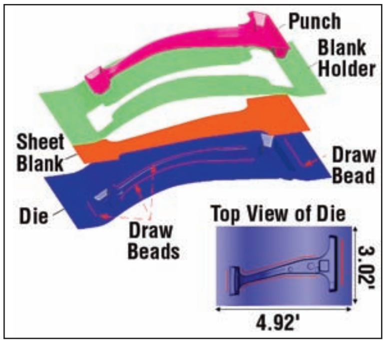

Figure 1

This B-pillar simulation model shows the geometries of the tool and the initial sheet blank.

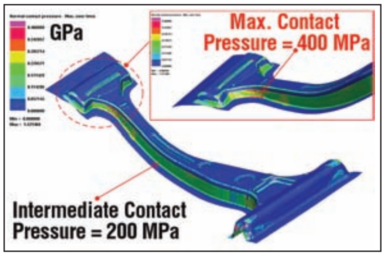

Figure 2

FEM predicted the contact pressure distribution in the B-pillar part.

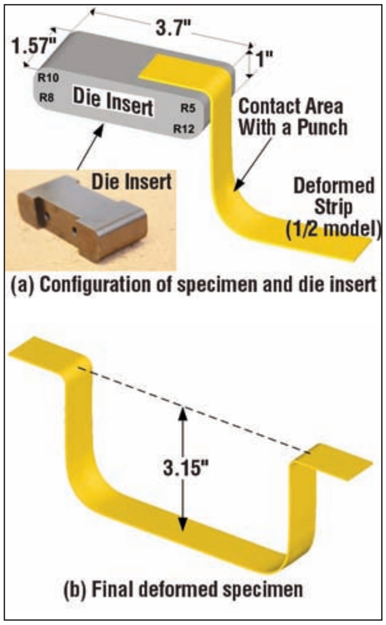

Figure 3

The die insert was made to have four different radii (top). The final deformed specimen had a U shape (bottom).

PVD-coated tool steel were selected for the test because they had shown different severities of galling in previous die coating evaluations with straight oil. With input from automotive stampers, steel producers, and lubricant companies, we selected various wet lubricants and dry-film lubricants (DFL) for the tests.

In the SDT, the maximum punch force was observed at the end of the stroke, so this force was used to evaluate the performance of the lubricants; the total punch force is influenced by the frictional force at the tool-workpiece interface.

Conclusions

The study resulted in several conclusions:

•Lubricants B (polymer-based with extreme-pressure [EP] additives) and C (water-soluble DFL) were found to be most effective, regardless of zinc coating types on the strips and tool surface conditions.

•Lubricants E (water-free DFL) and M (synthetic) showed reasonably small frictional responses with a PVD-coated die in forming GA strips.

•Lubricant L (water-free DFL) performed similarly to Lubricants B and C with an uncoated die in forming GI strips.

•Lubricant N (straight oil) reduced more friction in GI strips compared to GA strips. For the PVD-coated die, Lubricants L, M, and N showed acceptable performance in forming GI strips.

•The DT results showed that lubricant behavior changed depending on the mated zinc coatings and tool surface conditions. Therefore, it is important to screen lubricants by considering the types of zinc coatings, sheet materials, die materials, and die coatings being used. ST

Hyunok Kim is a research associate with the Center for Precision Forming (CPF), Dr. Taylan Altan, director, The Ohio State University, 339 Baker Systems, 1971 Neil Ave., Columbus, OH 43210-1271, 614-292-9267, www.cpforming.org.

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