#664

# Evaluating dry-film and wet lubricants for aluminum stamping

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Lubrication is critical in forming aluminum because the surface of aluminum sheet is smoother than that of steel. The right lubricant can reduce or even prevent wrinkling and premature failure.

Two types of lubricants are used for aluminum sheet metal forming: dry-film lubricants and mineral oil-based lubricants. Studies show that dry-film lubricants can have better lubricity than mineral oils, since they can provide a uniform coating thickness on the sheet and help to eliminate the cleaning operation.

In addition to lubricant, the surface finish of the sheet also affects the friction behavior during forming. Surface texturing using electrodischarge texturing (EDT) can provide better lubrication than using simple mill-finished (MF) sheet surface.

Center for Precision Forming (CPF) of The Ohio State University (OSU) conducted extensive deep-drawing tests to evaluate various lubricants, including dry-film and wet, to determine which lubricant can provide the best lubrication condition between the aluminum 5182-O blank (0.05 inch) and dies. Fourteen lubricants were tested as listed in **Figure 1**. The same amount of coating weight (1 gram/m$^2$) was applied for all the lubricants.

| Lubricant Code | Lubricant Type | Lubricant Code | Lubricant Type |
|---|---|---|---|
| A | Petroleum oil | H | Mineral oil-based |
| B | Petroleum oil | I | Mineral oil-based |
| C | Petroleum oil, Additive blend | J | Water-based |
| D | Petroleum oil, additive blend | K | Water-based |
| E | Emulsified oil (semisynthetic) | L | Water-based |
| F | Dry film | M | Dry film |
| G | Mineral oil-based | N | Dry film |

**Figure 1**

Fourteen lubricants were tested for their performance in deep drawing of an aluminum blank.

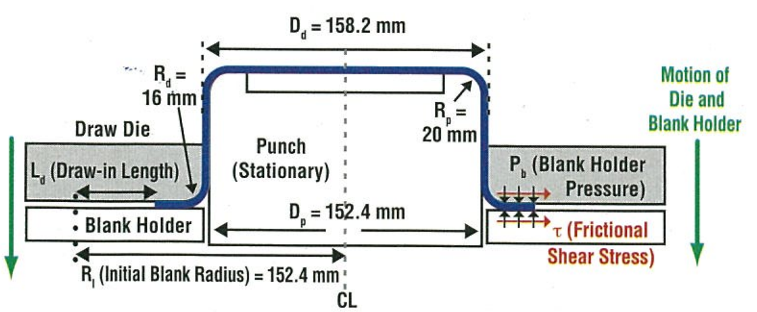


**Figure 2**

Cup drawing operations were used to evaluate the stamping lubricants.

## Cup Draw Test Principles and Procedure

Cup draw testing (see **Figure 2**) was selected to evaluate the stamping lubricants for this study, since it can emulate the near-production conditions well. The cup drawing tooling used in this study operates with a 160-ton hydraulic press that has a maximum ram speed of 12 inches per second (IPS). This press was moved from OSU/CPF to EWI in 2012.

The performance of the lubricants was evaluated by measuring the perimeter of the flange of the cup, drawn always to the same depth of 3.15 in. A lubrication condition is said to have failed at a certain blank holder force (BHF) if three consecutive cups cracked (see **Figure 3**).

## Experimental and Finite Element Simulation Results for MF Blanks

The perimeter variations of the drawn cups, shown in **Figures 4** and **5**, are with a BHF of 16 and 17 tons, respectively. Dry-film lubricant F performed best.

Finite element simulations were conducted to estimate the values of the friction coefficient between the workpiece and tools for the tested lubricants. PAM-STAMP® software was used. The perimeter of the flange obtained at the end of stroke in the simulation was compared to the perimeter of the flange obtained in the experiment and used to determine the coefficient of friction (CoF) from the simulation. The results in Figures 4 and 5 show that the CoFs of lubricants G and K are from 0.08

to 0.1, the CoF of lubricant F is about 0.08, and the CoF of lubricant I is about 0.12.

## Lubrication Performance for MF Surface and EDT

The friction behavior of Al 5182-O with EDT also was compared to that of Al 5182-O with MF surface. **Figure 6** shows the results for BHF of 16 tons and 17 tons.

The results show that the friction behavior of Al 5182-O with EDT surface is slightly better than that of Al 5182-O with MF surface.

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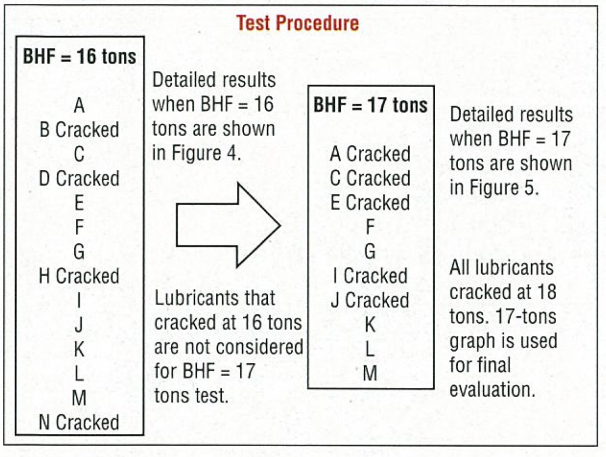


**Figure 3**

All lubricants were subjected to this test procedure.

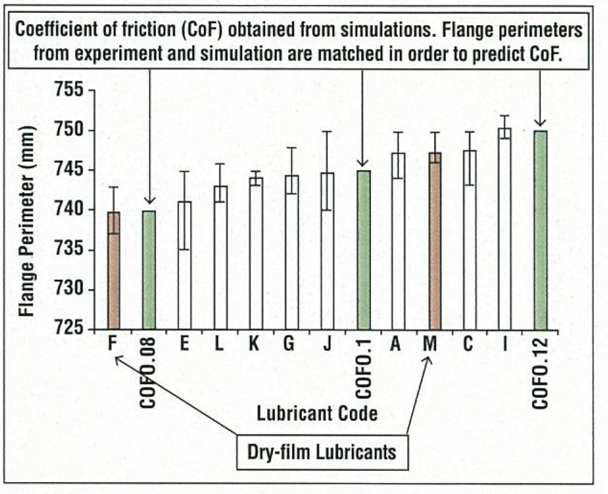


**Figure 4**

These flange perimeters were recorded from tests of 13 lubricants at 16 tons BHF. Lubricants B, D, and N failed. Note that the Y axis on the graph does not start from 0. The error bands show the deviation between samples.

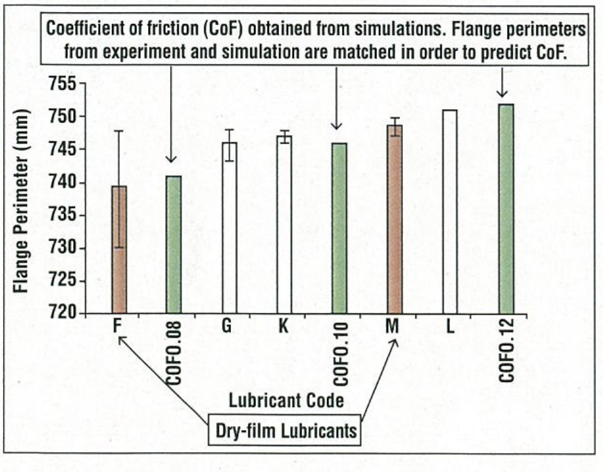


**Figure 5**

These flange perimeters were recorded from tests of five lubricants at 17 tons BHF. Lubricants E, J, A, C, and I failed. Note that the Y axis on the graph does not start from 0. The error bands show the deviation between samples.

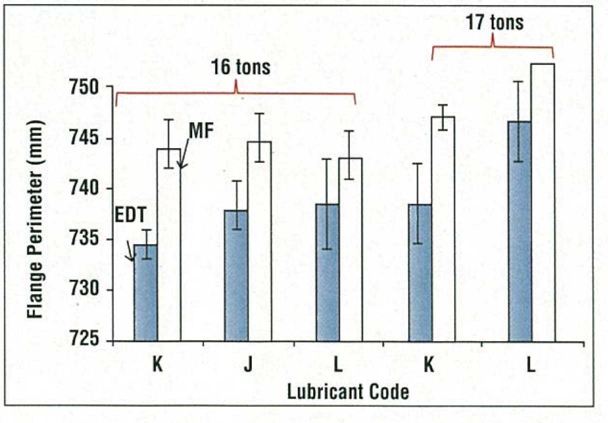


**Figure 6**

The friction behavior of AL 5182-O with EDT surface was slightly better than that of the same material with MF surface.