

# Stamping research gains support

## Forming lightweight alloys, UHSS emphasis of study

By **Taylan Altan**

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Global competition continues to force the metal forming industry to reduce costs, improve technology, and increase productivity. With these trends in mind, the Ohio State University (OSU) and Virginia Commonwealth University (VCU) established in June 2006 the Center for Precision Forming to focus on the needs of the metal forming industry.

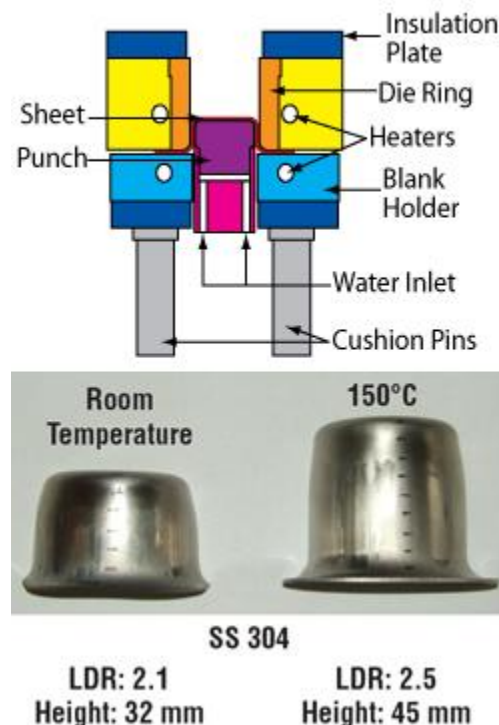
*This column was prepared by the staff of the Center for Precision Forming (CPF, formerly ERC for Net Shape Manufacturing), The Ohio State University, Taylan Altan, professor and director.*

Global competition continues to force the metal forming industry to reduce costs, improve technology, and increase productivity. With these trends in mind, in June 2006 The Ohio State University (OSU) and Virginia Commonwealth University (VCU) established the Center for Precision Forming to focus on the needs of the metal forming industry.

The CPF's objectives are to conduct R&D projects in cooperation with member companies and train engineers who are familiar with the fundamentals of metal forming science and technology.

The CPF's annual budget is about \$450,000. National Science Foundation provides \$150,000 a year, and the remaining funds are provided by industrial members: AIDA-America, DaimlerChrysler, Eltek Manufacturing, ESI North America, General Motors, Interlaken, Polar Ware, POSCO (Korea), Scientific Forming Technologies Corp., Sungwoo Hitech (Korea), Timken, Radar Industries, Weatherford, and Whirlpool.

### Elevated-temperature Round Cup Tooling



**Figure 1**

Experiments with this tooling were conducted in an AIDA-America servo press to investigate the formability of Al and Mg alloys and stainless steel at elevated temperatures. Result: At 150 degrees C, deeper SS 304 cups can be formed.

Member company representatives form the center's Industrial Advisory Board (IAB) and select research priorities and focus. The second IAB meeting, held March 1, 2007, in Richmond, Va., had strong industrial participation. It was decided to research forming lightweight alloys and ultrahigh-strength steels (UHSS).

Some of the CFP's current projects are:

1. Elevated-temperature stamping and hydroforming of Al and Mg alloys and stainless steel

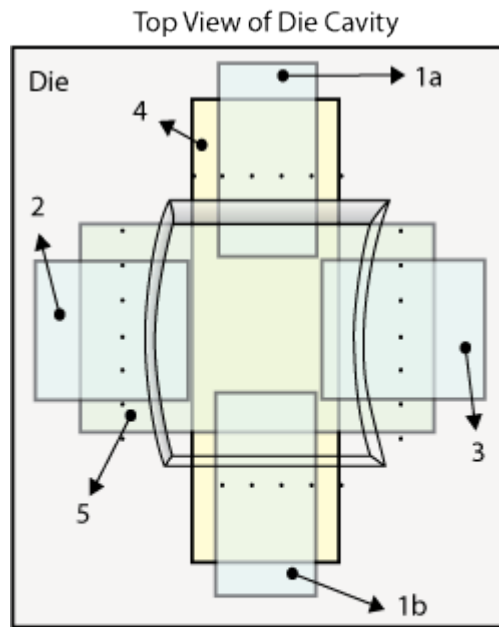
This project aims to:

- Estimate the formability of Al and Mg alloys and stainless steel at elevated temperatures.
- Evaluate lubricant performance.
- Demonstrate the advantages of warm forming for member-specific applications, such as deep drawing stainless steel sinks.
- Assist CPF members in developing a robust warm-forming process for selected applications.

**Figure 1** illustrates the tool used to investigate the formability of Al and Mg alloys and stainless steel at elevated temperatures.

2. Forming advanced ultrahigh-strength steel (A/UHSS) components

Forming A/UHSS is challenging because there isn't much prior experience in predicting springback. Also, significant variations in A/UHSS material properties may exist. CPF has proposed 2-D and 3-D experimental studies to improve springback prediction for A/UHSS materials using commercial finite element (FE) simulation programs (see **Figure 2**).



- Planned experiments
1. Straight flanging
  2. Stretch flanging
  3. Shrink flanging
  4. Straight hat shape drawing and stretching
  5. Curved hat shape drawing and stretching

**Figure 2**

Curved and straight flanges, as well as drawn and stretched strips of different widths, can be formed with the proposed tool design.

3. Sheet material properties at room and elevated temperatures

Extensive studies conducted in various metal forming research laboratories indicate the advantages of the biaxial bulge test over the uniaxial tensile test. CPF has conducted several industry projects to demonstrate the bulge test as a quality control indicator for incoming sheet coil.

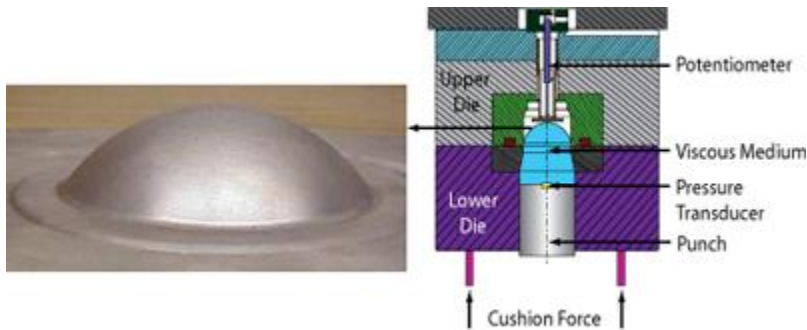
Sheet materials were tested at room temperature and elevated temperatures up to 300 degrees C. It was determined that the bulge test (see **Figure 3**) can be used for testing the quality of incoming sheet material and determining flow stress (true stress/true strain diagram).

4. Die wear testing for cold/warm forming lightweight materials

Existing wear testing methods do not represent actual production conditions. Tests such as pin-on-disk are costly and time-consuming. Others, such as strip pulling and draw-bead simulator, are cumbersome and require special sample preparation.

CPF proposes conducting a slider-on-sheet tribotest to characterize die wear and test alternative die materials, coatings, surface treatments, and lubrication systems provided by CPF members.

5. Lubricant evaluation in forming A/UHSS components



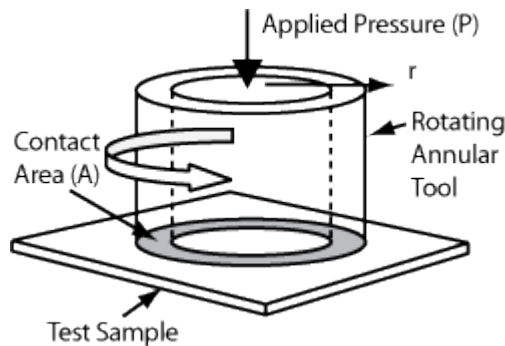
**Figure 3**

The bulge test can be used for testing incoming sheet material quality and determining flow stress (true stress/true strain diagram).

This study's objective (in cooperation with ILZRO) is to predict and eliminate galling during the forming of galvanized A/UHSS materials. The effects of process parameters such as interface temperature, pressure, and relative sliding speed on galling are investigated using the twist-compression test (TCT) (see **Figure 4**).

TCT is a laboratory screening test for evaluating stamping and tube hydroforming lubricants. One of the CPF's goals is to evaluate various tool materials and coatings supplied by different toolmakers. This study will enable members to select the best tribological system and process parameters to reduce galling.

6. Fuel cell manufacturing



**Figure 4**

In cooperation with IRMCO and Bohler-Uddeholm, CPF used the twist-compression test to predict galling during

the forming of galvanized A/UHSS materials. The test also can be used to evaluate the performance of various tool materials and coatings.

Another goal is to understand the mechanics of forming micro-mesoscale features such as channels and grooves. CPF also is looking to accurately characterize material behavior of thin sheet metals at micro-mesoscale through the tensile and bulging test and optimize process parameters and part geometries.

7. Multipoint control (MPC) die cushion technology

A robust stamping process should account for the variations in incoming sheet material properties, lubricant performance, and process conditions such as tool temperatures. MPC die cushion technology offers flexible control of blank holder force (BHF) to account for these variations. To reduce tryout time, CPF, in cooperation with the USCAR consortium, developed software for offline estimation of optimum BHF in individual cushion pins for forming large automotive parts.

Flexible BHF control also allows for better springback control and enhances drawability. Numerous companies offer customized nitrogen gas spring systems that can be used as MPC systems. This is a promising technology with rapidly expanding applications; for example, MPC systems are used extensively in deep drawing stainless steel sinks.

8. Sheet and tube hydroforming—advanced features and applications

The CPF has extensive experience working on industrial tube and sheet hydroforming projects. The tube hydraulic bulge test and friction tests, such as the guiding zone test and the expansion zone test, were developed to evaluate material properties and commercially available lubricants. Also, innovative methods using FE simulation were developed to estimate process parameters like forming pressures for tube and sheet hydroforming processes. This experience is being shared with CPF members.

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The CPF conducts research and development; educates students; and organizes workshops, tutorials, and conferences for the industry in stamping, tube hydroforming, forging, and machining.