

Dissecting defects

Part II: Testing for incoming sheet coil variation

Editor's Note: This article is Part II of a three-part series discussing methods used to control quality in stamping. Part I, which appeared in October, discussed quality defects commonly seen in stamped parts and process variables that affect formed part quality. Part III, which will appear in December, will discuss commercially available systems used in stamping process control.

Two major types of variation in incoming sheet coil are material properties and coil thickness. Various tests, both destructive and nondestructive, are used to determine these variations.

Tensile Testing

Tensile tests can be conducted for each batch of incoming sheet coil or heat, but variation of material properties within the coil or heat is difficult to determine without extensive testing.

The tensile test, which is a destructive test, determines material properties in only one direction—for instance, the direction of the sample length. In stamping, however, deformation is biaxial because the material usually is stretched and formed in two directions parallel to the surface of the sheet.

Usually tensile test data includes yield strength, tensile strength, and total elongation. Total elongation is an indication of material formability, but it includes deformation after necking of the tensile sample. Therefore, the strain hardening coefficient or uniform elongation defines formability more accurately.

Bulge Testing

The biaxial bulge test (see Figure 1 top) is another destructive test method for determining the sheet material properties. In this test, the maximum effective strain achievable without local necking is much larger (usually double) than

that in the tensile test. Material properties obtained from bulge tests emulate real-world stamping conditions. Therefore, it is a better test to obtain reliable material property data (especially flow stress data for finite element simulation purposes).

The bulge test is an especially suitable formability indicator. A sheet sample is clamped rigidly in the tools and bulged under pressure until it fractures (see Figure 1 bottom). The burst pressure and burst dome height are recorded. Burst height indicates the formability of the material. The higher the dome height of a material at fracture, the better the formability of that material.

Eddy Current Testing

Figure 2 describes a nondestructive material testing method based on the principle of eddy current. In this testing method, an eddy current is induced in the uncoiled blank material. The current values are measured and correlated to sheet material properties such as the yield strength, tensile strength, and uniform/total elongation. The method can be applied only to conducting materials.

To ensure consistent and exact correlation between the eddy current readings and the material properties of the tested coil, the system must undergo a teaching or calibration phase.

This teaching phase involves testing a few blanks from different batches, coils, or heats in two ways:

1. Nondestructive evaluation—eddy current measurement
2. Destructive evaluation—tensile or bulge test

Results from both evaluation methods are correlated to establish a rela-

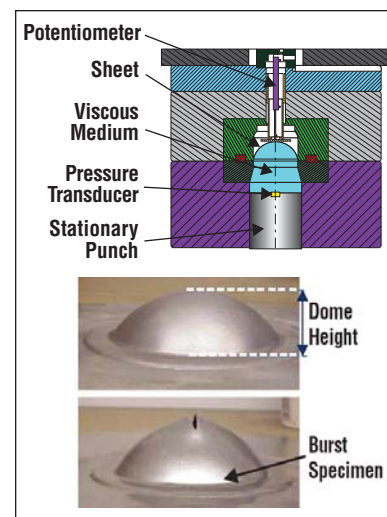


Figure 1

At top is a cross-sectional schematic of a biaxial bulge test set up at the CPF. In the test samples at bottom, the higher the dome height at burst, the better the formability of the tested sheet material. ¹

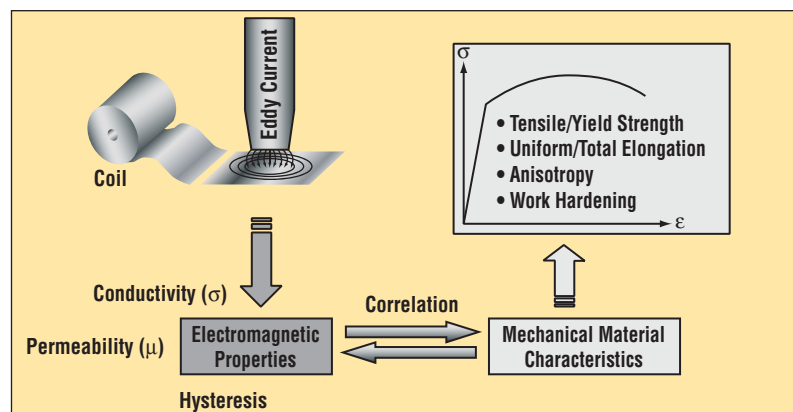


Figure 2

The eddy current system is one method of nondestructive testing. ²

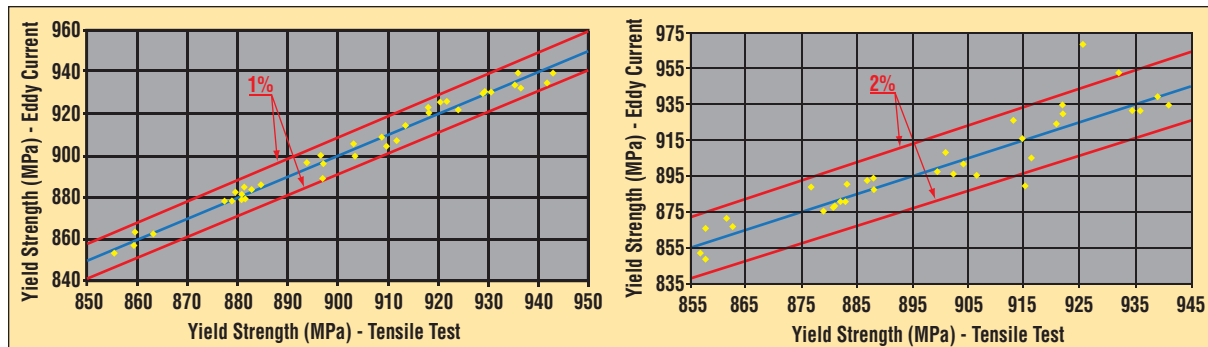



Figure 3

In the training phase, material data obtained from destructive evaluation methods is correlated with eddy current data. The developed correlation model fits all training data within a 1 percent error band. In the testing phase, for medium carbon steels, the correlation model is good within a 2 percent error band. Courtesy of 3R Technics GmbH, Zurich, Switzerland.

relationship between the two tests. The teaching phase is followed by a validation phase to verify the correlation model (see **Figure 3**).

Implementing an eddy current-based material property sensor in production allows the possibility of measuring the material properties of every blank fed to the press. The developed system has been tested and validated for numerous sheet materials and is commercially available for quantitative determination of sheet material properties.

Material properties can be determined with accuracy comparable with a tensile or bulge test. The substantial difference with eddy testing is that the sheet material can be tested nondestructively and online during the production cycle. Also, no sample preparation is required. The material will neither be deformed nor devalued during the testing procedure and can be processed and formed further. 

This column was prepared by Ajay D. Yadav, graduate research associate, of the Center for Precision Forming (CPF), The Ohio State University, for Taylan Altan, professor and director of the CPF, 339 Baker Systems, 1971 Neil Ave., Columbus, OH 43210-1271, 614-292-9267, www.cpfforming.org. The CPF conducts research and development; educates students; and organizes workshops, tutorials, and conferences for the industry in stamping, tube hydroforming, forging, and machining.

Notes

1. T. Yelich et al, "Summary Report - Flow Stress Determination and Formability Estimation in Sheet Materials Using the Bulge Test," Report No. CPF-2.1/07/01, Center for Precision Forming, The Ohio State University, 2007.

2. H. Hoffmann et al, "Automatic Process Control in Press Shops," in *proceedings from the 12th International Conference - Sheet Metal 2007*, pp. 881-888.