

Die materials and wear in stamping AHSS

Part II: Tests for evaluating galling, wear of tool materials and coatings

BY EREN BILLUR

Editor's Note: This article is Part II of a three-part series that reviews the die materials and die coatings used in forming AHSS. Part I, which appeared in the January/February issue, discussed the relationship between process conditions and tool failure mechanisms. Part III, to appear in the May/June issue, will discuss research results and recommended tool materials and coatings.

Stampers have many options for wear testing. Most methods are standardized by ASTM Intl. and are classified into three groups:¹

1. Evaluating a material's response to a specific type of wear
2. Screening materials, lubricants, and coatings
3. Investigating fundamental aspects of wear

However, none of the standard

tests is specifically tailored to evaluate wear phenomena in sheet metal forming operations. Over the years researchers have modified the standard tests and applied them to evaluate tool materials and coatings in sheet metal forming.

Scratching Test

The standard pin-on-disk test is used to determine wear in sliding material pairs, to evaluate lubricants, or to determine the coefficient of friction (see **Figure 1**). Since the material pair is in contact with the same surface (which is not the case in sheet metal forming), some modified tests, such as the slider-on-sheet test, were introduced in which tool material is in contact with fresh sheet material throughout the test² (see **Figure 1**).

Although the sliding speeds and

normal forces (and therefore the contact pressure) can be adjusted to a level that is similar to sheet metal forming processes, the effect of plastic deformation is ignored in these tests. Therefore, the results may not emulate the progression of tool wear in sheet metal forming.³

Analysis of the pin-on-disk test is standardized in ASTM G99, "Standard Test Method for Wear Testing with a Pin-on-disk Apparatus," with respect to volume loss.⁴ The volume loss can be measured directly from the specimen dimensions before and after the test, or it can be calculated from mass loss. If galling is present, volume loss may not reflect the tool wear, so this test method should not be used.⁵

Twist-compression Test (TCT)

In a twist-compression test (TCT), a rotating button (tool material) is pressed against a fixed metal sheet⁶ (see **Figure 2**). Rotation speed and pressure may be adjusted to simulate the metal forming process. However, similar to the pin-on-disk test, the tool material is rotating on the same surface, not on a fresh sheet surface as in metal forming. Thus, surface conditions of sheet metal forming or stamping operations cannot be emulated.

This test is used to evaluate lubri-

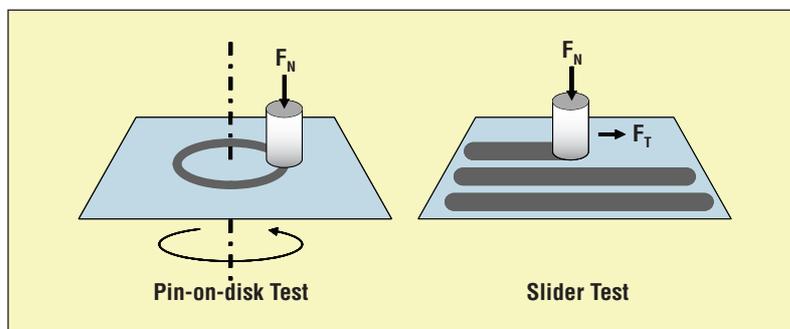


Figure 1

A scratching test determines wear in sliding material pairs, evaluates lubricants, and determines the coefficient of friction.

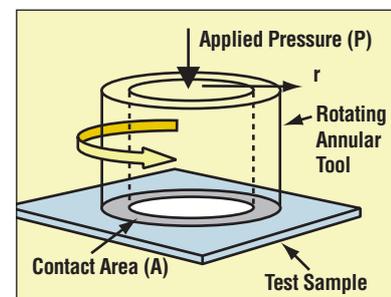


Figure 2

In a twist-compression test, a rotating button (tool material) is pressed against a fixed metal sheet.

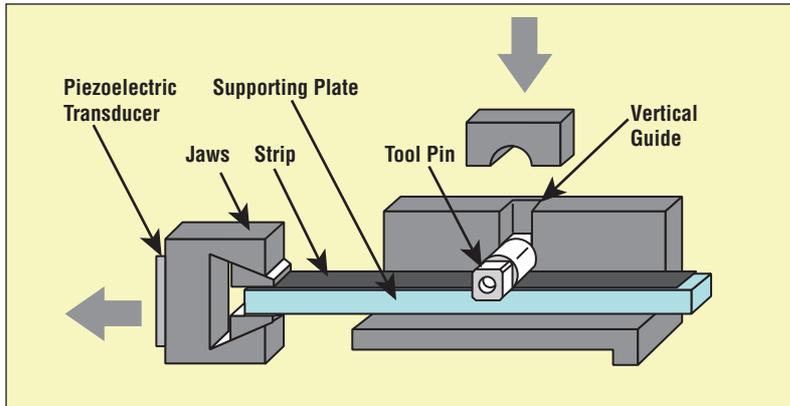


Figure 3

In a strip-reduction test, the thickness of a metal strip is reduced while it slides against the tested tool material to determine the galling tendency of a pair of materials and to evaluate lubricants.

cant performance very quickly and to determine threshold galling stress for given sheet and die materials. To evaluate lubricant performance, transmitted torque is recorded in time, enabling the calculation of the change in coefficient of friction (μ) in time. As a rule, when the coefficient of friction reaches 0.3, the test is stopped.⁷

Strip-reduction Test

In a strip-reduction test, the thickness of a metal strip is reduced while it slides against the tested tool material (see **Figure 3**). This test is used to determine the galling tendency of a pair of materials (tool and sheet) and to evaluate lubricants.

For the first application, the length of strip that could be drawn using a given tool material without galling is recorded. The results are compared within the evaluated tool materials to determine which tool material and coating are best for drawing and reducing a specific sheet material. The change in the surface finish of the tool after a reduction test can be used as a criterion for evaluating the performance of tool materials, coatings, and lubricants.

Strip-reduction tests include the effect of plastic deformation. Nevertheless, the state of deformation is limited to thickness direction only. However, in deep-drawing operations, the deformation is biaxial, and the sheet material undergoes thinning, thickening, and bending. All of these operations may change the surface texture, which cannot be emulated by strip-reduction tests.⁸

Forming Tests

Forming tests are designed to emulate the actual state of deformation in sheet metal forming processes (see **Figure 4**). They include strip drawing tests, strip ironing tests, cup drawing tests, draw bead simulations, and part forming tests.

The forming tests are conducted either up to a certain number of pieces or until wear, galling, or scratches are observed in the workpiece. In the first method, the number of parts produced without defects is an indication of tool performance. In the second method, the surface area where galling occurs is measured. These tests can emulate real production conditions as closely as possible, provided that parameters such as press

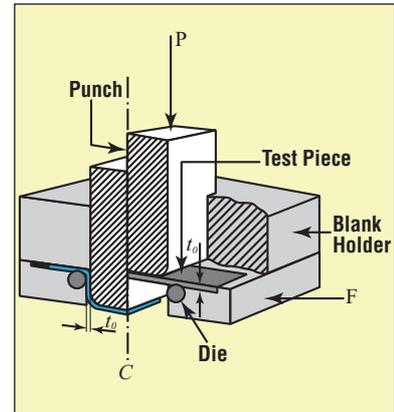


Figure 4

forming tests, such as the channel forming test, are designed to emulate the actual state of deformation in sheet metal forming processes.

speed, contact pressure, and lubrication are close to values used in actual production lines.⁹ 

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Notes

1. P.J. Blau and K.G. Budinski, "Development and use of ASTM standards for wear testing," *Wear* 225-229, pp. 1159-1170, 1999.

2. E. Van der Heide, A.J. Huis in 't Veld, and D.J. Schipper, "The effect of lubricant selection on galling in a model wear test," *Wear* 251, pp. 973-979, 2001.

3. H. Kim, H. Palaniswamy, and T. Altan, "Investigation of tribological conditions in forming uncoated and galvanized advanced/ultra high strength steels, CPF, 2.3/06/01, 2006.

4. ASTM G99, "Standard Test Method for Wear Testing with a Pin-on-Disk Apparatus," 2005.

5. *Ibid.*

6. Kim, "Investigation of tribological conditions."

7. *Ibid.*

8. *Ibid.*

9. *Ibid.*