

Die materials and wear in stamping AHSS

Part I: Die wear and die coatings

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Editor's Note: This article is Part I of a three-part series that reviews the die materials and die coatings used in forming AHSS. Parts II and III, which will appear in future issues, will discuss how to evaluate and select various die materials for specific applications.

Advanced high-strength steels (AHSS) are used extensively in the automotive industry to help improve crash safety and reduce weight. With the increased strength of AHSS, however, come dramatically increased springback and forming load (and, therefore, contact pressure) compared to milder steel grades.

In many cases, forming pressures are increased on purpose to reduce springback, but this can contribute to increased tool wear and galling. Therefore, it is necessary to explore the use of new tool materials and surface modifications.¹

Tool Failure Types and Causes

Figure 1 summarizes the principal modes of tool failure related to die wear and the steps required to avoid these failures,² defined as follows:

- **Wear** is damage to a solid surface involving loss or displacement of material. Wear is caused by sliding contact between the workpiece and tool. Two main types of wear are *abrasive*, caused by hard particles forced against and moving along a solid surface, and *adhesive*, caused by localized bonding between contacting solid surfaces

and leading to material transfer between these surfaces.

- **Plastic deformation** is caused by contact pressure exceeding the compression yield stress of the tool material.

- **Chipping** is a result of stresses exceeding the fatigue strength of the tool material.

- **Cracking** is caused by stresses exceeding the fracture toughness of the tool steel.

- **Galling** is a form of damage caused by sliding of two solids. It often includes plastic flow, material transfer, or both.

Four main factors have an effect on these failures:

1. **Contact pressure**—Local contact pressure between the sheet

and tool affects all types of tool failure. As stamping of AHSS requires increased contact pressure, the probability to observe tool failures increases significantly compared to stamping milder steel grades. For a given sheet material, contact pressure can be reduced by die design, such as using larger radii or reducing the sheet thickness.

2. **Surface quality**—Although the surface of the tool is much smoother than the surface of the sheet, the tool's surface quality affects galling. Polishing the tool surfaces before and after coating helps to reduce galling. The sheet's roughness has little influence on tool failure.

3. **Tool coating**—The proper coating with a low coefficient of friction is crucial to reduce galling and tool wear.

4. **Lubrication**—Forming AHSS requires better-performing lubricants, possibly with extreme-pressure (EP) additives, because of the high contact pressure and temperature that occur during the process.

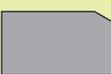
Tool Failure	Changes in Tool	
	Increase	Decrease
 Wear	Hardness Ductility	Friction coefficient
 Plastic Deformation	Hardness Yield stress	Local die pressure
 Chipping	Toughness Ductility	Sharp corners
 Cracking	Fracture toughness	Hardness Sharp corners
 Galling	Surface hardness	Friction coefficient

Figure 1

Shown here are the five tool failure mechanisms and the changes recommended to prevent them.²

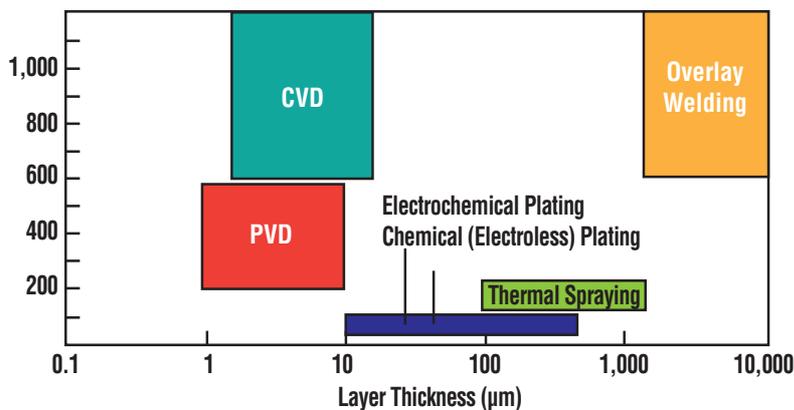


Figure 2

CVD coating requires higher temperatures than PVD coating and similar temperatures as TD coating.³

Surface Treatments and Coatings

Surface treatments and coatings help increase tool life and reduce friction. Heat treatments, nitriding, and hard chrome plating are among the most common techniques used. However, they can fail under the high contact pressure that is present when stamping AHSS.

Three coatings typically are used

for dies that stamp AHSS: physical vapor deposition (PVD), chemical vapor deposition (CVD), and thermal diffusion (TD).

CVD requires higher temperatures than PVD (see **Figure 2**) and similar temperatures as TD. The high temperature can soften the die, which then necessitates a rehardening process. It also can cause dimensional distortion.^{3,4}

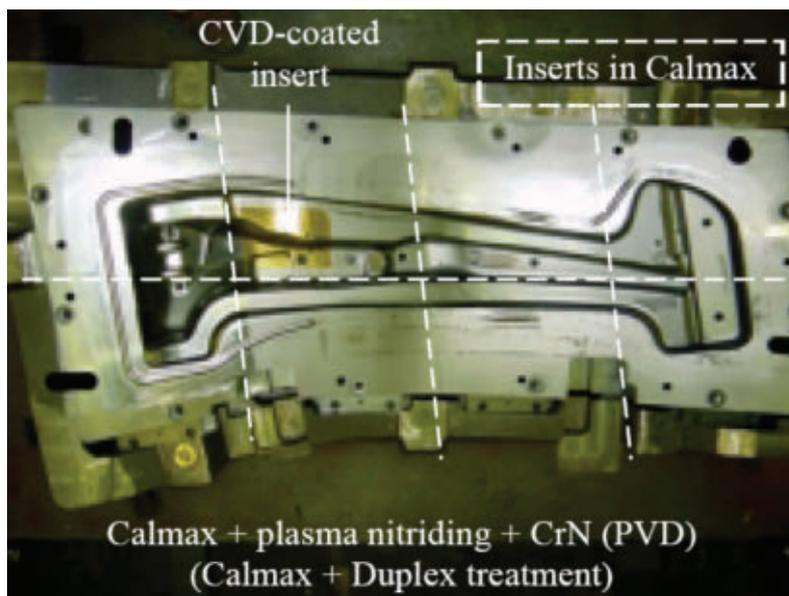


Figure 3

This industrial forming die is designed for stamping B-pillars.⁷

The most common coating materials for PVD and CVD are nitrides (such as TiN and CrN), carbides (such as TiC and WC/C), solid lubricant films (such as DLC and MoS₂), or a combination of these. Since many PVD and CVD coatings are brittle, they are applied to stiffen substrate materials, so the tool steel typically is surface-hardened before coating. Duplex coating, which consists of nitriding and PVD coating, is a common method.^{5,6}

Considering the high cost of coated tool steels, large forming tools are made of relatively inexpensive and soft materials, such as cast iron or low-grade tool steel. Locations subject to severe wear are replaced with *inserts* of high-grade tool steels with coating (see **Figure 3**)⁵

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Notes

1. J. Bergström, P. Krakhmalev, A. Gård, and F. Lindvall, "Galling in Sheet Metal Forming," in *proceedings of the IDDRG 2008*.
2. Uddeholm & SSAB, "Tooling Solutions for Advanced High Strength Steels, Selection Guidelines," 2008.
3. S. Hogmark, S. Jacobson, and M. Larsson, "Design and Evaluation of Tribological Coatings," *Wear*, 246, pp. 20-33, 2000
4. B. Janoss, "Selecting, Using Tool Coatings to Stamp AHSS," *The FABRICATOR*, July 2008.
5. Hogmark et al.
6. Janoss.
7. M. Liljengren, K. Kjellsson, T. Johansson, and N. Asnafi, "Die Materials, Hardening Methods and Surface Coatings for Forming of High, Extra High & Ultra High Strength Steel Sheets (HSS/EHSS/UHSS), in *proceedings of the IDDRG 2008*.