Galling reduction through die surface treatment

Testing three treatments for sheet metal stamping

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This brief article describes how tool galling occurs in stamping and describes results of tests on how TiCN, Hard-Cr, and CrCN were used on sample parts to help reduce galling.

Sheet metal stamping is one of many processes prone to galling, a form of wear. Galling occurs when metals with dissimilar hardness (the die and the sheet metal) come in contact at high speeds and pressures. Galling begins at tool defects such as notches or scratches and eventually develops into hard protrusions on the tool surface. These protrusions gouge the sheet material.

Because all large production tools in industrial sheet metal forming contain defects, material transfer is unavoidable. Die roughness undoubtedly influences galling, but various surface treatments have been used to reduce the galling tendency of a particular problem production part.

Effect of Roughness

A survey of production parts, performed by one of this article’s authors at the Ford Motor Co. plant in Geelong, Australia, revealed galling tendency to be a function of the draw depth and part gauge (see Figure 1). This is understandable, because the larger the draw depth and the thicker the sheet material, the higher the contact friction and forming forces.

Galling occurred predominantly in two stages of the multistage press operation: deep drawing and flanging-wiping. This allowed the identification of galling tendencies at the design stage, giving scope for preventive action.

Surface Modifications Tested

Normal die preparation involved polishing the dies to a 2.4-micrometer finish. A study of the existing process found that dies prepared this way required repolishing when roughness reached 4.5 µm because of splitting and poor quality.

For this trial, a die with four symmetrical problematic sections was selected. A different finish was used on each of the four sections. The die surfaces were polished to a smoother finish (see Figure 2) before coating. One surface was left uncoated as a control. Three different hard coatings—TiCN (titanium carbonitride), Hard-Cr (hard chrome), and CrCN (chromium carbonitride)—were used on the other surfaces. Sample parts were collected at intervals during the trial, and the average roughness of each section was measured.

Effect of Roughness

During normal production some material transfer was evident after 20 parts, and repolishing was required after 1,000 parts. With the smoother die finish used in this trial, the critical roughness value was not reached until after 7,000 parts.

Given that all other galling-sensitive parameters—speed, pressure, lubrication, and sheet material—were constant in this trial, it can be concluded that die roughness has a significant effect on galling. This result highlights the importance and benefits of care in die building and maintenance, even for uncoated dies.

Effect of Surface Treatment

All three surface treatments improved the galling resistance of the die.

The CrCN- and TiCN-coated dies did not exceed the critical average roughness in the trial, although the CrCN was close after 20,000 cycles. While improving the
surface finish of the die increased the die life by a factor of 7. Hard-Cr, CrCN, and TiCN coatings increased the die life by factors of 12, 20, and more than 20, respectively (see Figure 3).

Galling is characterized by three stages:
1. An increase in roughness as material transfer is initiated
2. A stable period during which a transfer phase is established
3. A dramatic increase in roughness as the transfer layer reaches a critical stage and large material accumulation becomes possible

The Hard-Cr and uncoated sections displayed these characteristics. The TiCN and CrCN coatings exhibited a prolonged, steady transfer stage. This can be interpreted as a postponement or elimination of the critical material transfer stage. Although the TiCN coating performed best in the trial, the coating was thin and not suitable for large areas.

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