Die Wear and Galling in Stamping DP980 Steels

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Die Wear of Non-Coated Die

- Wear
- Build-up
- Galling
Imperfect Die Heat Treatment

Good Heat Treatment of the Die is Required: 58~60 RC

Wear/Damage

No heat-treat die in stamping DP980

No Wear/Damage

Proper heat-treat die in stamping DP980
# Sheet Steel and Die Material Properties

<table>
<thead>
<tr>
<th>Die Material</th>
<th>T (mm)</th>
<th>Yield (MPa)</th>
<th>Tensile (MPa)</th>
<th>T.E %</th>
<th>N</th>
<th>R</th>
<th>Ra (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR1</td>
<td>1.4</td>
<td>826</td>
<td>1005</td>
<td>15.3</td>
<td>0.088</td>
<td>0.76</td>
<td>0.60</td>
</tr>
<tr>
<td>CR2</td>
<td>1.4</td>
<td>592</td>
<td>1049</td>
<td>13.1</td>
<td>0.116</td>
<td>0.82</td>
<td>2.10</td>
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<tr>
<td>GI</td>
<td>1.0</td>
<td>733</td>
<td>1040</td>
<td>13.2</td>
<td>0.118</td>
<td>0.97</td>
<td>0.58</td>
</tr>
<tr>
<td>GI-Prephos</td>
<td>1.0</td>
<td>710</td>
<td>1026</td>
<td>13.5</td>
<td>0.110</td>
<td>0.78</td>
<td>0.57</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Die Material</th>
<th>Ra (µm)</th>
<th>Rockwell Hardness</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2-as received</td>
<td>0.08</td>
<td>17 (96 Rb)</td>
<td>Rc</td>
</tr>
<tr>
<td>D2-40RC</td>
<td>0.13</td>
<td>42</td>
<td>Rc</td>
</tr>
<tr>
<td>D2-50RC</td>
<td>0.29</td>
<td>47</td>
<td>Rc</td>
</tr>
<tr>
<td>D2-60RC</td>
<td>1.07</td>
<td>60</td>
<td>Rc</td>
</tr>
<tr>
<td>Ion Nitride (IN)</td>
<td>0.48</td>
<td>60</td>
<td>Rc</td>
</tr>
<tr>
<td>Chrome Nitride (PVD)</td>
<td>0.09</td>
<td>58</td>
<td>Rc</td>
</tr>
</tbody>
</table>
Effects of Die Hardness

Die Ra Deformation (%) vs. Die Hardness (RC)

Steel Ra Deformation (%) vs. Contact Pressures (MPa)

Wear ↑ Pressure ↓ Die Hardness

Abrasive Wear

Galling

Contact Pressures (MPa)
Variation of Die Materials

Test with CR1

D2-1

Test with CR1

D2-2

Test with CR2

D2-1

Test with CR2

D2-2
Variation of Die Materials

D2-1: 96RB (~ 17RC)  
D2-2: 98RB (~ 17RC)
Short Term, Anti-Galling Strategy-Dry Lubricant

Test with Dry Lubricant

No Die Wear
No Die Build-up
No Steel galling
Friction Behavior

Tryout Condition

Production Condition

Friction Coefficient vs. Die Hardness (HRC)

- CR1
- CR2
- GI
- GI+Phos

Friction Coefficient vs. Contact Pressure (MPa)

- CR1-No heat-treat
- CR1-60RC
- GI-PVD
- CR1-PVD

Tryout Condition:
- CR1
- CR2
- GI
- GI+Prephos

Production Condition:
- D2 No heat-treat
- D2 60RC
- PVD
USS Cyclic Bend Die Wear Test

Grips and Actuators

Die

Specimen

Cycle 1 Pulling

Cycle 2 Pulling

Cycle 3 Pulling

Die

Sheet metal

Cyclic Bend Test

Load (lbs)

Time (sec)

Cyclic Bend Test

Left Load

Right Load

Cyclic Bend Test

Load (lbs)

Time (sec)

Cyclic Bend Test

Load (lbs)

Time (sec)
Die Wear in Production Condition

CR DP980

GI DP980

GI+Prephos DP980

Best

Best

Best
Die Wear in Production Condition

D2 60RC

CR DP980

Abrasive Wear

D2

GI DP980

Minor Zn Build-up

D2

GI+Prephos DP980

Minor Zn Build-up

D2

Ion Nitride

Steel Build-up

IN

PVD

Zn Build-up

IN

PVD

PVD
Die Wear in Production Condition

- CR
- GI
- GI + Prephos

Ra Deformation

- D2 60RC
- Ion Nitride
- PVD

Steel Build-up

ZN Build-up

Abrasice Wear

CR

GI

GI + Prephos
Summary

- Insufficient die surface hardness was found to be the root cause of die wear and galling in stamping DP980 steels, and a tool steel with 60RC hardness is recommended for non-coated die tryouts.
- Newly developed dry lubricants can be used to prevent die wear and galling in non-coated die tryouts with DP980.
- Cold-roll DP980 is found to have higher friction, galling and die wear characteristics than coated DP980 in both the non-coated die tryout and production conditions.
- PVD die is recommended for stamping cold-roll DP980, while Ion Nitride die is for GI-coated DP980.
- Pre-phosphate coating is observed to reduce friction and prevent die wear and galling in stamping DP980 steels.