Evaluation of Die Wear with Stamping DP1180 Steel

A/SP Stamping Tooling Optimization

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## Stamping Tooling Optimization Team Members

**A/SP Project Lead:** Donald Adamski – General Motors  
**A/SP Project Manager:** Eric McCarty – A/SP  

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**JPC Mentor:** Jody Hall, SMDI

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Introduction

Objectives:

• Study die wear durability of various tooling materials and coatings for flanging operations on bare DP1180 steel.

• Update OEM tooling standards based on the test results.

Project Phases:

• **Phase 1:** Can we use the current die materials and coatings in production of 980 grade steels? (2015) 100%

• **Phase 2:** If not, what die materials and coatings should we use to form 1180 grade steels? (2016) 100%

• **Phase 3:** Why did some of the die inserts perform better than others? (Ongoing......) 30%
Experimental Material: Bare DP1180

The phase volume fraction of martensite was found to be approximately 70%.

<table>
<thead>
<tr>
<th>Sample Orientation</th>
<th>Yield Strength (MPa)</th>
<th>Ultimate Tensile Strength (MPa)</th>
<th>Uniform Elongation (%)</th>
<th>Total Elongation (%)</th>
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<tr>
<td>L</td>
<td>919</td>
<td>1182</td>
<td>5.6</td>
<td>10.6</td>
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<tr>
<td>T</td>
<td>926</td>
<td>1212</td>
<td>5.1</td>
<td>8.8</td>
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<td>D</td>
<td>909</td>
<td>1198</td>
<td>5.4</td>
<td>10.4</td>
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Dark color: Martensite
Light color: Ferrite
Die Wear Experiment in Production Environment

- Over 100k hits;
- 33 die inserts;
- Combination of 10 die materials and 9 coatings;
- 42 Ton testing materials;
- Preserve one panel every 500 hits;
Progressive Die Setup

Upper Die

Lower Die

Contact points
Progressive Die Setup
Forming Simulation for Progressive Die Wear

A “worst” case scenario:
1. Relative aggressive die insert design;
2. Uncoated sheet metal;
3. No lubrication.
The combinations of 8 die materials and 7 coatings were evaluated up to 20k hits.

NO. 1, 2, 8, 10, 11, and 12 were replaced by new inserts after 15,000 hits.
2015 Progressive Die Wear Experimental Results

2015 Die Wear Performance

- Very Rough
- Rough
- Safe

Die Insert ID:
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- N1
- N2
- N8
- N10
- N11
- N12

Images:
- Safe
- Rough
- Very Rough
# 2016 Progressive Die Wear Experiment Matrix

## Die Mater.
- SLD-i
- TD2
- DC53
- Cast Caldie
- TD2
- SLD-i
- Toolox 44
- Cast Caldie
- S2333
- S2333

## Coating
- Concept + most
- Duplex Variantic
- Concept + most
- Concept + most
- Duplex CrN + most
- Cool sheet
- Cool sheet
- Cool sheet
- Cool sheet
- Cool sheet

## Hardness (Rc)
- 58-62
- 55-58
- 62-64
- 58-62
- 55-57
- 55-58
- 58-62
- 58-62
- 50-54
- 40-45

The combinations of 8 die materials and 5 coatings were evaluated up to 85.8k hits.

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No. 8 was replaced by No. 14 after 4,000 hits.

No. 3 was replaced by No. 13; No. 5 was replaced by No. 15; No. 14 was replaced by No. 16; After 70,000 hits.
2016 Progressive Die Wear Experimental Results

2016 Die Wear Performance

- Very Rough
- Rough
- Safe

Hits

- 100.0k
- 80.0k
- 60.0k
- 40.0k
- 20.0k
- 0.0

Die Insert ID

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16

1 2 3 4 5 6 7 8 9 10 11

Safe

Rough

Very Rough
Roughness Measurements using Wyko Machine

As-received Sheet Sample

Wyko NT1100
VSI mode
Objective: 10X
FOV: 5X
Long wave length cutoff: 800 μm
Short wave length cutoff: 8 μm
Stylus Pc height: 1.25 μm

Mapping area: 5 x 10 mm²
Ra: 1.83 μm
Roughness Measurements using Wyko Machine

Insert 5, SLD-i + Cool Sheet

Failed at 50k hits
Roughness Measurements using Wyko Machine

Insert 5, SLD-i + Cool Sheet

Failed at 50k hits

Mapping area: 1.2 x 5 mm²
Ra: 9.69 μm (1.83 μm)
Roughness Measurements using Wyko Machine

Insert 7, TD2 + Cool Sheet

No Failure after 100.8k hits
Roughness Measurements using Wyko Machine

Insert 7, TD2 + Cool Sheet

Mapping area: 1.2 x 5 mm²
Ra: 1.19 μm (1.83 μm)

No Failure after 100.8k hits
Roughness Results after 100,800 hits

Roughness on formed panel

Die Inserts

Ra (µm)

Hits

0 50k 100k

As-Received
2016 Die Wear Performance: Crack Initiation Resistance

The bar chart illustrates the performance of various die inserts ranked by safety. The x-axis represents the die insert ID, while the y-axis shows the number of hits. The chart categorizes the performance into three levels: Very Rough, Rough, and Safe. The data indicates that some inserts show higher resistance to crack initiation compared to others.
2016 Die Wear Performance: Crack Propagation Resistance

2016 Die Wear Performance-Ranked by Rough

- Very Rough
- Rough
- Safe

Die Insert ID

Hits
2016 Die Wear Overall Performance

2016 Die Wear Performance-Ranked by Safe and Rough

- **Very Rough**
- **Rough**
- **Safe**

Die Insert ID

Hits

- 2L 4R 6R

Values:
- 7
- 11
- 10
- 9
Correlation Between Die Wear and Roughness

2016 Die Wear Performance-Sorted by Roughness

Roughness

Very Rough
Rough
Safe
Correlation Between Die Wear and Hardness

2016 Die Wear Performance-Sorted by Hardness

< 54 Rc  > 54 Rc

Hardness

Die Insert ID

Hits

Very Rough
Rough
Safe
Correlation Between Die Wear and Radius

The design radii: 2.8 mm.
The Factors Influencing Die Wear Performance

Coating Method

Die Material

Die Wear

Die Design

Die Manufacturing

Alignment & Clearance

Surface Roughness
Conclusions

• The die material and coating method in large volume production of 980 and lower grades steels was not suitable for forming next generation AHSS, 1180 grade steels.

• The die materials, such as ductile iron and low alloy cast steel, should not be considered for die design in stamping 1180 grade steels.

• The inserts #7 (TD2, Cool Sheet), 9 (Cast Caldie, Concept+Most), 10 (DC53, Concept+Most), and 11 (TD2, Duplex+Variantic) are the potential candidates for stamping 1180 grades steel in mass production.

• The die wear performance was influenced by combination of die material selection, die material hardness, die design, coating method, die surface roughness, die insert manufacturing, die alignment, and AHSSs.
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