GREAT DESIGNS IN STEEL

Die Wear Testing- Phase II, OEM Additional Materials

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A/S P

A/S P Auto/Steel Partnership

Members

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- Philippa Chiu, Stellantis
- Jose Luis Galaviz, Stellantis
- Nathan Blandford, Toyota

Project Details

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Objective

Compare wear performance of select OEM die systems (die material, heat treatment and coating).

Problem Statement

- Established wear tests, such as pin-on-disk, assess accumulated wear over the same surface, which does not replicate tool wear in stamping operations where the surface changes with each die stroke.

- In the previous project phase, accelerated sliding wear test developed by A/SP and Univ of Windsor, assessed tool wear over a continuously renewed surface on uncoated high strength steel. The test's applicability to coated automotive sheet steels is not known.

Project Details

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Goal

To validate the Sliding Wear Test for coated advanced high strength steels.

Objectives

Test and compare the slide wear results for the following sheet steels:

- DP980 GI – CR600Y980T-DP: Hot Dip Galvanize (60G60G) coated
- 3rd Gen 980 GI – CR600Y980T-RA-SE: Hot Dip Galvanize (60G60G) coated
- 3rd Gen 980 GA – CR600Y980T-RA-HE: Hot Dip Galvanneal (45G45G) coated
- 3rd Gen 1180 GA – CR850Y1180T-RA: Hot Dip Galvanneal (45G45G) coated

Project Details

Participants

- Betz Industries (In-Kind)
- Alro Steel (In-Kind)
- Diehl Steel (In-Kind)
- Voestalpine (In-Kind)
- IonBond (In-Kind)
- Oerlikon Balzer (In-Kind)
- University of Windsor
- Microfixtures
- Sun Steel
- Synergy Additive Manufacturing, LLC

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Die Wear Pin- Material, Processing and Coating

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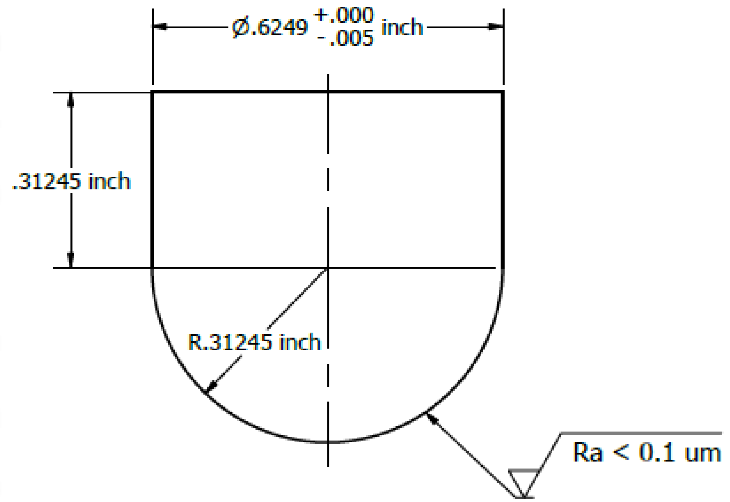

Pin Material	Heat Treat	Pin Coating
4140	No Heat Treat	M2
6510	No Heat Treat	M2
A2	Quench + Tempered	Ion Nitride + Multi-layer Cr based Coating
Proprietary A	Quench + Tempered	Ion Nitride + Multi-layer Cr based Coating
Proprietary B	Double Tempered @ or above 975 deg F	Ion Nitride + Multi-layer Cr based Coating
Proprietary C	Double Tempered @ or above 975 deg F	Ion Nitride + Multi-layer Cr based Coating

Project Approach - Testing Conditions

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Die Pin Materials/Coatings & Sheet Materials/Coatings:

1. 4140-M2-DP980-GI
2. D6510-M2-DP980-GI
3. A2-IN+MLCBC-3G980-GI
4. PA-IN+MLCBC-3G980-GI
5. PB-MLCBC-3G980-GA
6. PC-MLCBC-3G1180-GA

Pin size: ~15mm in diameter
(Pins: plasma nitride + coatings)

Sheet size: 300mm x 500mm

Test conditions:

Load: 600N (135 lbs)
Sliding velocity: 0.1 m/s
Distance per track: 0.1 m
Mill Oil density: 1 g/m^2
Number of tracks per row: 88

Number of sheets per pin: 3
Number of rows per sheets: 4 (2 front and 2 back)
Number of tracks per pin: 3 × 4 × 88 = 1056
Total sliding distance per pin: 105.6 m

PA= Proprietary Pin Material (A) **PB**= Proprietary Pin Material (B) **PC**= Proprietary Pin Material (C) **MLCBC**= Multi-Layer Chromium Based Coating

Tabletop Die Wear Tester

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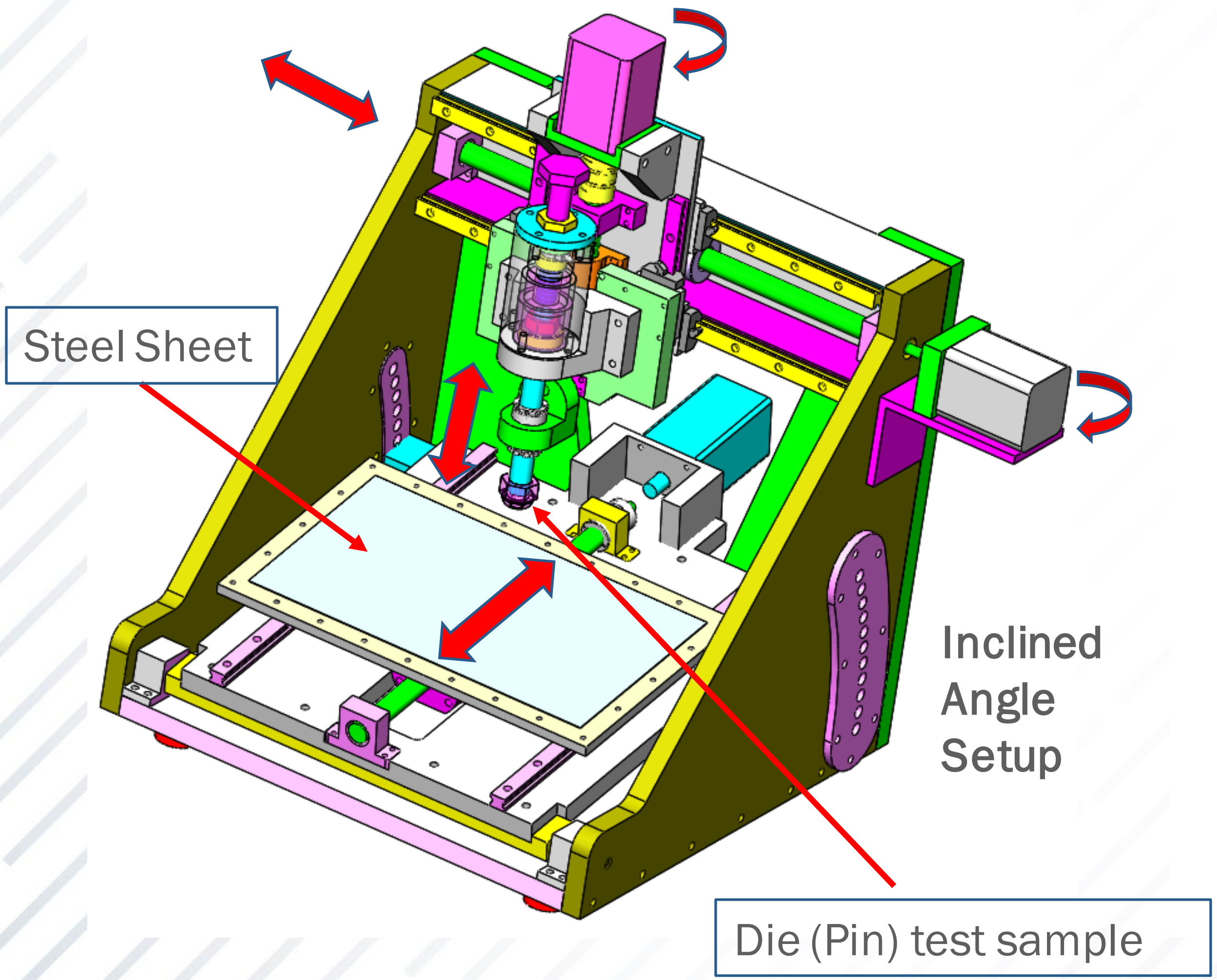
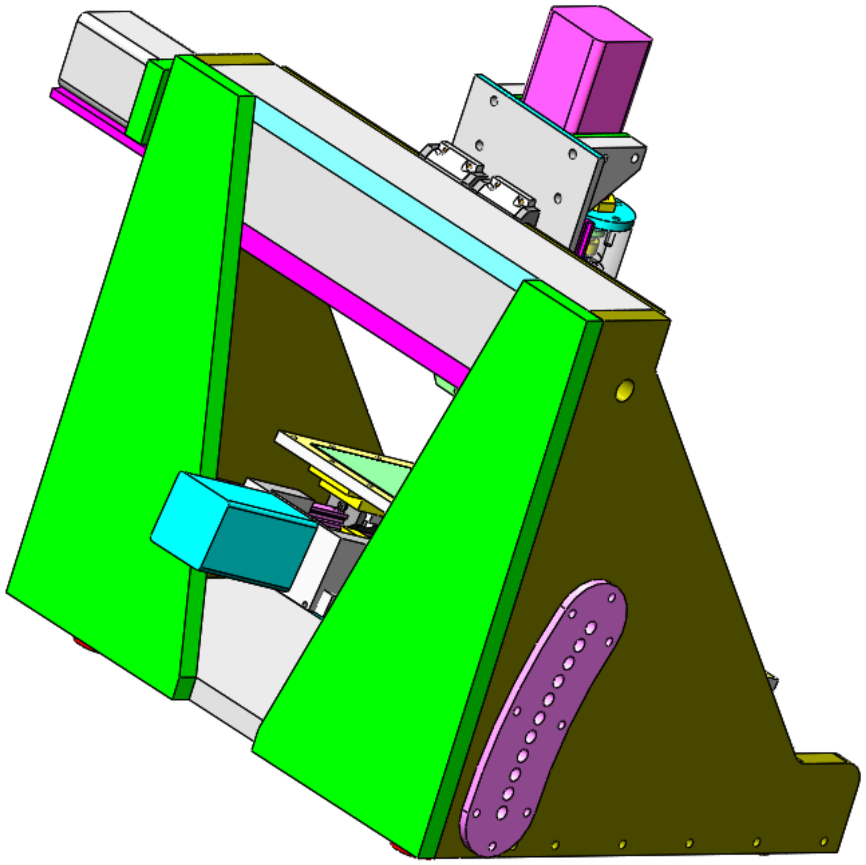
Front Isometric View



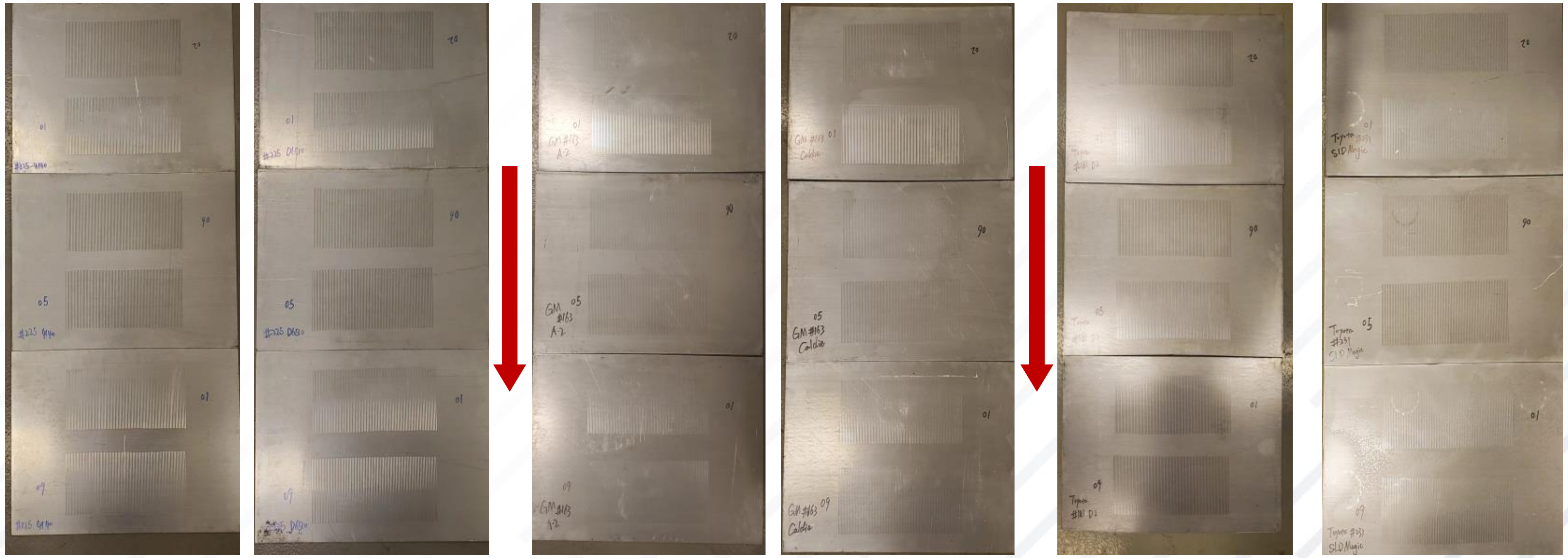
Back Isometric View



Project Results: Materials Tested

		CASE #1		CASE #2		CASE #3	
Test Material	Pin Material	4140	D6510	A2	Proprietary (A)	Proprietary (B)	Proprietary (C)
	Pin Coating	M2		Ion Nitride + Multi–Layer Cr Based Coating		Ion Nitride + Multi–Layer Cr Based Coating	
	Sheet Material & Coating	DP980-GI		3G980-GI		3G980-GA	3G1180-GA

Sheet Samples



Project Results: Materials Tested

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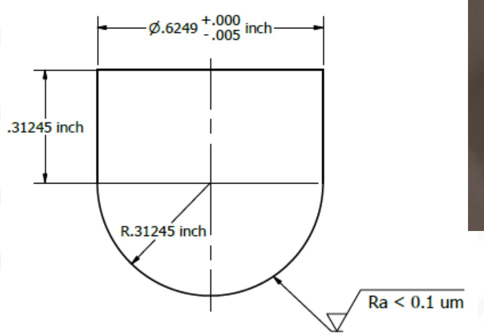
		CASE #1		CASE #2		CASE #3	
Test Material	Pin Material	4140	D6510	A2	Proprietary (A)	Proprietary (B)	Proprietary (C)
	Pin Coating	M2		Ion Nitride + Multi–Layer Cr Based Coating		Ion Nitride + Multi–Layer Cr Based Coating	
	Sheet Material & Coating	DP980-GI		3G980-GI		3G980-GA	3G1180-GA








Die Pins

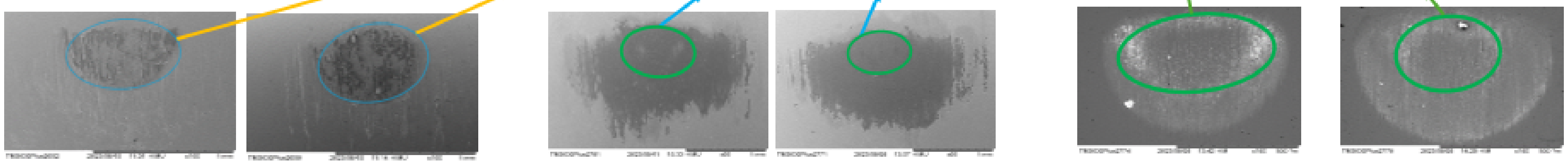
Project Results: Sheet Wear and Die Pin Wear

		CASE #1		CASE #2		CASE #3	
Test Material	Pin Material	4140	D6510	A2	Proprietary A	Proprietary B	Proprietary C
	Pin Coating	M2		Ion Nitride + Multi-layer Cr based Coating		Multi-layer Cr based Coating	
	Sheet Material	DP980-GI		Gen3 980-GI		Gen3 980-GA	Gen3 1180-GA
Sheet Wear Track Width (mm)	Row #1 (1st sheet)						
	Row #6 (2nd sheet)						
	Row #12 (3rd sheet)						
Sheet Wear Track Depth (µm)	Row #1 (1st sheet)						
	Row #6 (2nd sheet)						
	Row #12 (3rd sheet)						
Pin Wear Scar	Formation	Minor Material Transfer + Scratches		Top Layer (solid lubricant) wear		Scratches + Minor Material Transfer	Scratches + Minor Material Transfer
	Affected Area (mm^2)						
	Wear/Contact Area (mm^2)	Galling	Galling	Minor Wear	Minor Wear	Minimum Wear	Minimum Wear

KEY - TRACK WIDTH	
0% TO 4.9%	5% TO 9.9%
10% TO 14.9%	>15%

KEY - TRACK DEPTH	
0% TO 24.9%	25% TO 49.9%
50% TO 74.9%	>75%

KEY - PIN WEAR	
LEAST	
	MOST



Project Results: Die Pin Analysis

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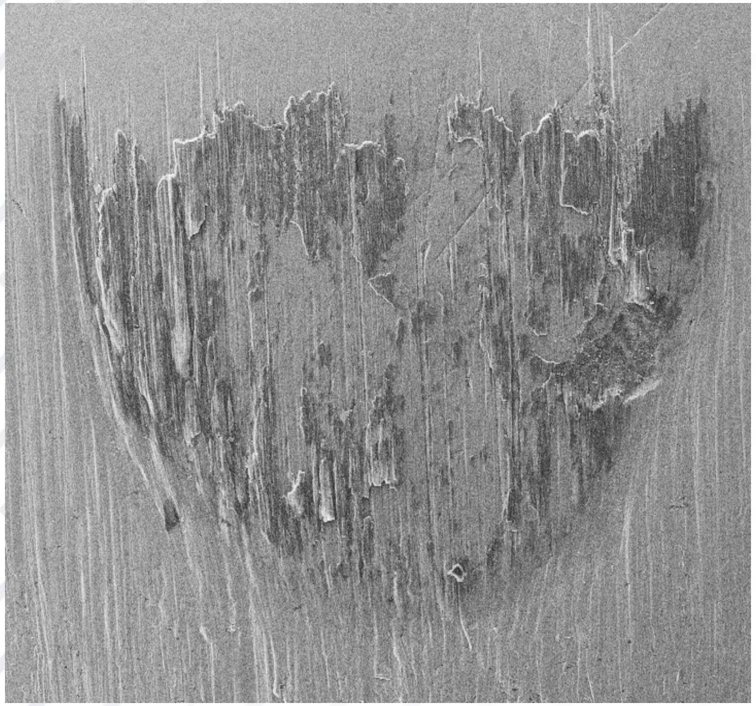
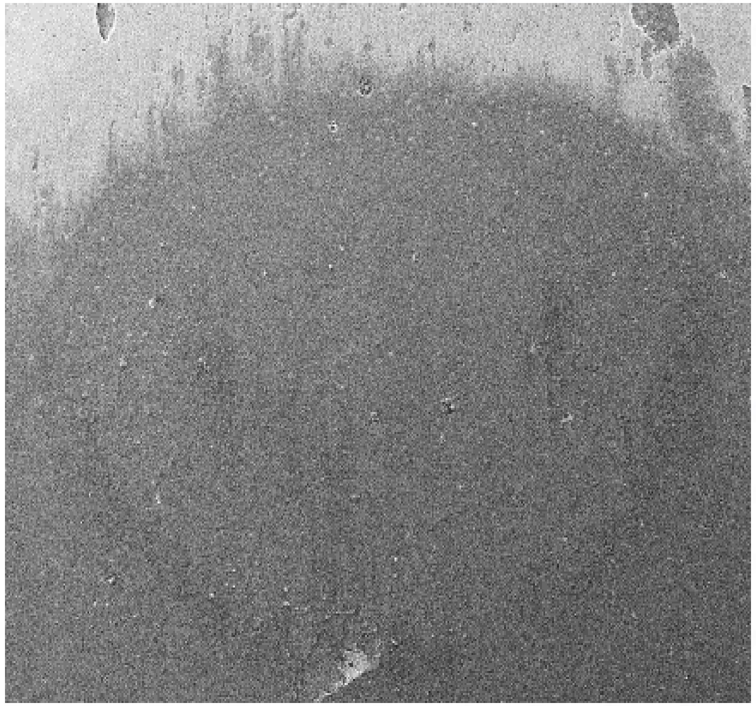


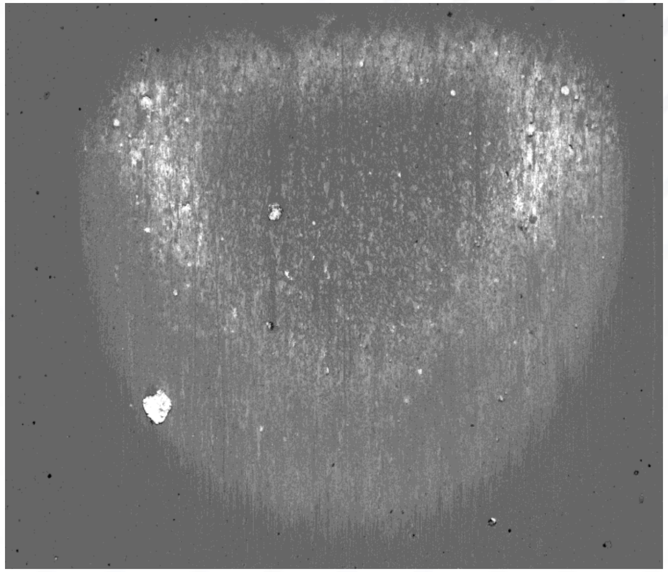
(4140-M2-DP980-GI)
Contact Width: ~0.92 mm

1



(P(A)-IN+MLCBC-3G980-GI)
Contact Width: ~0.90 mm

2

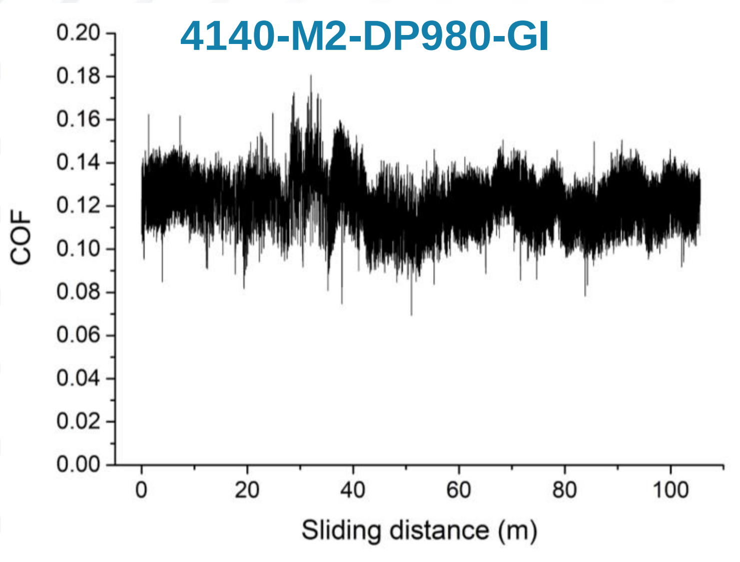


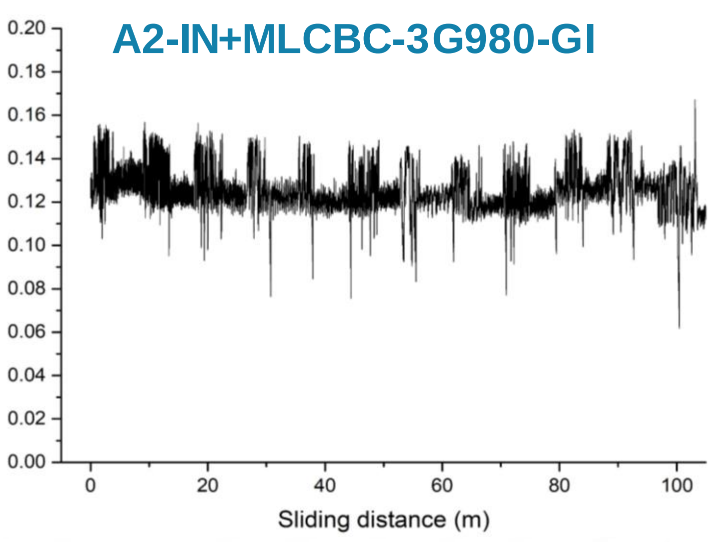
(P(B)-MLCBC-3G980-GA)
Contact Width: ~0.77 mm

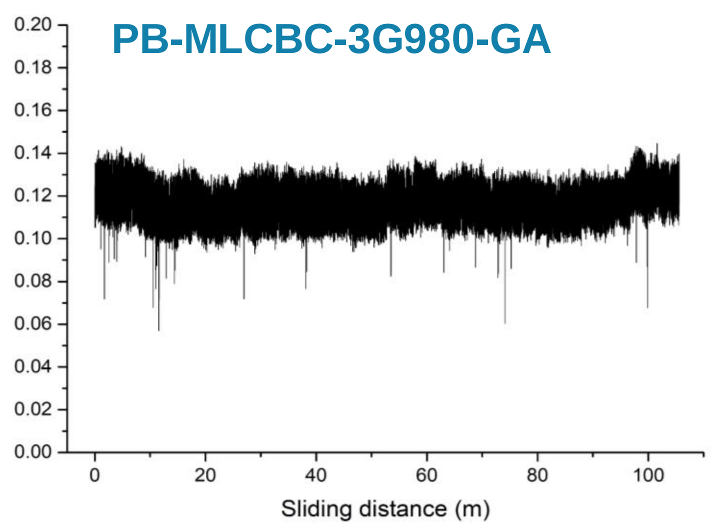
3

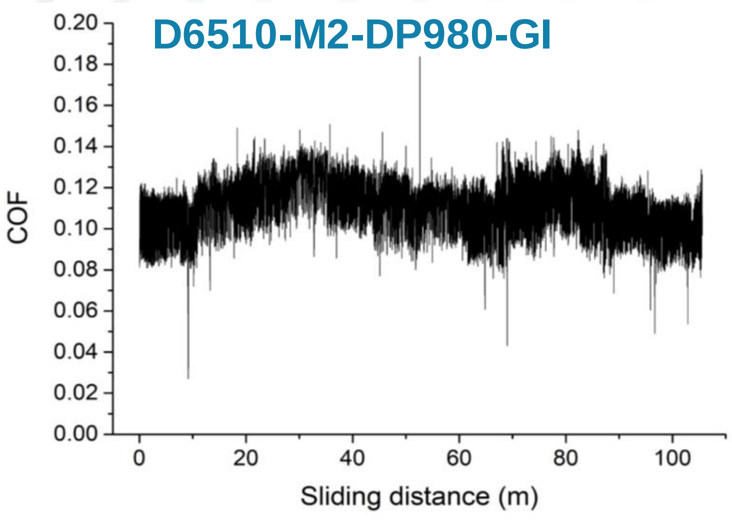
Observations:
1- Zn-wear debris severely adhered on the M2 coating surface at the contacting and surrounding areas.
2- Some Zn-wear debris adhered on the multi-layer Cr based coating at the contacting and surrounding areas.
3- Minimum Zn-Fe wear debris (high hardness) attached on the multi-layer Cr based coating.

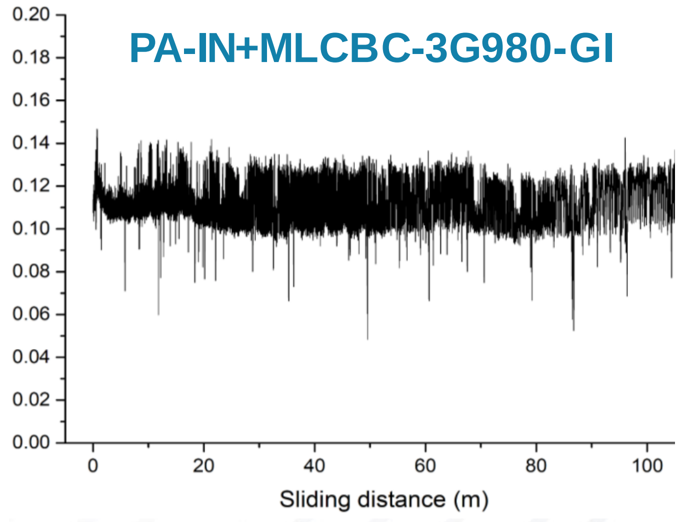
Project Results: Coefficient of Friction

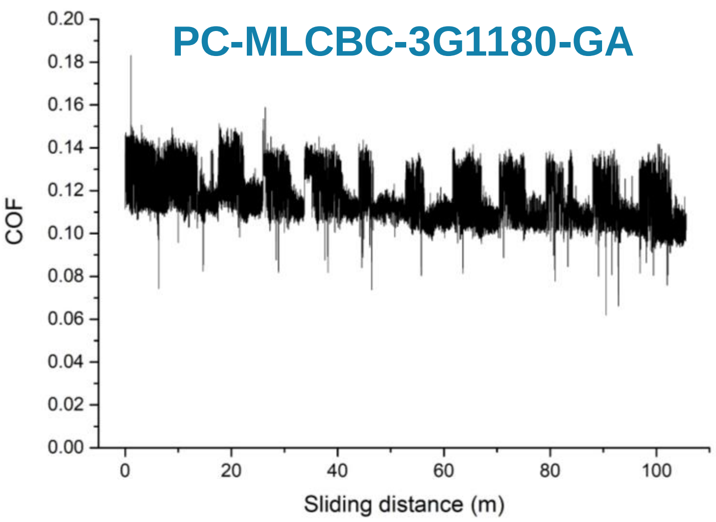












Project Summary / Conclusion

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a. Overall:
   - The test method was able to show that wear and friction behavior were largely influenced by coating, substrate and sheet materials/coatings.

b. M2 and MLCB Coatings
   - For the M2-coated pin case, the wear track width and depth on the steel sheet increased with the sliding distance (Case #1). The wear tracks on steel sheets didn’t change much for cases of both MLCB-coated pins (Case #2 and Case #3).
   - M2 coating had a significant material transfer from the sheet metal and appeared to have many wear scratches. The top (solid lube) layer of MLCB coating was worn off around the contact areas, which may be related to a negative effect of the GI coating on the steel sheet.

c. Sheet Steel coatings
   - The GA coating caused a less material transfer to the pin surface, likely due to its higher hardness of Zn-Fe alloyed surface. The zinc from the GI coated steel transferred and adhered to the pin surfaces (severe for M2 coated pins and less severe for the ionitrided+MLCBC case), which caused a much wider wear scar on both M2-coated and ionitrided+MLCB coated pins.
   - M2-coated pin against the GI steel could show a higher coefficient of friction (COF). However, COF value was influenced by many variables.

Value Proposition

- The Sliding Wear Test improves our understanding on the effect of sheet coating and tool materials and coatings to sheet-die friction, sliding energy, and wear pattern/mechanism, which can guide stamping process and die design for advanced and ultra high strength steels.

Pros and Cons

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- Advantages
  - The Sliding Wear Test more closely represents the contact and sliding conditions in the stamping production.
  - The test is very effective in evaluating tool systems (base metal, heat treat, coating, surface finish, etc.) against sheet steel, coated or uncoated.

- Disadvantages
  - The test is time consuming and costly, but the results are valuable based on the advantages listed earlier.
  - For soft surface and low friction conditions, such as coated sheet steel, more test coupons are required, which increases testing time and cost.
  - The correlation with stamping operations and standardized wear tests is not yet known.

Next Steps

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- The Stamping Tooling Optimization project team is performing a literature study to determine state of the art developments in die wear testing and technologies.
- Additional analysis of the tested pins will be performed.

For more information

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