Evaluation of Die Wear with Stamping DP1180 Steel

A/SP Stamping Tooling Optimization

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Introduction

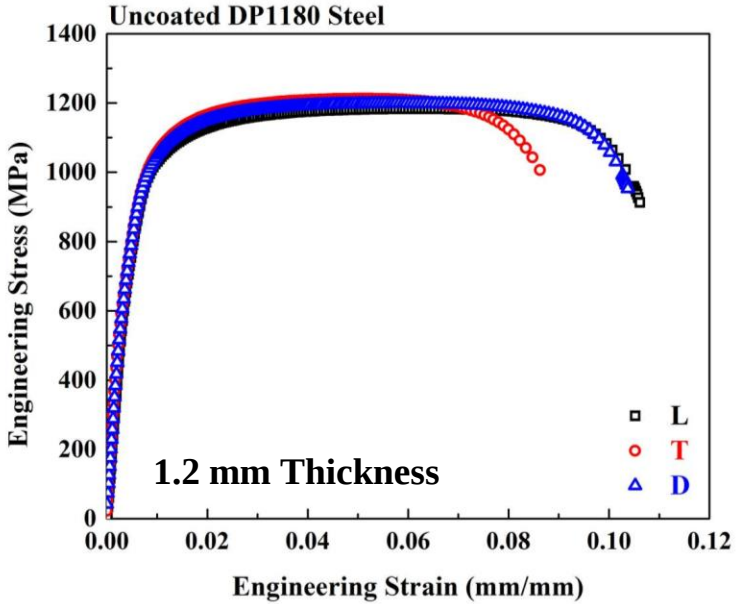
Objectives:

- 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.

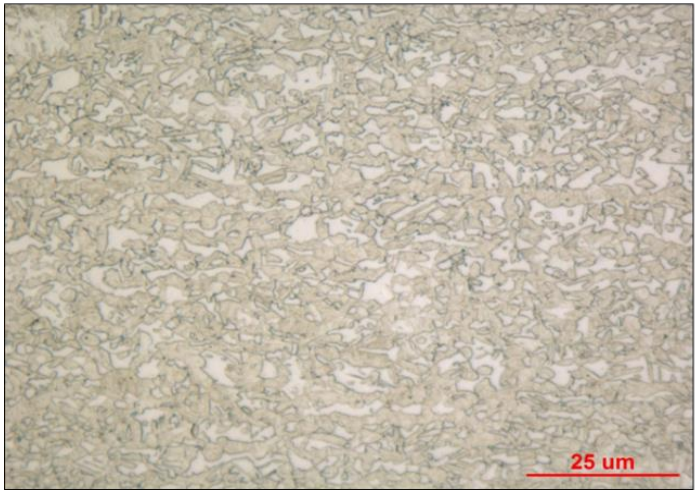
Project Phases:

- **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



Sample Orientation	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Uniform Elongation (%)	Total Elongation (%)
L	919	1182	5.6	10.6
T	926	1212	5.1	8.8
D	909	1198	5.4	10.4



Dark color: Martensite
Light color: Ferrite

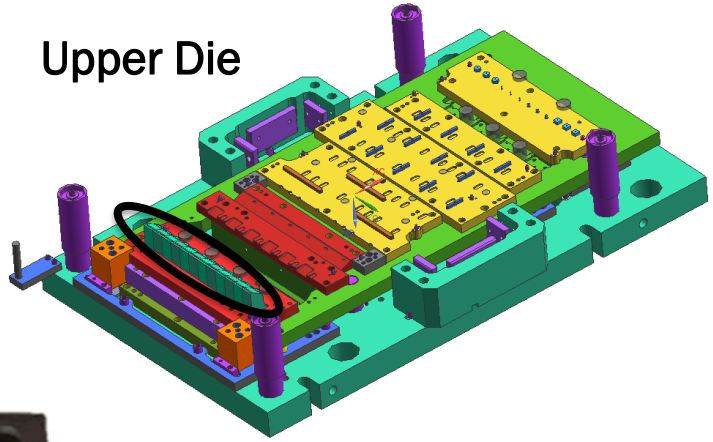
The phase volume fraction of martensite was found to be approximately 70 %.

Die Wear Experiment in Production Environment

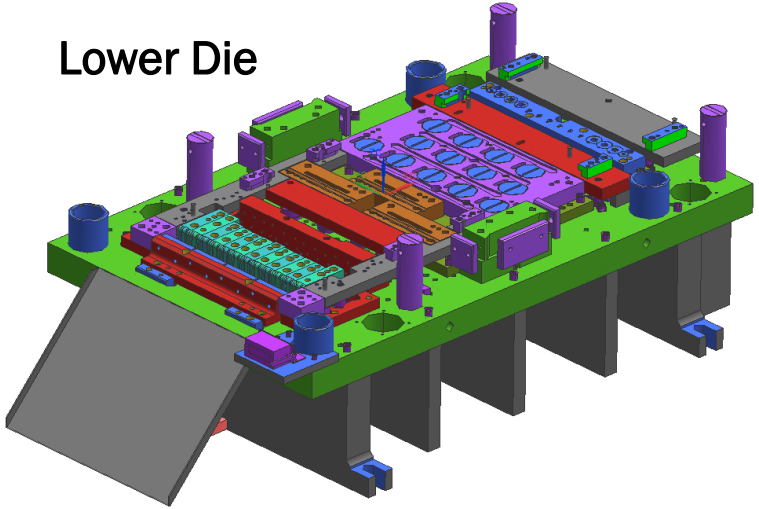
- Over 100k hits;
- 33 die inserts;
- Combination of 10 die materials and 9 coatings;
- 42 Ton testing materials;
- Preserve one panel every 500 hits;

Progressive Die Setup

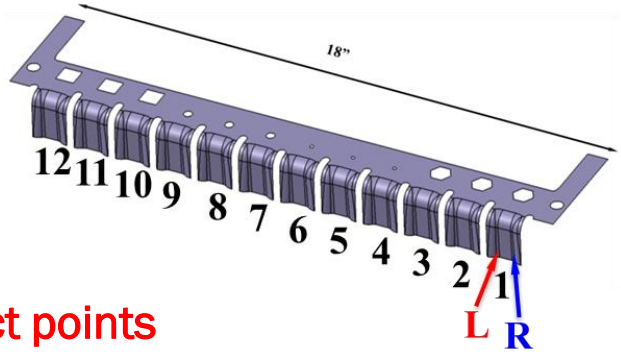
Upper Die

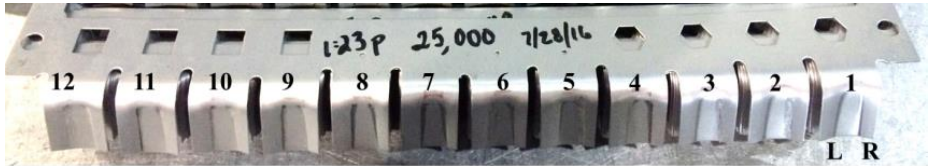


Lower Die

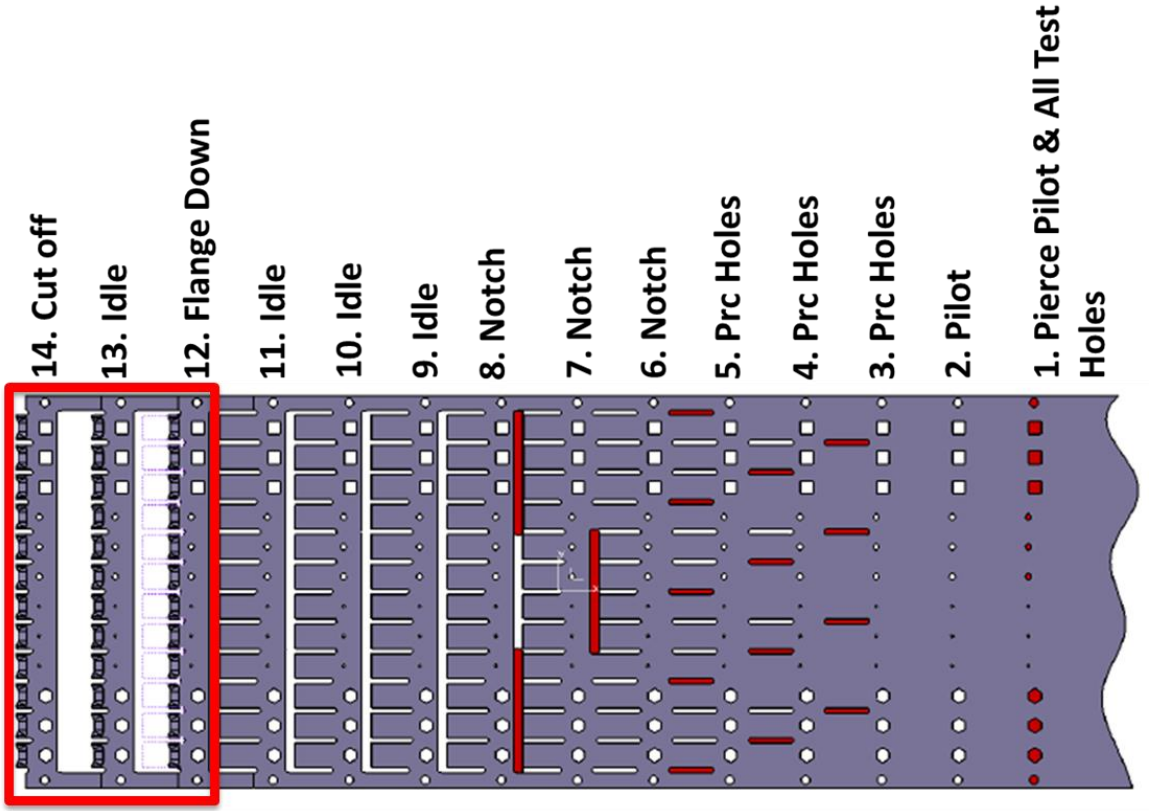


Contact points

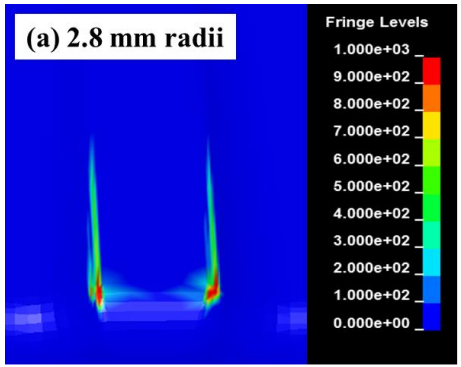


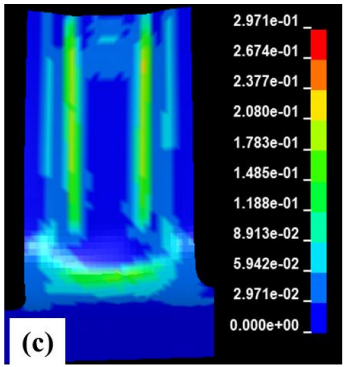


Progressive Die Setup



Forming Simulation for Progressive Die Wear

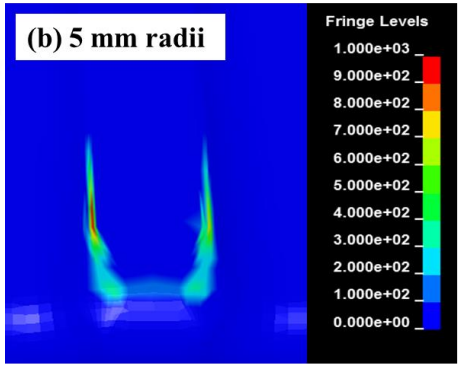


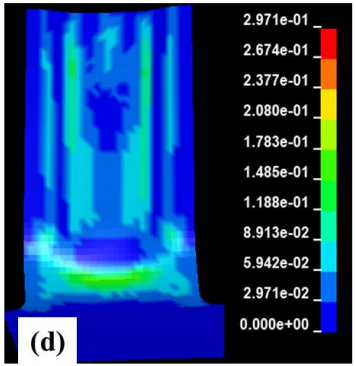


2.8 mm radii

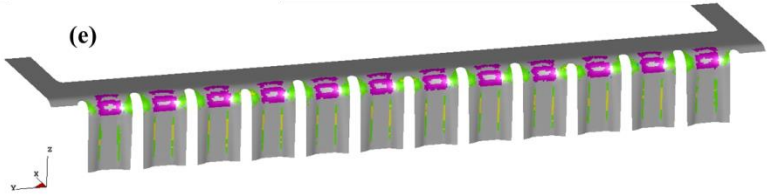
Sliding Energy Density

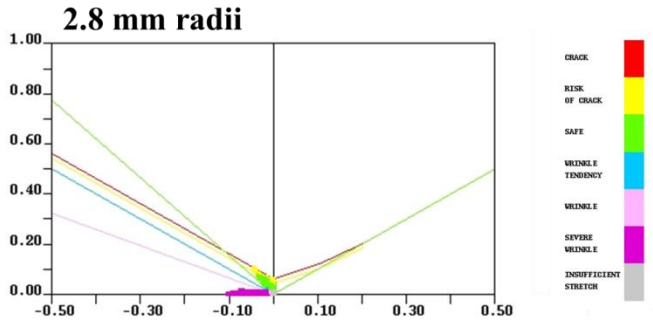
Effective Strain





5 mm radii





A “worst” case scenario:

1. Relative aggressive die insert design;
2. Uncoated sheet metal;
3. No lubrication.

2015 Progressive Die Wear Experiment Matrix

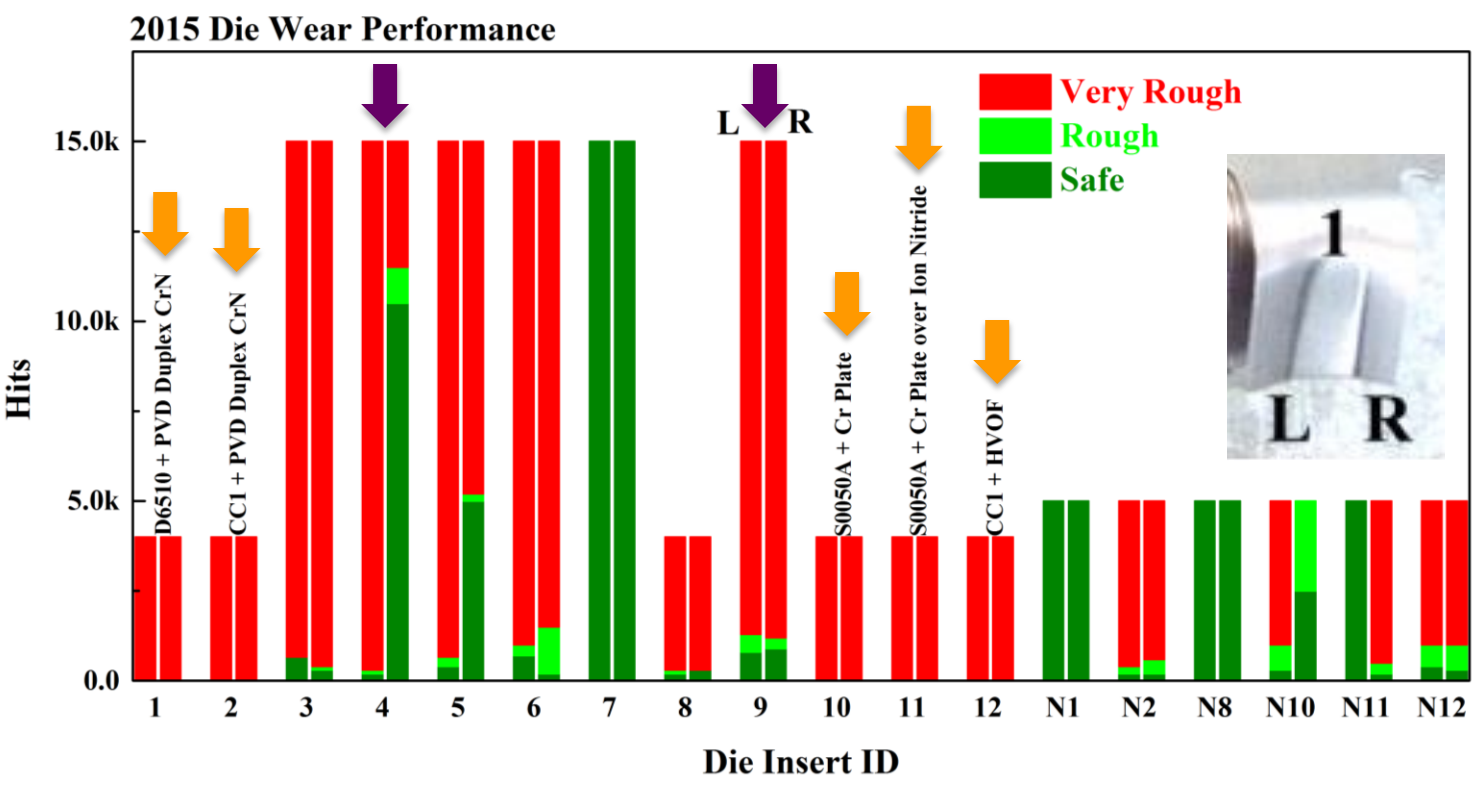
	12	11	10	9	8	7	6	5	4	3	2	1
Die Mater.	CC1	S0050A	S0050A	S2333	TD2	TD2	DC53	TD2	TD2	T44	CC1	D6510
Coating	HVOF MPD	Cr Plate over Ion Nitride	Cr Plate	PVD Duplex CrN	Concept	Cool Sheet	PVD Duplex CrN	PVD Duplex CrN	PVD Duplex CrN	PVD Duplex CrN	PVD Duplex CrN	PVD Duplex CrN
Hardness (Rc)	54-58	38-43	54-58	40-45	55-60	55-57	55-60	55-57	55-58	44-46	38-42	54-58

	12	11	10	9	8	7	6	5	4	3	2	1
Die Mater.	D2 (NEW)	D2 (NEW)	D2 (NEW)		TD2 (NEW)						D2 (NEW)	D2 (NEW)
Coating	PVD Duplex CrN	PVD Duplex CrN	PVD Duplex CrN		Concept + Most						PVD Duplex CrN	PVD Duplex CrN
Hardness (Rc)	58-60	58-60	58-60		58-60						58-60	58-60

NO. 1, 2, 8, 10, 11, and 12 were replaced by new inserts after 15,000 hits

The combinations of 8 die materials and 7 coatings were evaluated up to 20k hits.

2015 Progressive Die Wear Experimental Results



2016 Progressive Die Wear Experiment Matrix

	12	11	10	9	8	7	6	5	4	3	2	1
Die Mater.	SLD-i	TD2	DC53	Cast Caldie	TD2	TD2-old	TD2	SLD-i	Toolox 44	Cast Caldie	S2333	S2333
Coating	Concept + most	Duplex Variantic	Concept + most	Concept + most	Duplex CrN + most	Cool sheet	Concept + most	Cool sheet	Cool sheet	Cool sheet	Cool sheet	Cool sheet
Hardness (Rc)	58-62	55-58	62-64	58-62	55-58	55-57	55-58	58-62	-	58-62	50-54	40-45

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

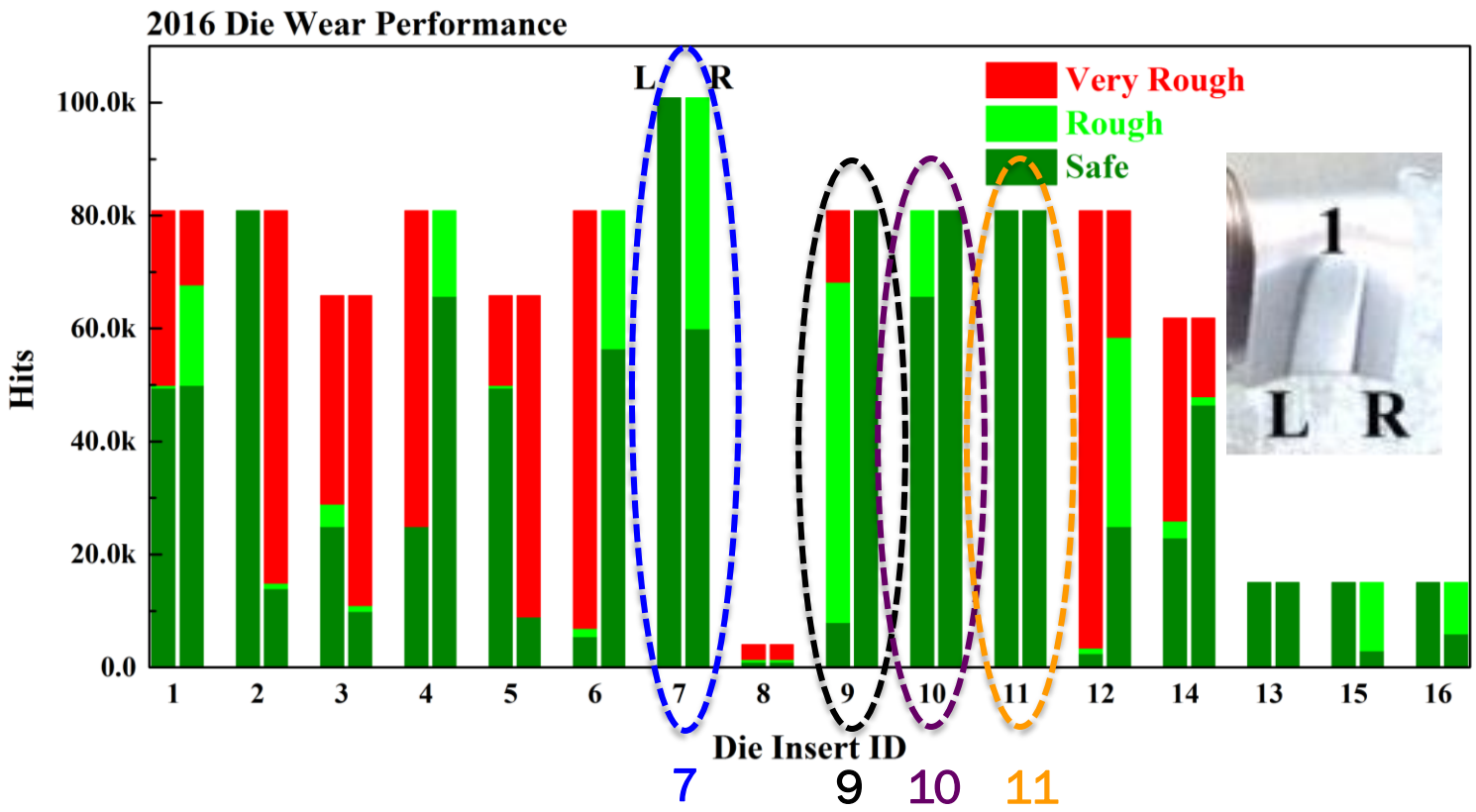
No. 3 was replaced by No. 13;
No. 5 was replaced by No. 15;
No. 14 was replaced by No. 16;
After 70,000 hits

	14 and 16
Die Mater.	TD2
Coating	Concept + most
Hardness (Rc)	55-58, N.A.

	15		13
Die Mater.	S2333	Die Mater.	TD2
Coating	Concept + most	Coating	Concept (only)
Hardness (Rc)	40-45	Hardness (Rc)	55-58

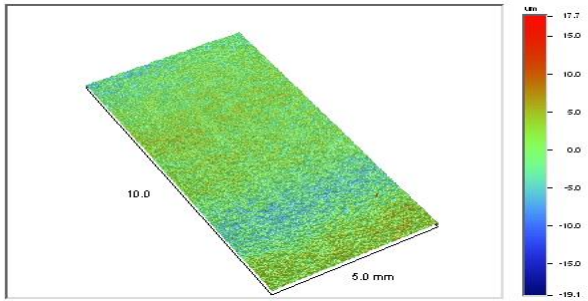
The combinations of 8 die materials and 5 coatings were evaluated up to 85.8k hits.

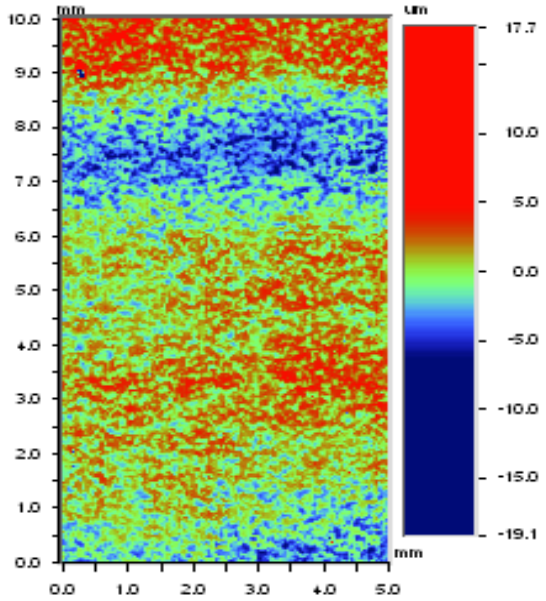
2016 Progressive Die Wear Experimental Results



Roughness Measurements using Wyko Machine

As-received Sheet Sample



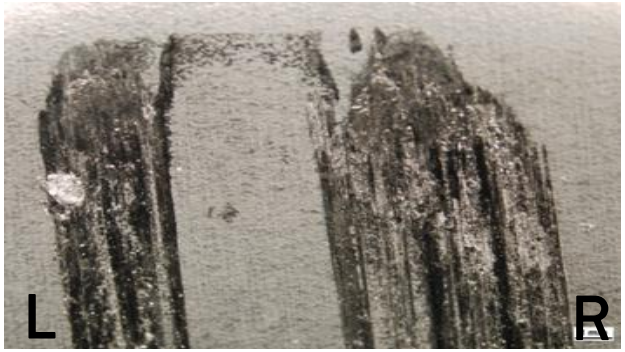


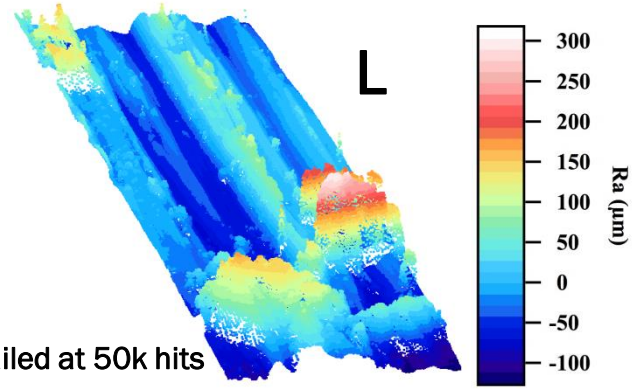
WYKO NT1100
VSI mode
Objective: 10X
FOV: 5X
Long wave length cutoff: 800 µm
Short wave length cutoff: 8 µm
Stylus Pc height: 1.25 µm

Mapping area: 5 x 10 mm^2
Ra: 1.83 µm

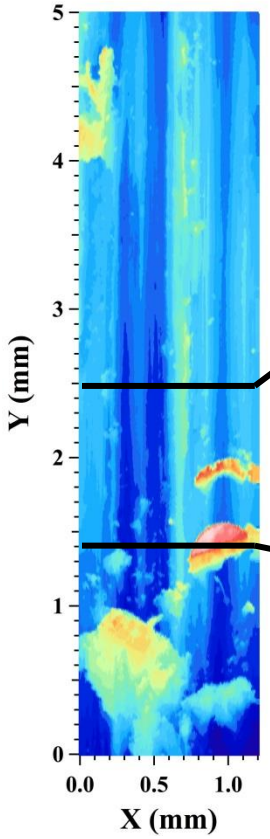
Roughness Measurements using Wyko Machine

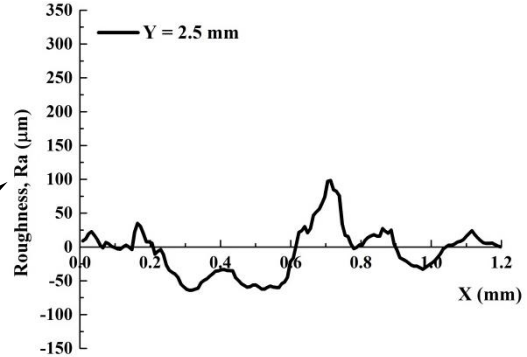
Insert 5, SLD-i + Cool Sheet

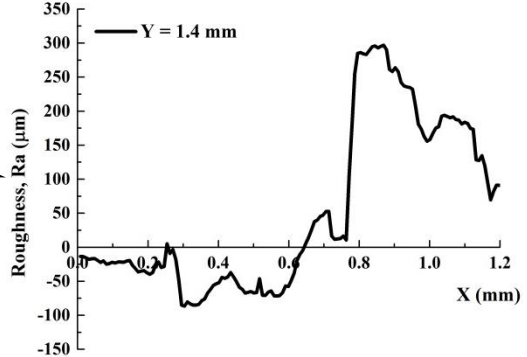




Failed at 50k hits

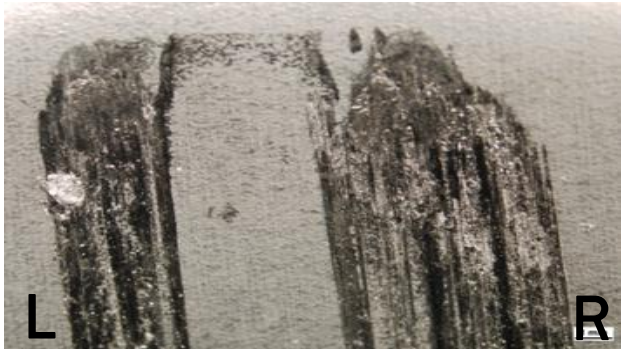


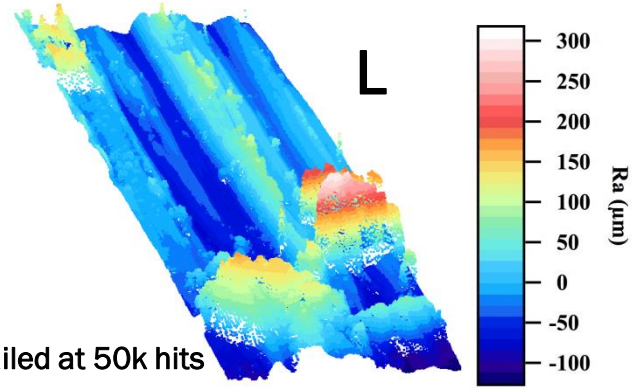




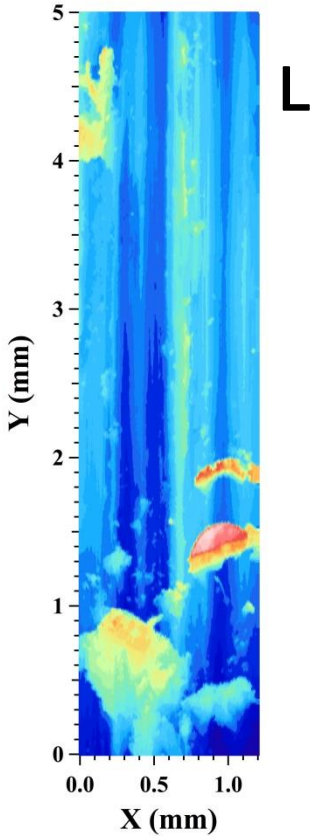
Roughness Measurements using Wyko Machine

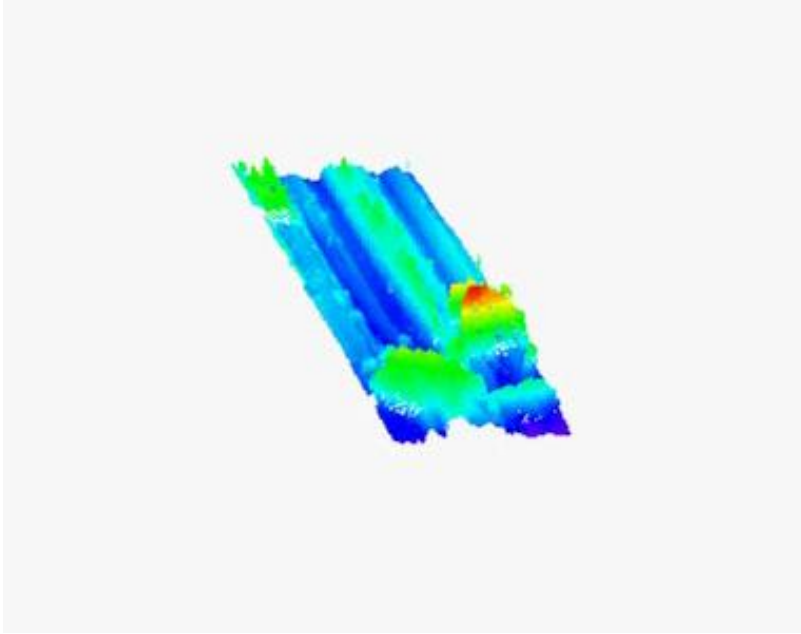
Insert 5, SLD-i + Cool Sheet





Failed at 50k hits



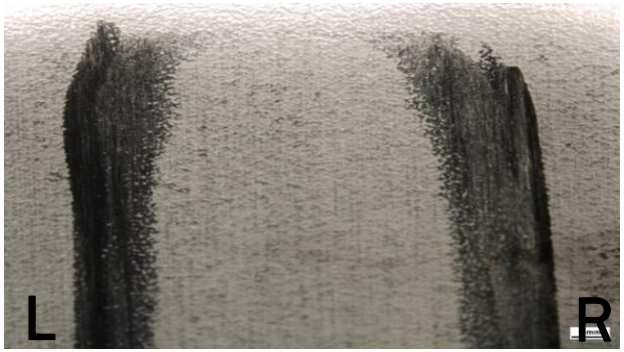


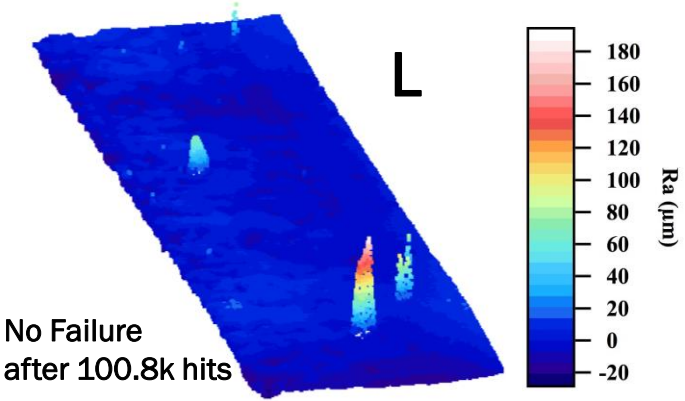
Mapping area: 1.2 x 5 mm^2

Ra: 9.69 μm (1.83 μm)

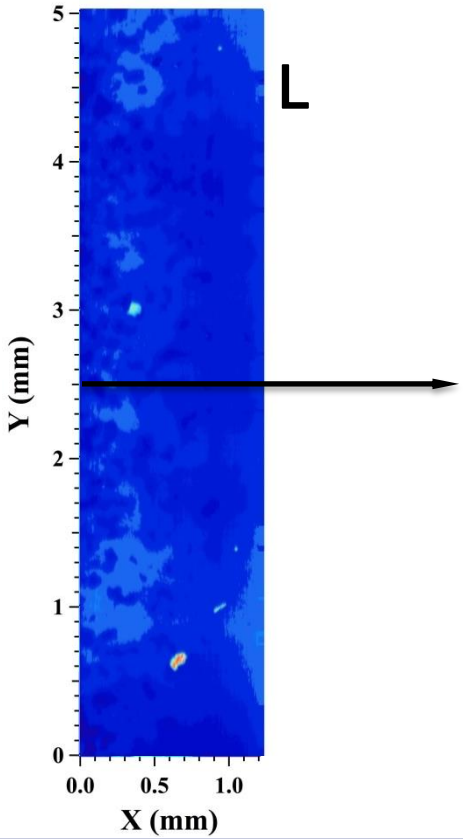
Roughness Measurements using Wyko Machine

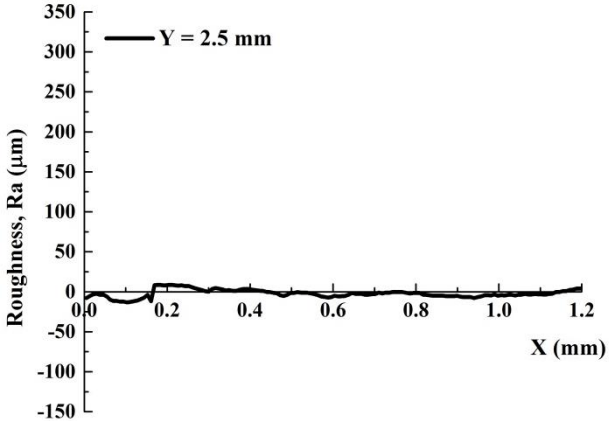
Insert 7, TD2 + Cool Sheet





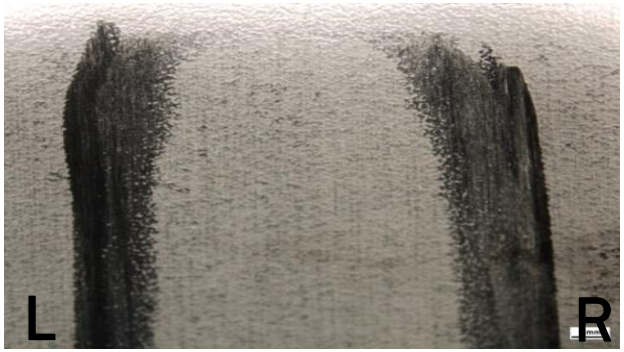
No Failure
after 100.8k hits

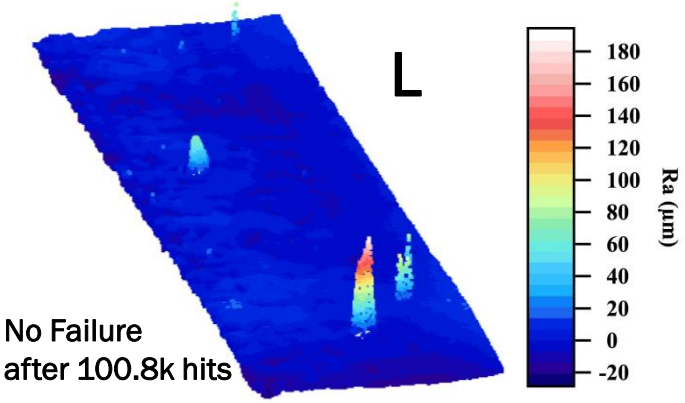




Roughness Measurements using Wyko Machine

Insert 7, TD2 + Cool Sheet





No Failure
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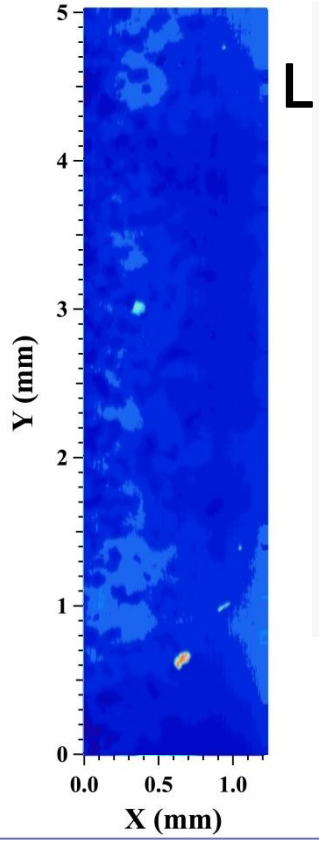
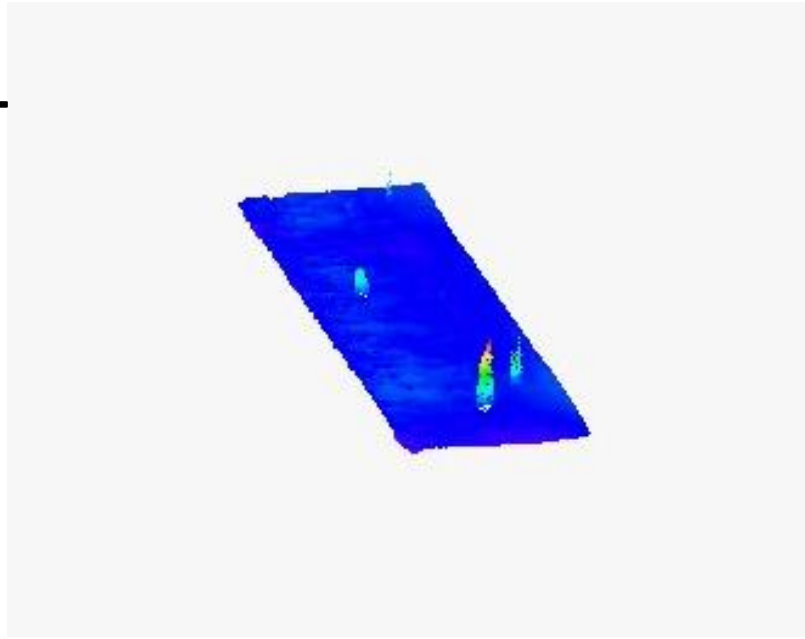
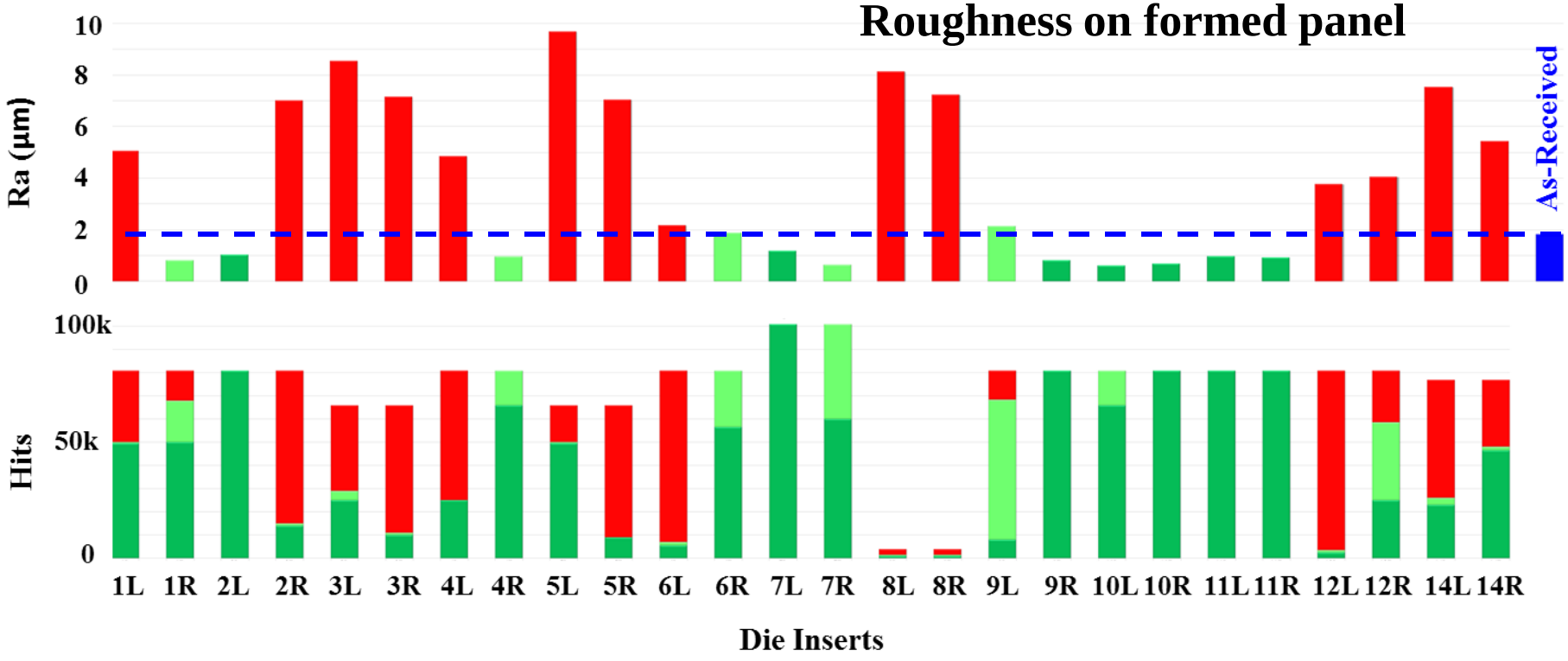


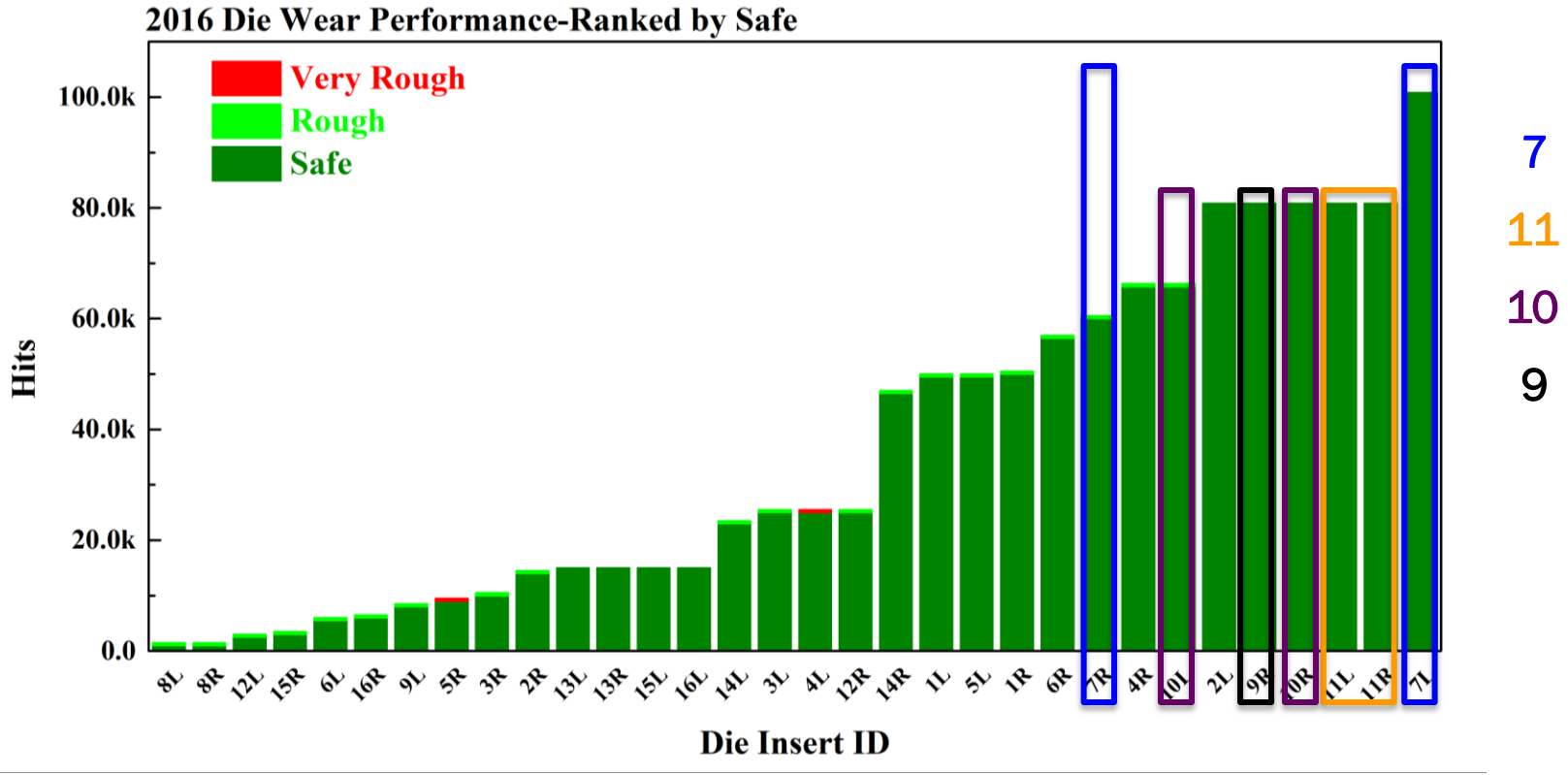


Mapping area: 1.2 x 5 mm^2
Ra: 1.19 μm (1.83 μm)

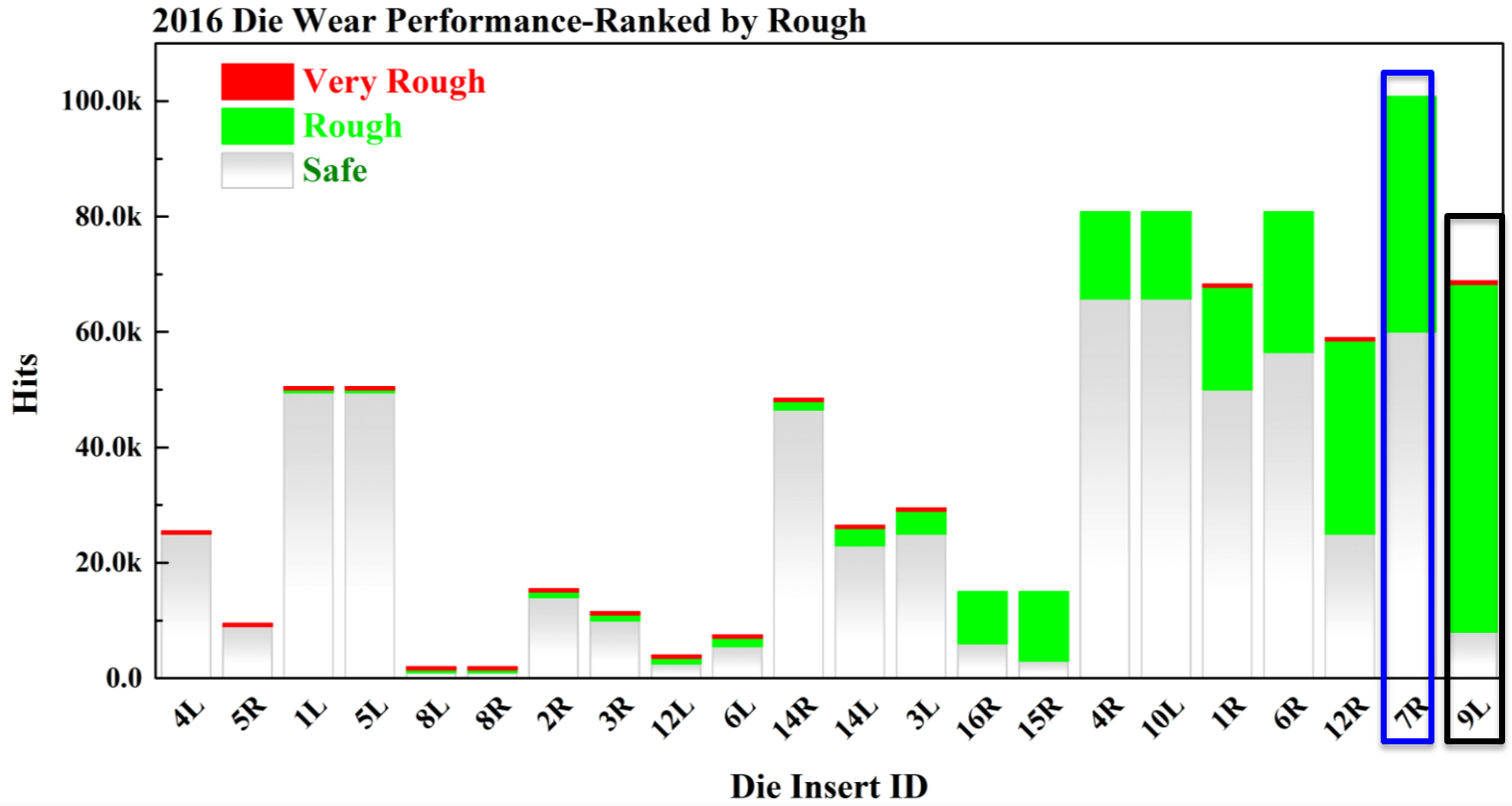
Roughness Results after 100,800 hits



2016 Die Wear Performance: Crack Initiation Resistance



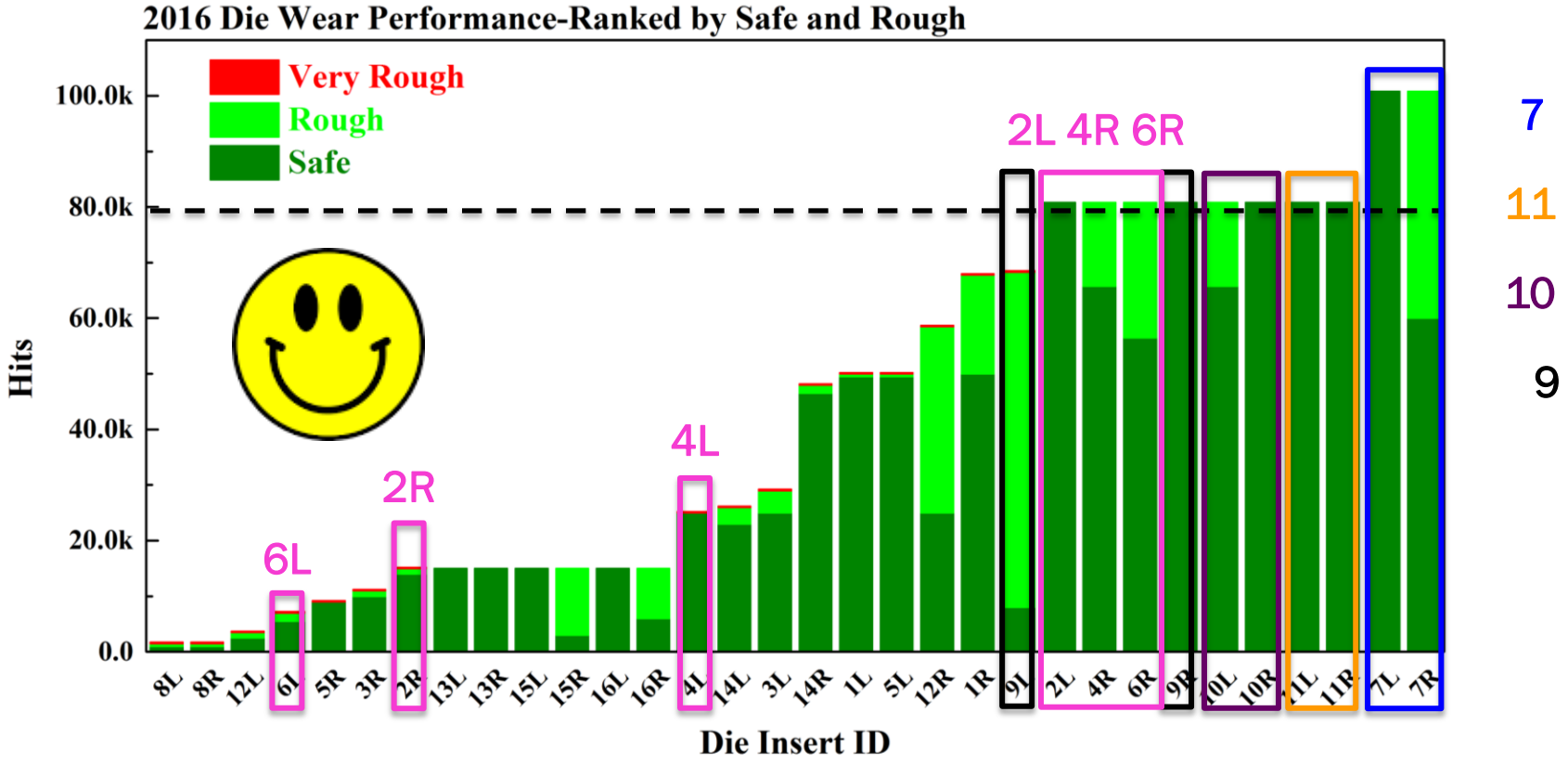
2016 Die Wear Performance: Crack Propagation Resistance



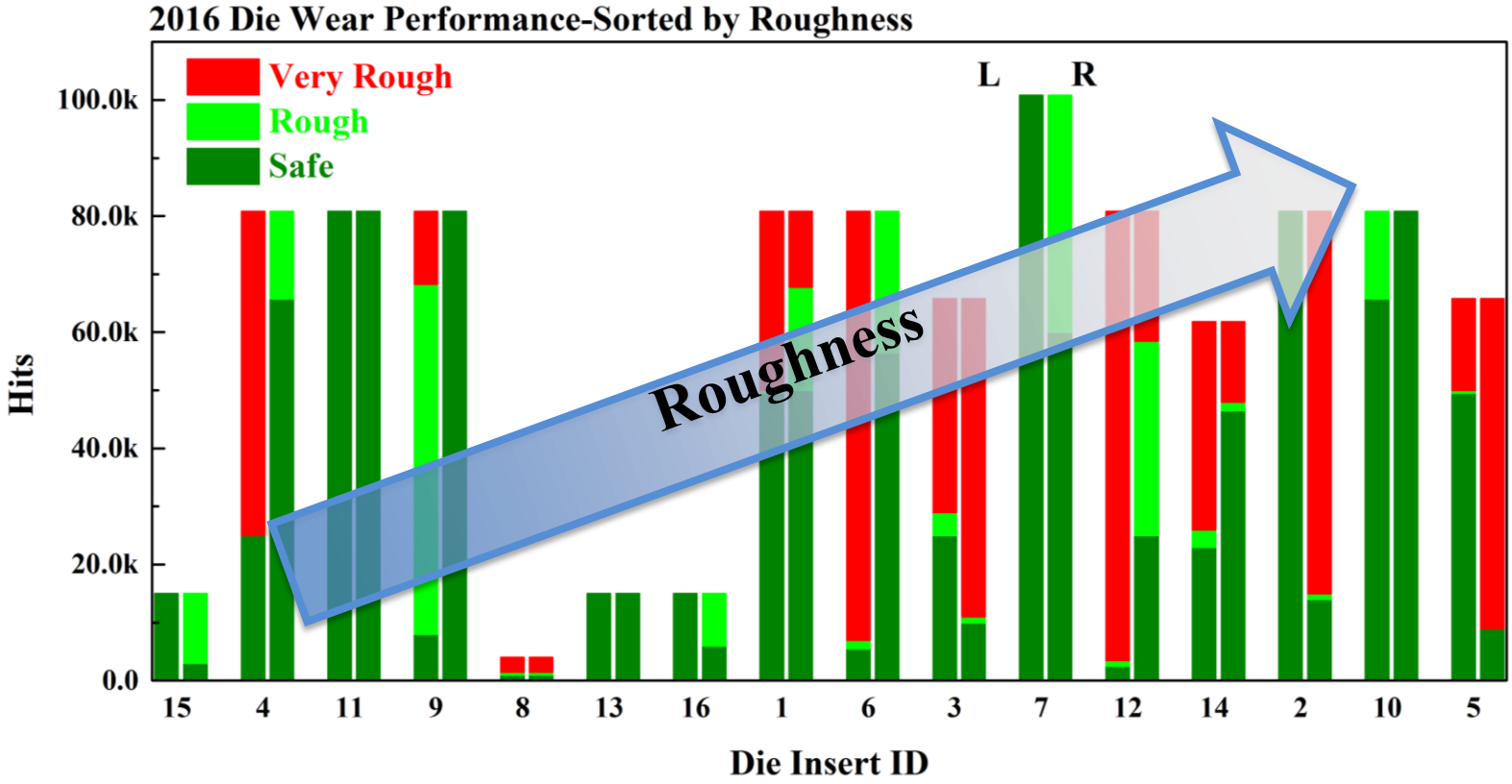
9

7

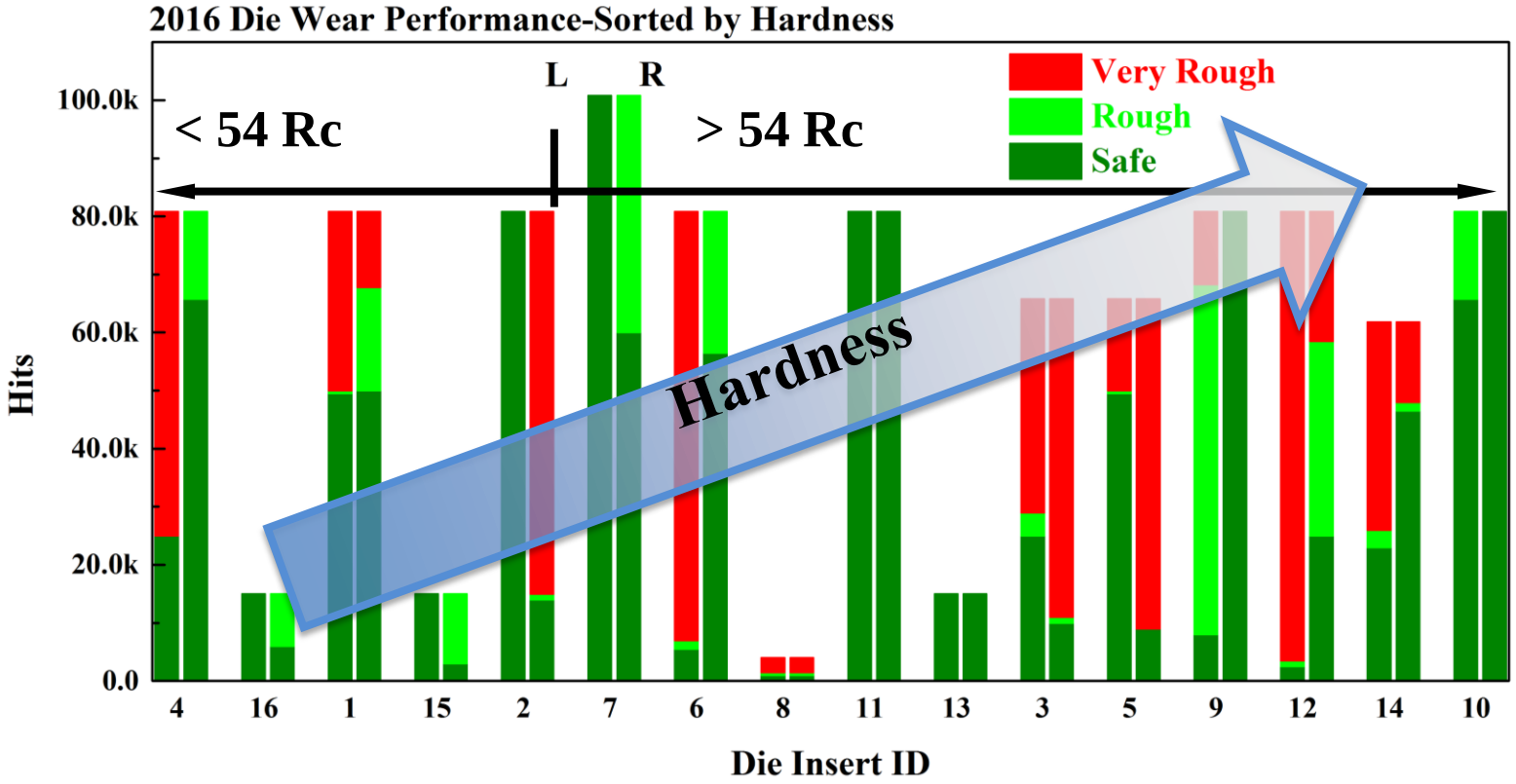
2016 Die Wear Overall Performance



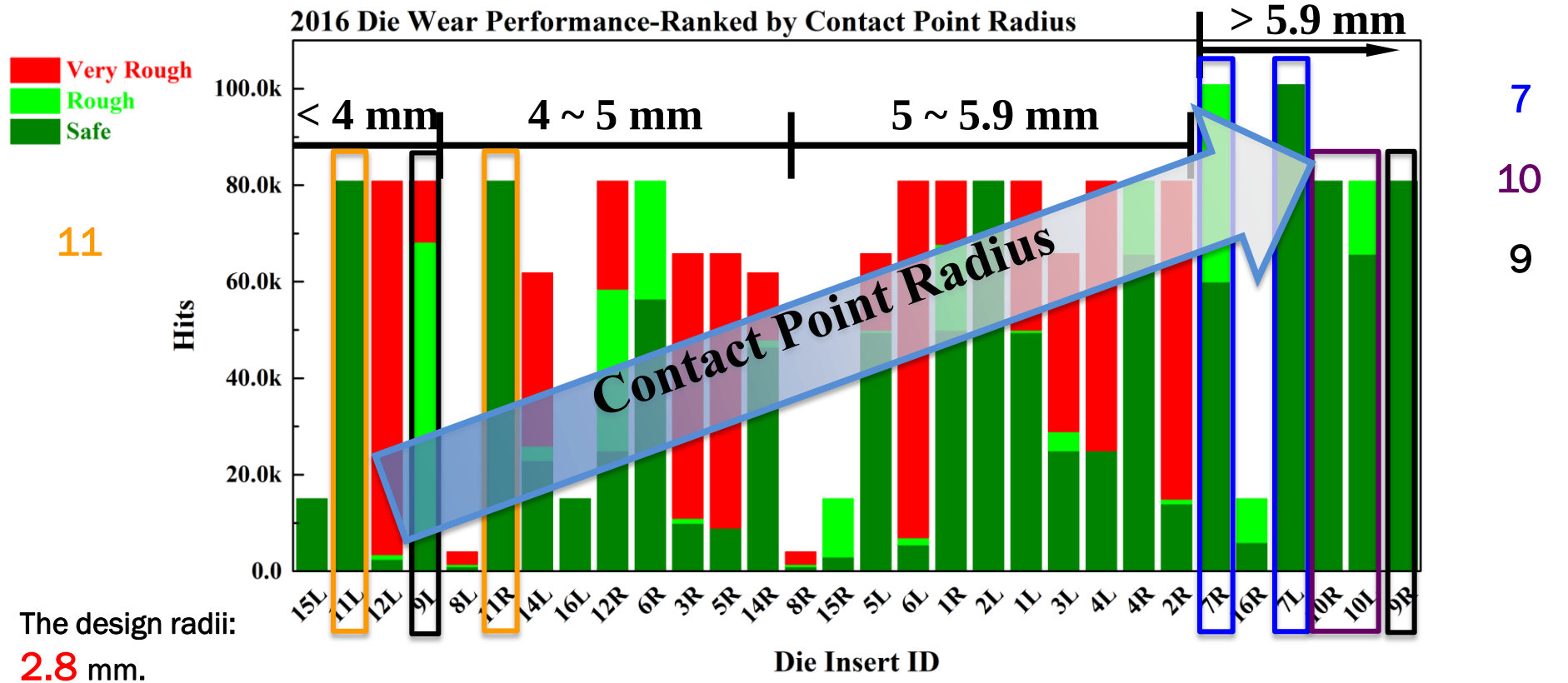
Correlation Between Die Wear and Roughness



Correlation Between Die Wear and Hardness



Correlation Between Die Wear and Radius



11

7

10

9

The design radii:

2.8 mm.

The Factors Influencing Die Wear Performance

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.

For More Information

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