

GREAT DESIGNS IN **STEEL**

Additive Metals - Phase II, Direct Energy Deposition(D.E.D.)

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Stamping Automation Engineer – Servo Press

General Motors Company

(Presenting for Auto/Steel Partnership)





Auto/Steel
Partnership

Members



METALSA

NUCOR®

POSCO



PROJECT TEAM MEMBERS

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Project Lead: Jonathan Ellert

Project Co-Lead: Brendan Larsen

Project Manager: Michael White, A/SP

Project Team Members:

- Ohyoung Choi, General Motors
- Patrick Ricchi, General Motors
- Paul Wolcott, General Motors
- Shawn Schaffert, General Motors
- Dean Kanelos, Nucor
- Arnie Newsome, Nucor
- Jiwoong Ha, Posco America
- Philippa Chiu, Stellantis
- Andrew Pardin, Stellantis

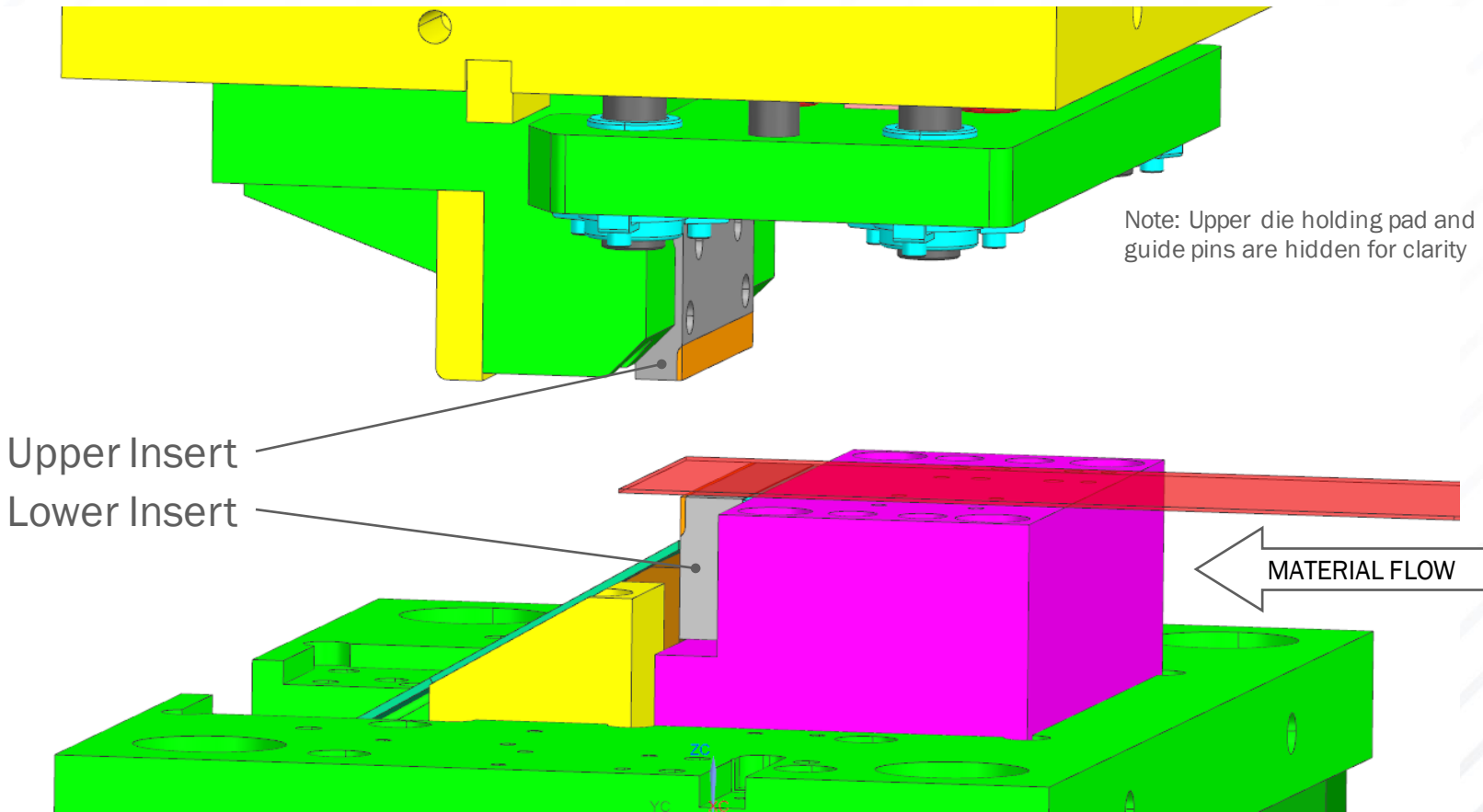
Project Details

- Problem Statement:
 - Powder-based additive manufacturing has been studied in forming operations. There is minimal information regarding trimming operations.
- Goal:
 - To validate the use of powder-based direct energy deposition (DED) for trimming operations in stamping dies.

Project Details (Con't)

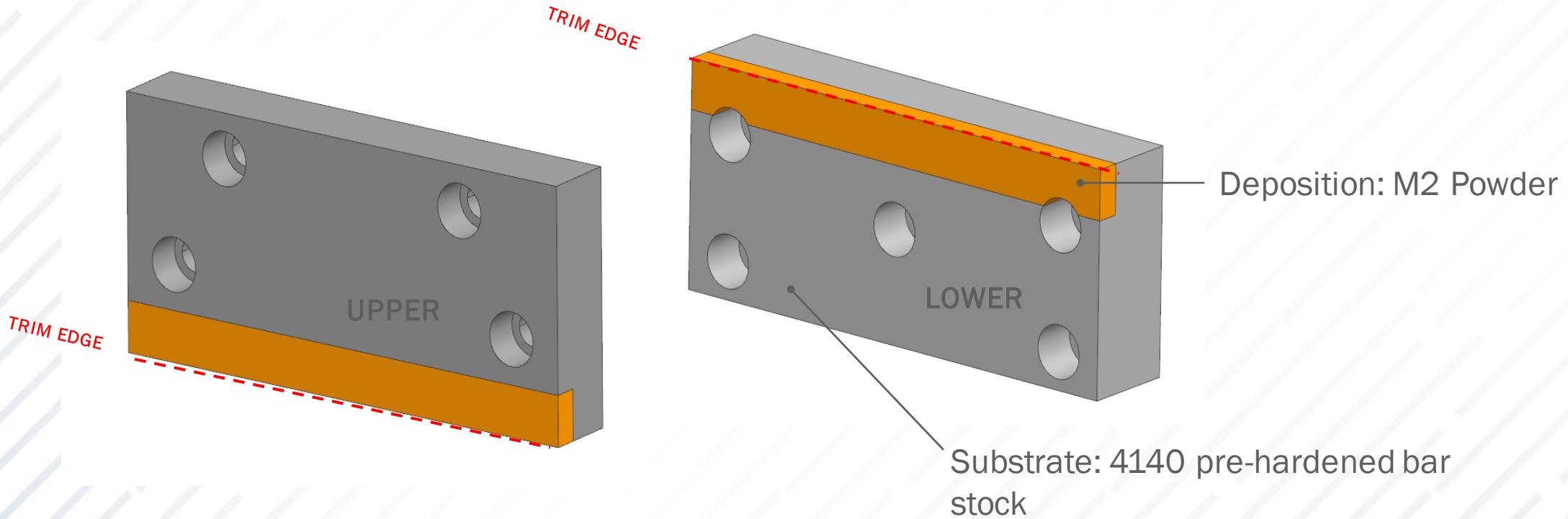
- Participants:
 - FormAlloy
 - GM Flint Tool & Die
 - Oakland University
- Approach:
 - Fabricate a pair of trim inserts (one upper, one lower)
 - Pre-hardened 4140 substrate with M2 powder DED at the trim edge
 - Conduct a trial of 50,000 hits
 - Stamping die trial using DP980 1.4mm thick sheet steel at Oakland University
 - Analyze the Condition of the insert and sheet metal parts
 - At predetermined increments, the inserts will be analyzed and photographed for wear.
 - The sheet metal parts will be monitored for defects.

Stamping Die for Trim Material Testing



Project Approach – Materials Studied:

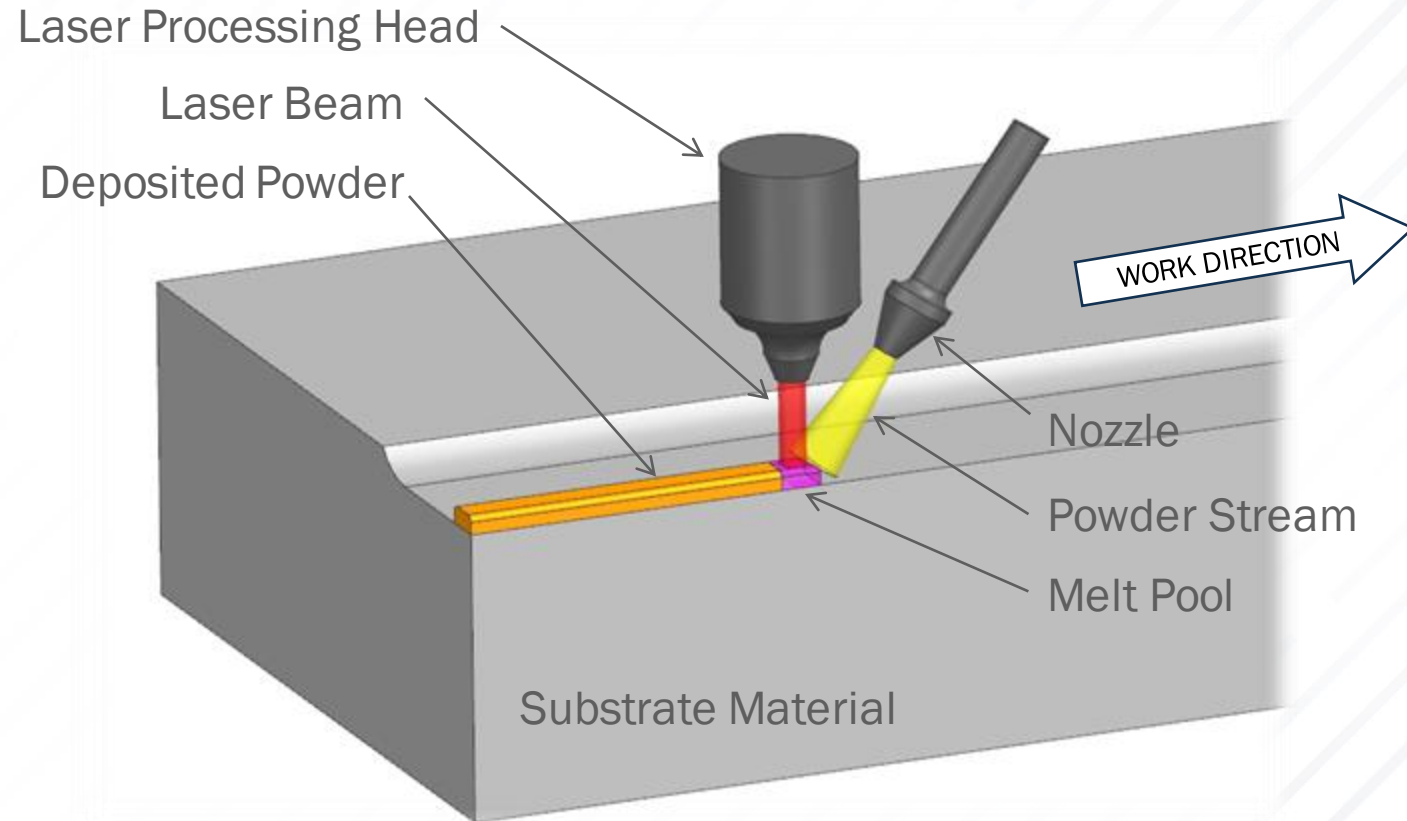
2 basic trim inserts were manufactured for testing, 1 for the lower die and 1 for the upper die



Powder-Based Direct Energy Deposition (DED)

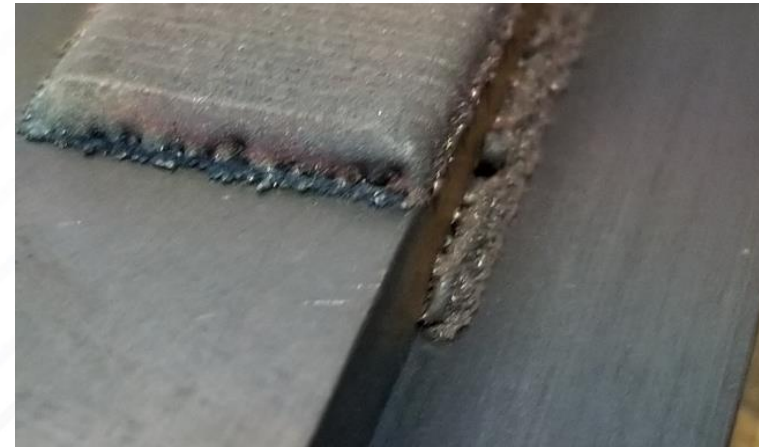
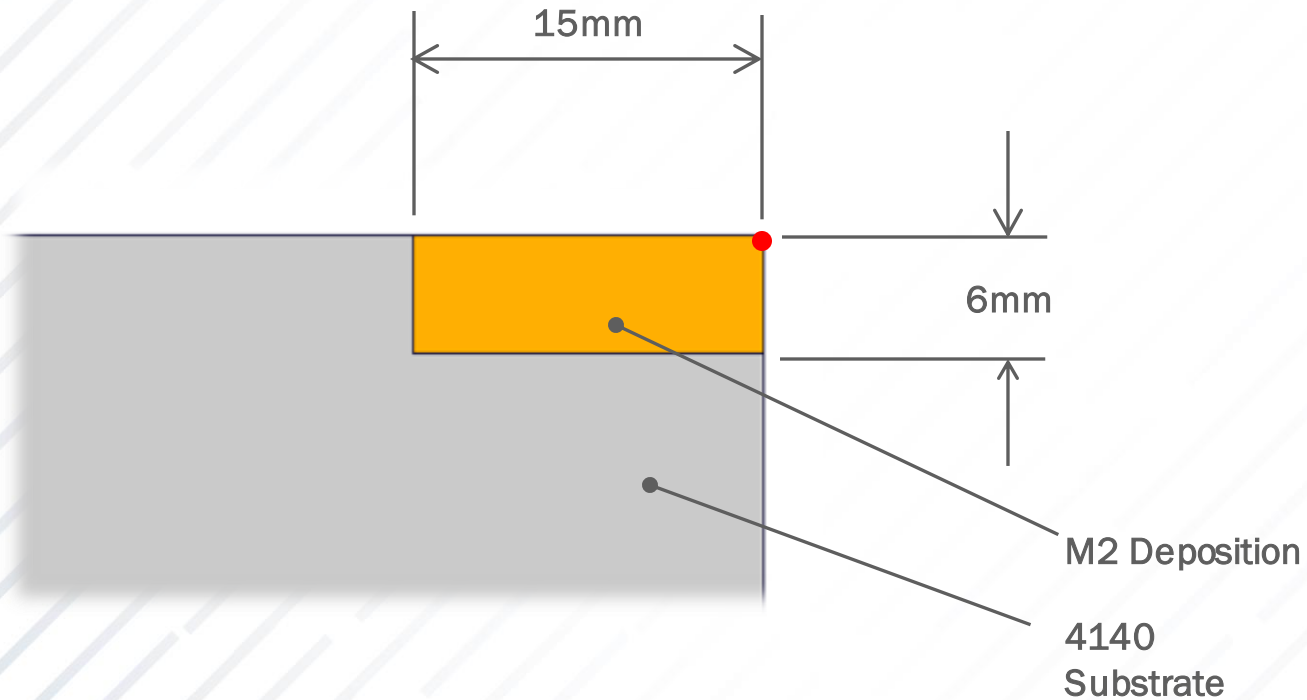


Spring Valley, CA
Founded 2016

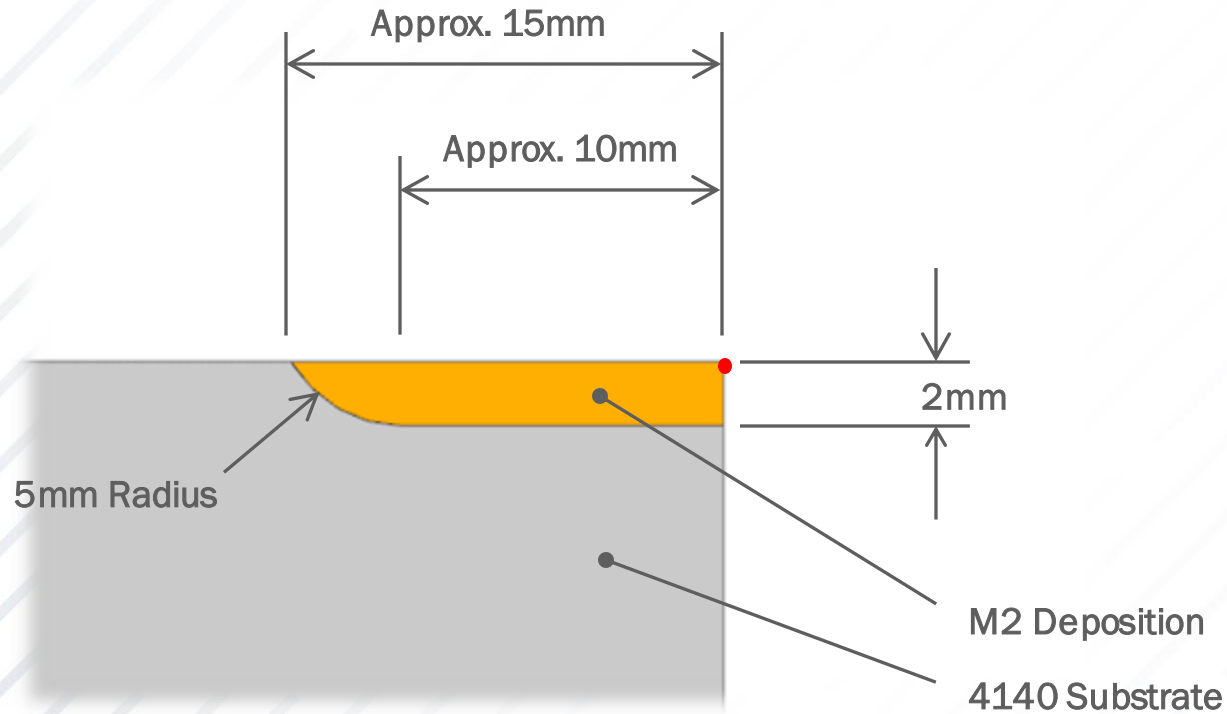


Project Results: Trim Insert Design – 1st Attempt

For the first attempt a standard end mill was used to cut a groove in the 4140 substrate. Depositing the M2 powder into a 90° corner was an issue with the printer we had available.

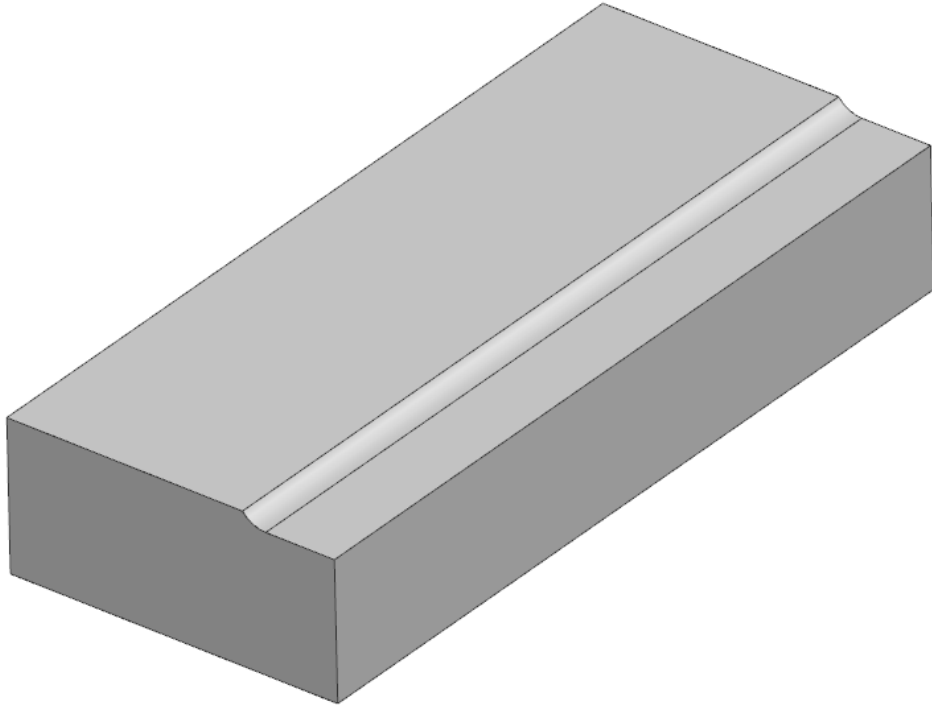


Project Results: Trim Insert Design – As Tested



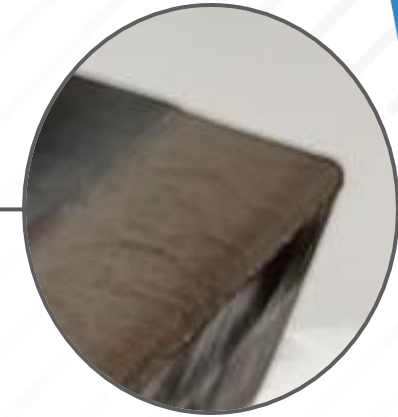
- 1mm of material was added to the front and top of the trim inserts for final machining
- 10mm diameter ball nose cutter was used to leave a 5mm radius where the deposition transitions back to the substrate
- 15mm is a standard dimension for the depth of trim edge on an insert using standard manufacturing practices

Trim Insert – Preheating Prior to Deposition



Substrates were pre-heated prior to deposition. An induction heater was used at 90% power to heat up the insert to 315°C (600°F) and held at that temperature for 30 seconds.

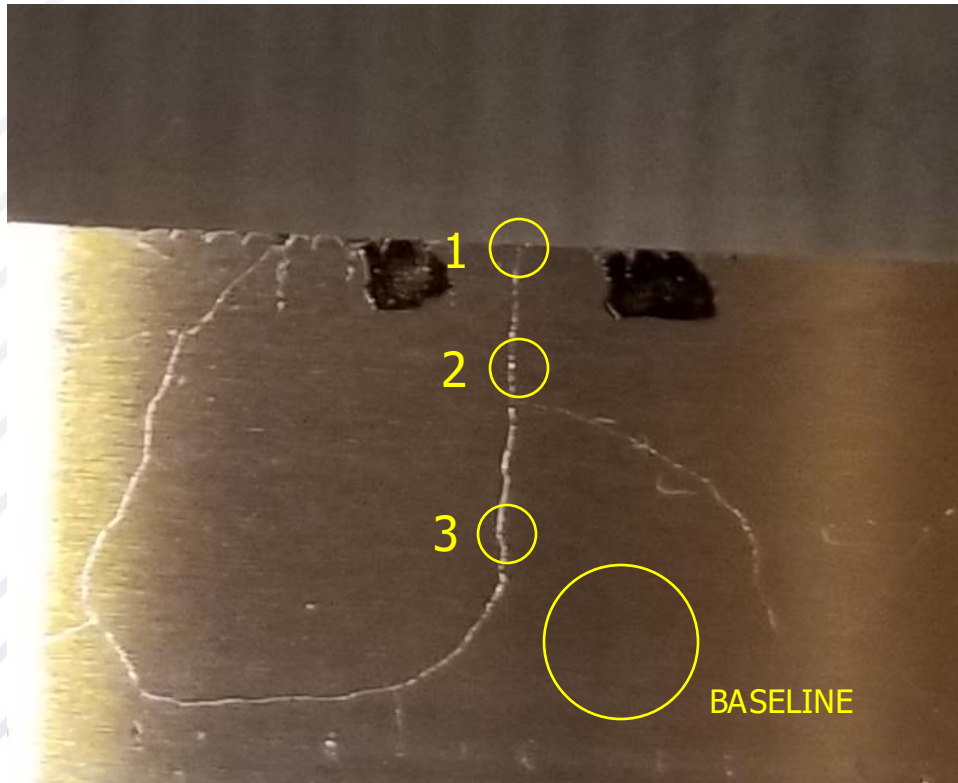
Trim Inserts – After Deposition



Trim Inserts – After Final Machining



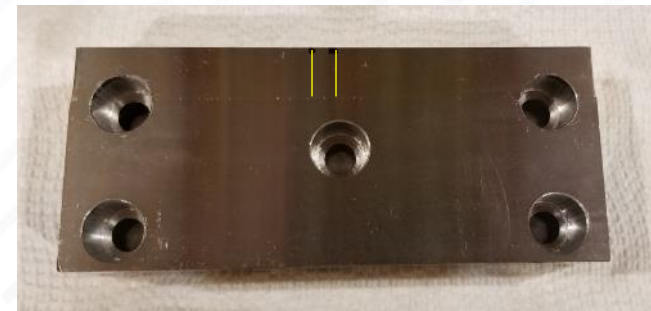
Pre-Test: 3D Microscopy of Visible Cracks



After finish machining several cracks were visible in the deposited M2 material. The cracks in the lower insert were more severe than the upper insert.

CT scans of the cracks were taken before running the 50,000-hit test for comparison after the test.

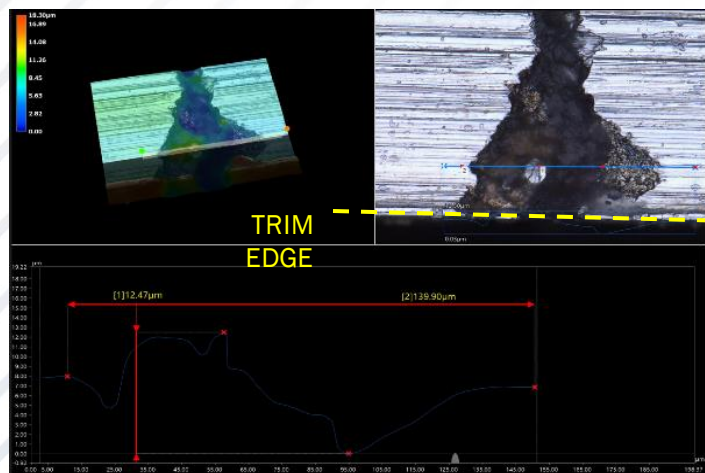
crack that was scanned
is between the lines



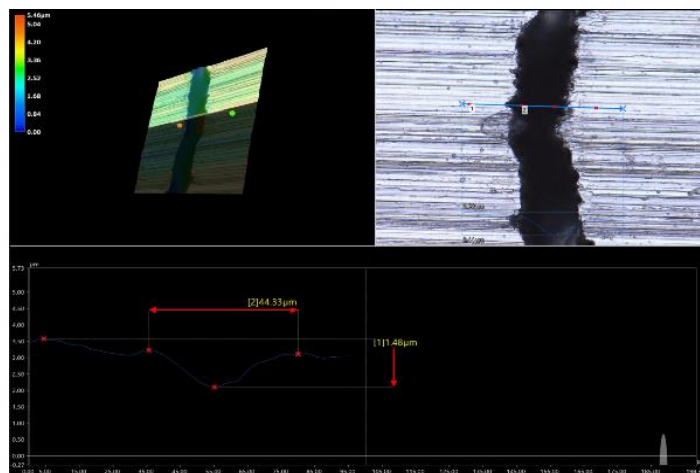
Pre-Test: 3D Microscopy of Visible Cracks

The width and depth of the cracks were measured using a Keyence VHX-7000 at 1000x magnification.

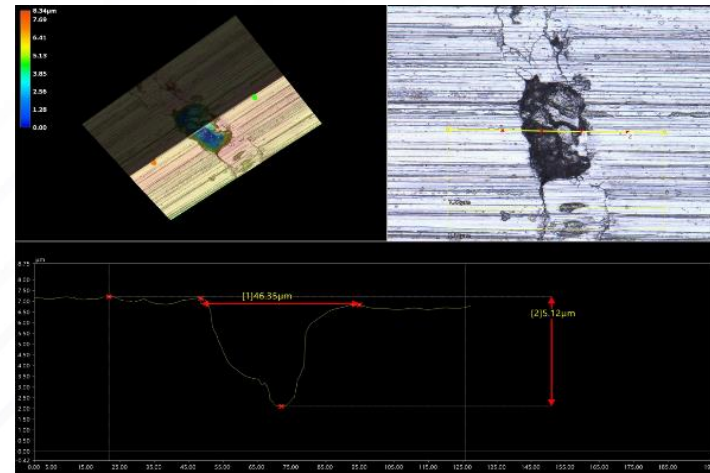
SCAN POINT #1



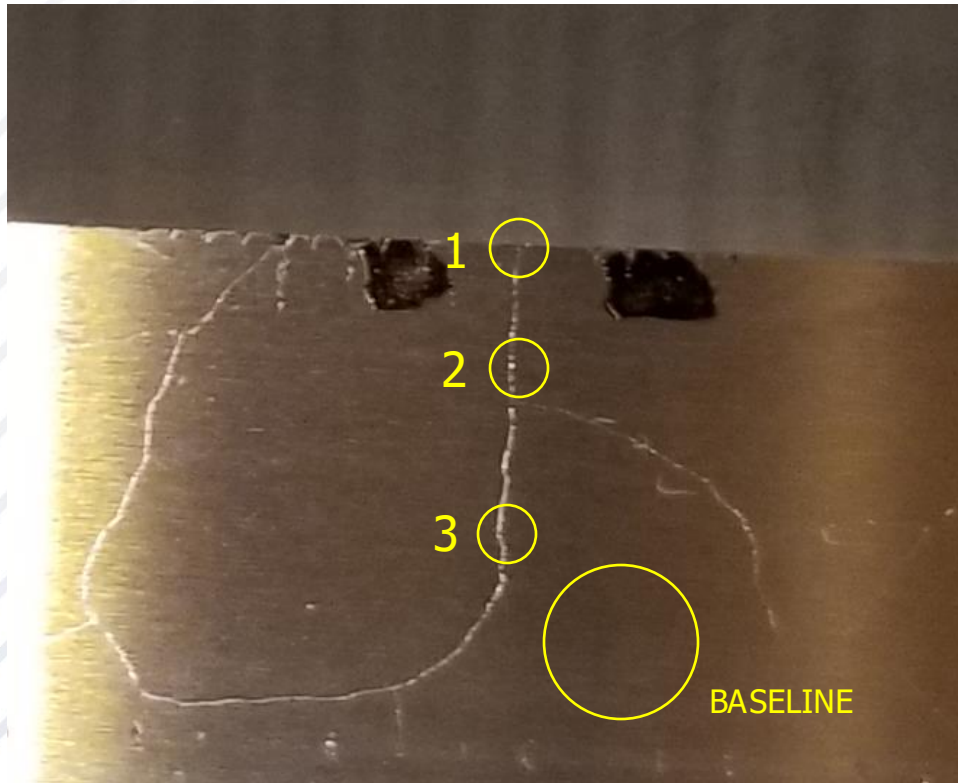
SCAN POINT #2



SCAN POINT #3



Pre-Test: 3D Microscopy of Visible Cracks



Crack Depth Analysis – Lower Insert Results

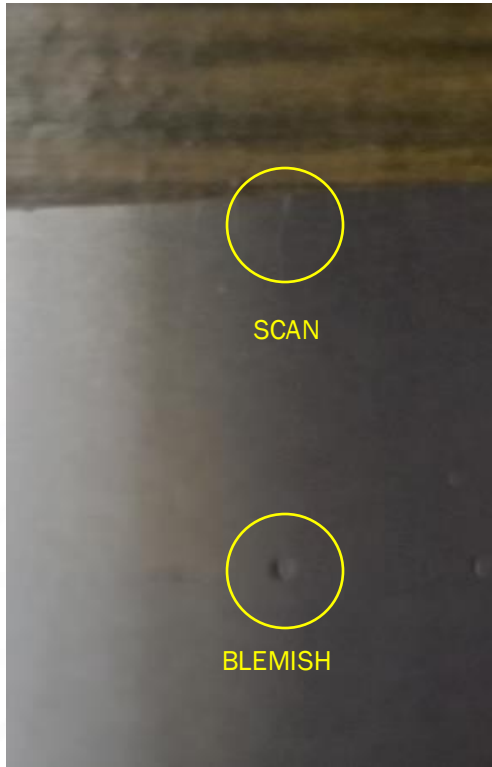
1.5 μm = Baseline Surface Roughness

139.9 μm Wide, 12.4 μm Deep

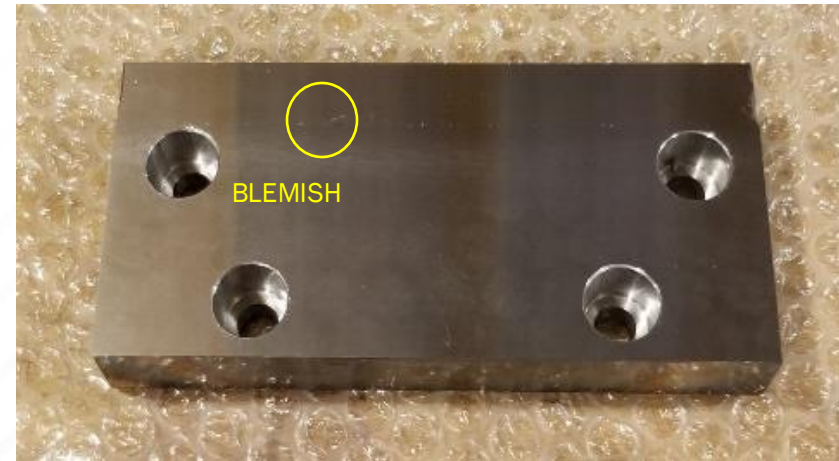
44.3 μm Wide, 3.5 μm Deep

46.3 μm Wide, 5.1 μm Deep

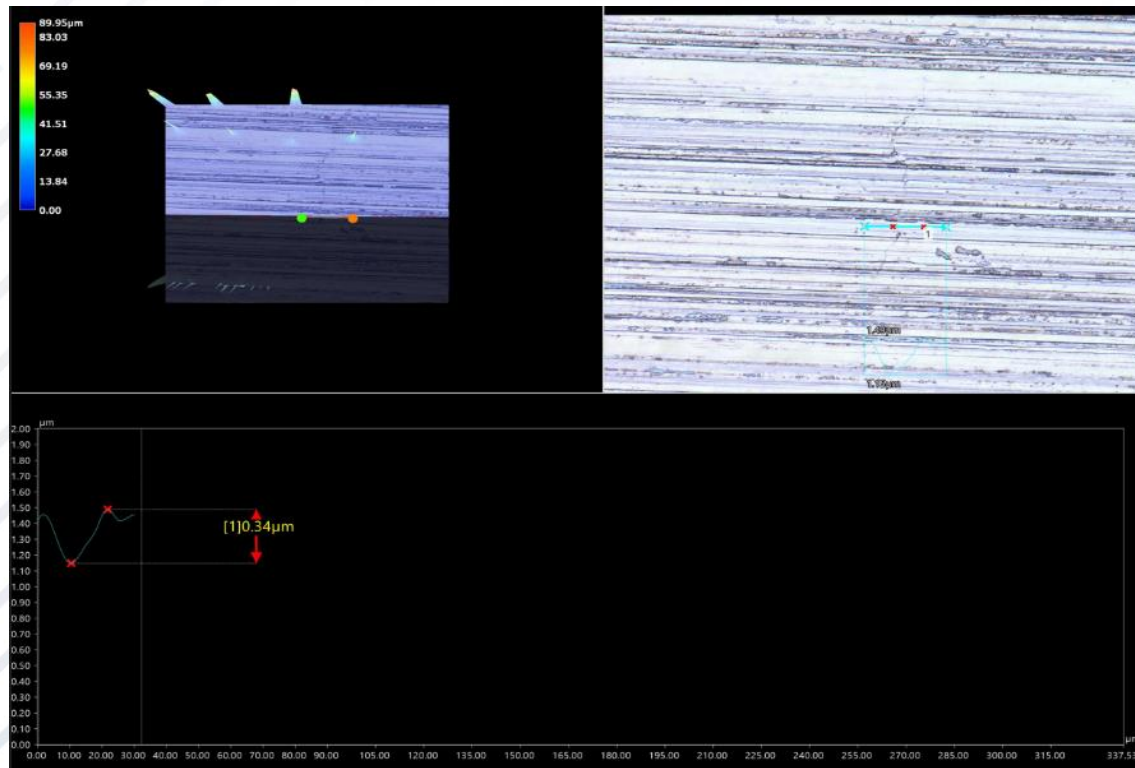
Pre-Test: 3D Microscopy of Visible Cracks



The cracks on the upper insert were far less severe
(hard to see and photograph)



Pre-Test: 3D Microscopy of Visible Cracks



Crack Depth Analysis – Upper Insert Results

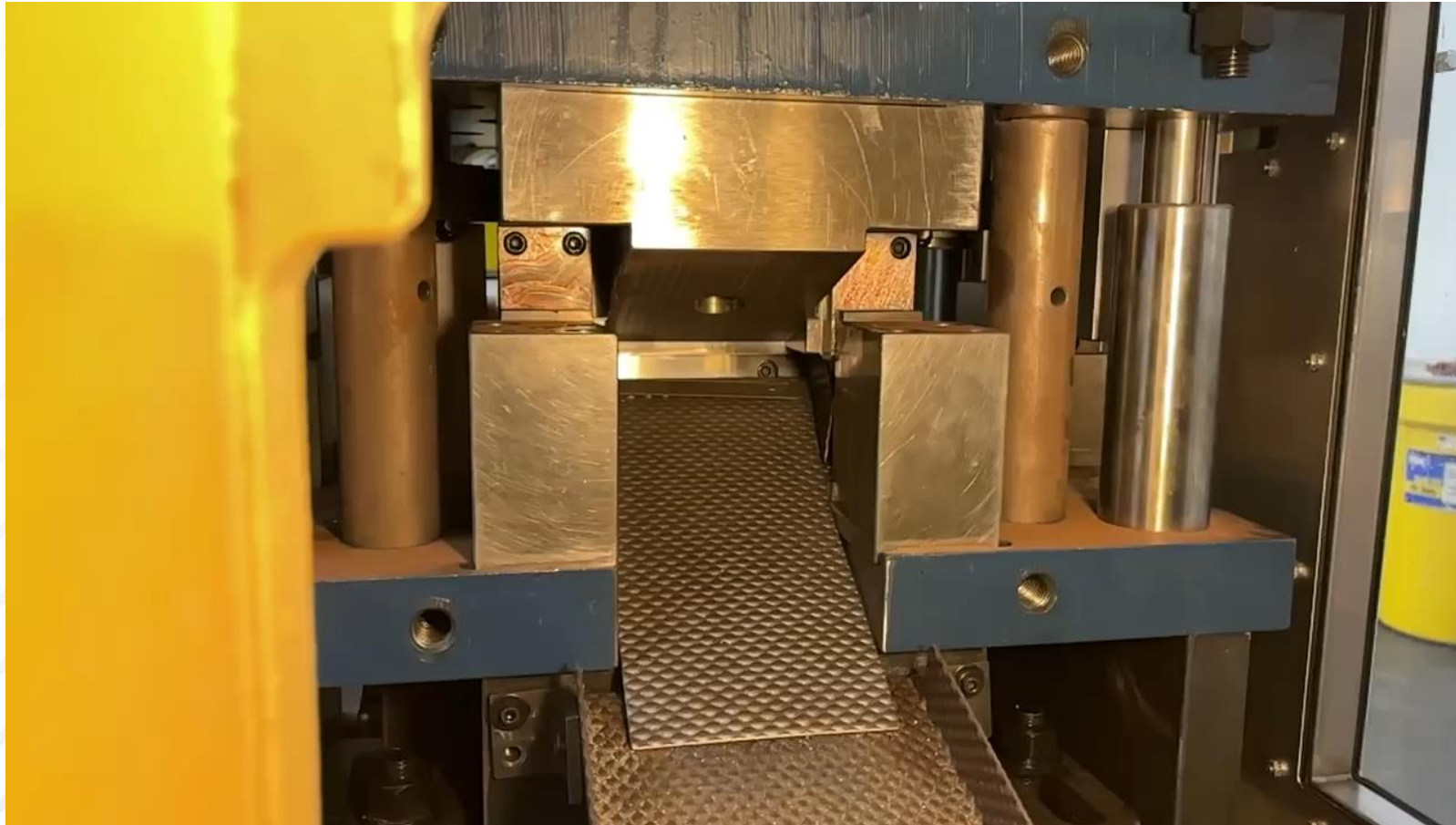
0.34 μm = Baseline Surface Roughness

0.87 μm = depth of crack (single scan)

The cracks in the upper were deemed insignificant.

Test Component Processing

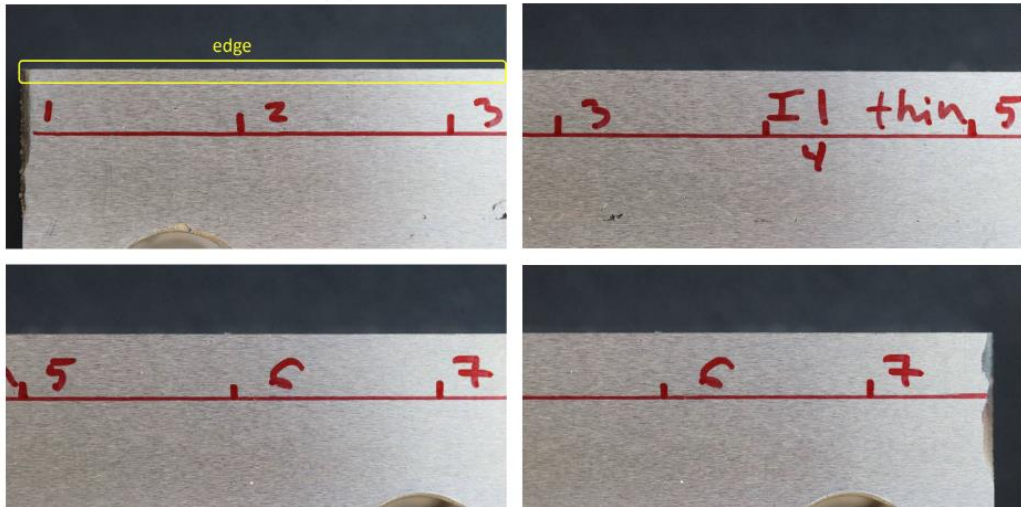
50,000 hits on DP980 sheet steel at Oakland University



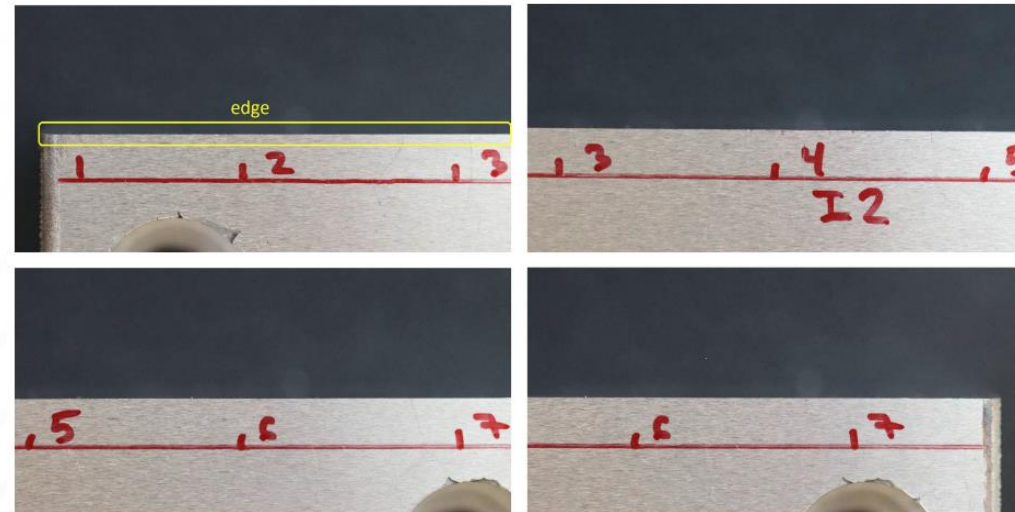
Trim Insert Testing Results

The edge of the inserts were divided into 7 different zones for analysis. Pictures of die inserts were taken as a baseline before testing, then after every 1000 hits, until 5000 hits have been reached. After 5000 hits have been completed, pictures were taken after each additional 5000 hits up to 50,000. If there was a noticeable change to the sheet metal part, the test would be stopped, and pictures of the insert would be taken at that point.

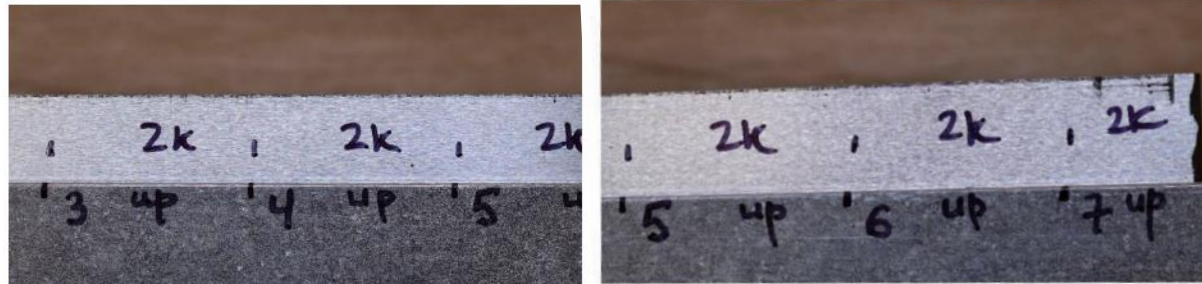
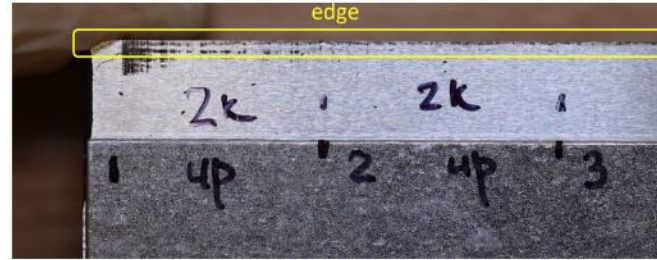
Upper Insert Initial Condition



Lower Insert Initial Condition



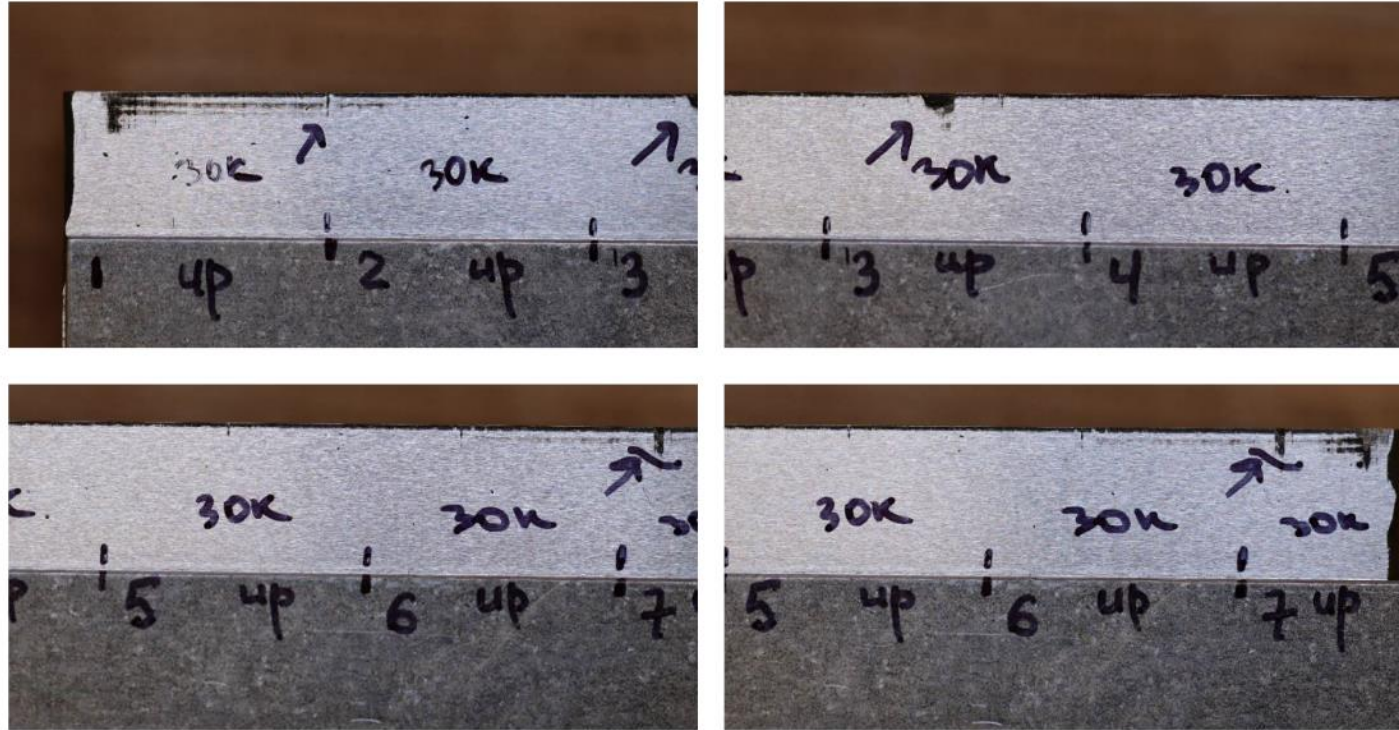
Trim Insert Testing Results



- About 1400 – 2000 hits, a part of the insert chipped out on the edge of the upper insert.
- There were no burrs or defects detected in the test components.

Trim Insert Testing Results

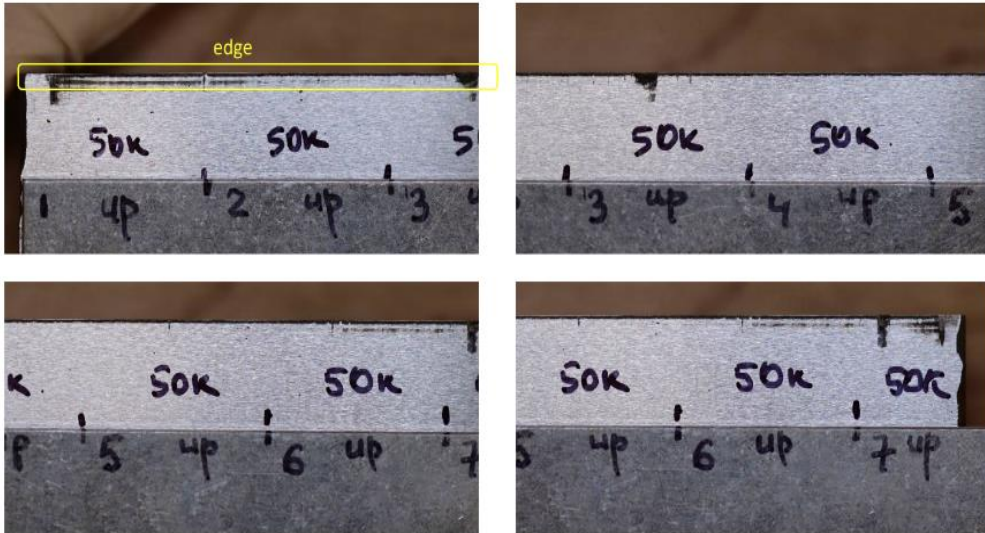
Upper Insert at 27,000 hits



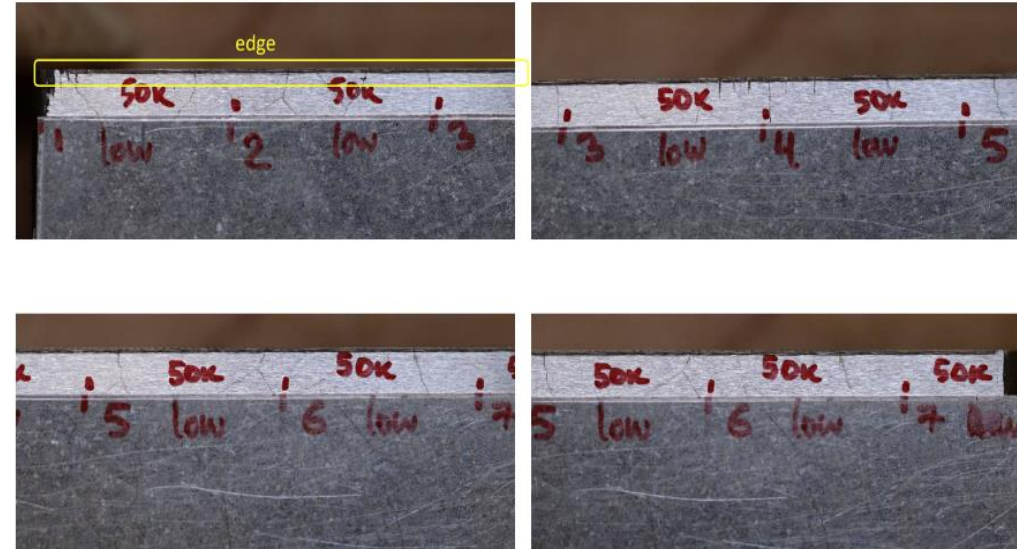
- About 27,000 hits, a part of the insert chipped out towards the middle of the upper insert.
- There were no burrs or defects detected in the test components.

Trim Insert Testing Results

Upper Insert At 50K Parts Cut



Lower Insert At 50K Parts Cut

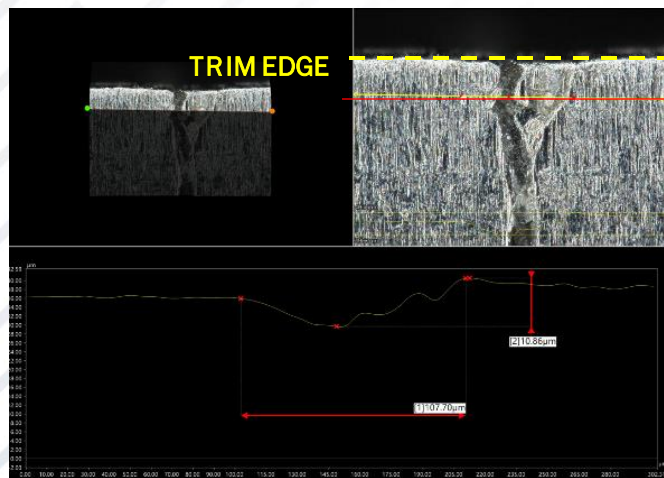


- The fracture mechanism was leaving a burr on the scrap side of the sheet metal parts.
- The chipping, or chipped areas remained consistent, and it did not escalate.
- The chipping happened on the upper where the lower insert had the lowest quality of material deposition on the insert components.

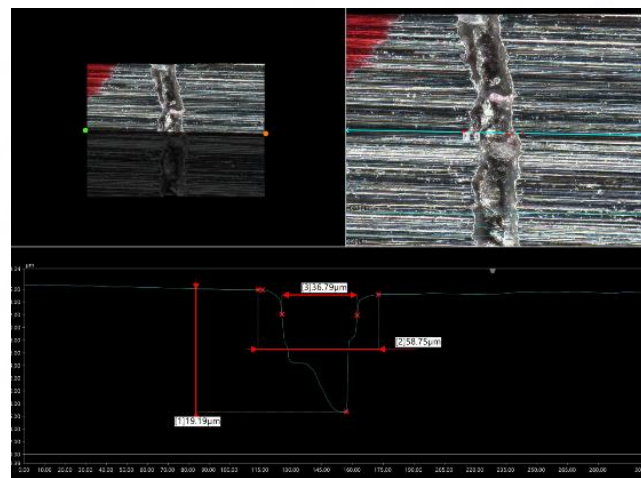
Post-Test: 3D Microscopy of Visible Cracks

The width and depth of the cracks were measured using a Keyence VHX-7000 at 1000x magnification.

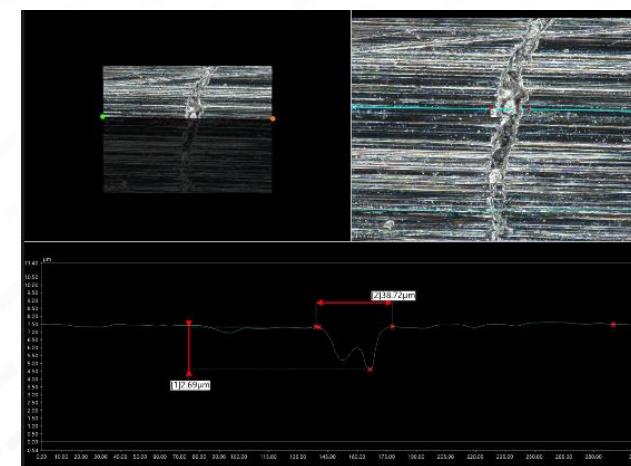
SCAN POINT #1



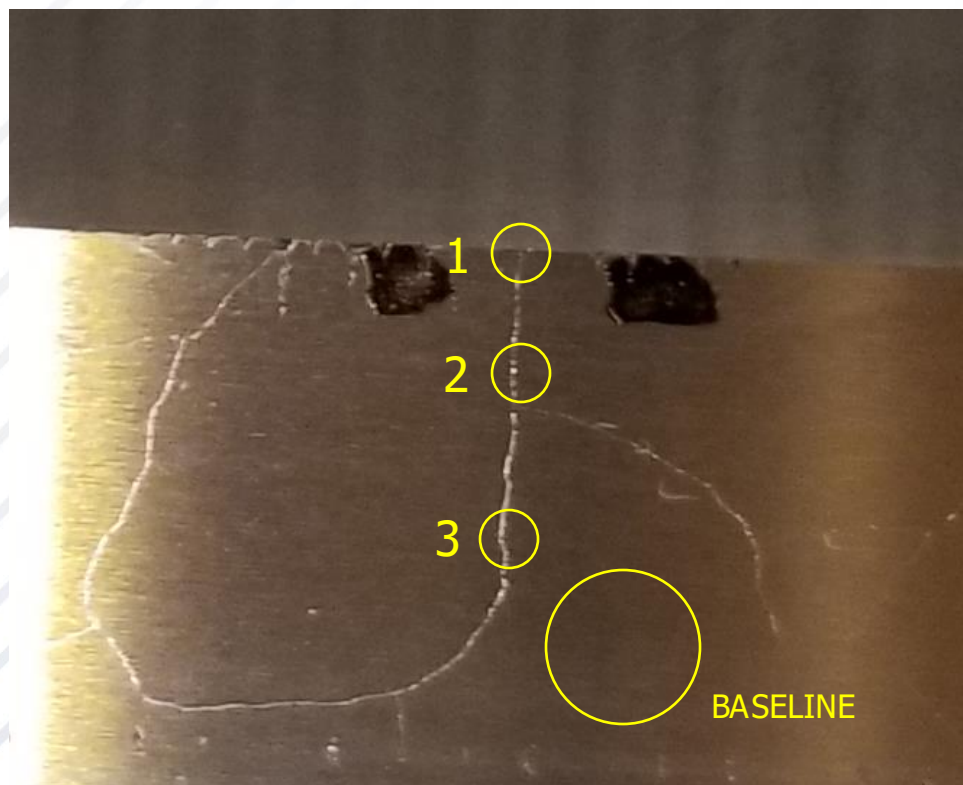
SCAN POINT #2



SCAN POINT #3



Post-Test: 3D Microscopy of Visible Cracks



Crack Depth Analysis – Lower Insert Results
The Post-Test scan points are in a slightly different location, with in 1-2mm of the Pre-Test scans.

SCAN POINT #1:

Pre-Test: 139.9 μ m Wide, 12.4 μ m Deep

Post-Test: 117.7 μ m Wide, 10.8 μ m Deep

SCAN POINT #2:

Pre-Test: 44.3 μ m Wide, 3.5 μ m Deep

Post-Test: 36.7 μ m Wide, 19.8 μ m Deep

SCAN POINT #3:

Pre-Test: 46.3 μ m Wide, 5.1 μ m Deep

Post-Test: 38.7 μ m Wide, 3.8 μ m Deep

- Some minor chipping was observed at (2) points during the testing. The chipping was on only the upper insert.
- The chip outs remained consistent and did not escalate over time.
- The trim inserts with powder-based DED trim edges showed satisfactory performance.

- To explore the capabilities and limitations of the metal additive manufacturing as a fabrication method for small die inserts for stamping trimming operations.
- With the growing popularity and use of laser hardening cells, powder-based DED printer heads can be retro-fitted within these existing cells. There is a potential for large stamping die castings to be cast of a lower grade material and deposit a grade powder-based material along the trim edge as required.

- The Stamping Tooling Optimization project team is investigating a 3rd phase of this project using wire fed direct energy deposition for a trim operation.

For more information

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