OPENHYBRID

WP8 Demo parts and requirements

- Siemens - blade
- CRF - press tool
- Weir – Volute and Pitot tube

CONTENTS

- Examples of end user case requirements
  - CRF tool die
  - Weir volute
- General DED process and application (powder + laser directed energy deposition)
- End user case process development and application
  - Weir volute
  - CRF tool die
  - Siemens blade
  - Weir pitot tube

This project has received funding from the European Union's HORIZON 2020 research and innovation programme under grant agreement No 723917 – OpenHybrid.

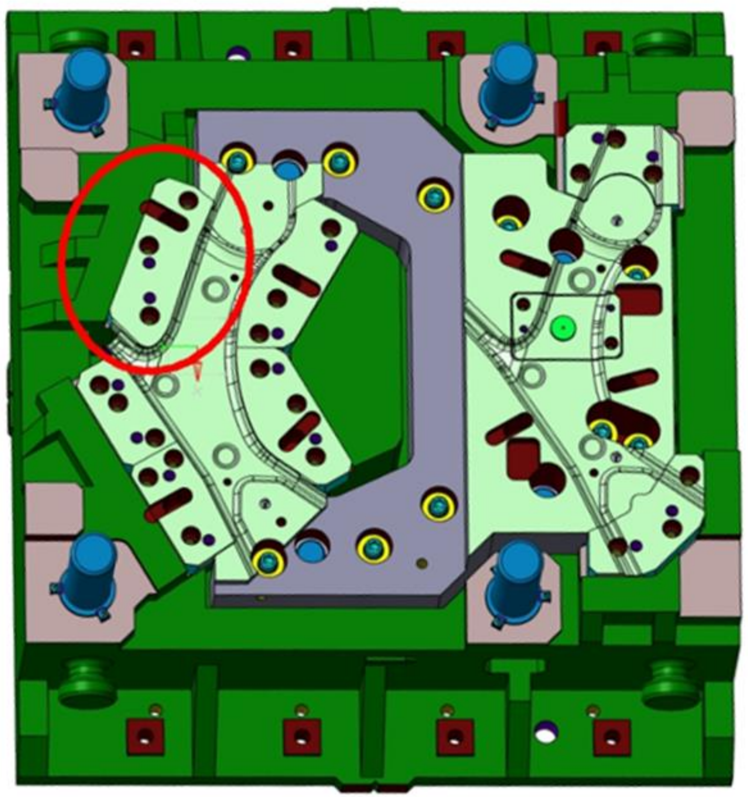
Current manufacturing process:

Automotive car body - metal sheets together welded

Sheets -> shaped -> trimmed

Tool requirements:

- The trimming die tool need sharped edge and are subject to higher wear,
- Up to 8 dies on a tool
- Lower tool paired with upper



Lower trimming die

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Current process

- Normal operating condition generate excessive wear at 30,000 shots (approximately 3 months)
- The repairing operation consist is done manually.
- Long repairing time, with higher costs (that are lower with respect to a new tool replacement).
- Press Shop, hence, the warehouse stores some insert tools to replace worn tool when is under repairing operation.

New tool

Worn tool

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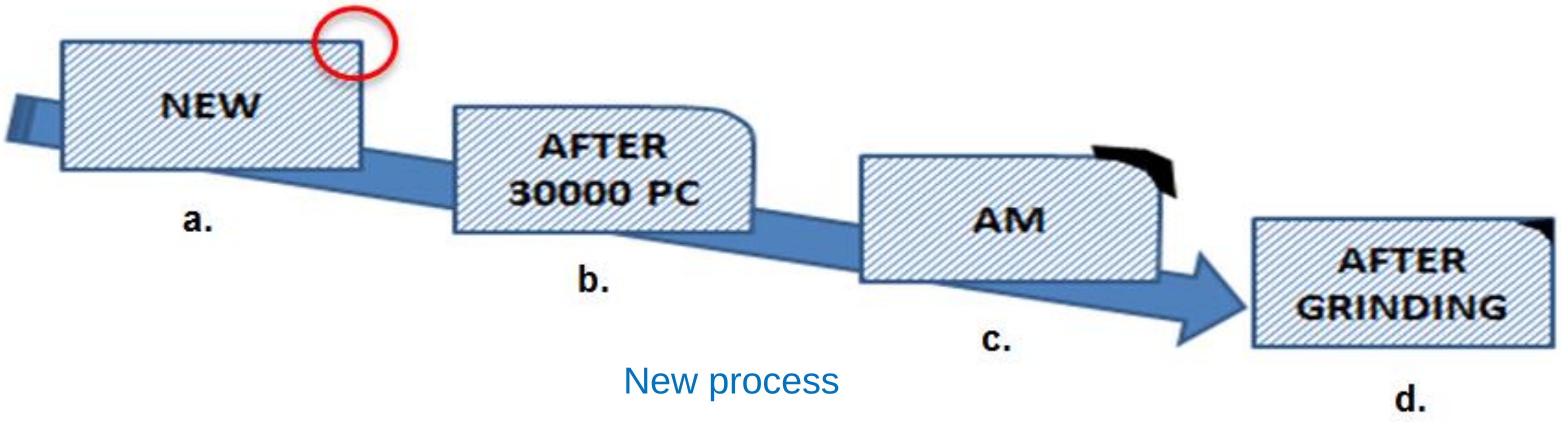
Open Hybrid solution

With the OH system we can expect as benefit:

- Reduce manufacturing costs and time by minimizing the process steps
- Reduce manufacturing costs and time reducing as well potential reworking operation
- Get more reliable component and Increase of the service life (>> 30,000 shots) by implementing the worn part with AM material features
- Reduce spare part stored in warehouse



New process

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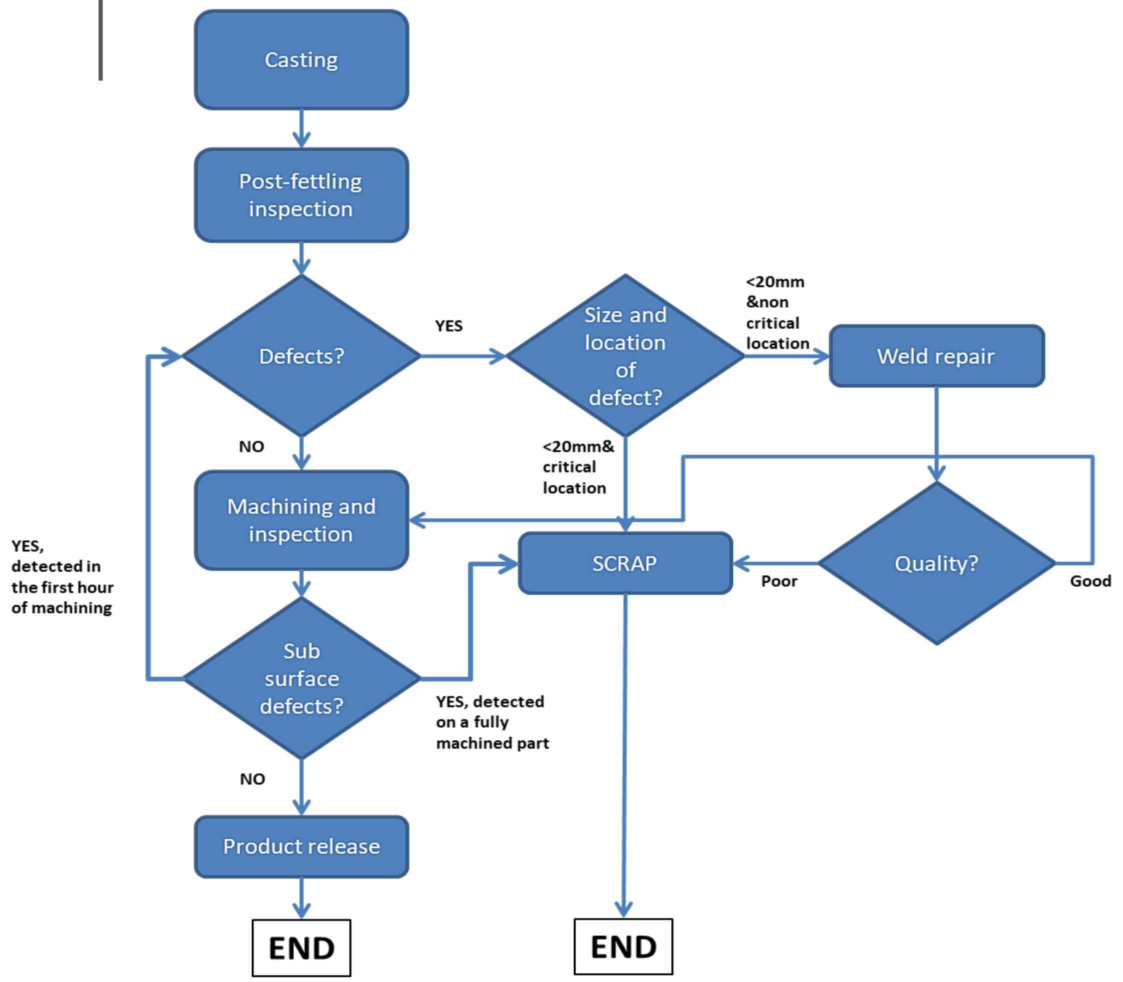
OVERVIEW OF THE REQUIREMENTS OF WEIR VOLUTE

Weir volute



Manual Metal Arc welding

56hr Pre-Heat process

Improvements:

Health and Safety

Quality of the repair

Lead time

Environment

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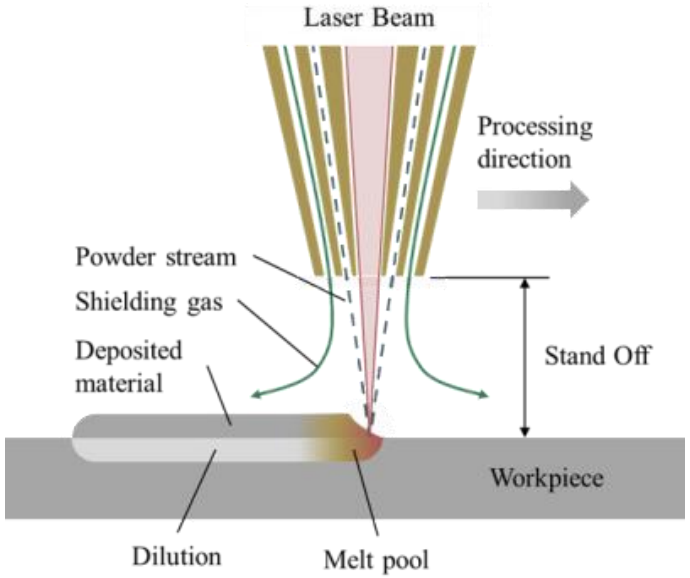
OpenHybrid DED Parameter Development and Demonstration

DED PROCESS OVERVIEW (POWDER + LASER)



- **Process:** Powder or wire filler material and substrate melted by laser

  After Solidification: Fine microstructure with a metallurgical "fusion" bond with substrate (>99.5% dense but often above 99.9%)
- **Scan strategies:** Areas can be clad and volumes built by multiple layer deposition.
- **Powder-gas beam focus:** Control is key to success

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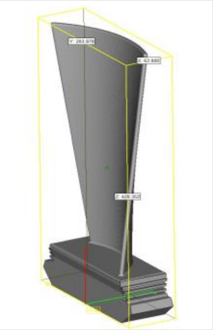
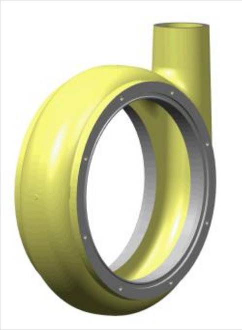
SIEMENS	WEIR		CRF
Turbine Blade	Volute	Pitot tube	Tool die

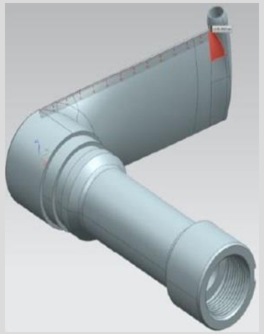
Turbine Blade



Volute

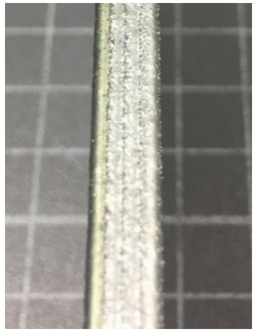


Pitot tube

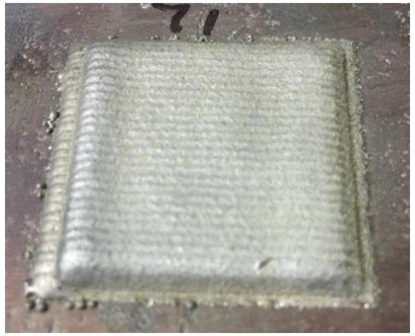


Tool die

Stellite 21 onto X22 steel



Ni-WC onto white cast iron



Stellite 6 onto In718

Tool steel powder onto tool steel (0.9% C 'Sleipner')

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OVERVIEW OF KEY PROCESS PARAMETERS AND THE EFFECTS ON MATERIAL CHARACTERISTICS

Process parameters

Laser beam
- Laser power
- Spot size
- Beam profile
- Wavelength
- Polarisation

Machine
- Scanning speed
- Shielding gas
- Preheating
- Overlap
- Toolpath

Substrate
- Geometry
- Composition
- Reflexivity
- Thermal Conductivity

Powder feeding
- Powder feed rate
- Injection angle
- Nozzle distance
- Nozzle geometry

Powder feedstock
- Particle shape
- Particle size
- Composition
- Thermo-physical properties

Deposit characteristics

Structural
- Porosity
- Cracking

Metallurgical
- Microstructure
- Dilution
- Grain size
- Homogeneity
- Corrosion resistance

Mechanical
- Hardness
- Residual stress
- Wear resistance
- Tensile strength
- Toughness

Geometry
- Deposit dimensions
- Surface roughness

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Parameter change		Effect on clad bead width	Effect on clad bead height	Effect on penetration & dilution
Laser power ↑		↑	↑	↑
Traverse speed ↑		↓	↓	↓
Powder feed ↑		↓	↑	↓

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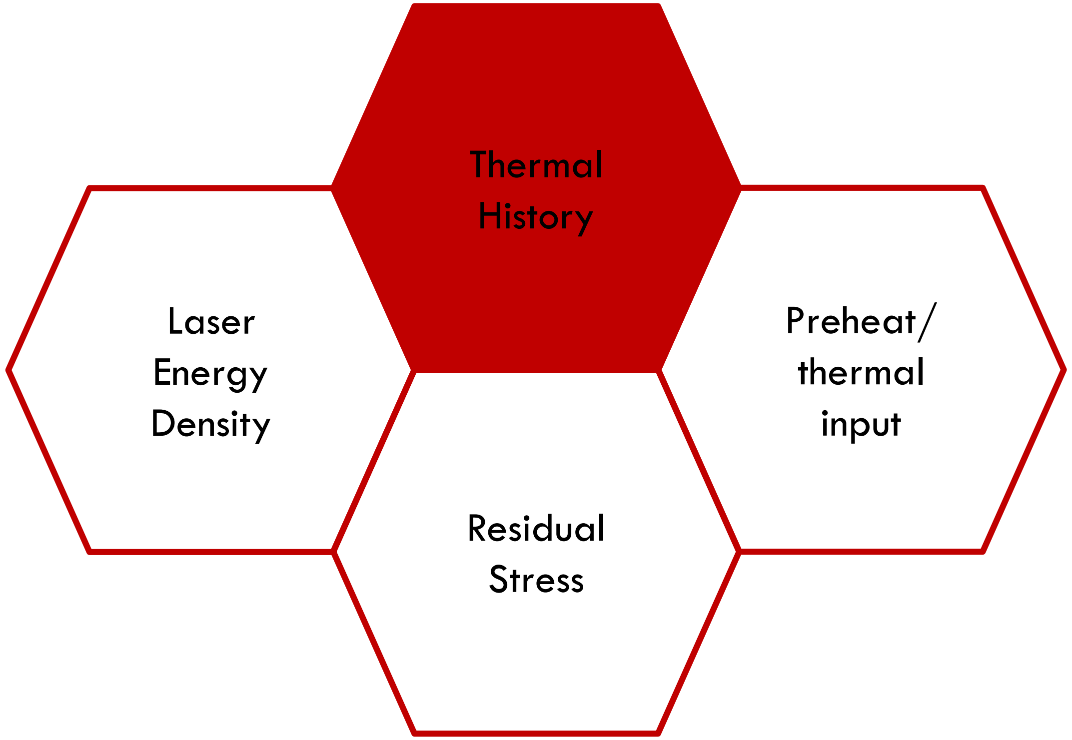
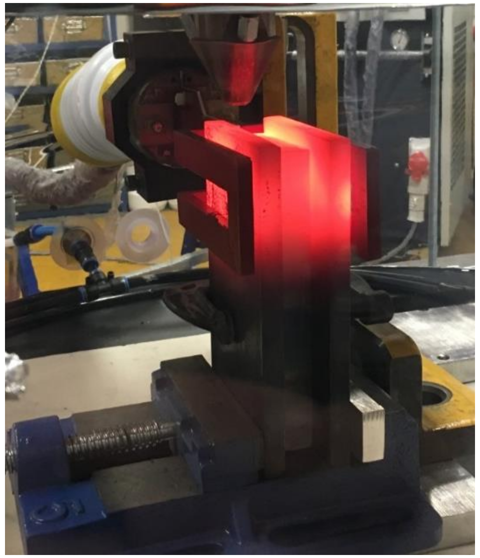
KEY PARAMETERS IN OPENHYBRID USER APPLICATIONS

Crack susceptible materials (filler and/or substrate) often narrow the feasible processing window and require additional process refinement.



One of the methods used in OpenHybrid:

Induction heating assisted DED



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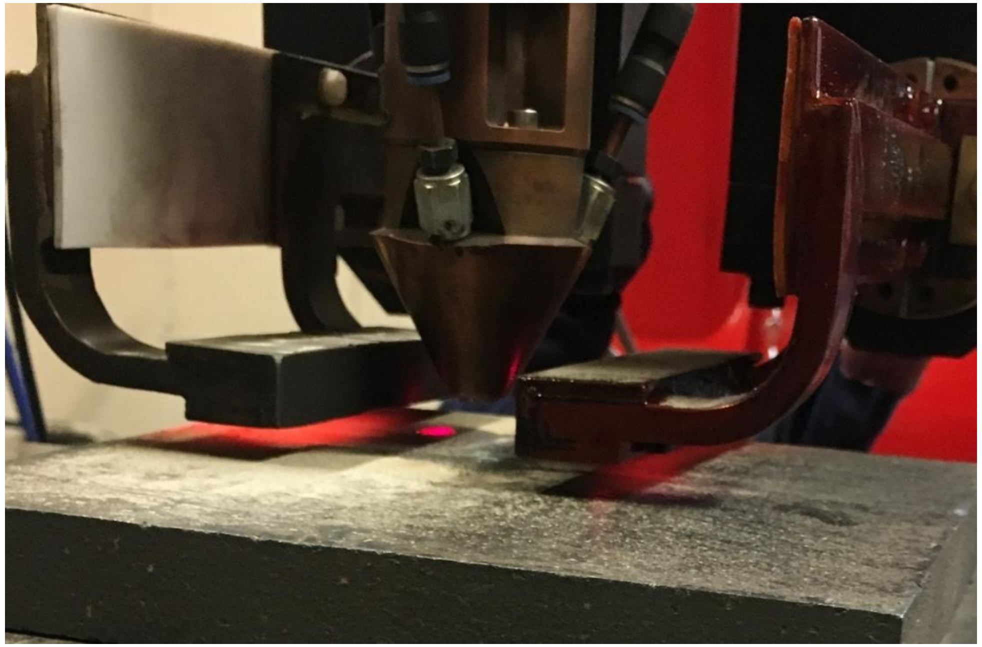
— Application: Repair of Volute

Heating the entire component (>2m Ø and >1000kg) is possible but is not the most economical or practical solution, especially when the repair site is relatively small (<100mm^2)

— OH approach: Induction heating

Heating using specially designed induction coils to locally heat the targeted repair area. Induction heating was required during DED processing and during cool down (not just as a pre-heat step).



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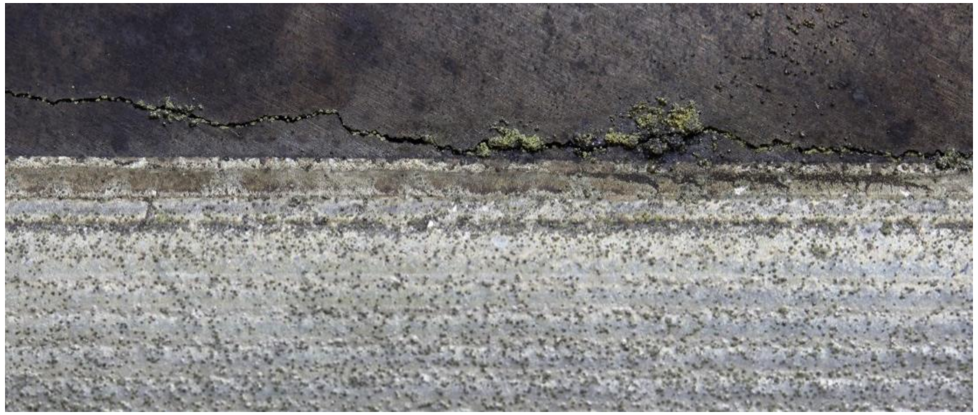
Substrate: white cast iron >650Hv

Repair material: NiCrSiB-WC (60% wt.)

Interfacial (buffer) material: NiCrSiB

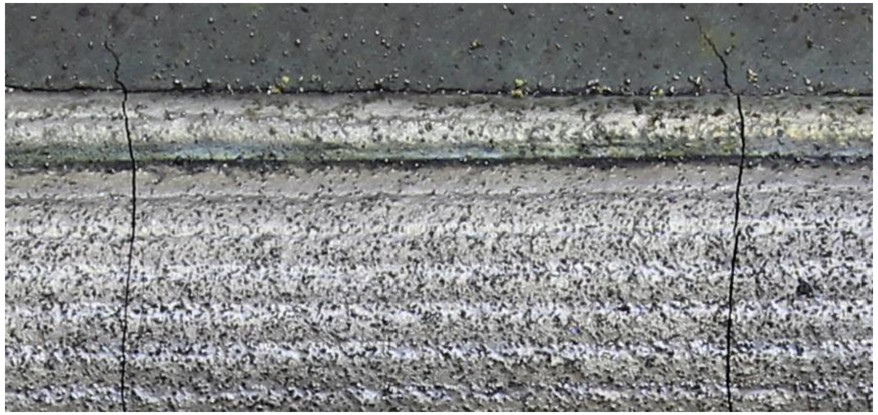
No Interfacial material:

Direct application of Ni-WC onto white cast iron (with induction heat 600°C) led to significant cracking within the substrate



Without controlled precisely cooling rates:

Ni-WC onto NiCr interlayer onto white cast iron (with induction preheat 600°C) without controlling the post process cooling rateled to significant cracking within substrate and deposit



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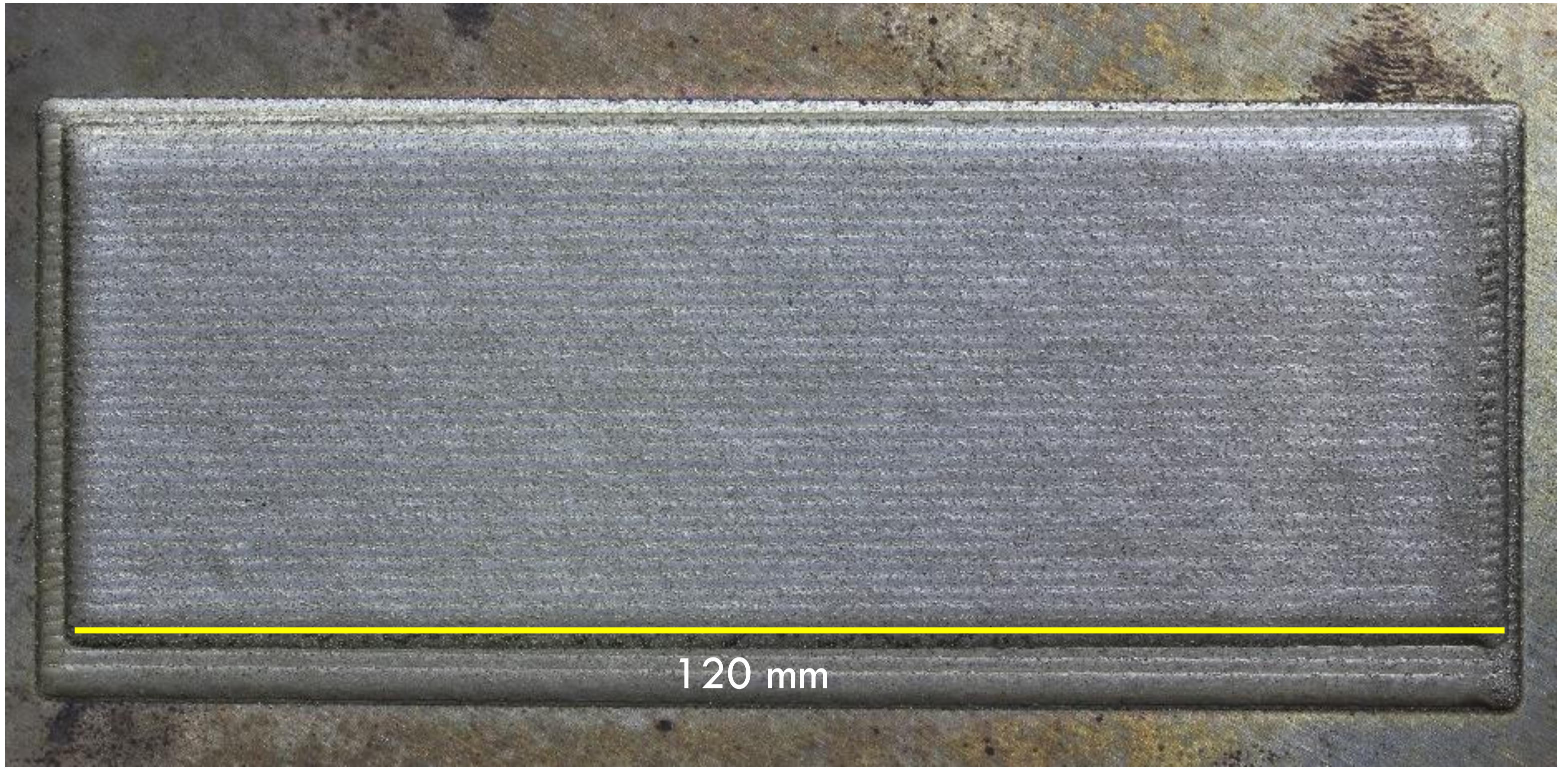
Result:

- Crack free ~2600WC ~680HV matrix hardness (similar to cast iron substrate). High density >99%.



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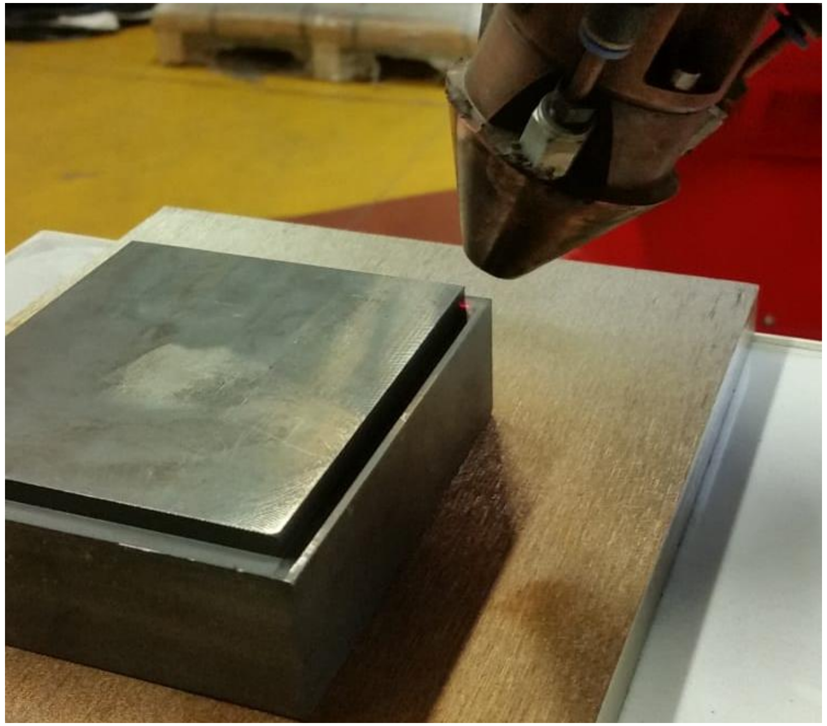
USER CASE 2: DEVELOPMENT - CRF TOOL DIE

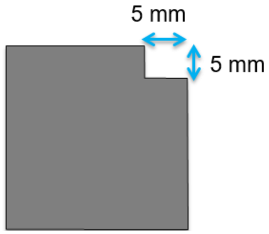
Challenge: Repair of damaged tool edge

Substrate: 0.9% Carbon ‘Sleipner’ tool steel.

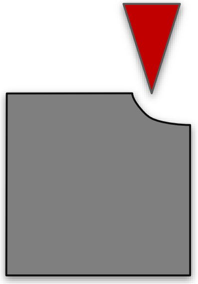
Powder: ‘Sleipner’ tool steel.



Pre-heat required due to hard tool steel material, applied using a heating plate at 225-300°C.



Higher risk defect scenario



improved preparation

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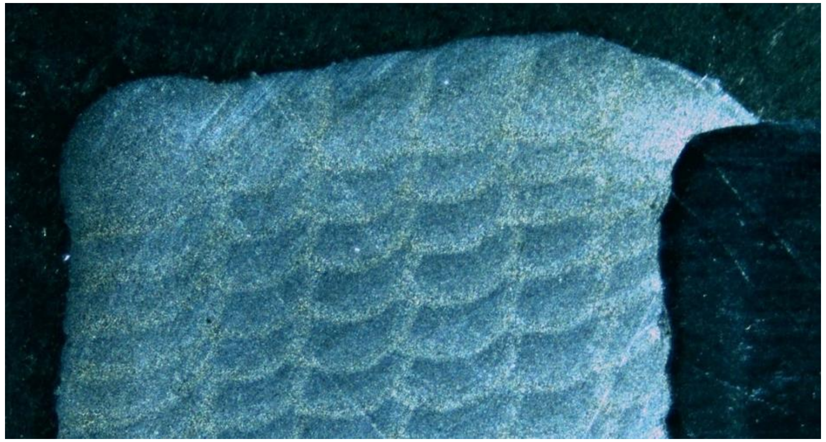
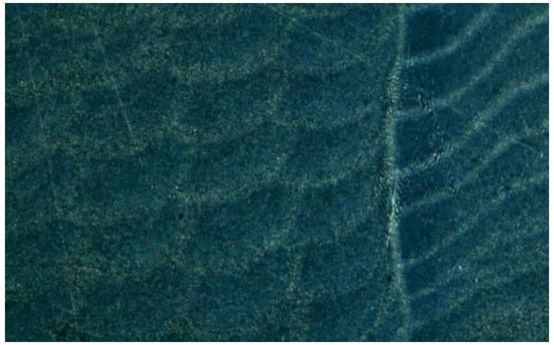
DEVELOPMENT - CRF TOOL DIE

For the CRF repair, the deposited material needed bonding soundly to both the base of the grooved substrate and the wall of the substrate. Depositing against a vertical wall can add risk of lack of fusion defects.



Joining deposit vectors is a another region with increased risk of defects (lack of fusion, porosity).



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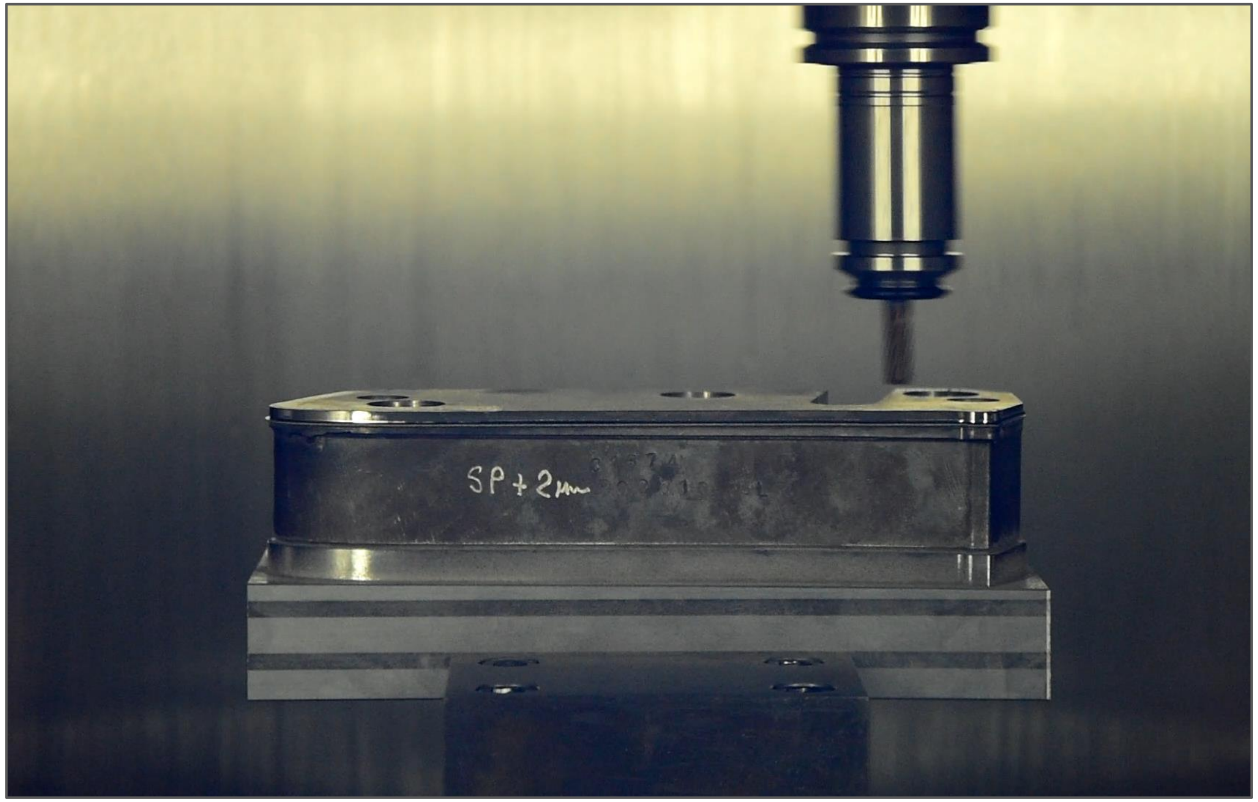
MILLING DAMAGED VOLUME



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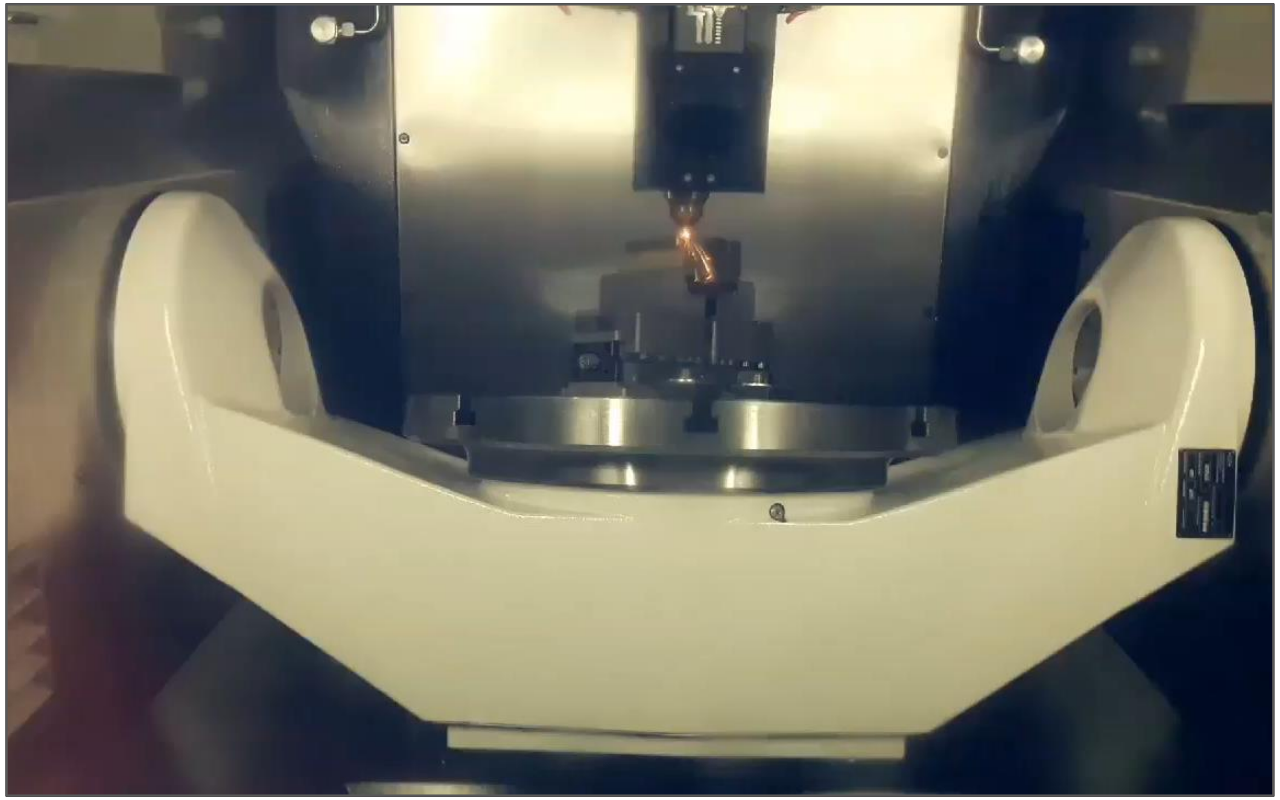
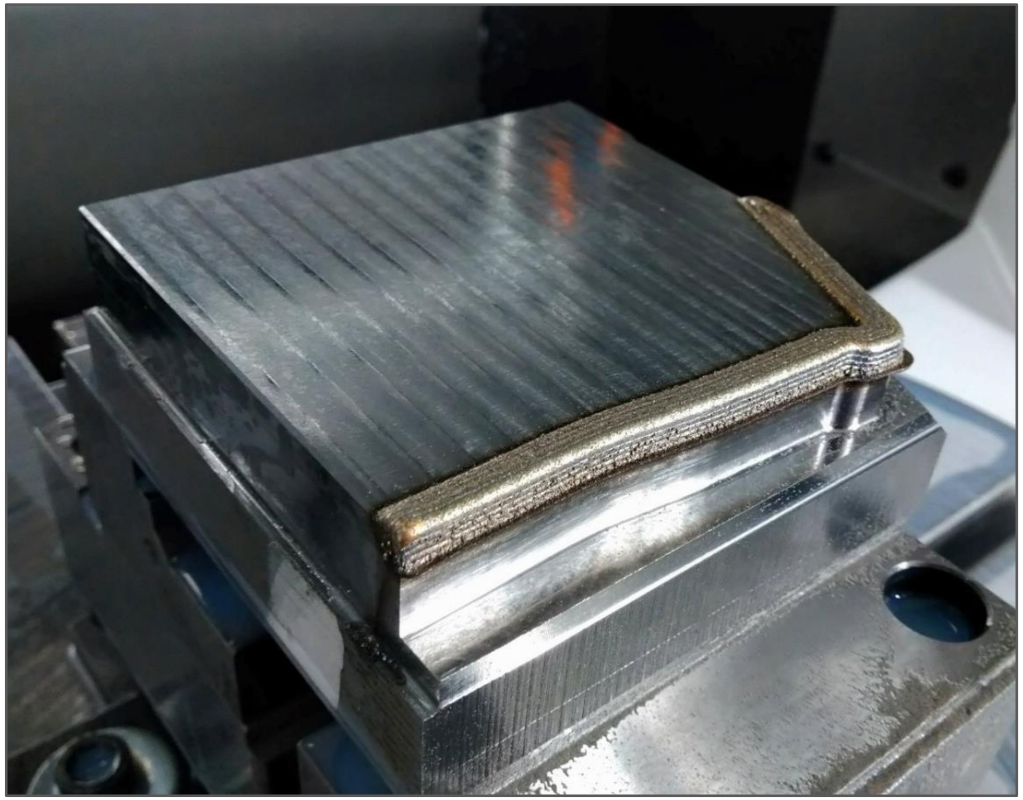
DEPOSITING NEW MATERIAL





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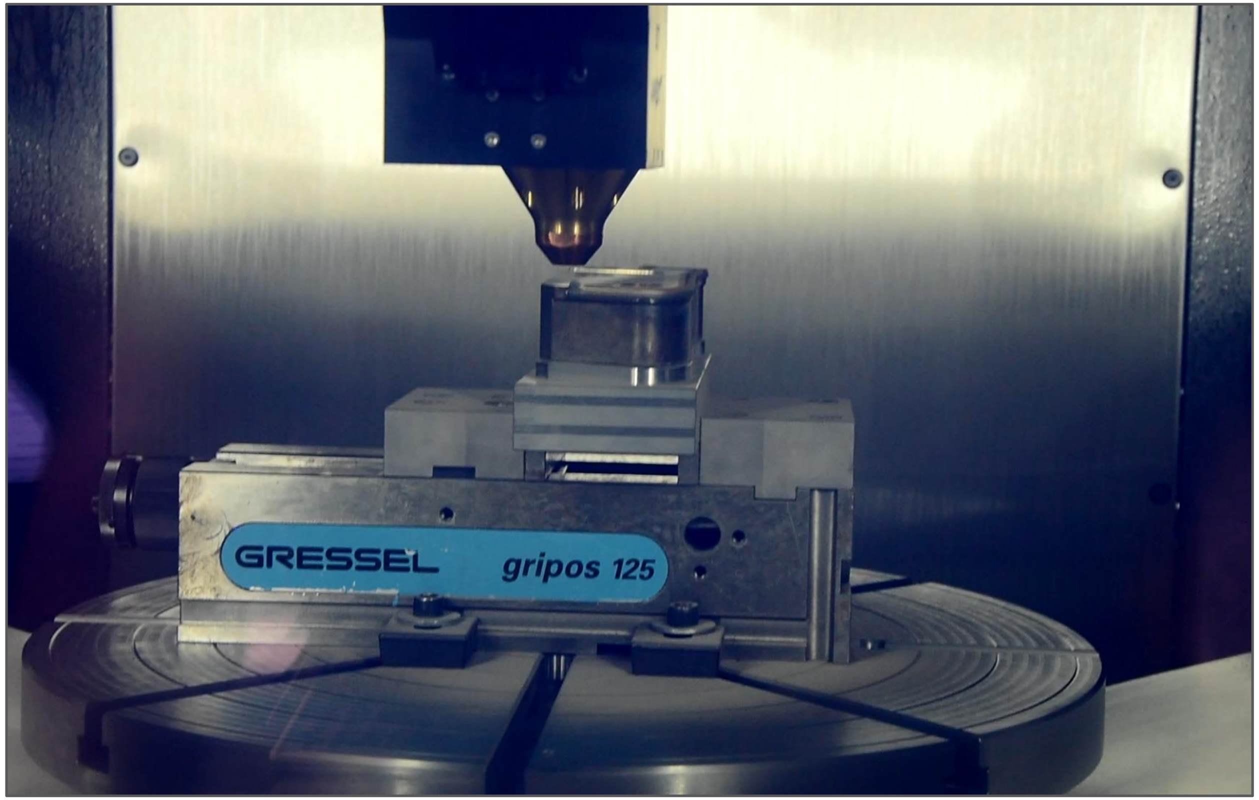
REPAIRING PREVIOUSLY REPAIRED TOOLS



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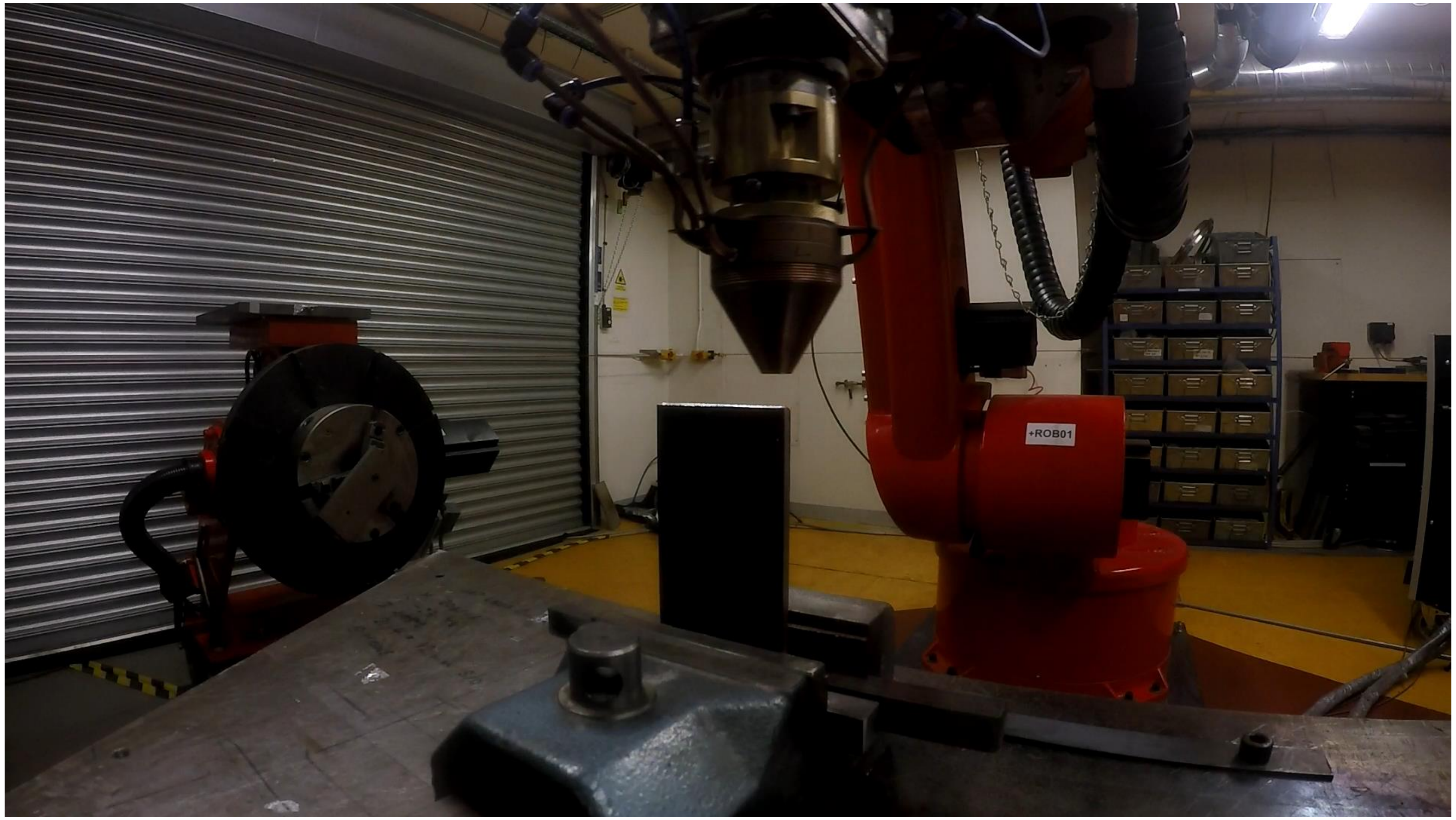
USER CASE 3: DEVELOPMENT - SIEMENS BLADE

Challenge: Repair of turbine blade edge

Substrate: X22CrMoV steel

Powder: Stellite 21



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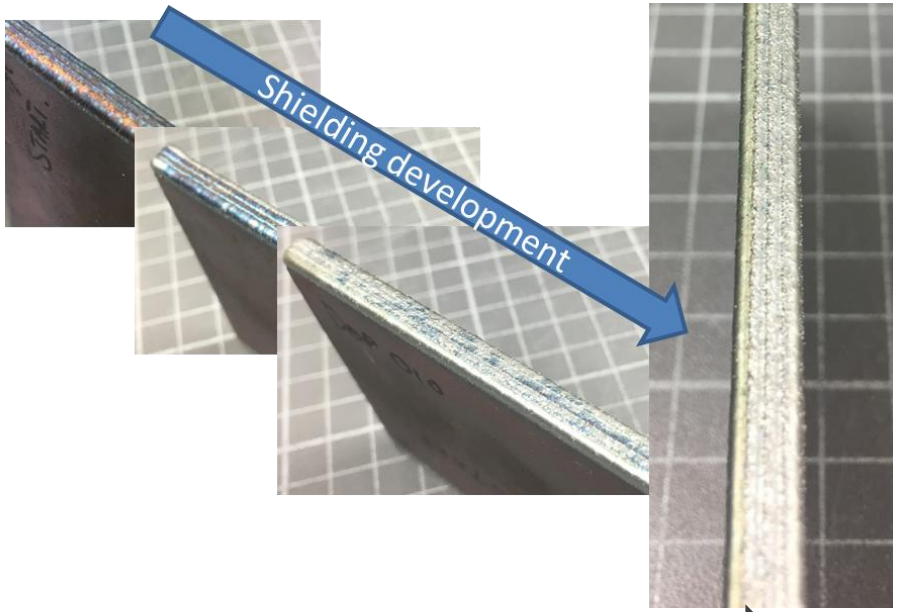
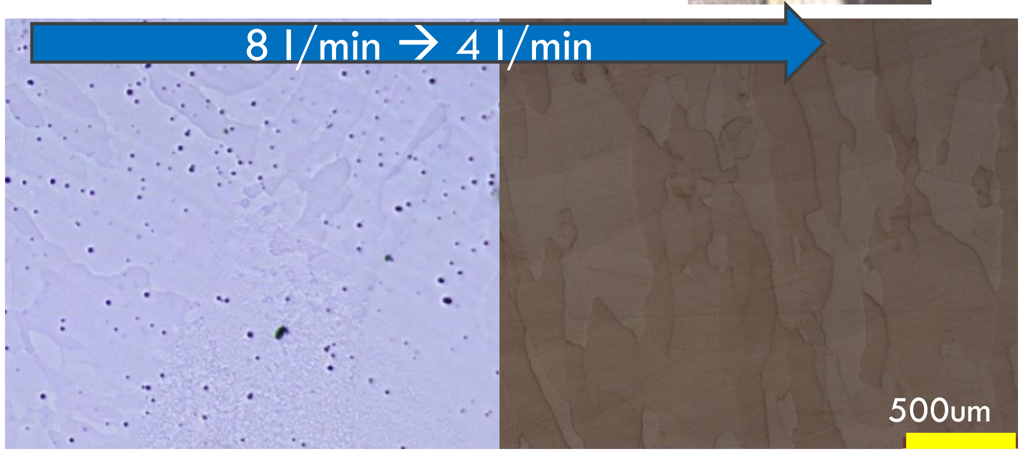
Stellite 21 applied to X22-steel





- From left to right the shielding gas rate is reduced from 8 l/min to 4 l/min.

- Titanium alloy example of shielding induced argon entrapped porosity.

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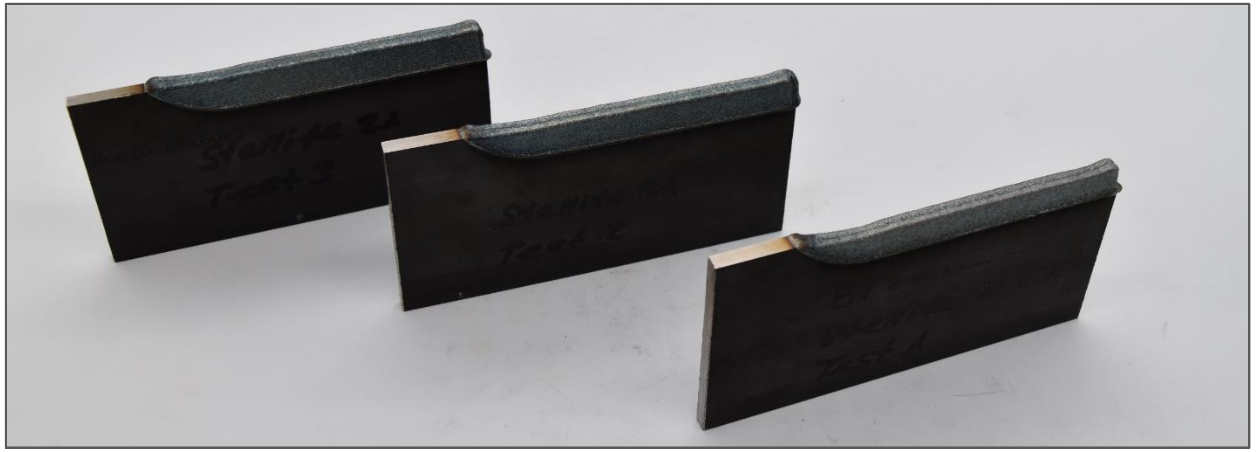
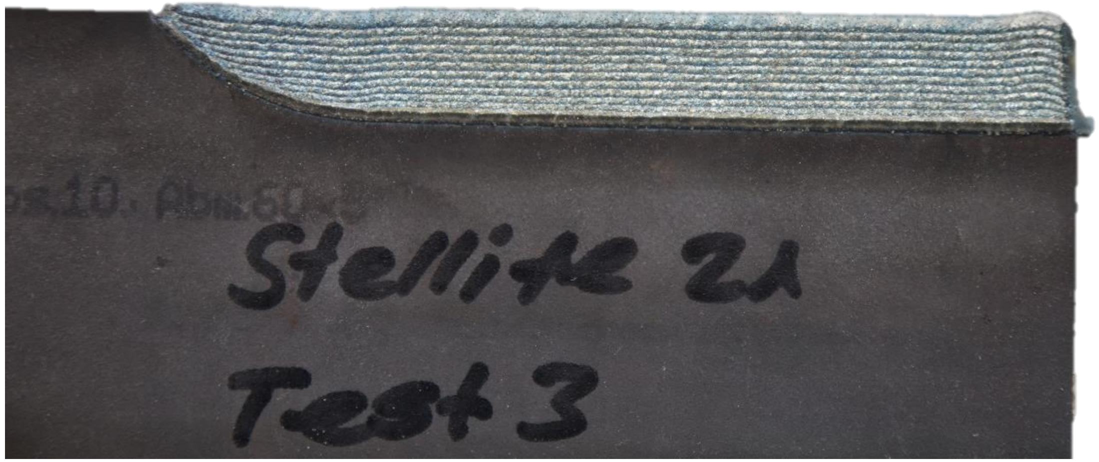
Risk of cracking in the HAZ without preheating/controlled cool down or 'soft' interlayer

300 degree preheat and application of Stellite 21 material for crack free result





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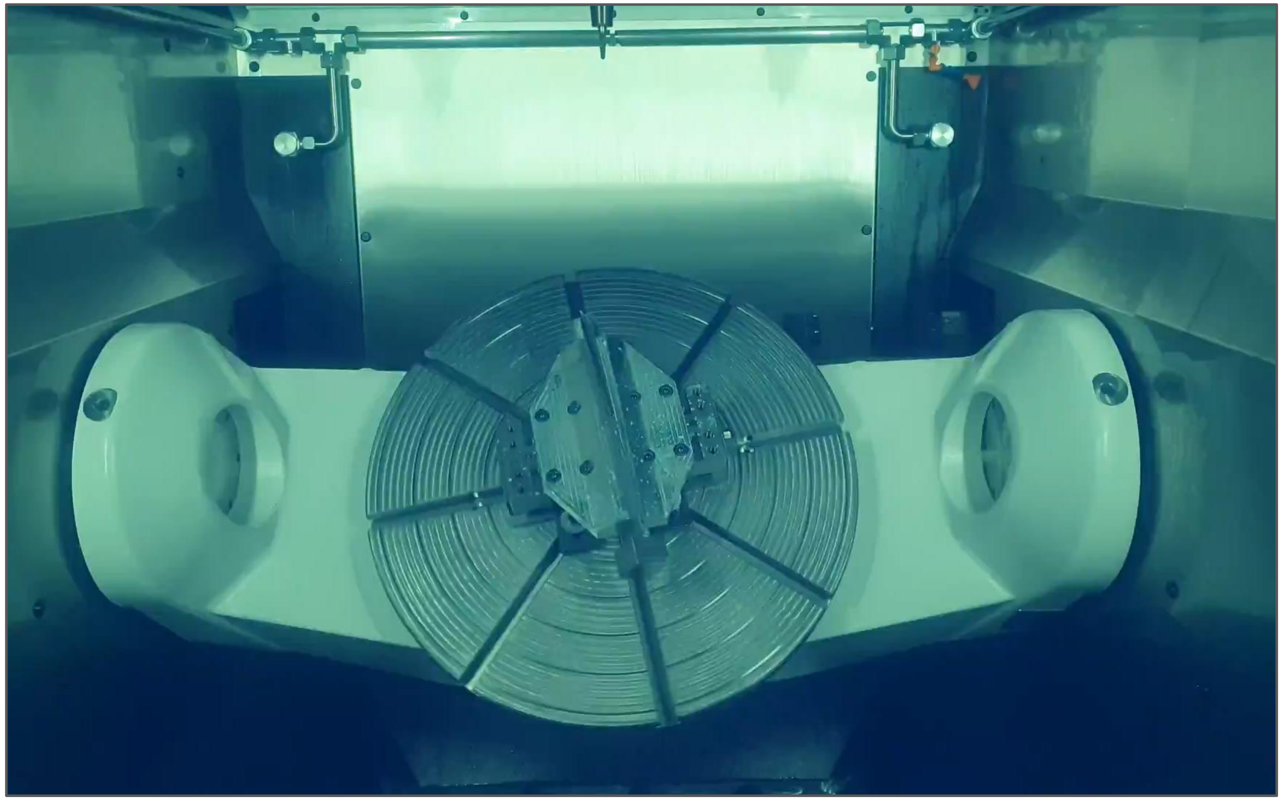
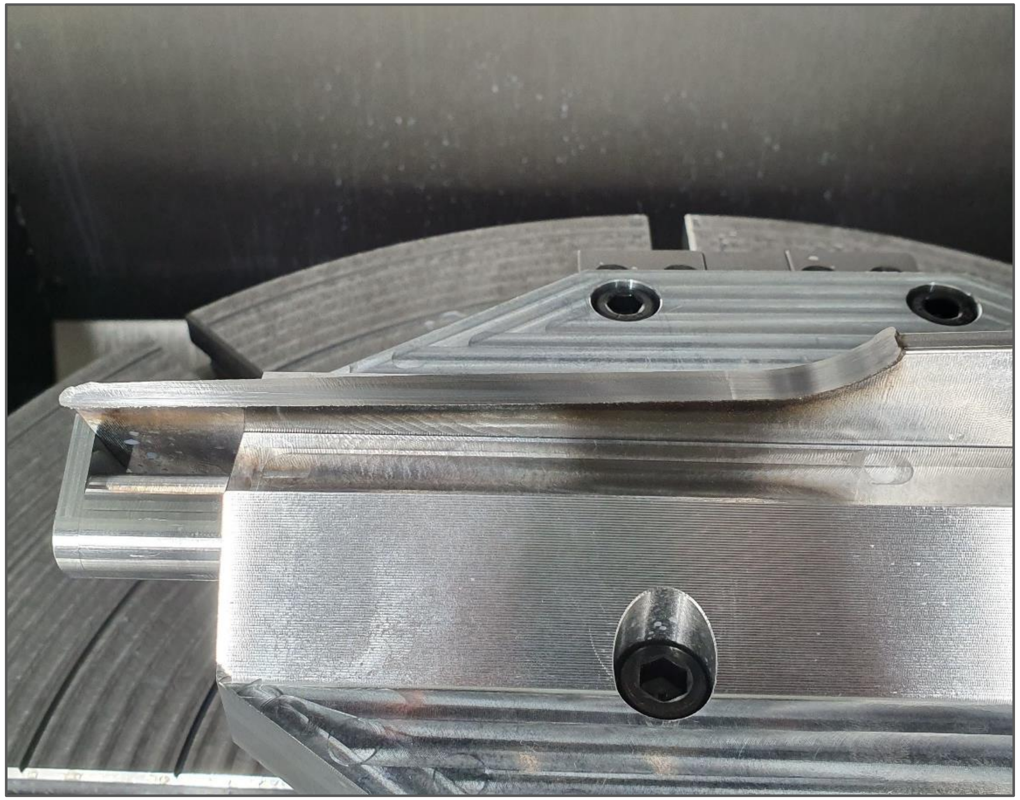
MILLING DAMAGED VOLUME





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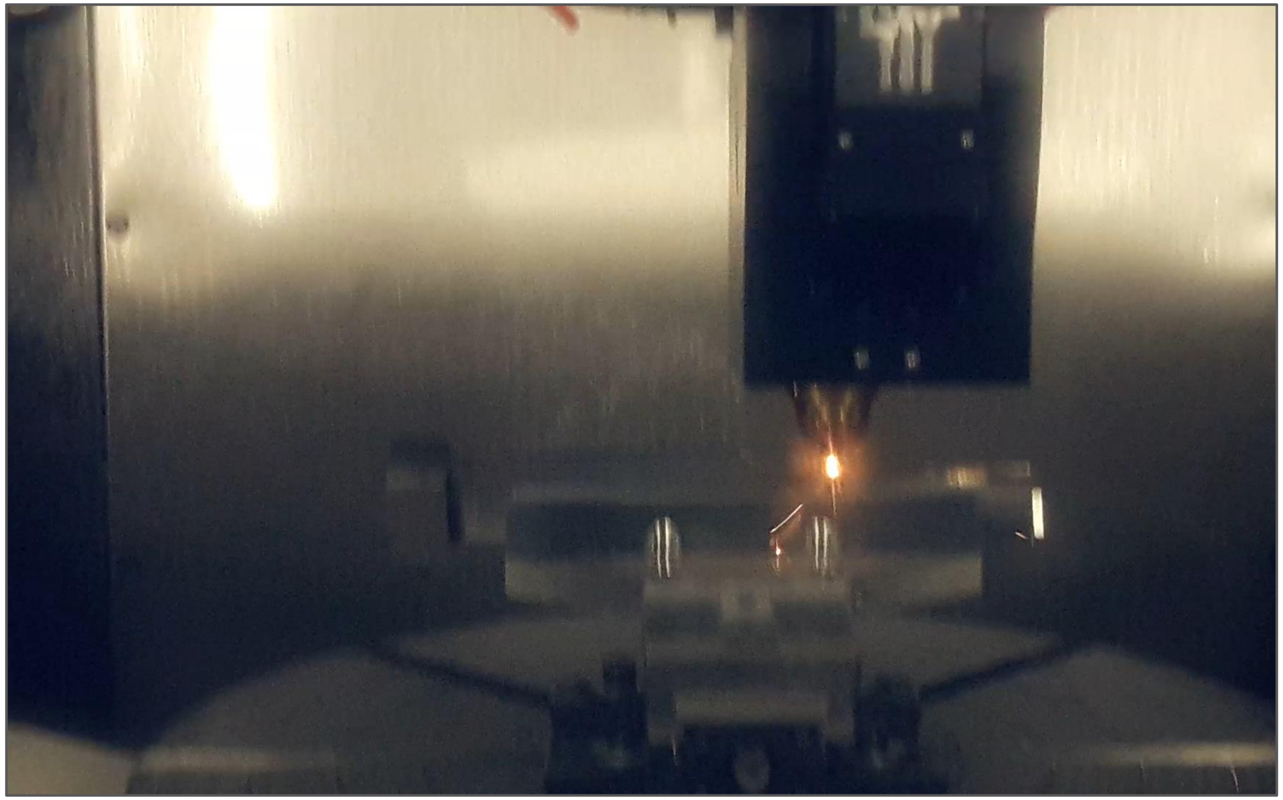
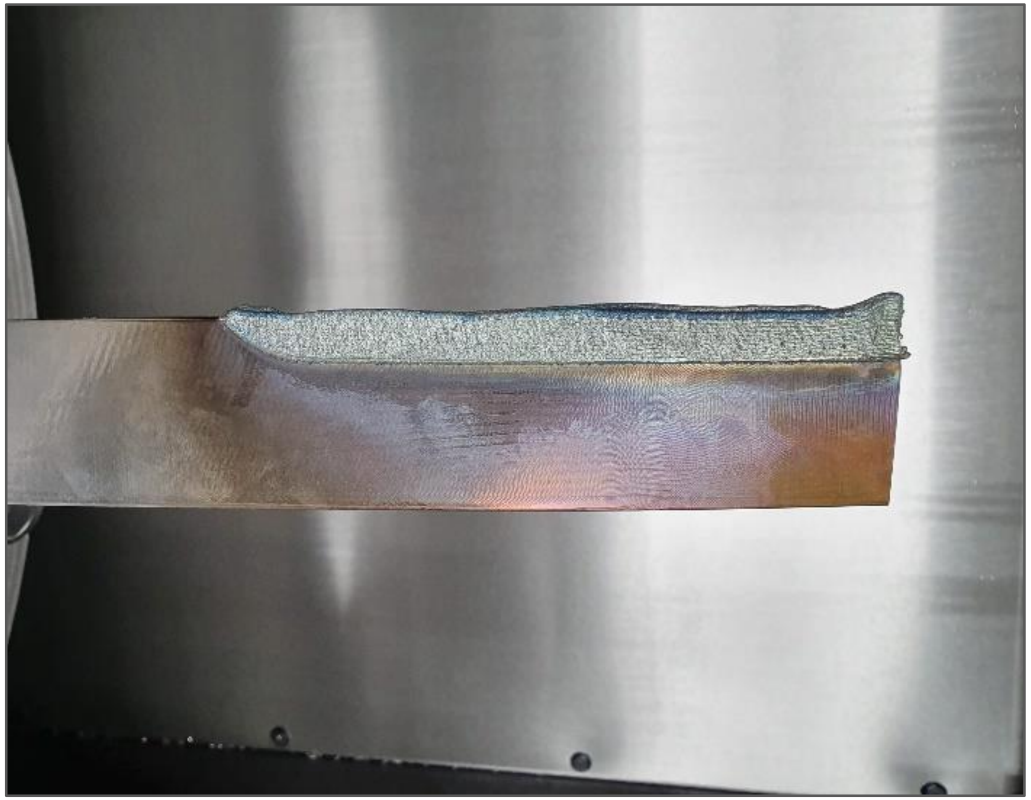
DEPOSITING NEW MATERIAL





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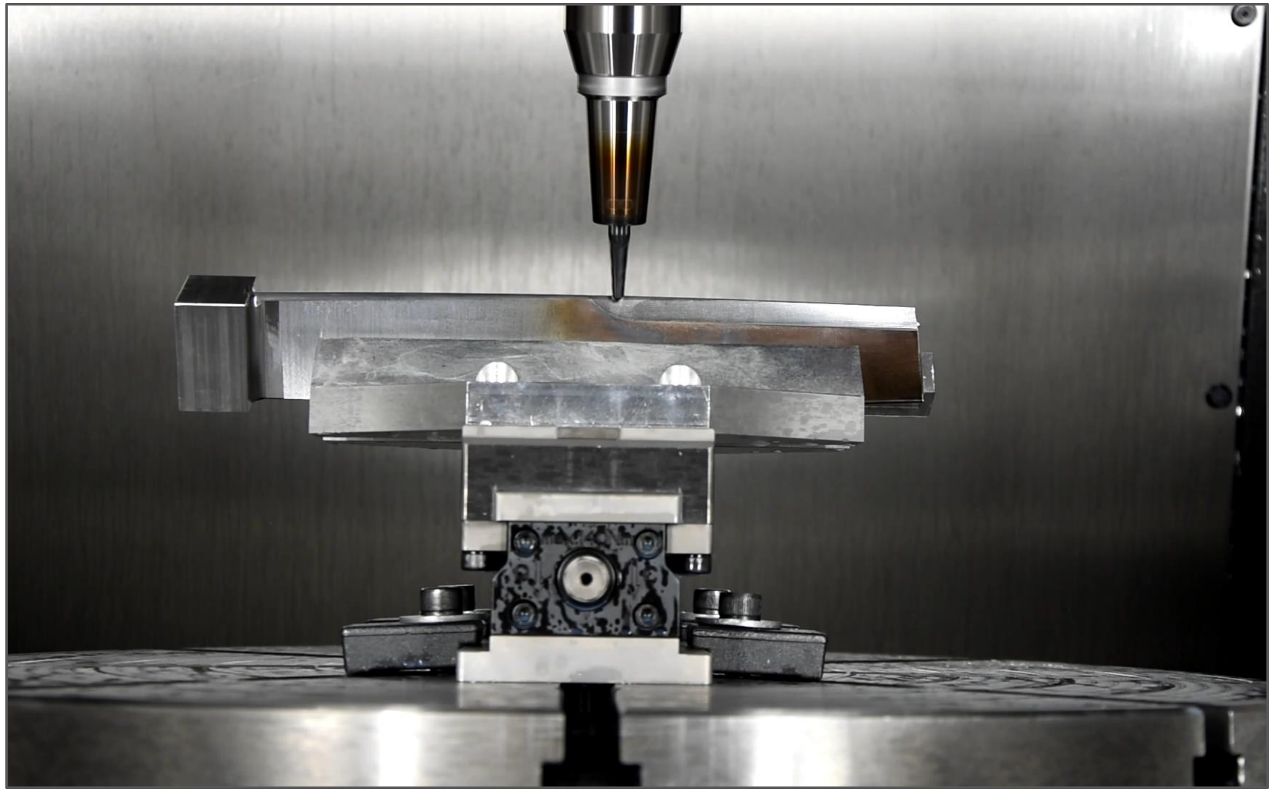
FINISHING



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Challenge:

- **Application:** repair of pitot tube
- **Substrate material:** In718 and 17-4 PH Steel versions
- **Repair material:** powder alloy Stellite 6

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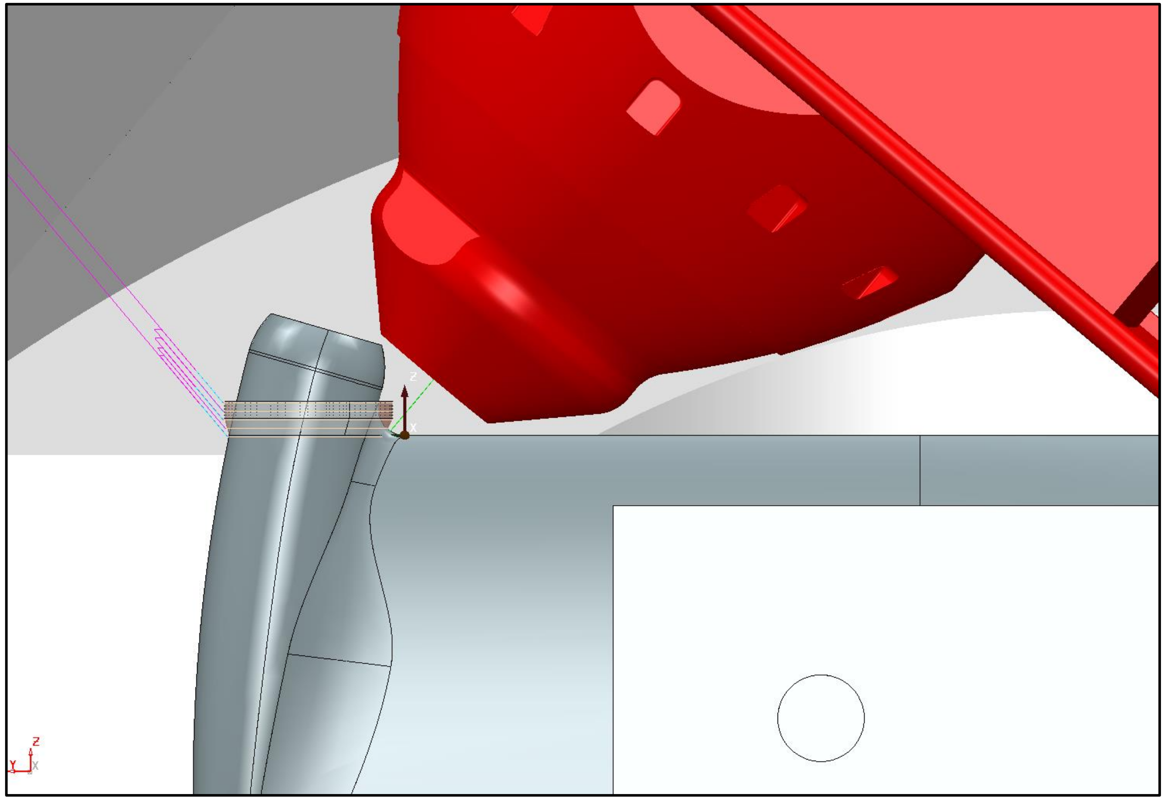
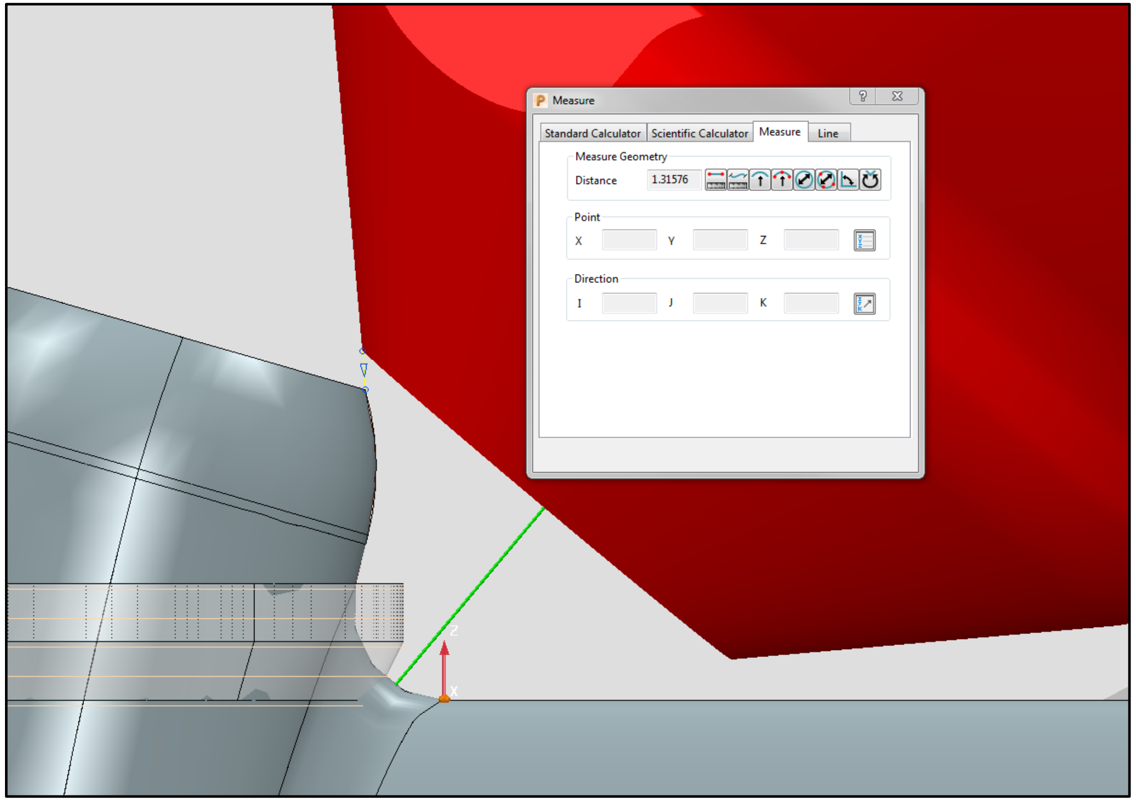
GEOMETRICAL CHALLENGE





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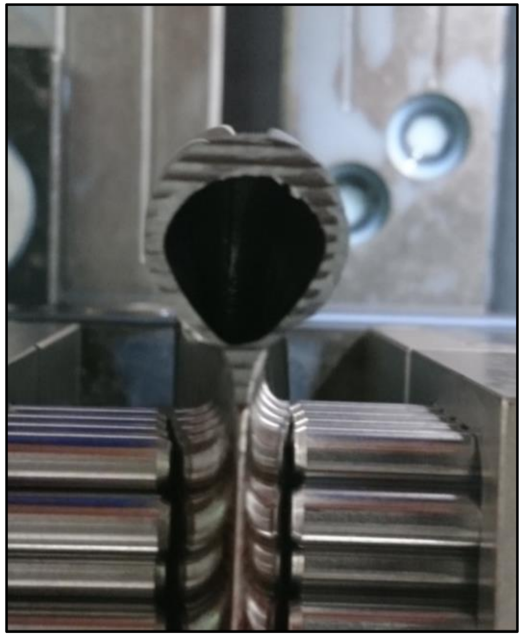
DEMONSTRATION - WEIR PITOT TUBE

DEPOSITING NEW MATERIAL - ENLARGING DEPOSITION SURFACE



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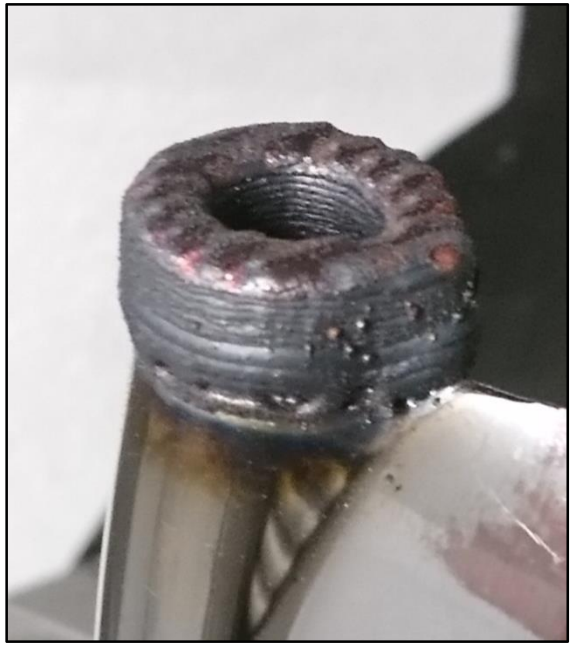
DEPOSITING NEW MATERIAL



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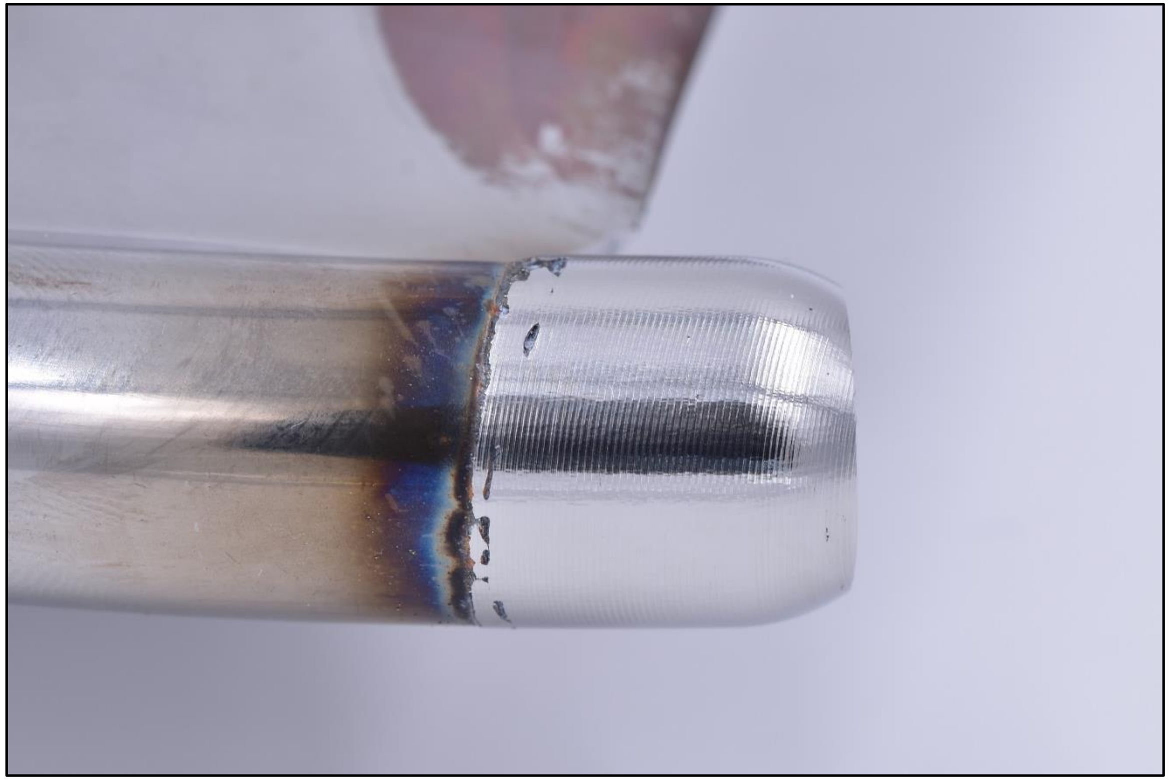
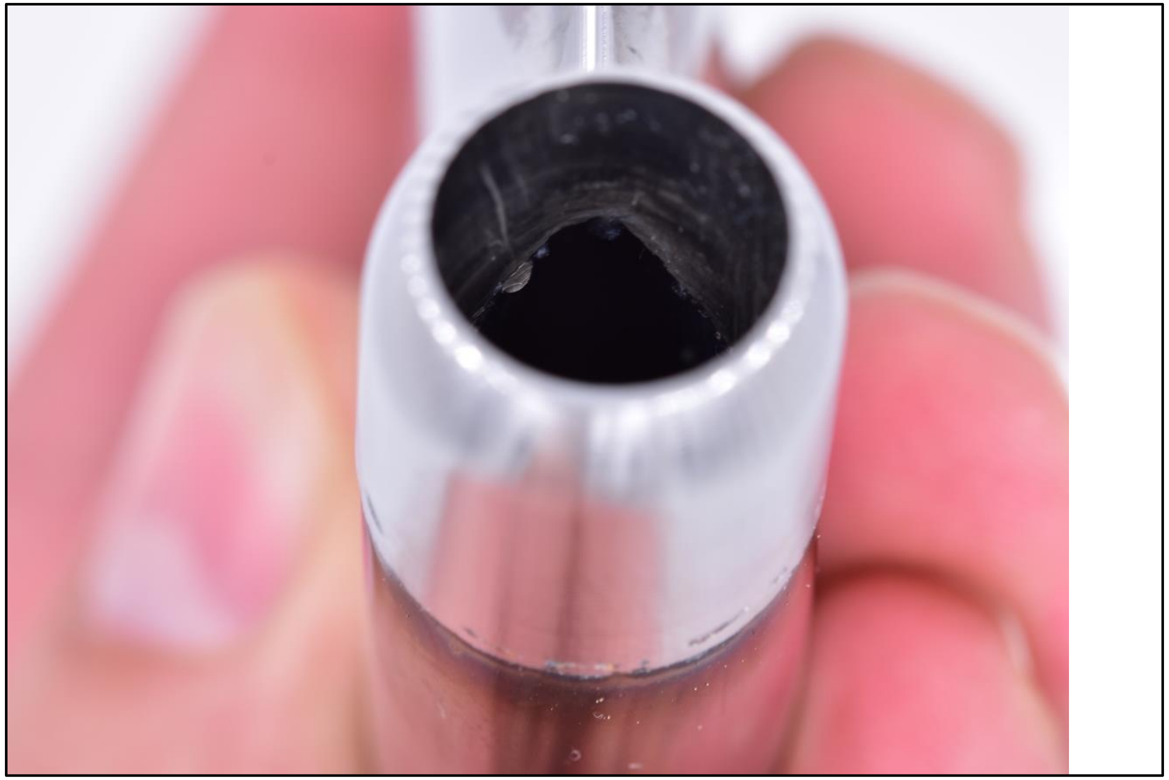
RESULT – REPAIRED PITOT TUBE





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Thank you for your attention!

Alex Josifovic

Jonathan Créquy

Josh Barras

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