ETHER NDE

Advancements in Eddy Current scanning of materials including AM, Carbon Fibre and Graphene

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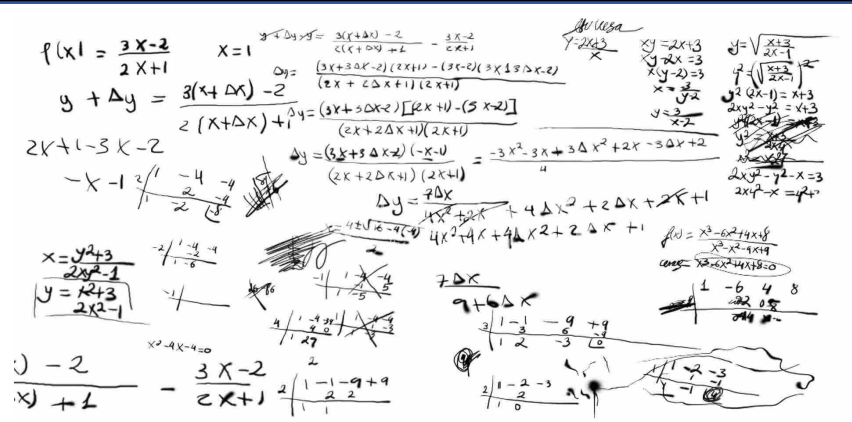
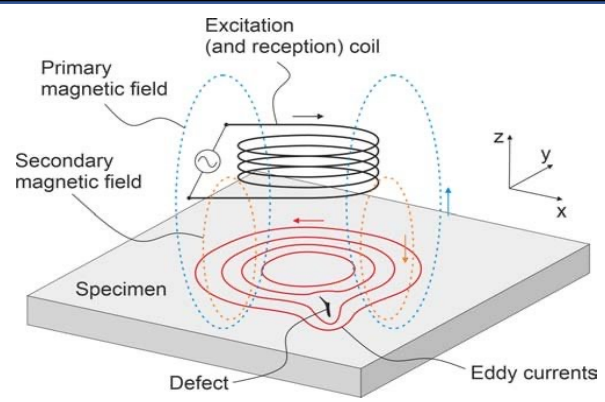
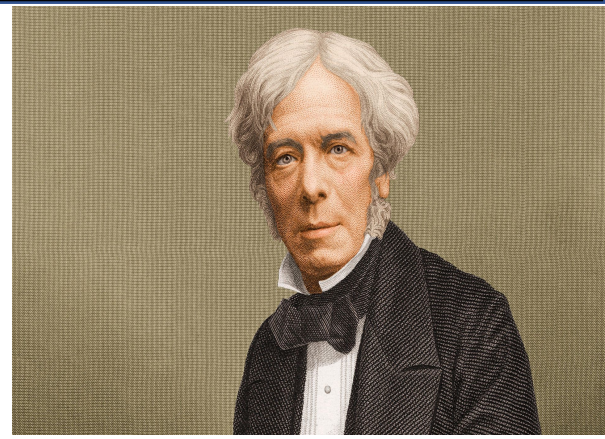
Introduction

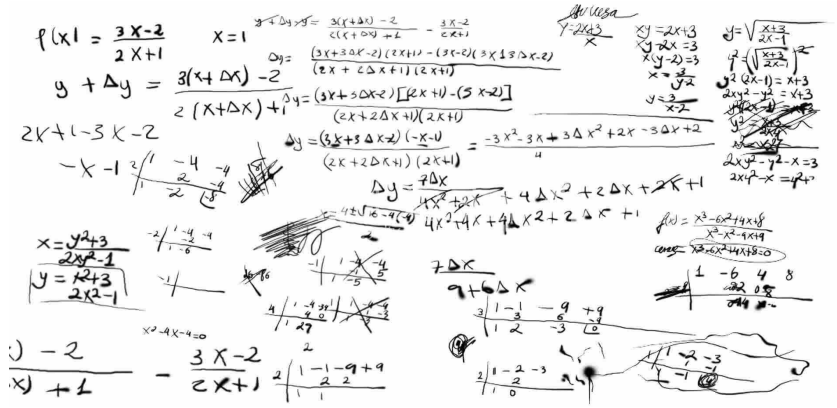


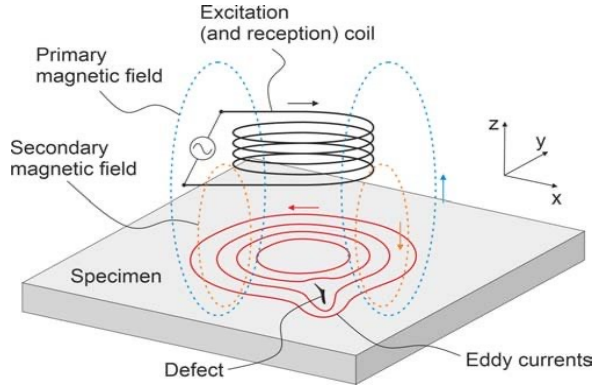


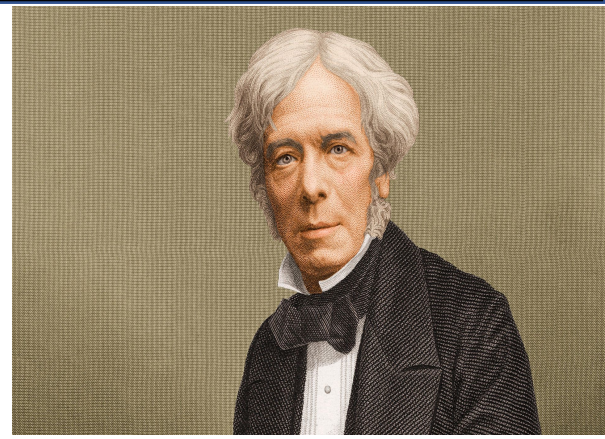


- Our historical use and understanding of Eddy Current testing methods on airframe and aerospace structures constructed of metals is well known and documented.
- From meter display instrumentation to phase plane display instruments the use of the Eddy Current method has met the challenges of the aerospace industry.

Introduction

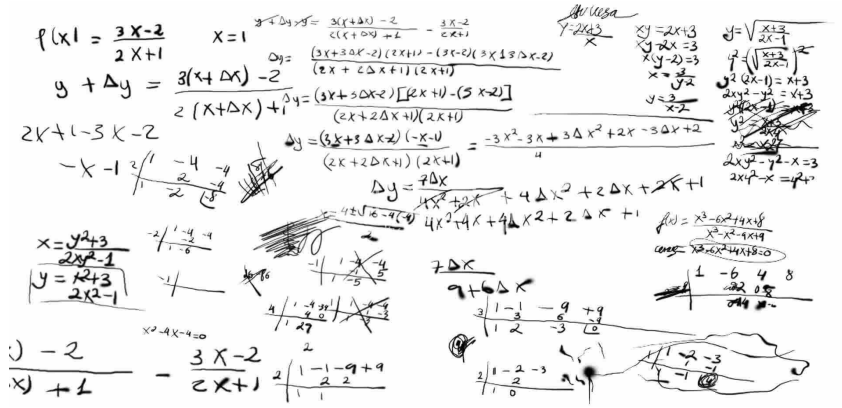


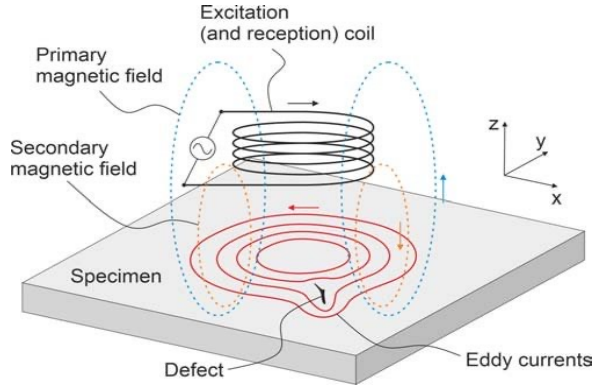


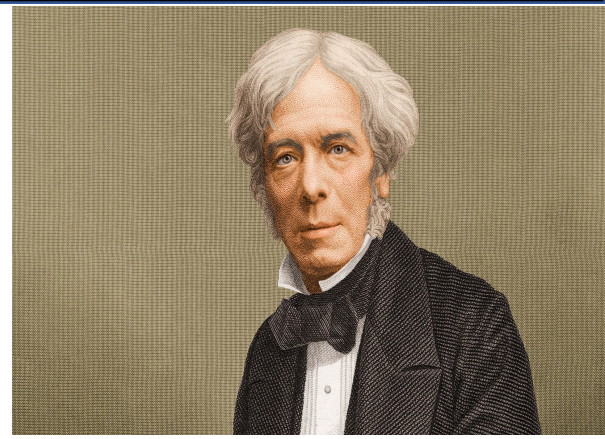


- As this industry evolves the use of other materials now adds to the test and detection challenges on not only Eddy Current but also the more conventional NDT methods such as Ultrasonics and X-Ray for example.
- These challenges remain the same with the introduction of thicker larger structures, more complex geometries and newer configurations such as engine blades now made from composites.

Introduction



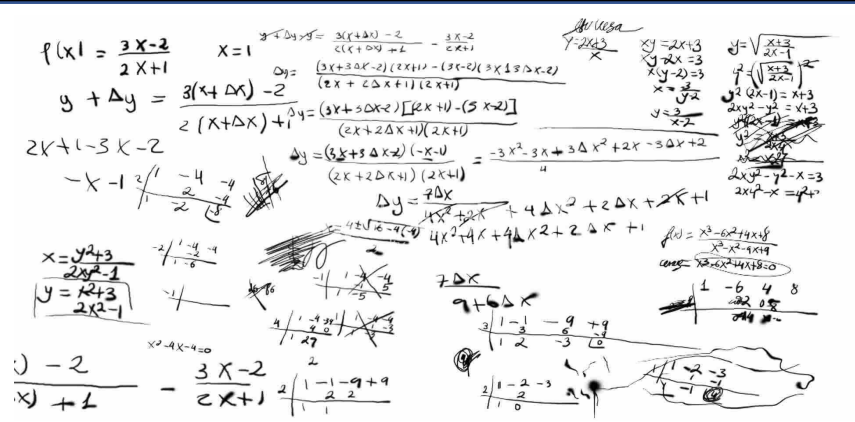


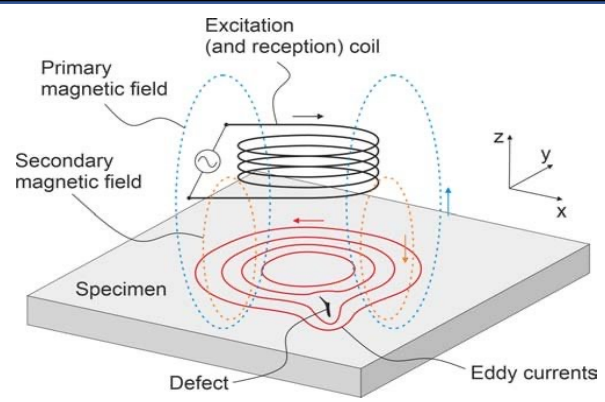


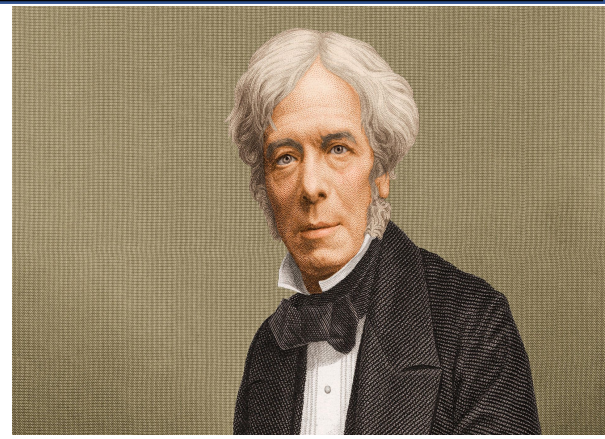
- The application questions also remain the same:
  - Can you test this part?
  - How small of a defect can you find?
  - Can I do it with what I have?

And of course, the Big One: How much $$$$$

Introduction







- This presentation will address the following:
  - Introduction of EThер NDE's standard off the shelf portable Eddy Current Testers and accessories used for these new challenging applications.
  - Imaging and signal analysis and how this can be used to assist the inspector for improved testing detection.
  - Additive Manufacturing and the integration of Eddy Current in the testing process
  - The implementation of ECTR

Portable EC Units w/Unique features

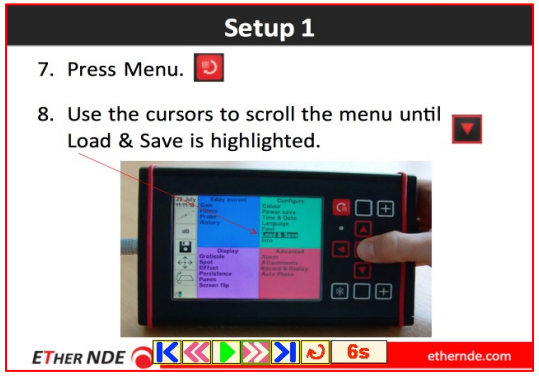
Offering industry leading performance display and eddy current detection capability.

FEATURES

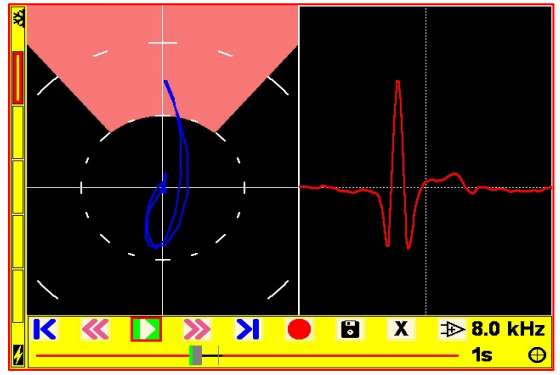
EQUIPMENT	Rotary	Data Recording	Dual Frequency With Auto-Mix	Conductivity	Guides	Loop	Trace	Enhanced Protection	Frequency
AeroCheck2	●	●			●	●	●	●	10Hz-20MHz
AeroCheck+	●	●	●	●	●	●	●	●	10Hz-12.8MHz

FEATURES

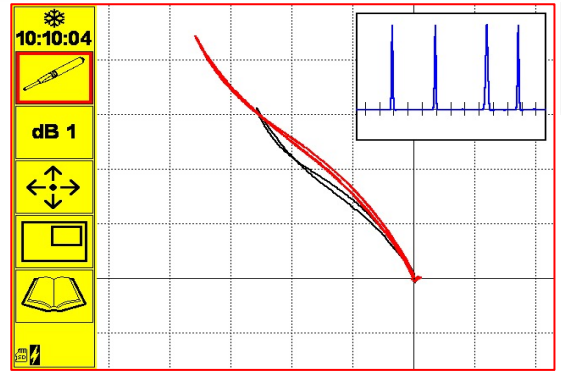
EQUIPMENT	Data Recording	Lift Off Gain Compensation	Conductivity	Guides	Loop	Trace	Enhanced Protection	Frequency
WeldCheck2	●			●	●	●	●	Single 10Hz-20MHz
WeldCheck+	●	●	●	●	●	●	●	Dual 10Hz-12.8MHz



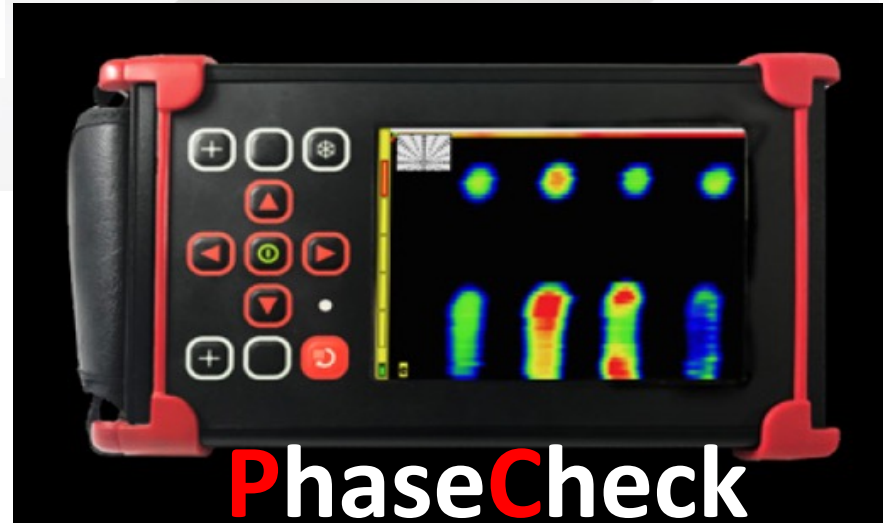
OP & Procedure Guide



Record & Replay with Auto Mix



Trace & Loop



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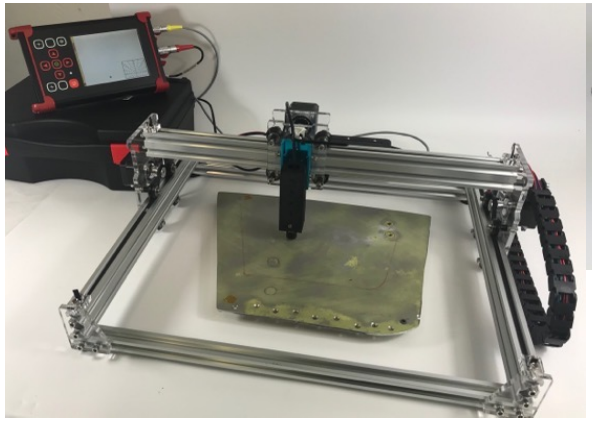
ETherNDE PhaseCheck Portable Instrument

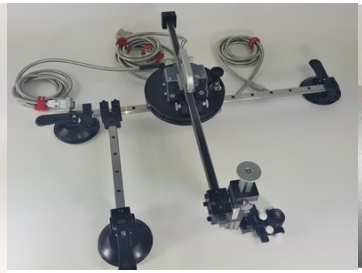
"A **picture is worth a thousand words**" – Eddy Current C-Scan imaging made easy

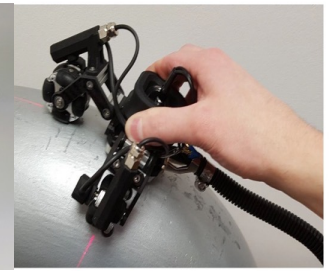
To date "pictures" (C-Scan) in Eddy Current has been limited to expensive large laboratory instruments.

Dual Frequency High Performance Eddy Current Flaw Detector with C-Scan Capability – allows the connection of up to two encoders and two probes

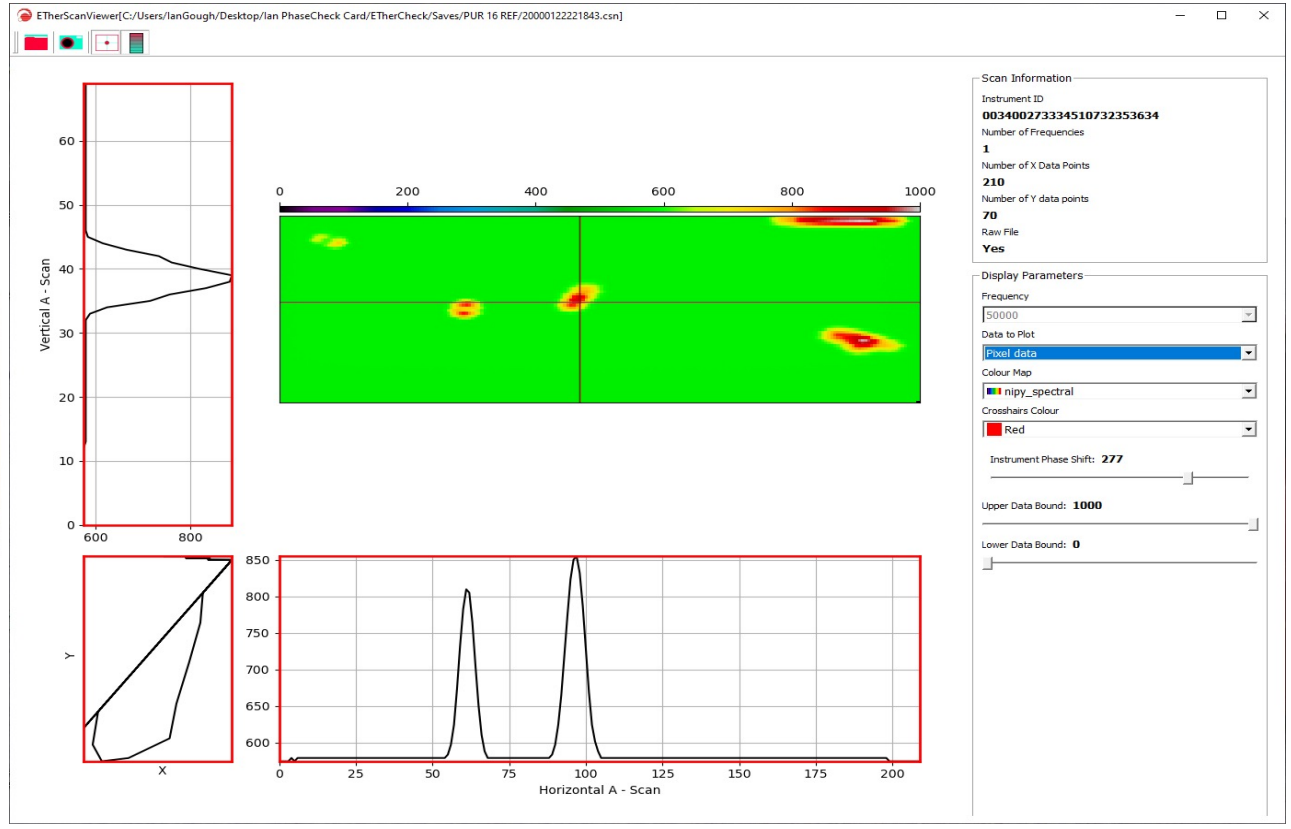
Supporting Encoders and Manipulators







The PhaseCheck instrument was used in conjunction with the ETher Imaging and Measurement Software for the detection and display analysis of these test.



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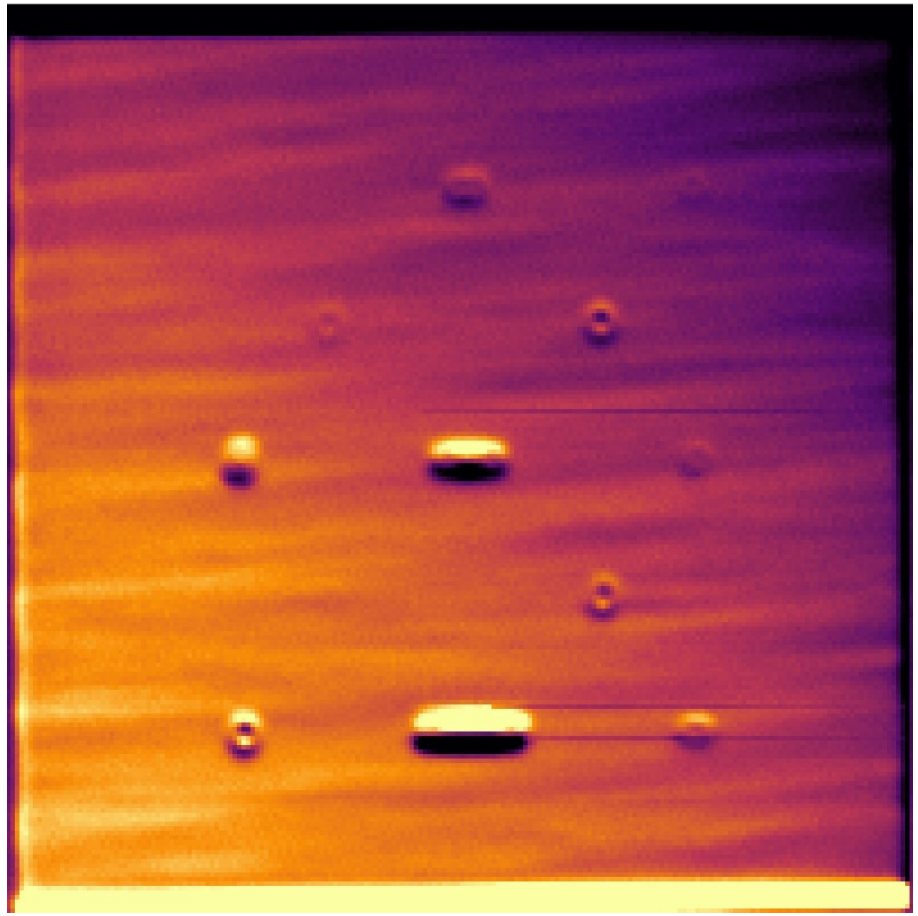
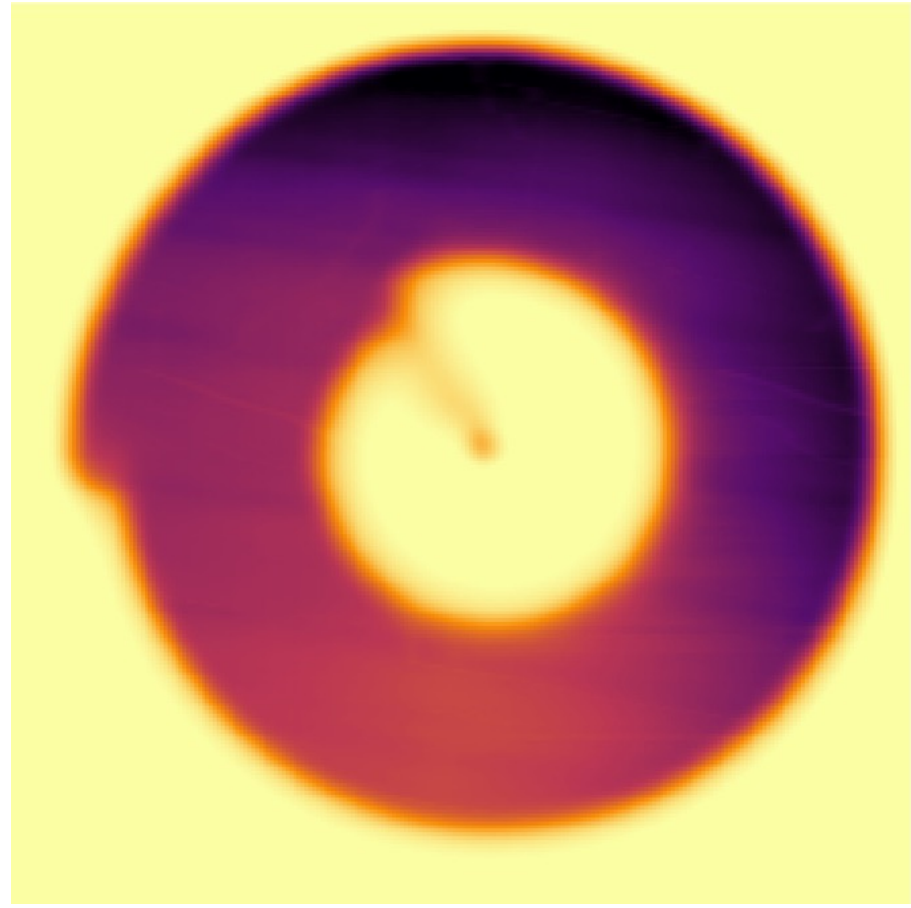
PhaseCheck

C-Scan Video

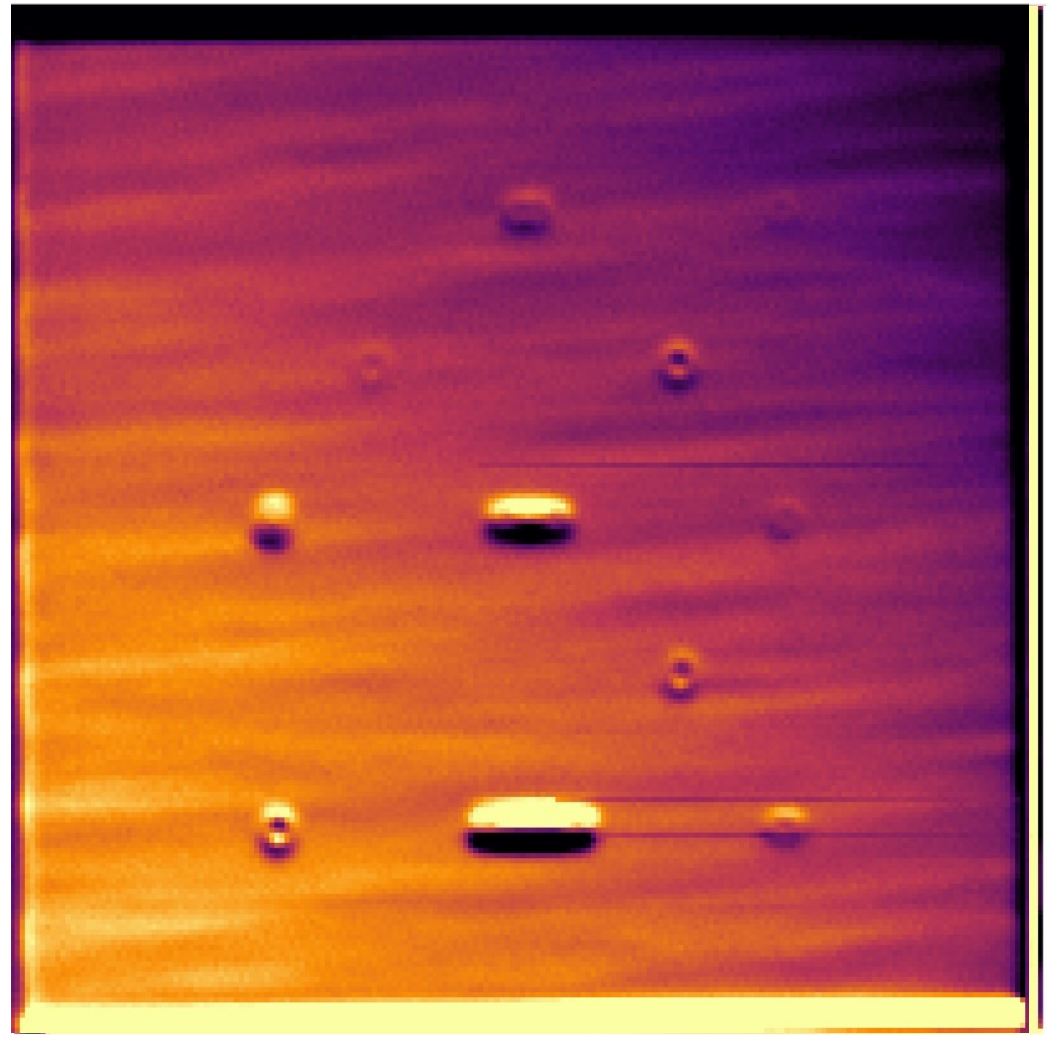
Metals Testing Application





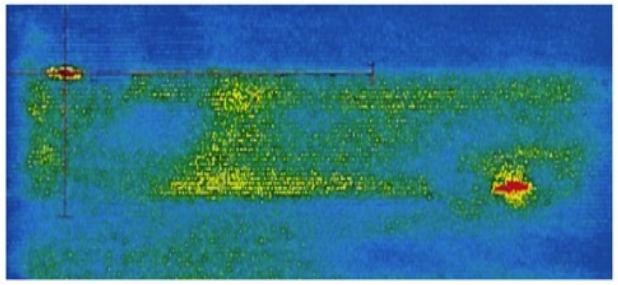
Stainless 316 Plate
2MHz Differential Bi Directional Probe

- Developed a directional EC probe both Absolute and Differential.
- 0.2mm deep by 0.2mm diameter FBH note visible
- Surface condition circa 200 um

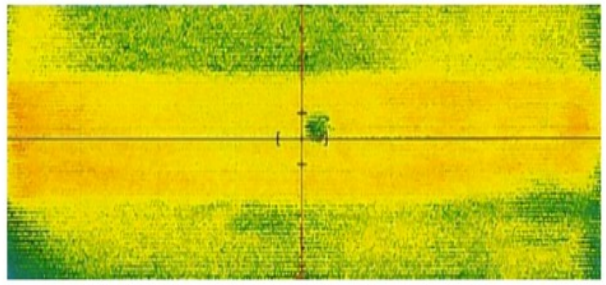


Carbon Steel Weld with Abs and 2D probe

Results on these welds are given in a paper presented at QNDE in 2018 by Manchester University, UK entitled "Surface-Breaking Flaw Detection in Mild Steel Welds using Quantum Well Hall Effect Sensor Devices" using co Z eqpt and R inspectors.

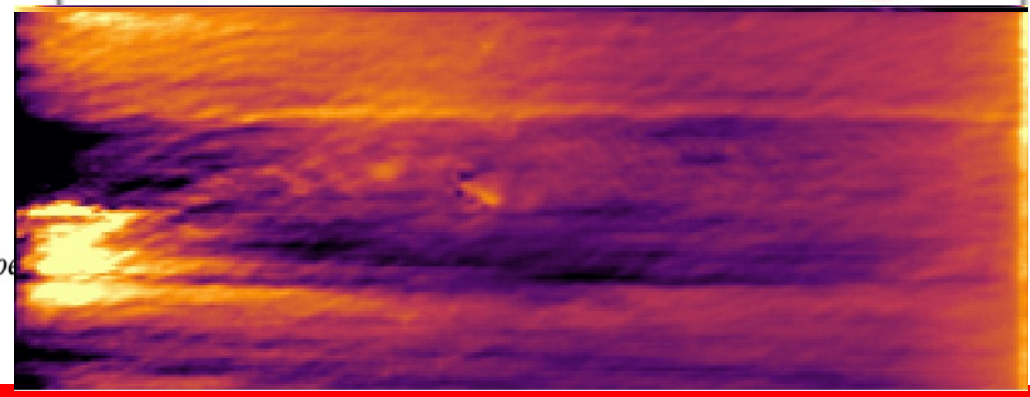


(a)

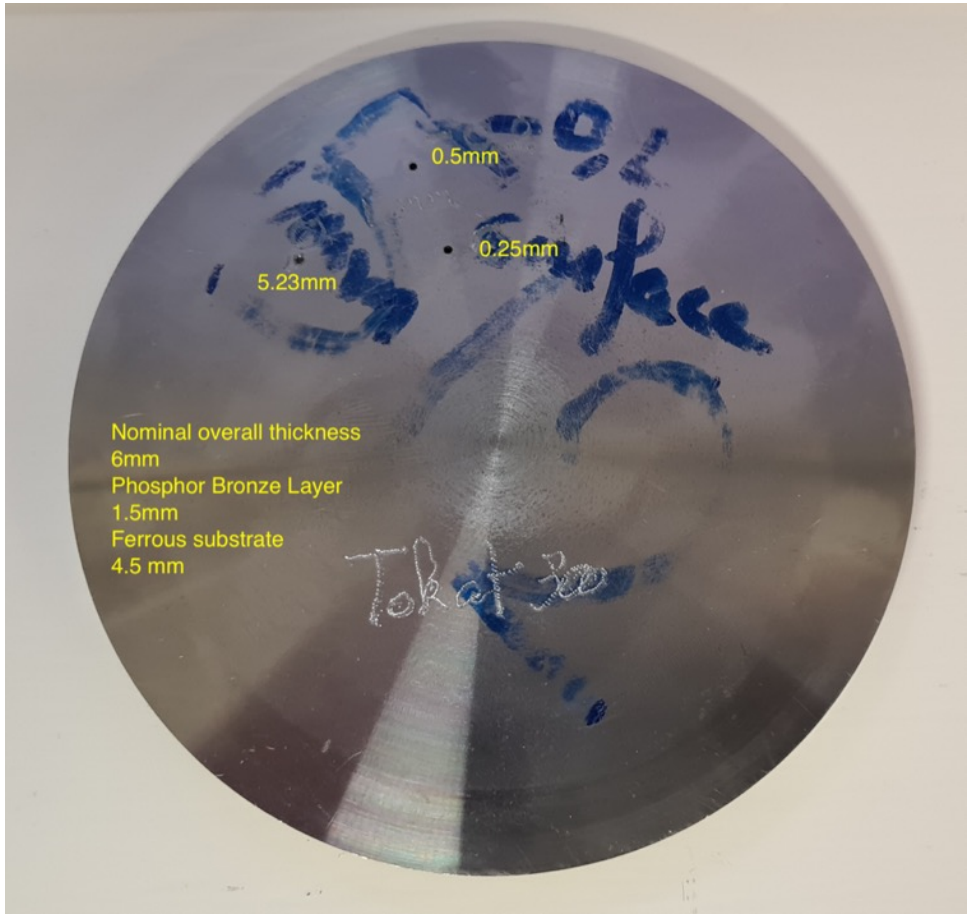


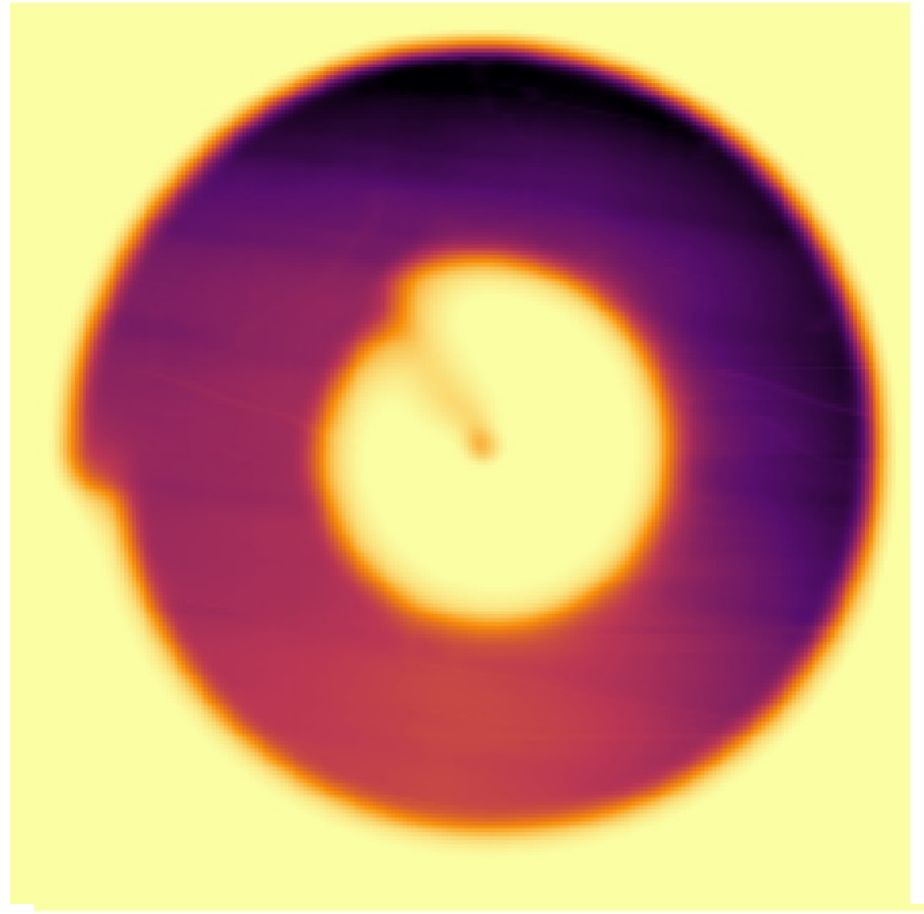
(b)

FIGURE 3. ECT phase shift images of complete weld scans of two samples from this study. (a) ECT indications of two 8 mm toe cracks on sample 6441-02. (b) ECT indications of 5 mm linear porosity cluster on sample 6441-03.

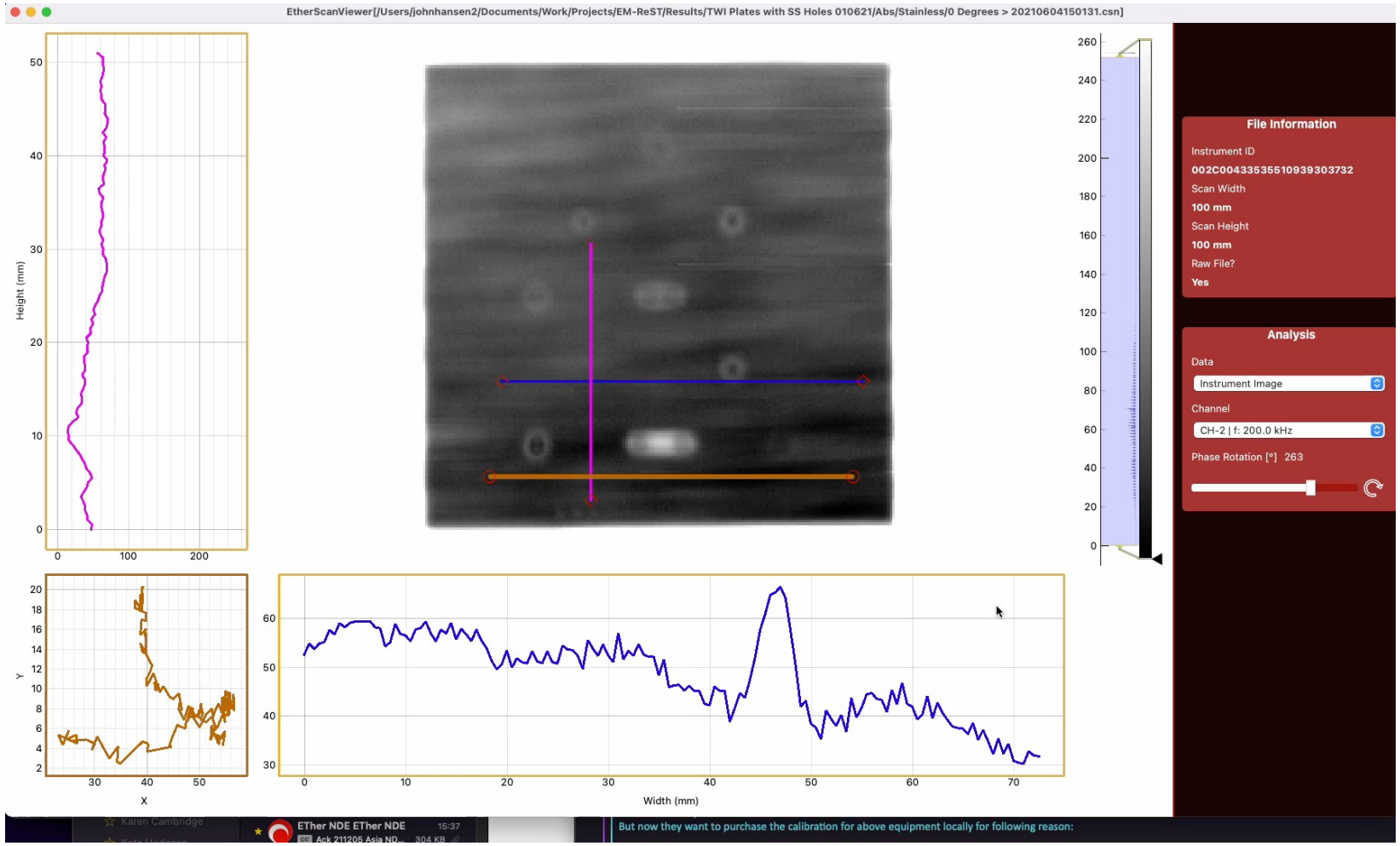


Sub Surface Defects in Bimetallic Phosphor Bronze AM Layer on Carbon Steel Substrate





Demonstration of imaging/measurement SW



Preliminary Tests

Eddy current inspection of Carbon fibre raw materials and cured parts in the Aerospace industry

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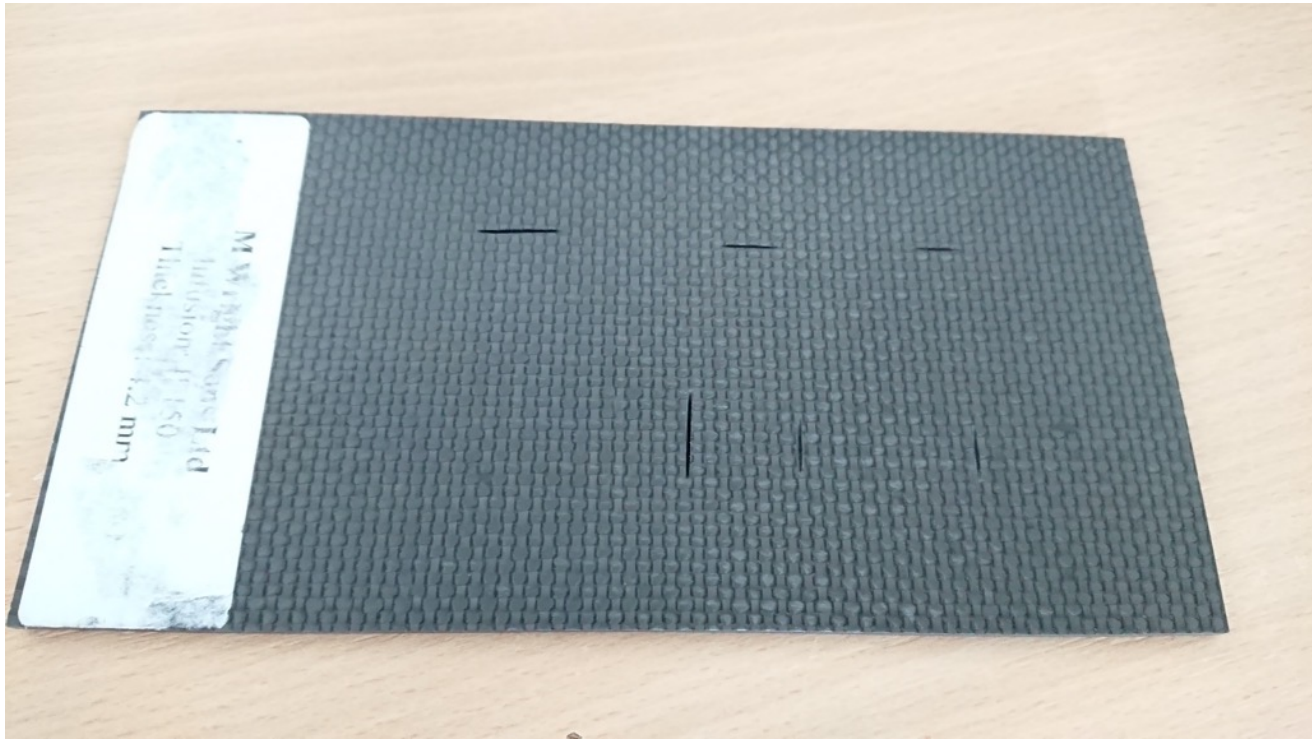
Notched 4.2 mm sample



Notches

Left to Right

Top

2.3mm deep by 17mm

1.28mm deep by 12mm

0.7mm deep by 10 mm

Bottom

2.5mm by 18mm

1mm by 11mm

0.9mm by 10.5 mm

Sample nominal 4.2mm but Right side 4.3mm left side 3.8mm

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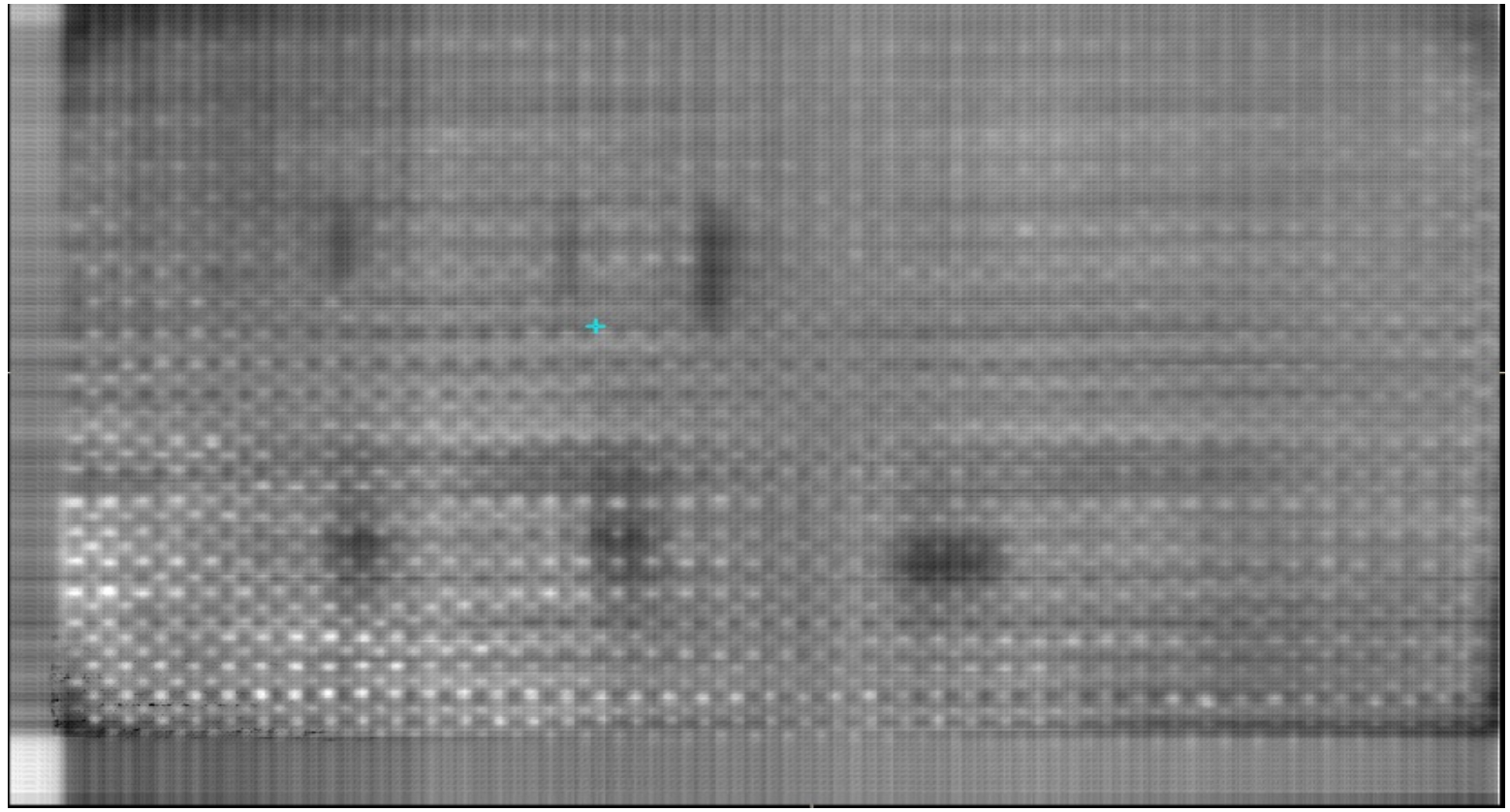
4mm Sample with surface notches



2MHz Pencil Probe at 4MHz @ 0.25 mm resolution (164215)

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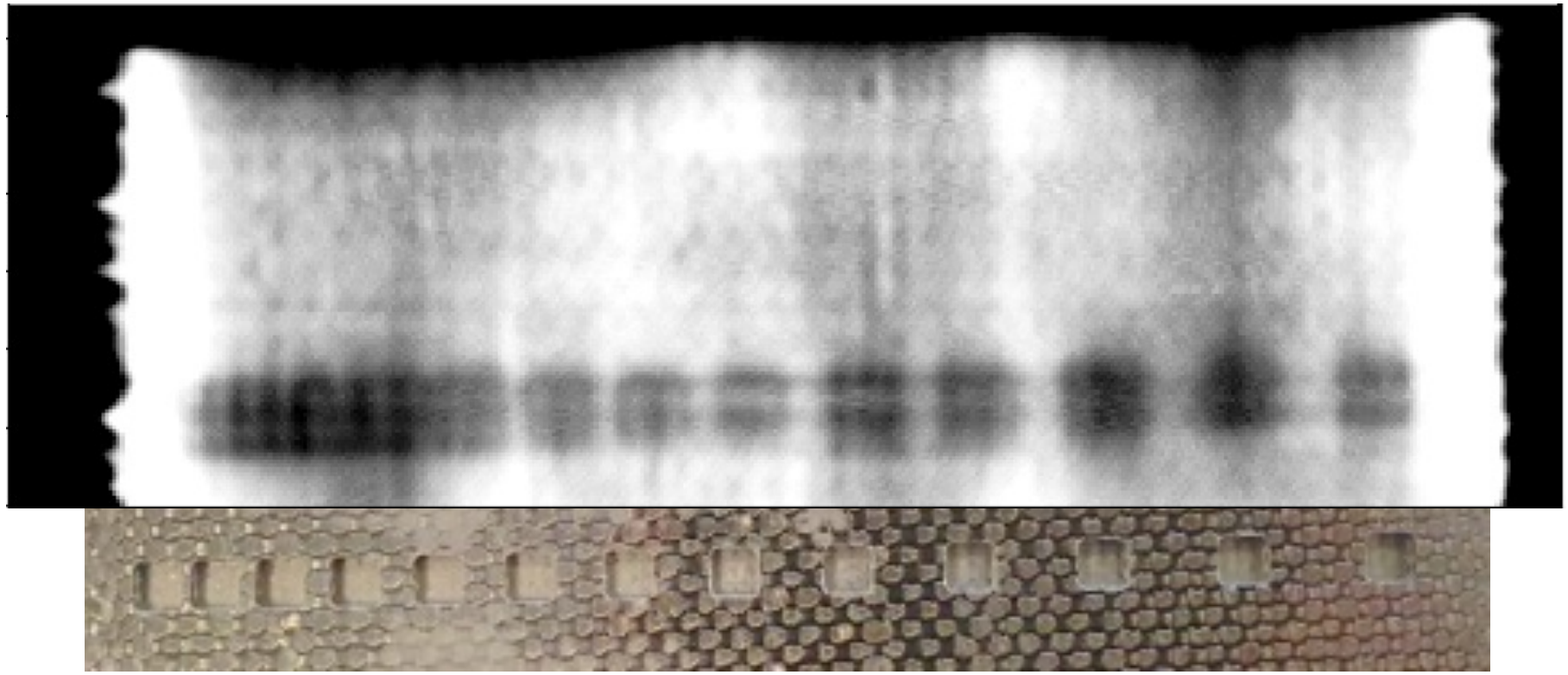
4.2 mm Resolution Sample



8mm TX-RX Probe @ 9MHz scan of 50% depth 6x6mm FB squares

CFLUX

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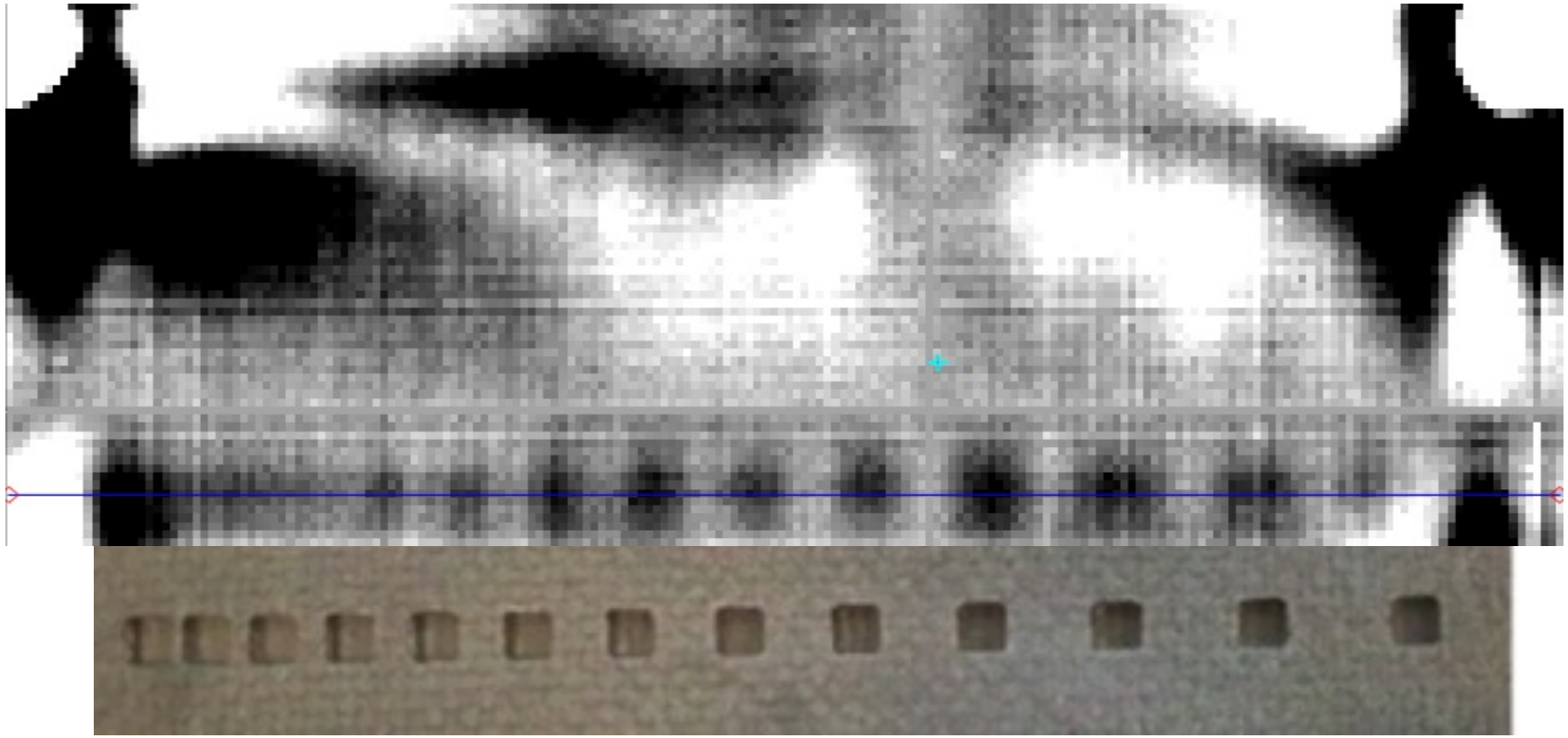
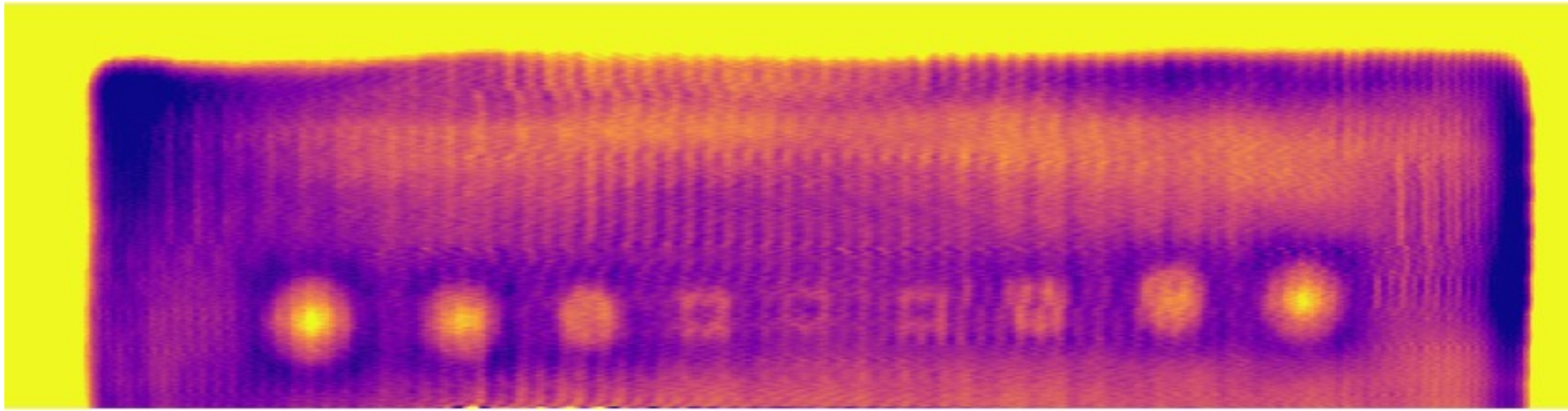
15mm resolution sample with filtering



24mm TX-RX Probe @ 400kHz scan of 13% depth of 6x6 mm FB squares

CFLUX

3mm CFRP 2 by 2 Twill 8 ply Sample Scan



9 embedded 1mm thick 10x2mm dia discs

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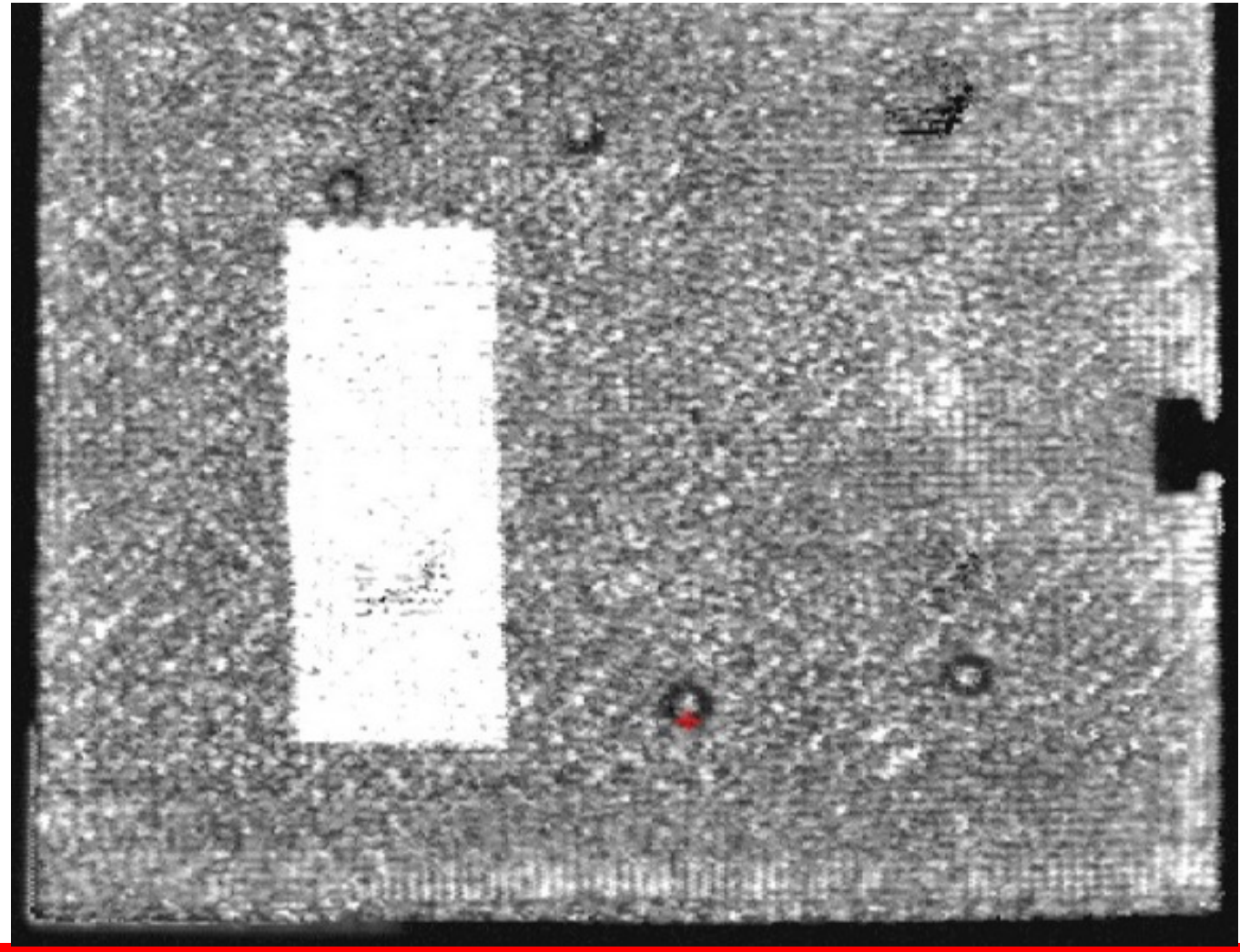
UT Compared with EC

Illustrating the Orthogonal nature of UT and EX



On Loom Inspection

Integrated a prototype system at MWS for on-line defect detection for on loom defect detection.

On Loom Inspection Video

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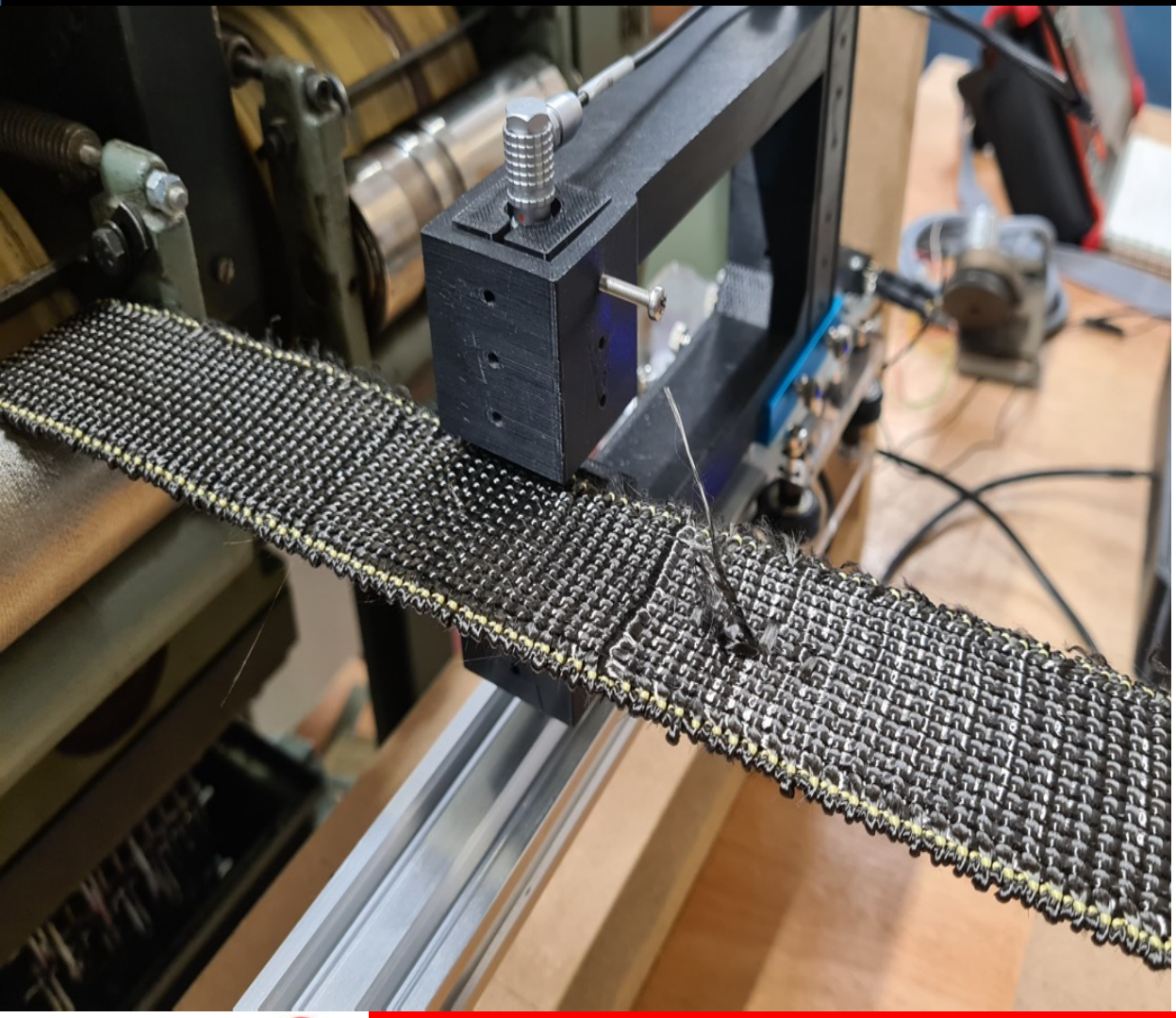
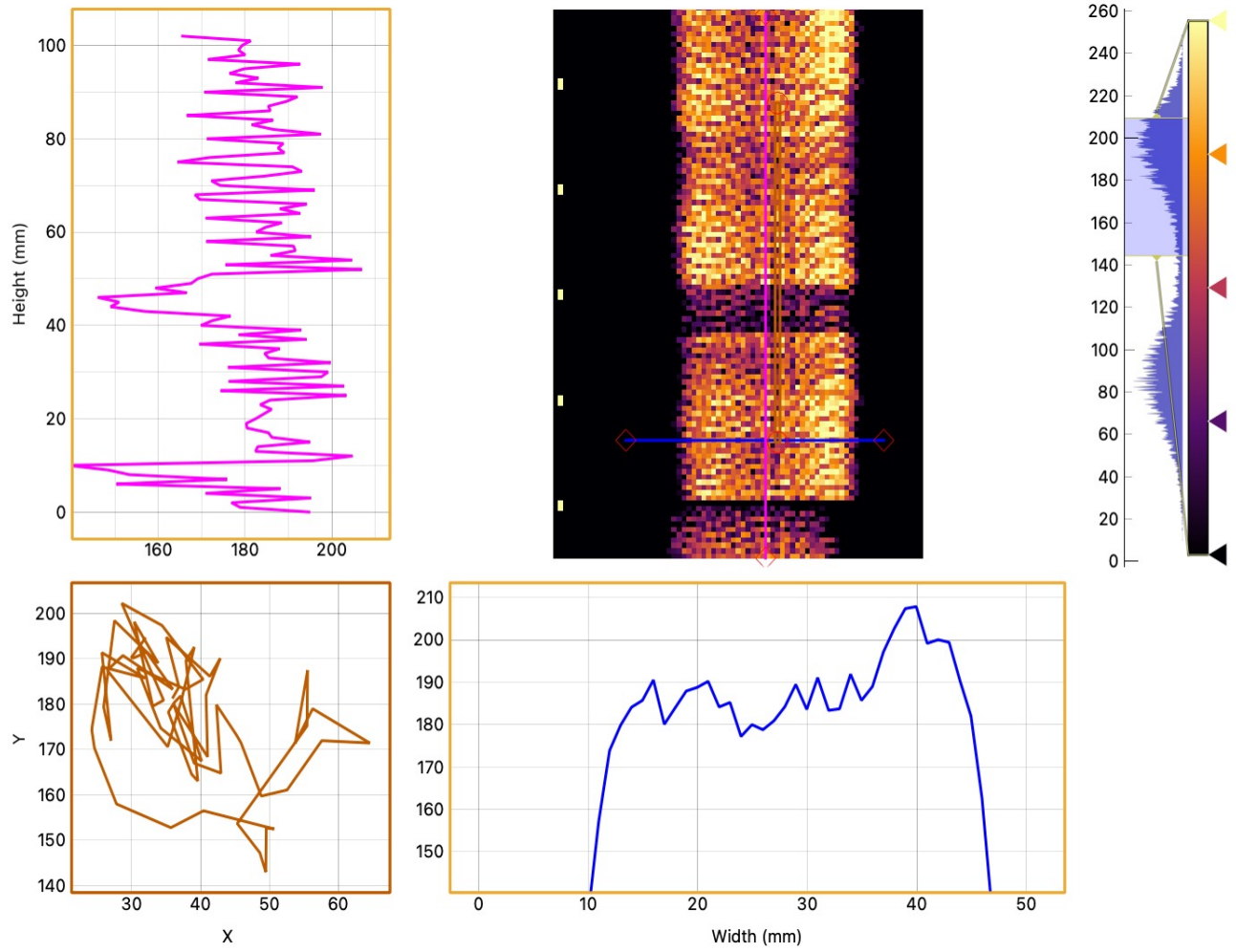
Defects detected





filename: 20210318163154.csn | channel: CH-1 | f: 3.0 MHz | image data: Y Component Image | phase rotation: 149°

Approach

- Curved demonstrator (design and tooling), FEA and mechanical testing

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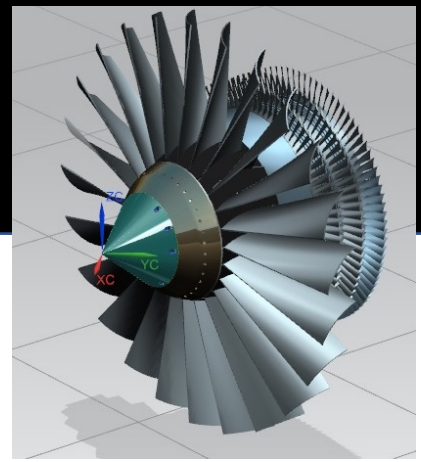
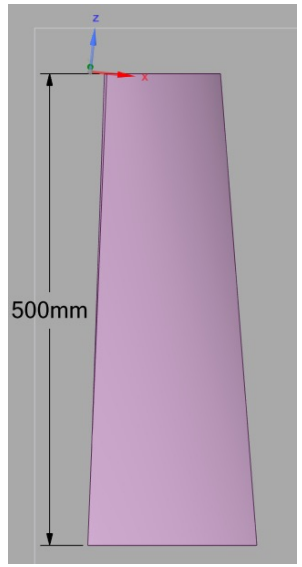
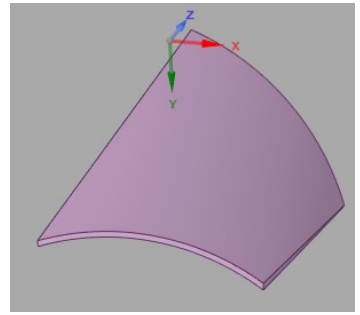
Curved Demonstrator design-FAR



- Our curved demonstrator is a fan blade from a CMF56 engine, which is used in the A320 and A240 aircraft.
  - Minimum radius is 200mm.
- Typical volumetric flaw types can be placed into the part during manufacture
- The demonstrator allows for parts of different thicknesses to be produced from the same tool.
- We can apply load conditions of bounded at one end, and a point load applied at the other – creating a cantilever load case.





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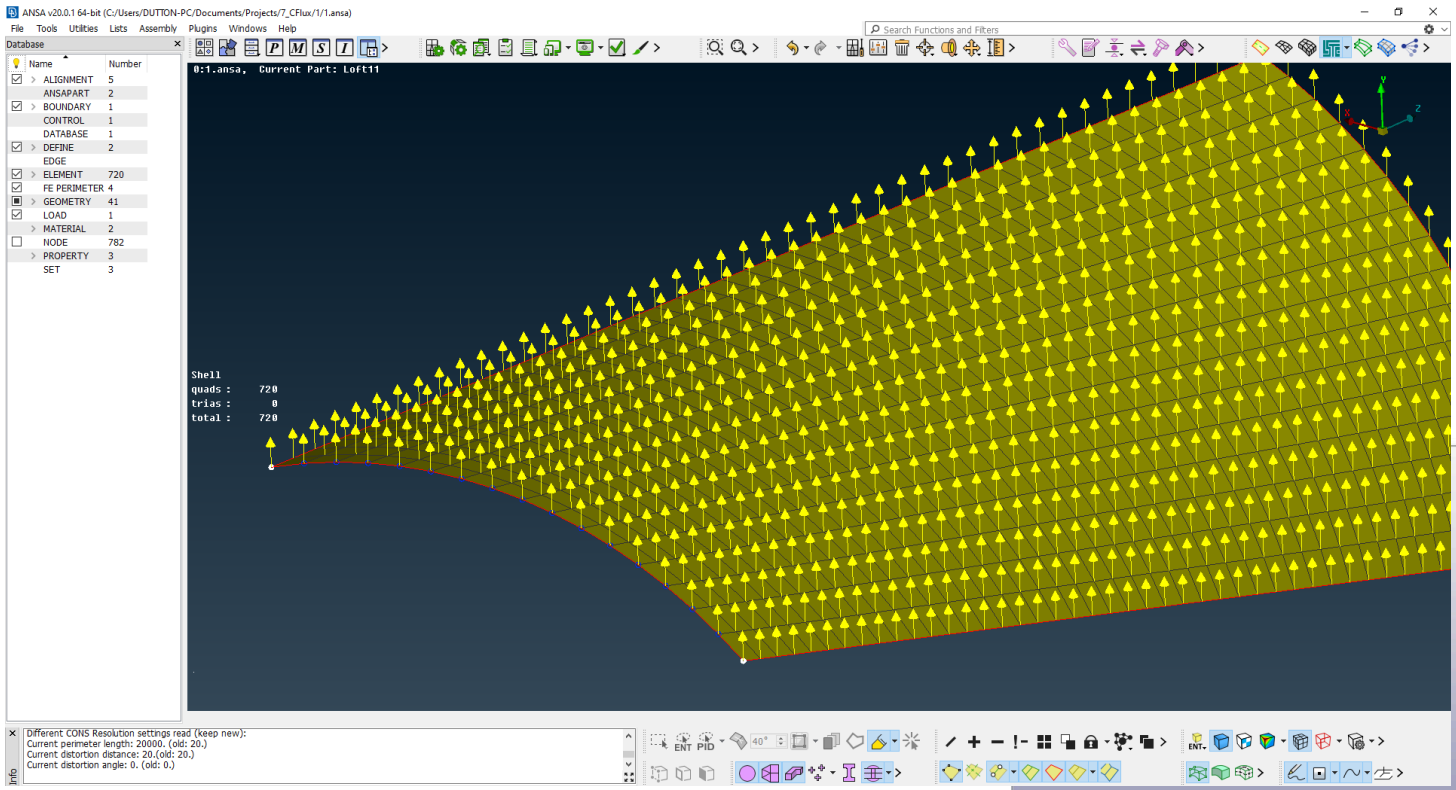
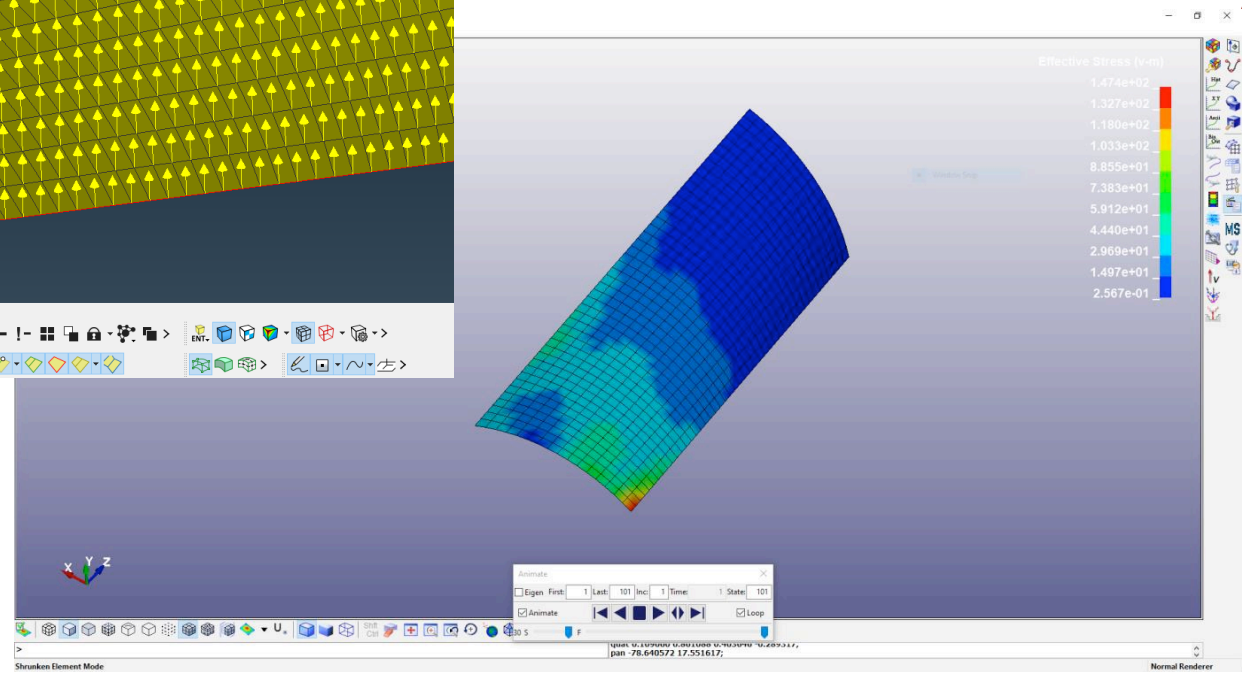
FEA analysis of curved demonstrator





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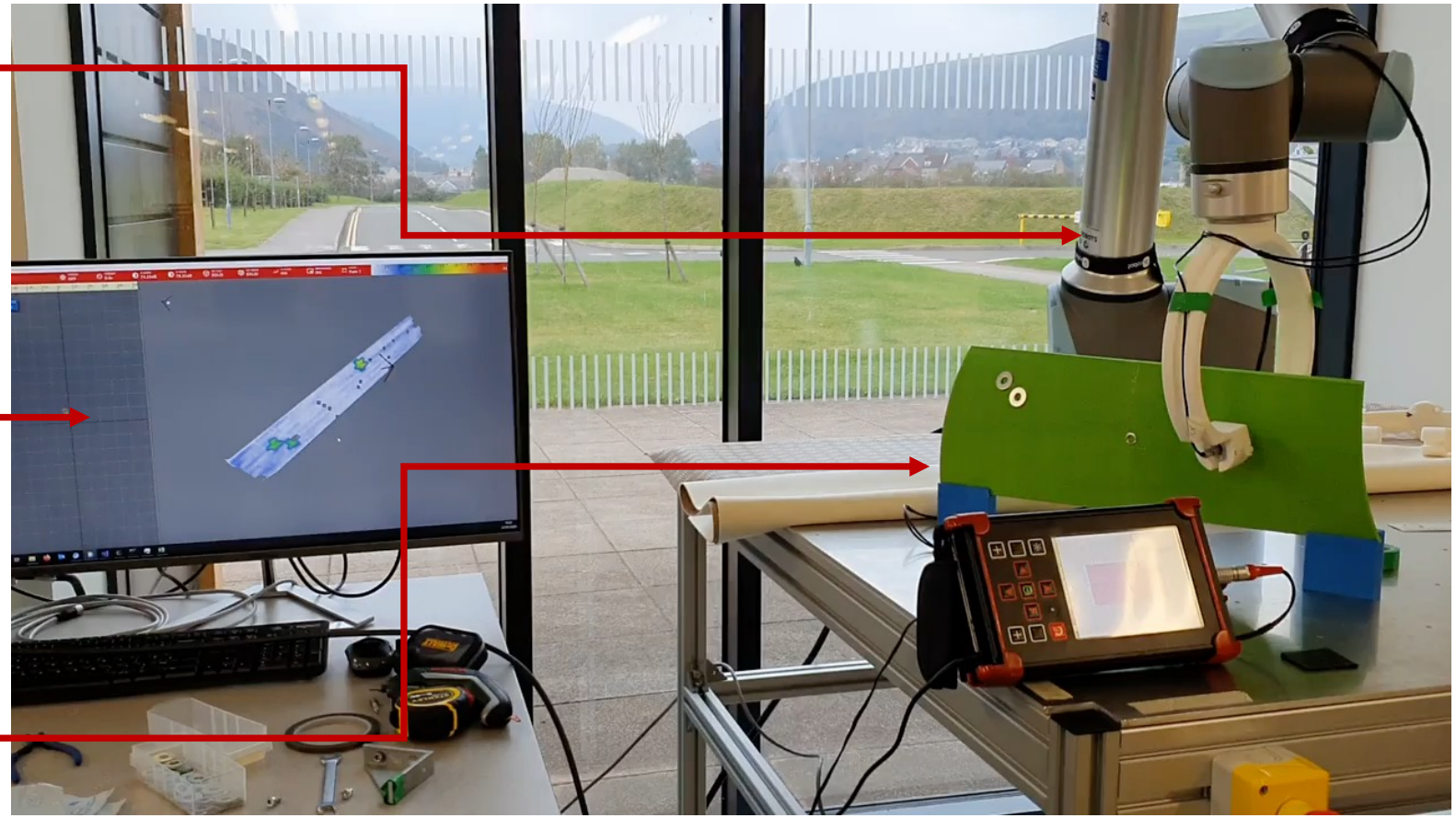
The CFLUX 30236 Program Consortium Robot Integration Probe Assembly Design

- Cobot for automatic scanning of 3D parts
- Offline path Planning via RoboDK
- 3D printed Curved demonstrator, M. Wrights and sons



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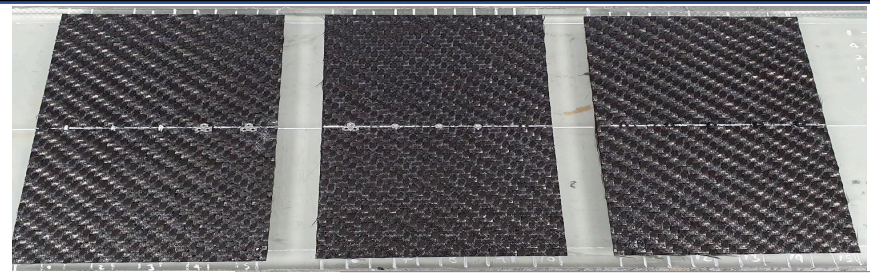
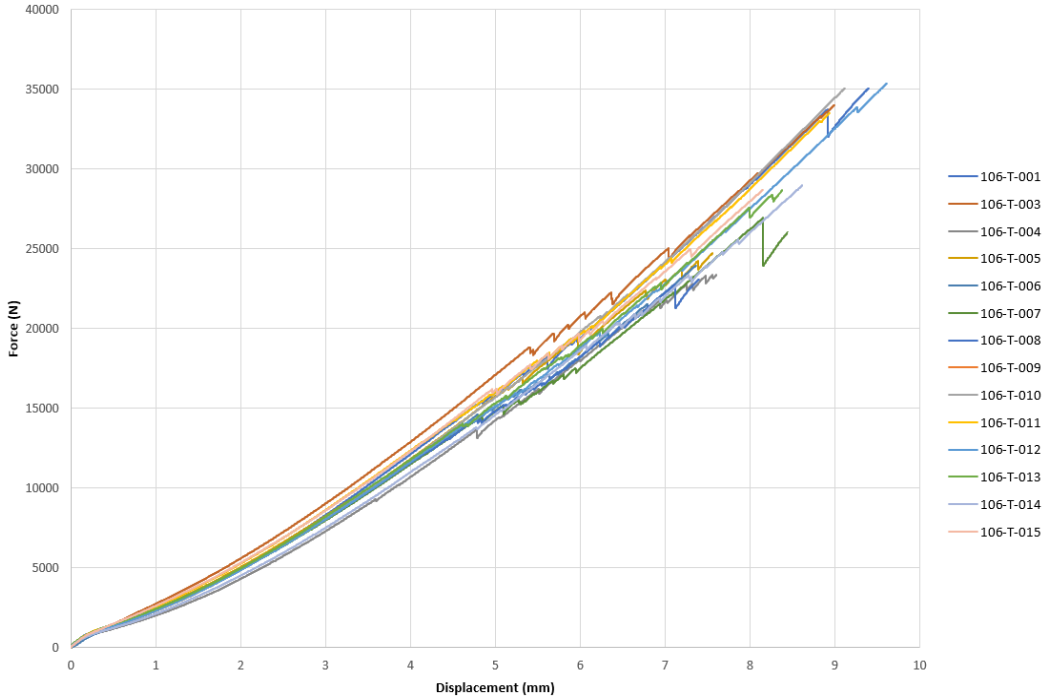
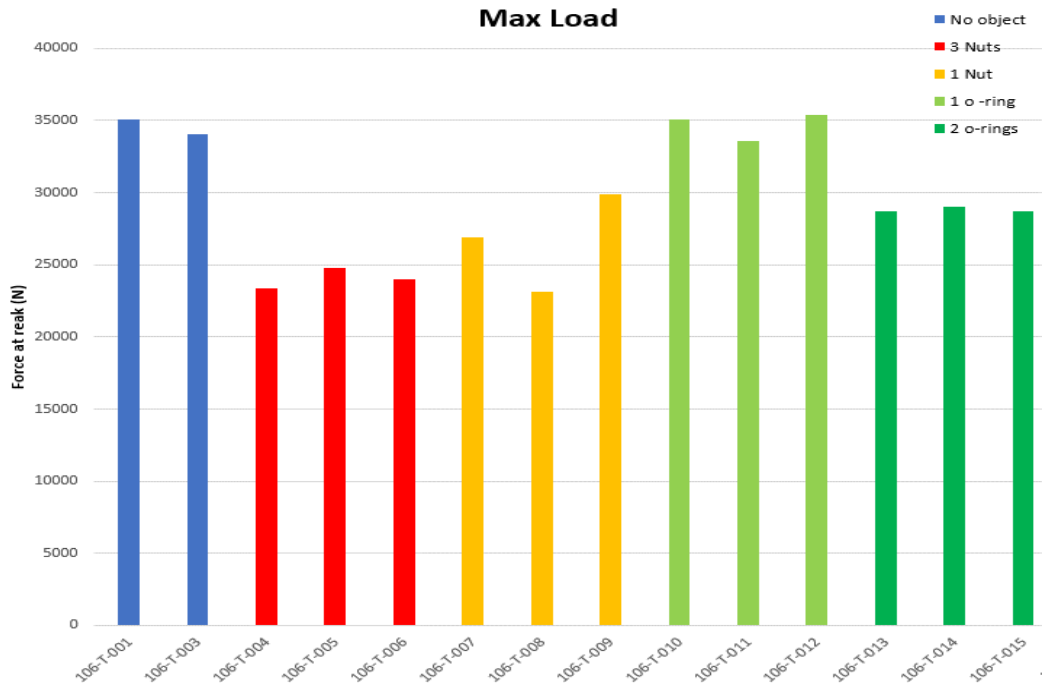
Tensile testing of coupons-FAR

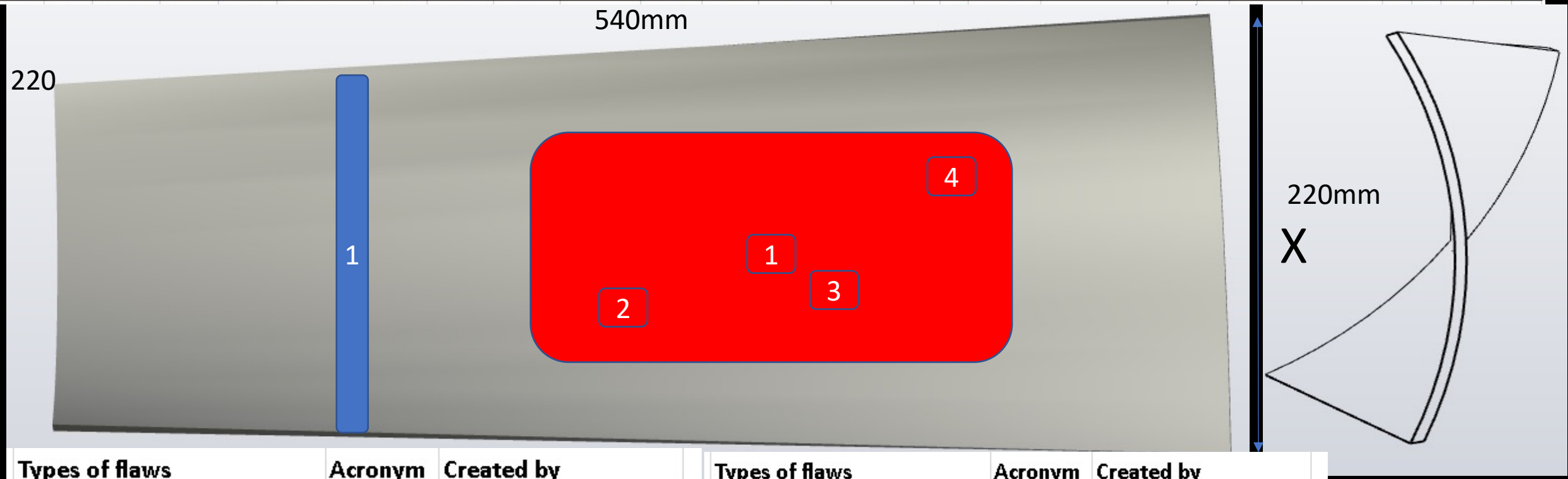






CFLUX

Sample number	Thickness MM	Defect number																		Off Machine				
		Y	X	Def-FLAW 1	Flaw Material	Y	X	Def-flaw 2	Flaw Material	Y	X	Def-FLAW 3	Flaw Material	Y	X	Def-FLAW 4	Flaw Material	Y	X	Def-FLAW 5	Flaw Material	Width (mm)	Length (mm)	Depth (mm)	Weight (g)	CURED
A4-4	4	150	ALL	MW																		217	535	7	472	Y
A4-4	4	200 - 450	30 - 180	FO	SAWDUST	220	60	FB		320	80	FB		420	160	FB						217	535	7	472	Y

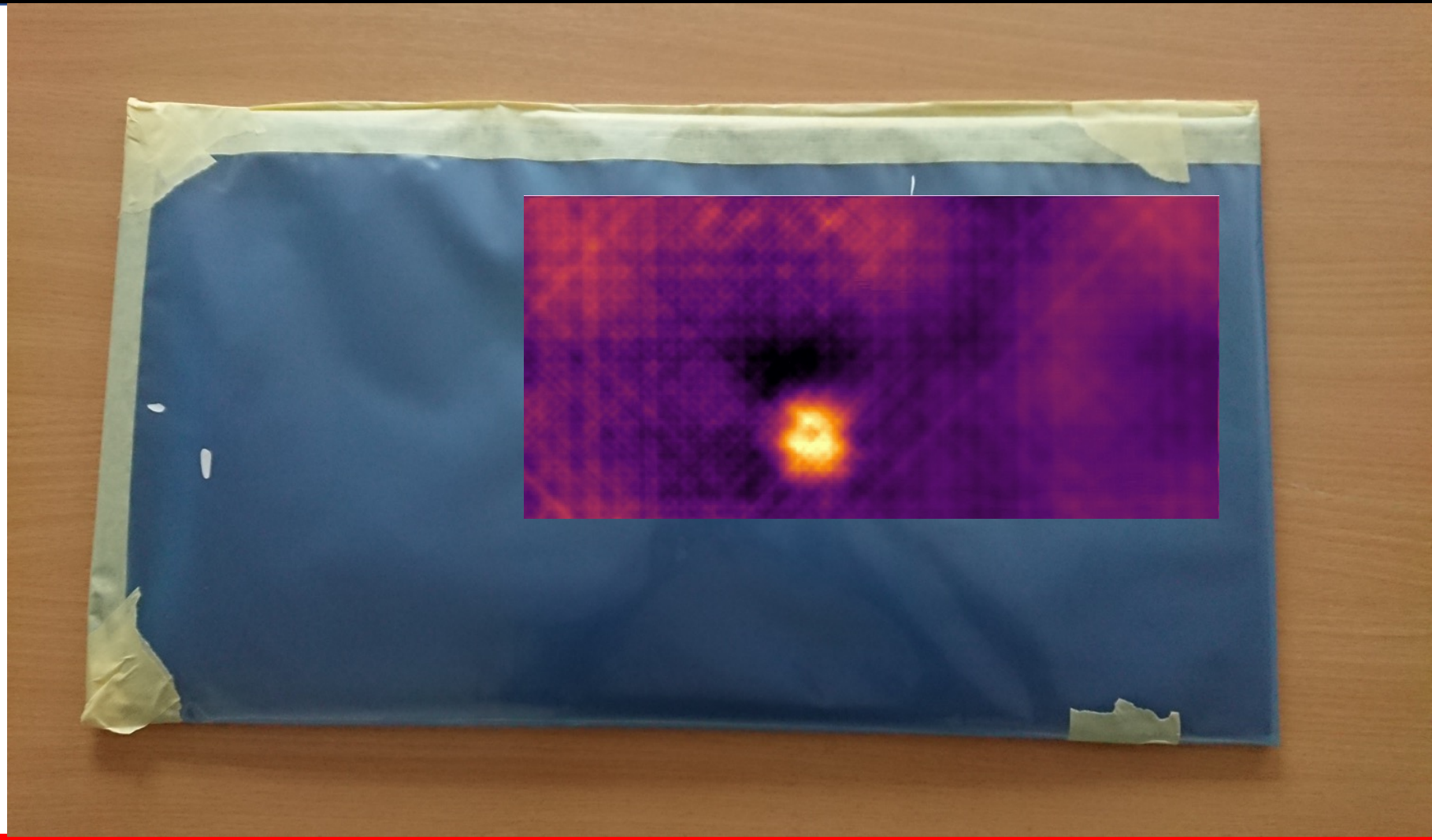


Types of flaws	Acronym	Created by
Raw fabric		
Delamination	D	Thin object insertion
Knots	K	Add artificially
Missed weft insertion	MW	Mechanical damage
Filamentation bundles	FB	Add artificially
Missing tows	MT	Mechanical damage
Cut fibres	CF	Mechanical damage
Edge effects	EE	

Types of flaws	Acronym	Created by
Cured		
Voids	V	Hollow balls
Microcracking	MC	Contaminate fabric
Delamination	D	Thin object insertion
Fibre undulation	FU	Mechanical damage
Varience in Vf	VVf	Mechanical damage
Foreign object	FO	Object insertion
Blister	B	Surface heating?
Surface damage	N	notches

Lightning Strike On Graphene Sample

Tx RX 2 MHz inspected in its wrapping



CONCLUSION

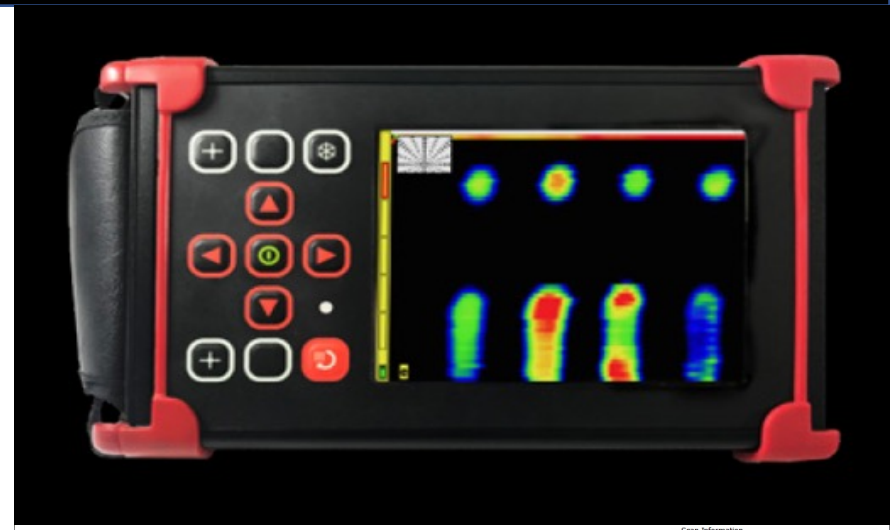
Why is this important?

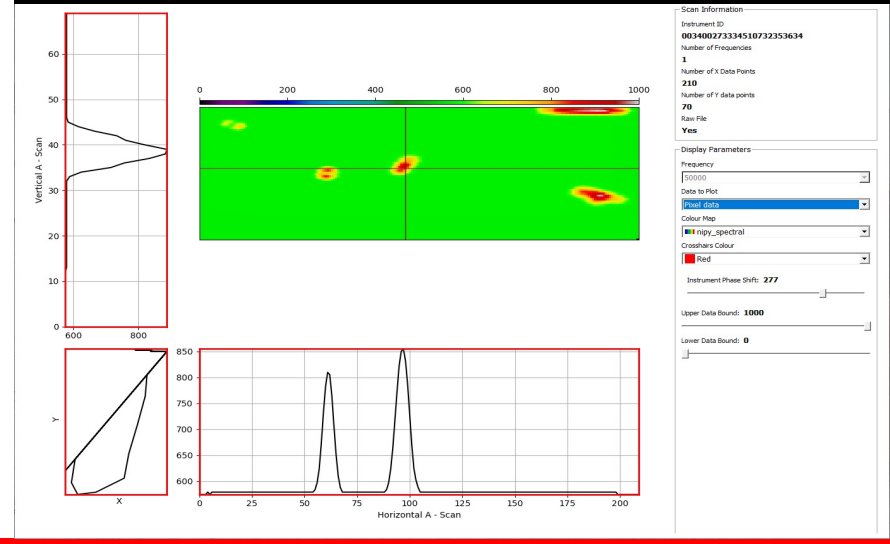
"A **picture is worth a thousand words**"

Eddy Current is no longer held to the conventional conductive metal's applications.

As the industry is tasked with making lighter, cheaper parts and structures while still maintaining strength and integrity, Eddy Current methods are being re-visited to see how they can be applied to meet the detection criteria and demands of the OEM and vendors.

There is no silver bullet you still must ask the basic questions in order to best determine the method to use. With the advent of more powerful imaging and processing of raw data and probe design, Eddy Current continues to add its name to new and immerging processes.





ETHER NDE