A Review of The Benefits of PWI/TFM for Weld Inspection

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Next Generation Ultrasonic Inspection Historical Constraints

Historical Constraints

\circ Too Slow!

 The volume of data (i.e. A-Scans) generated by FMC/TFM is much larger than PAUT (n vs. n²) = greater processing time = slower inspection speeds

• Too Much Data!

 \circ The volume of data (i.e. A-Scans) generated by FMC/TFM is much larger (n vs. n²) = much larger file size

Lack of Sensitivity/Penetration

 With a single element transmitting, sensitivity and penetration may be reduced

Next Generation Ultrasonic Inspection A Review of PWI/TFM and Associated Benefits

Benefits of PWI (PWI/TFM)

- PWI <u>acquisition</u> with TFM <u>image</u> processing = PWI/TFM
- Represents an optimization of both FMC data set acquisition and TFM image post-processing
- <u>5x-100x faster than traditional</u> <u>FMC/TFM</u>
- Provides greater sensitivity
- Very good penetration/SNR for attenuative materials (Ti, Inconel, etc.)
- Smaller file sizes
- Generally, an "up-correlation" in inspection frequency; e.g. austenitic welds inspected with 5MHz
- Reduced technique development time NDT in Canada 2019 | June 18-20 | Edmonton, Alberta

PWI (PWI/TFM) Explained

 PWI/TFM utilizes a larger transmitting aperture than FMC/TFM, but with the proper algorithmic image processing, the data set can still be used to create a TFM image



PWI (PWI/TFM) Explained

 As seen in the image below, several elements are transmitting at once, but the image reconstruction still considers each elemental transmit/receive pair, as in "standard" FMC/TFM



PWI Inspection Speed Inspection Speed (Example)

- Inspection speed (TPAC historical)
 - For 300mm metal path with 128 Element Probe x 2mm Pitch
 - 2.5MHz = ~2"/s
 - 5MHz = ~1"/s
- With recent new software developments by TPAC, inspection speeds of >12"/s are achievable

PWI Inspection Speed – Don't Blink!



PWI/TFM Sensitivity

128L PAUT Probe

~800mm Metal Path

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Extended Metal Path Inspection

nton, Alberta

PWI Sensitivity

Extended Metal Path Inspection



One Setup, No "Focal Laws"!

Review of Wave Modes



Review of Wave Modes





x [mm]



16

18

20

85

90

x [mm]

95

Multi-Modal PWI Acquisition



Mutiple wave mode acquisition available in TPAC PWI/TFM

Multi-Modal PWI Acquisition



"Modal Merge" also available in TPAC analysis

Multi-Modal PWI Acquisition



57. Incomplete Root Penetration in Double Vee, UT, RT



"Modal Merge" also available in TPAC analysis

Next Generation Ultrasonic Inspection **PWI/TFM Inspection Examples**

Carbon Steel Plate

- Part
 - ~2" T
 - Manufactured Slag Inclusion
- Probe
 - 5MHz
 - 64 Element
 - No wedge
 - Centered on weld
 - TT Mode



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Carbon Steel Plate

PWI acquisition with TFM image reprocessing 1M TFM reconstrucion points • 1000 x 1000



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Carbon Steel Plate

PWI acquisition with **TFM** image reprocessing ▶ 1M TFM reconstrucion points • 1000 x 1000



4" Thick Plate

- Part
 - Carbon Steel
 - 4" T DV
 - Inclusion, I.P., Crack
- Probe
 - 5MHz
 - 64 Element
 - TT Mode



4" Thick Plate

PWI acquisition with TFM image reprocessing
1M TFM reconstruction points (1000 x 1000)



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CRA (Inconel 59) Welded SDH Block

- Part
 - Carbon Steel Pipe with Alloy 59 Weld
 - ~1.75" T
 - Ø0.125" SDH at 1/4, 1/2, and 3/4 T
- Probe
 - 5MHz
 - 64 Element
 - LL Mode

CRA (Inconel 59) Welded SDH Block

- PWI acquisition with TFM image reprocessing
- ~250K TFM reconstruction points
 – 500 x 500



Dissimilar Metal SDH Block

- Part
 - -SS > Inc Weld > CS
 - ~1.25" T
 - SDH
- Probe
 - 5MHz
 - 64 Element
 - LL Mode



Dissimilar Metal SDH Block

PWI acquisition with **TFM** image reprocessing ~250K TFM reconstrucion points • 500 x 500



Conclusion

- PWI/TFM offers:
 - Faster acquisition speeds
 - TPAC can offer >12"/s
 - Superior resolution of TFM imaging
 - Better characterization and sizing
 - Higher frequency/higher resolution inspection of attenuative materials compared to PAUT
 - Reduced technique development time
 - Being focused "everywhere" reduces the need for determining focal laws/using multiple groups
 - TPAC can offer inspection with multiple wave modes in one acquisition
 - Greater (full) coverage with one line scan (each side)

Thank You!

Questions or Comments?