Ultrasonic Inspection: Transducer Design for Bolt Inspection
1. How to Model PAUT Applications
2. What are the Major Steps in the Process
3. How We Solved Real-World Problems
4. Conclusions
Project Overview

Current inspection technique

Critical Requirements

Model Current technique for baseline.
Model improvements
Why

- SAVINGS
- BETTER POD
- RELIABILITY
- CONFIDENCE
- TIME SAVINGS
Outside Factors

- **Instruments**
  - 16:64 / 32:128 / 64:128
  - Linear / Sector / Matrix / DDF / FMC

- **Inspection Locations**
  - Flat, Curved, ID / OD
  - Access

- **Inspection Requirements**
  - Speed / POD / Data Storage
  - Cost
Modeling Inputs

- Specimen
  - Geometry
  - Material

- Probe / Wedge
  - Acoustic Performance
  - Style / Inspection Type

- Flaws
  - FBH, Notch, SDH, Multifaceted
Specimen Types
Modeled Results ≈ Empirical Results
5MHz Segmented Annular Transducer
Optimization

Probe

- Frequency
- Style
  - Annular
  - Matrix
  - Segmented
- Virtual Probe
- Instrument Setting
  - Angles
  - Focus
BEAM PROFILES

- SOUND INTENSITY
- GEOMETRY RESTRICTIONS
Optimizations – Variation Study

- PROBE SIZE
- REFRACTION ANGLE
- FREQUENCY
Nuclear Vessel Shroud
Support Bolts
Test Requirements / Inputs

- Contact test
- Full 360 scan electronically
  - eliminate need to rotate probe
- Fixed access area - max OD of probe 0.580”
- Set location for defects
- Maximum 32 element probe
- Topaz instrument
Initial Model Setup

- Input bolt geometry
- Input current probe/wedge
- Add defects to bolt
- Verify model
Optimization

Set-up 1
30 Elements
12.7mm Element Dia
12 Degree segments
5 element Virtual probe
1 element step
0 Delay laws

Set-up 2
31 Elements
12.7mm Element Dia
36 Degree segments
9 element Virtual probe
1 sector element step
Direction & Depth Scan
9 deg @ 25.4 to 17 degree @ 12.7

Set-up 3
31 Elements
16mm Element Dia
36 Degree segments
9 element Virtual probe
1 sector element step
Direction & Depth Scan
9 deg @ 25.4 to 17 degree @ 12.7
Model Results

- Larger diameter produced better response
- Delay caused noise issues (NOT SHOWN)
- Segmented outperformed annular
Prototype Design Build Model Results

3 notches
Thread noise
Empirical Results

CLEAN  EDM NOTCH 1  EDM NOTCH 2  EDM NOTCH 3
Project Conclusion

- Production probes were made and used for inspection with great results
- New order received for production probes for other inspections
- New project for a smaller diameter bolt with smaller access area started and completed with customer
Conclusions

• Modeling saves time
  • Dozens of configurations modeled in a week compared to months to build custom probes

• Modeling saves money
  • Confidence to manufacture one probe compared to multiple probes

• Modeling provides confidence
  • Provided technical validation of inspection

• Model results can only be as good as the data provided to the model