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Experimental validation of a Phased Array Model applied in Ultrasonic Inspection of AM Parts

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This project is a collaboration between Chalmers University of Technology and GKN Aerospace Sweden AB in NFFP7-project and financially support by Vinnova

BACKGROUND

Laser metal deposition with wire (LMD-w)

- Improve material use
- Enable new and lighter design possibilities

Inspection needs...

- To manage high demands on **structural integrity**
- To handle **complex structures**
- To reach **efficient** volumetric inspection procedures

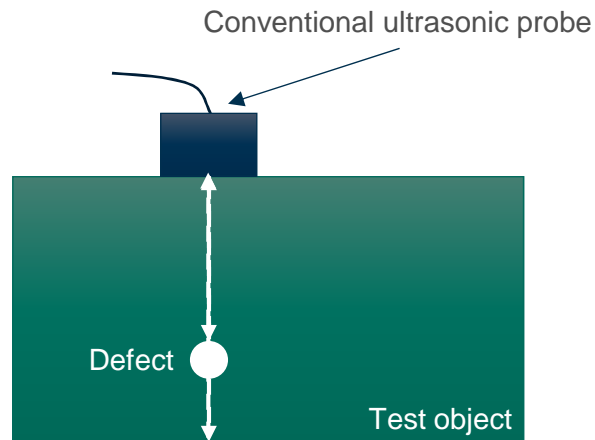


OBJECTIVES

- Present the improvement of defect detection ability using **phased array technique**
- **Validate** the phased array numerical model in a simulation tool, simSUNDT

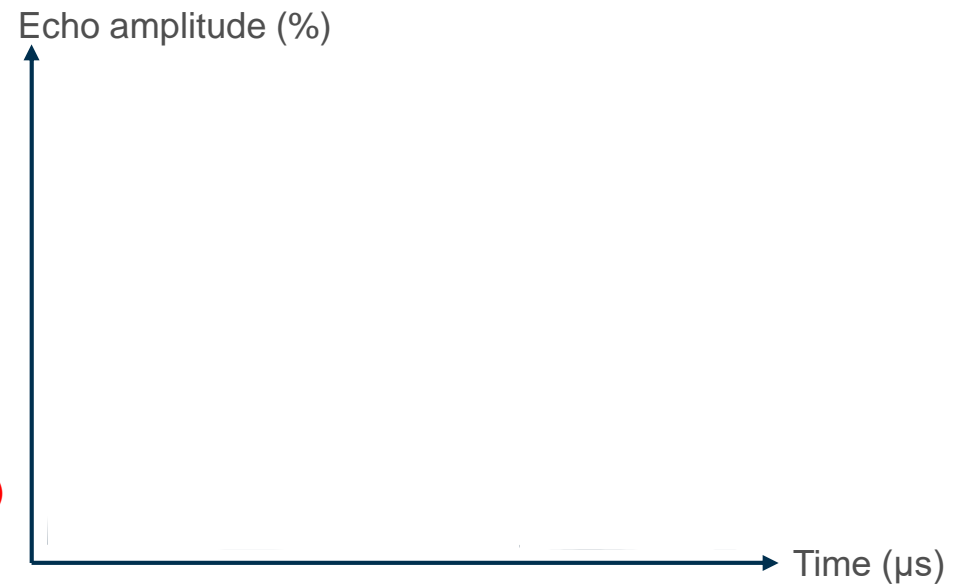
ULTRASONIC TESTING (UT)

— A testing method using high frequency sound energy to exam and measure the component defects.



- Non-destructive
- Safe operation
- Indirect presentation (needs interpretation) as other NDT methods

Results presentation: UT A-scan

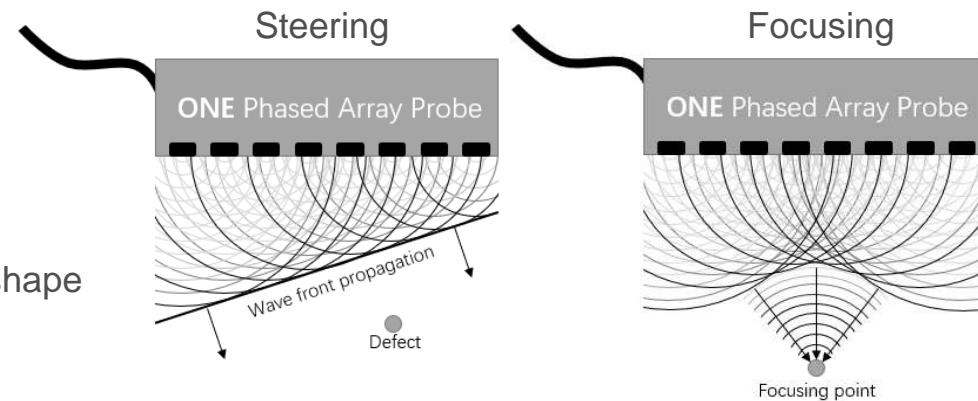


ULTRASONIC PHASED ARRAY SYSTEM

— A set (**array**) of normal piezoelectric probes driven at slightly different times (**phased**) to generate a desired wave field in the far field.

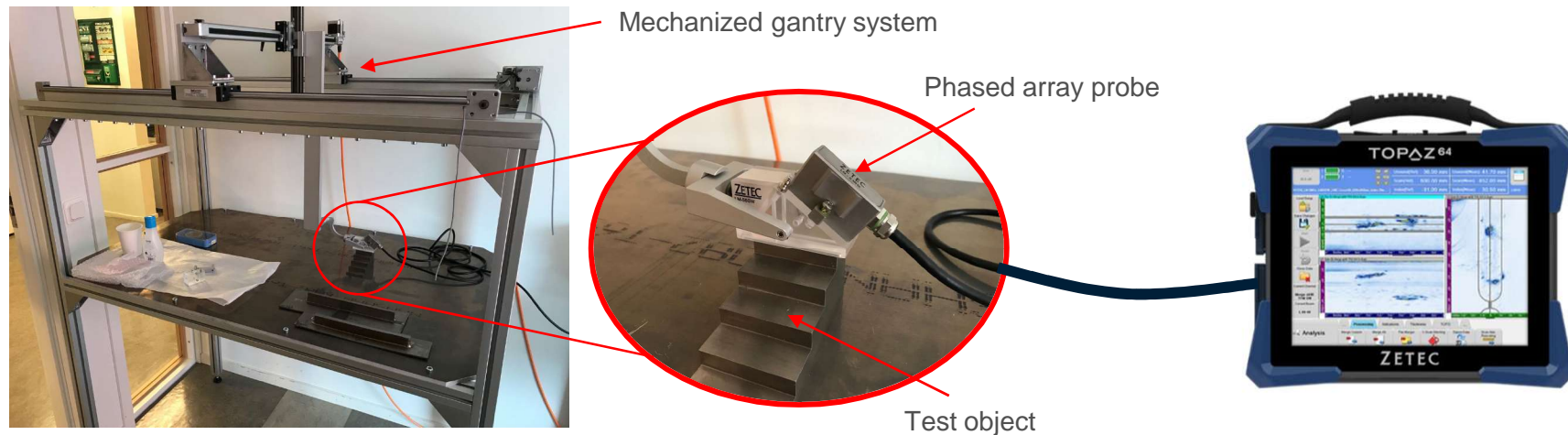
Advantages

- **Steer** and **focus** the beam
- Simplify the inspection
- Test with multiple angles
- Adjust and optimize the wave front shape
- Rapid top-view scans



LABORATORY

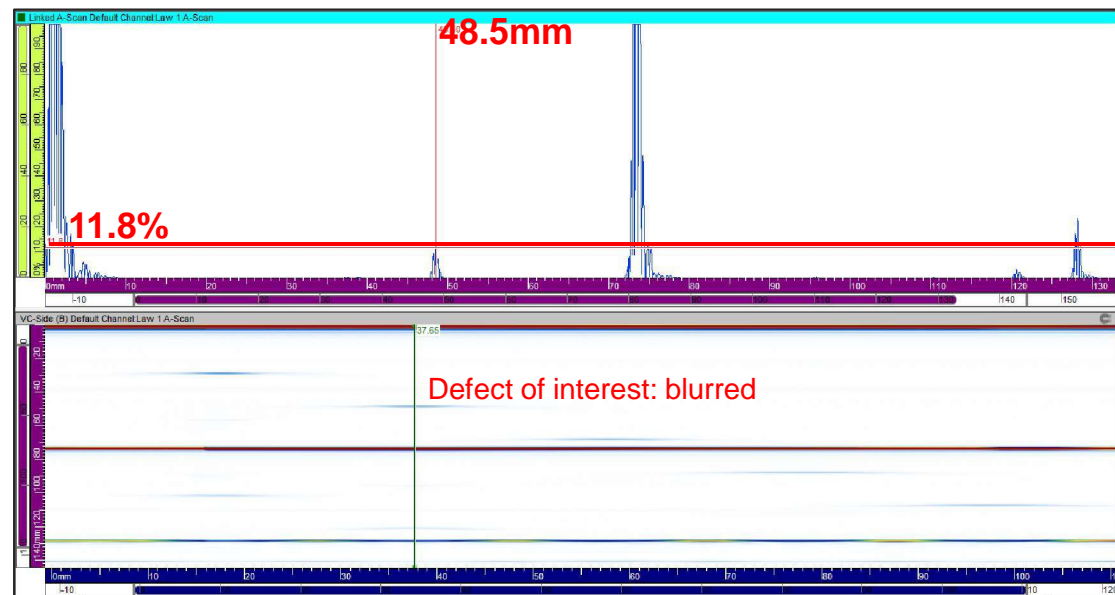
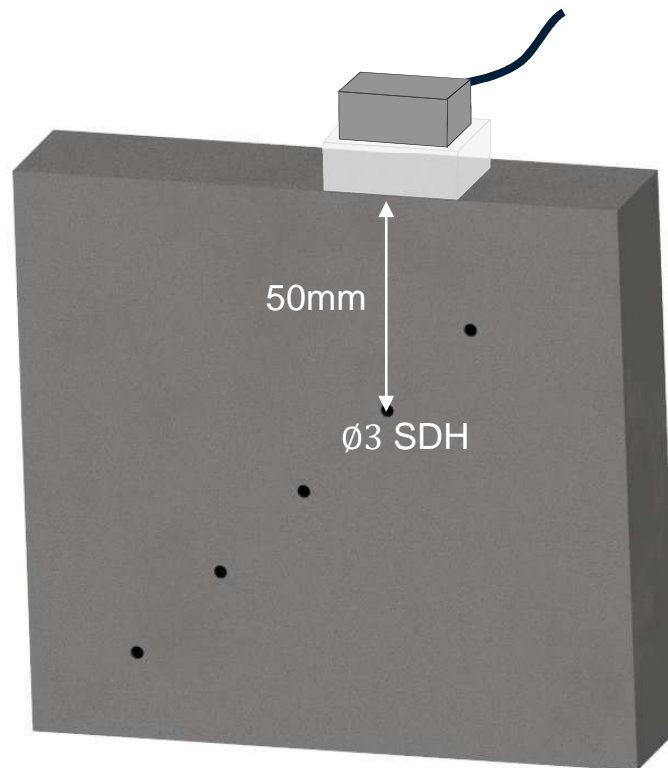
- Research lab at Scientific Center of NDT(SCeNDT), Chalmers
- Mechanized gantry inspection system with position accuracy
- Phased array probe and data acquisition system (TOPAZ 64)



EXPERIMENTAL DEMO

Phased array probe inspection

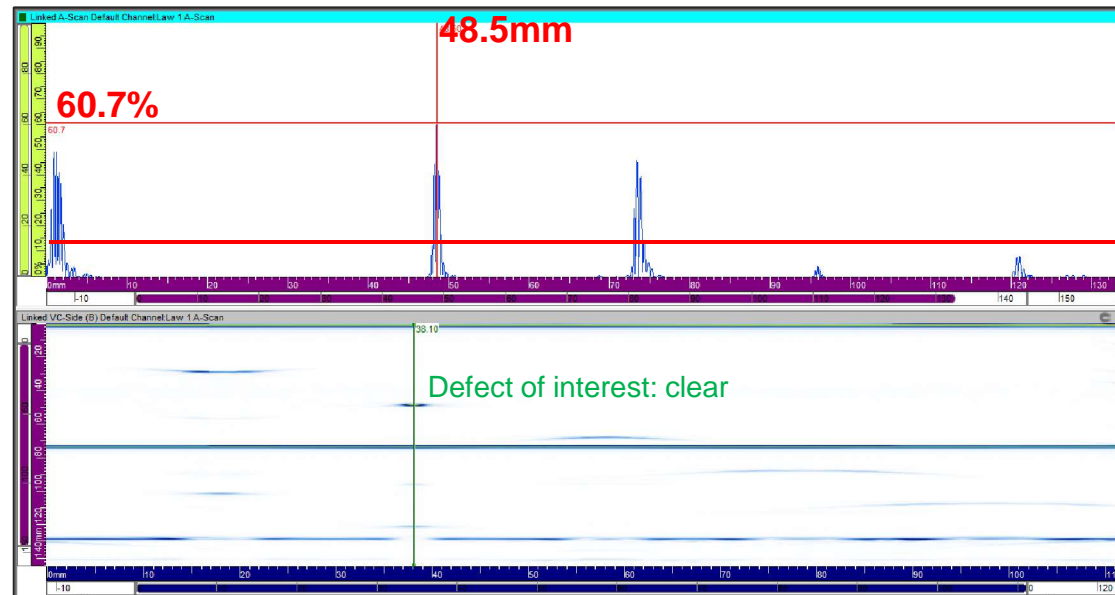
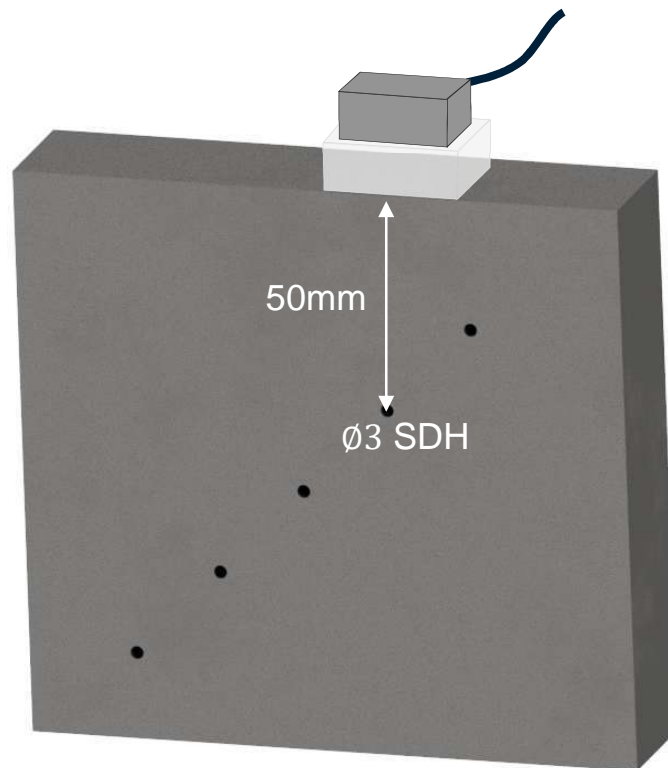
- Normal incident wave
- Stainless steel with Side-drilled hole (SDH)
- **With** beam focusing at **depth of 50mm**
- **64 elements** activated



EXPERIMENTAL DEMO

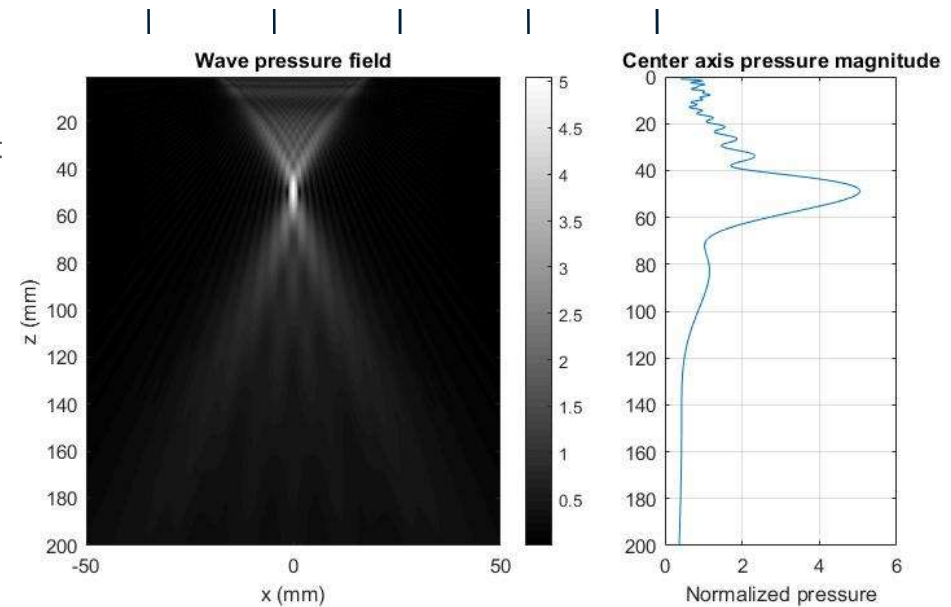
Phased array probe inspection

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PRINCIPLE OF BEAM FOCUSING

1. Phased array probe trigger each element with time shift
2. Wave energy is focused at a certain depth / point
3. Defect at that depth reflects more energy back
4. High amplitude and clear image of the defect obtained



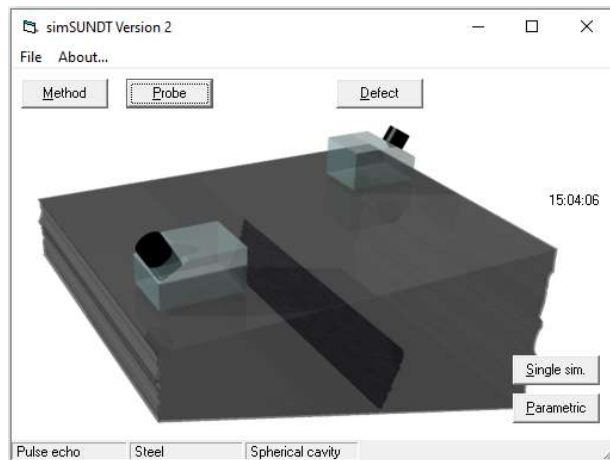
Advantage of phased array probe: set focus depth without physically adjusting the probe

MODEL SIMULATION

Numerical simulation model and software: *simSUNDT*

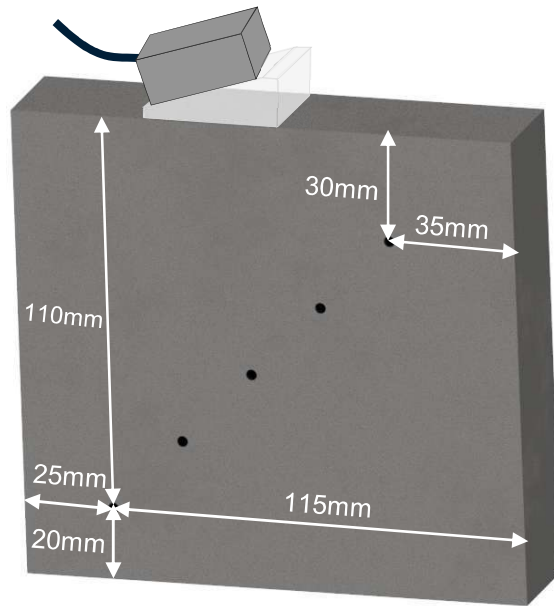
Developed by Scientific Center of Non Destructive Testing (SCeNDT), Chalmers University of Technology, Sweden

Purpose of better understanding of the technique and saving the experimental cost for method verification



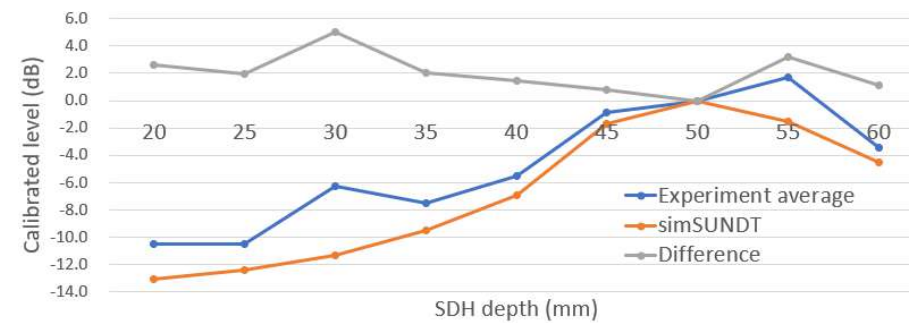
- Mathematical kernel *UTDefect* that conducts the actual mathematical modelling
- **Integral transforms and equations** to model the probes and the scatterings
- Simulate the **entire testing procedure** of actual NDT situation
- **Calibration** option is available towards reference reflectors
- Various probe types and configurations for different purposes
- Volumetric and crack-like defects are available types of defect

RESULTS COMPARISON



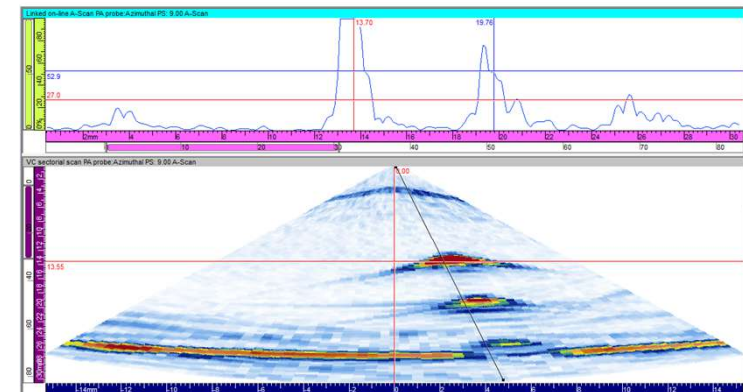
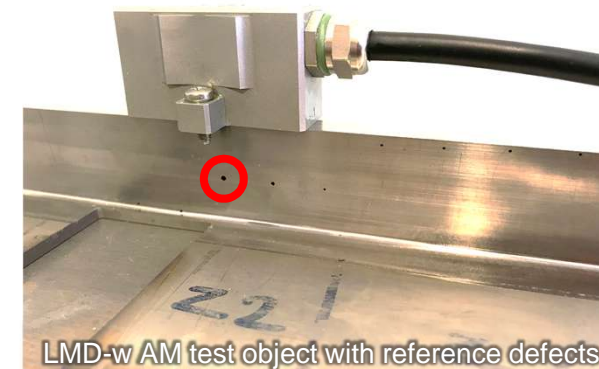
Stainless-steel test piece

- 5 side-drilled holes (SDH) as defect
- 9 target depths from four scanning surface (20:5:60 mm)
- 45° angled inspection (with wedge) with focusing depth at 50mm



PHASED ARRAY UT ON AM

- Minor defects can be detected to check AM material integrity
- High and narrow geometries need understanding of phased array signals and method optimization
- Understanding the full inspection situation (sensor, component, signal processing) is crucial to efficiently evaluate the material integrity



CONCLUSION

- Phased array technique can improve the inspection procedure
- Numerical simulation tools are available to support technique understanding and technique verification with good accuracy (phased array model validated within 4dB difference in depth of interest)



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