Induction hardening depth measurements by laser ultrasound for automotive industry

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Resource efficiency increase by laser ultrasonics (REAL)

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SWERIM LULEÅ TEKNISKA UNIVERSITET VOLVO SCANIA Bodycote SANDVIK

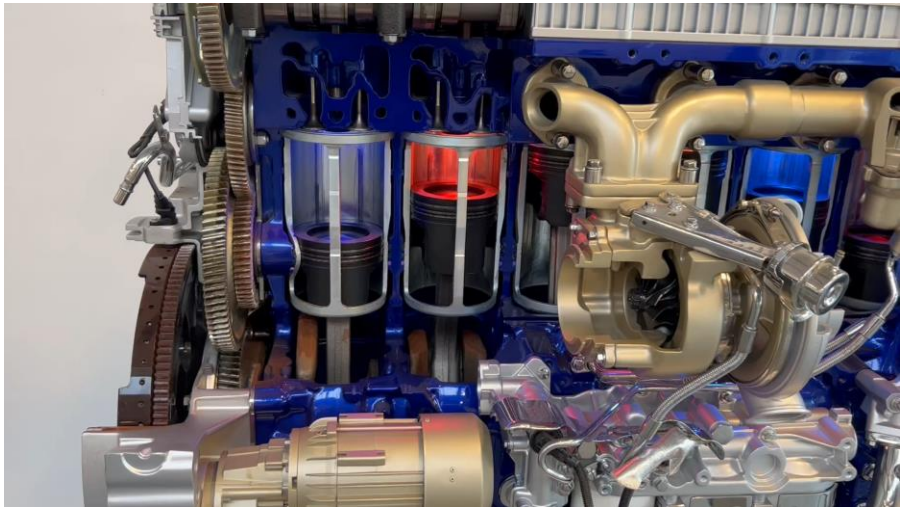
Background

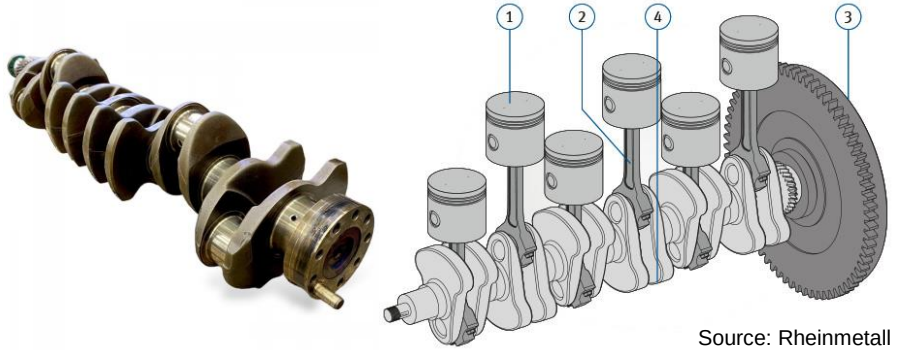
Induction hardening
Commonly used for load-bearing components in automotive

- Crankshafts, hubs and driveshafts
- Increase the strength, hardness and abrasion resistance
  - By changing the microstructure in the surface zone
  - → The hardening depth is critical for the performance

At present:
A few percent of all manufactured hardened components are destructively tested

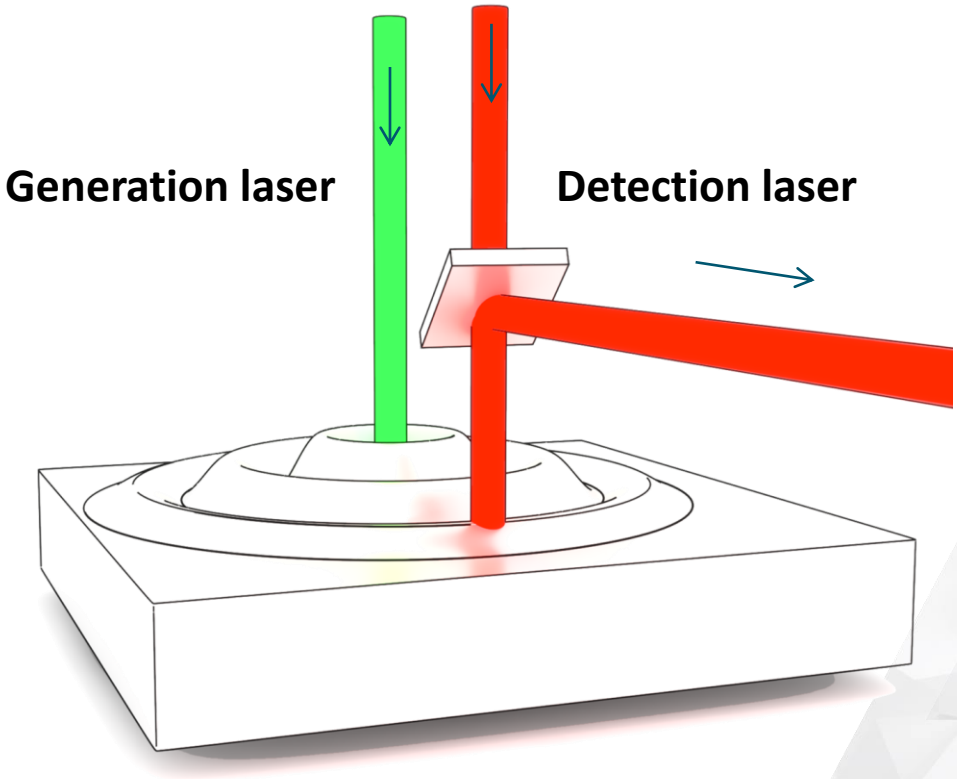
Long term vision:
Controlling and monitoring the hardening process in-situ





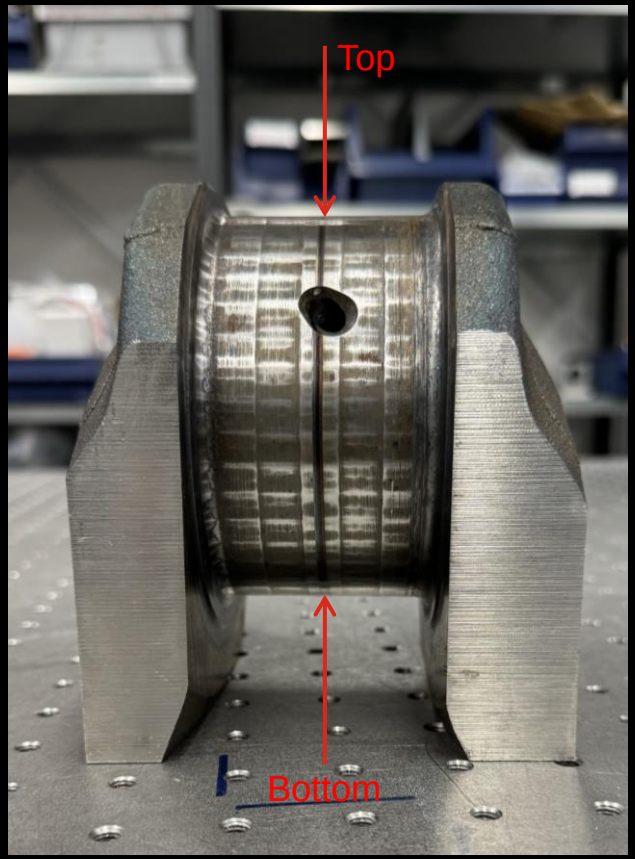
Source: Rheinmetall

Laser ultrasonics – LUS



Samples

Destructive testing

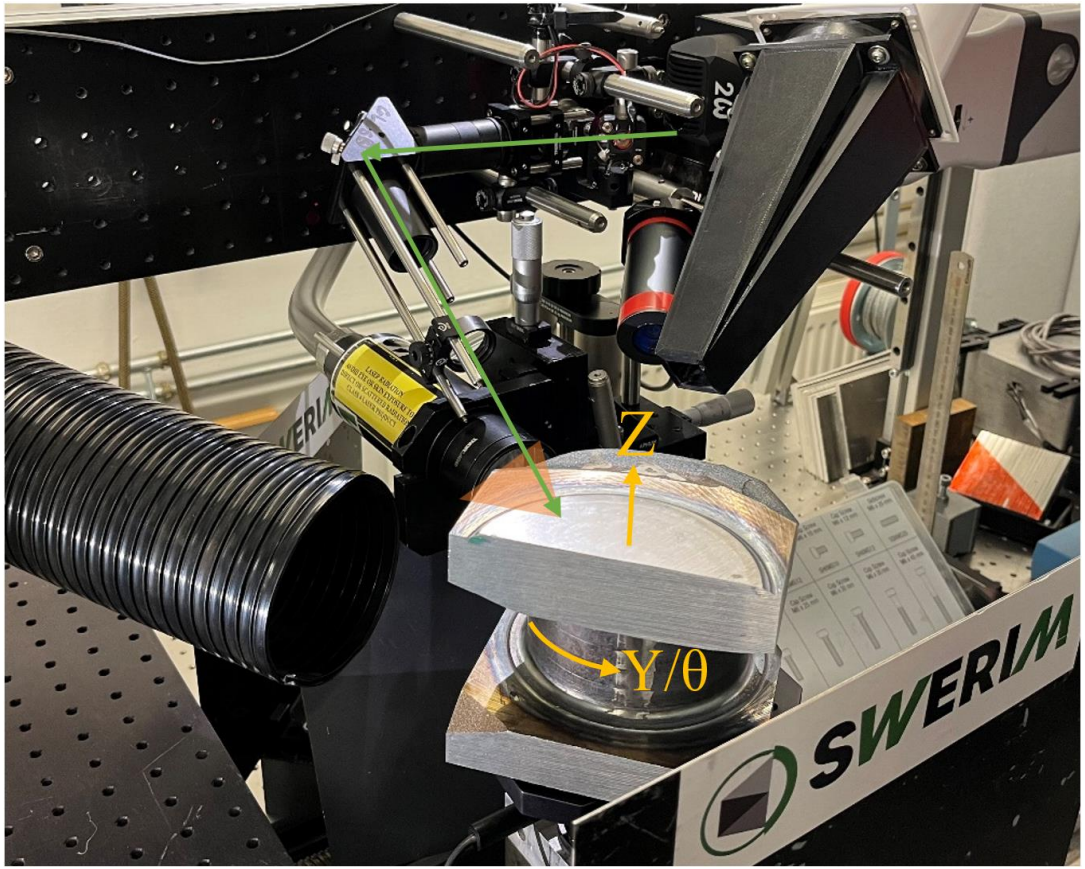


Swerim LUS system

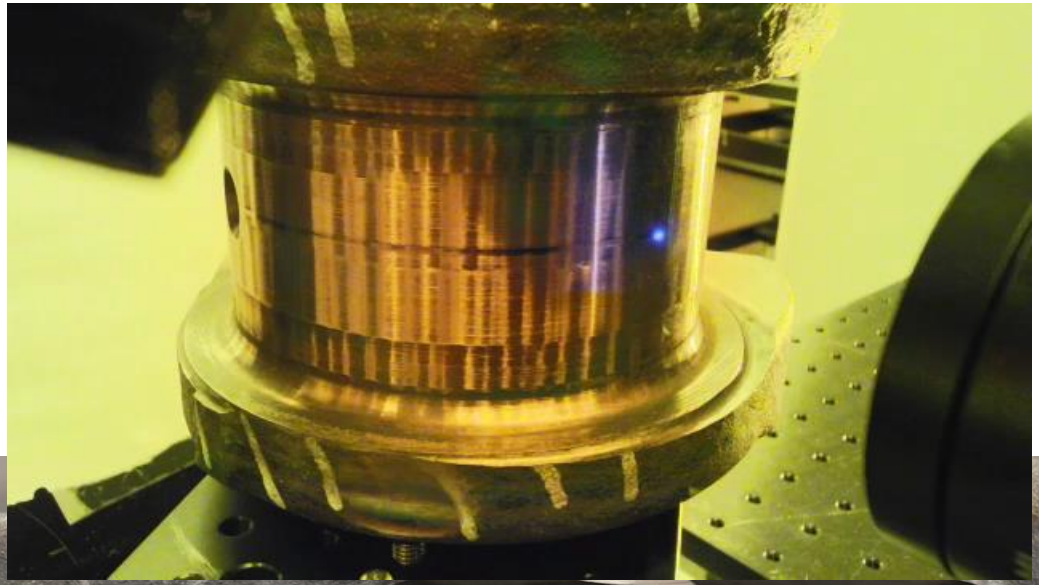
Generation laser
532 nm, 5.5 ns, 20 Hz

Detection laser
1064 nm, 60 Hz

Setup



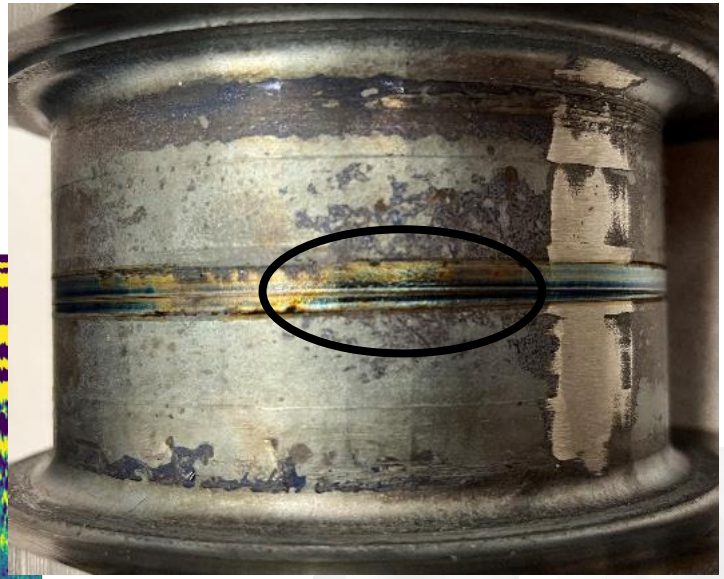
Setup

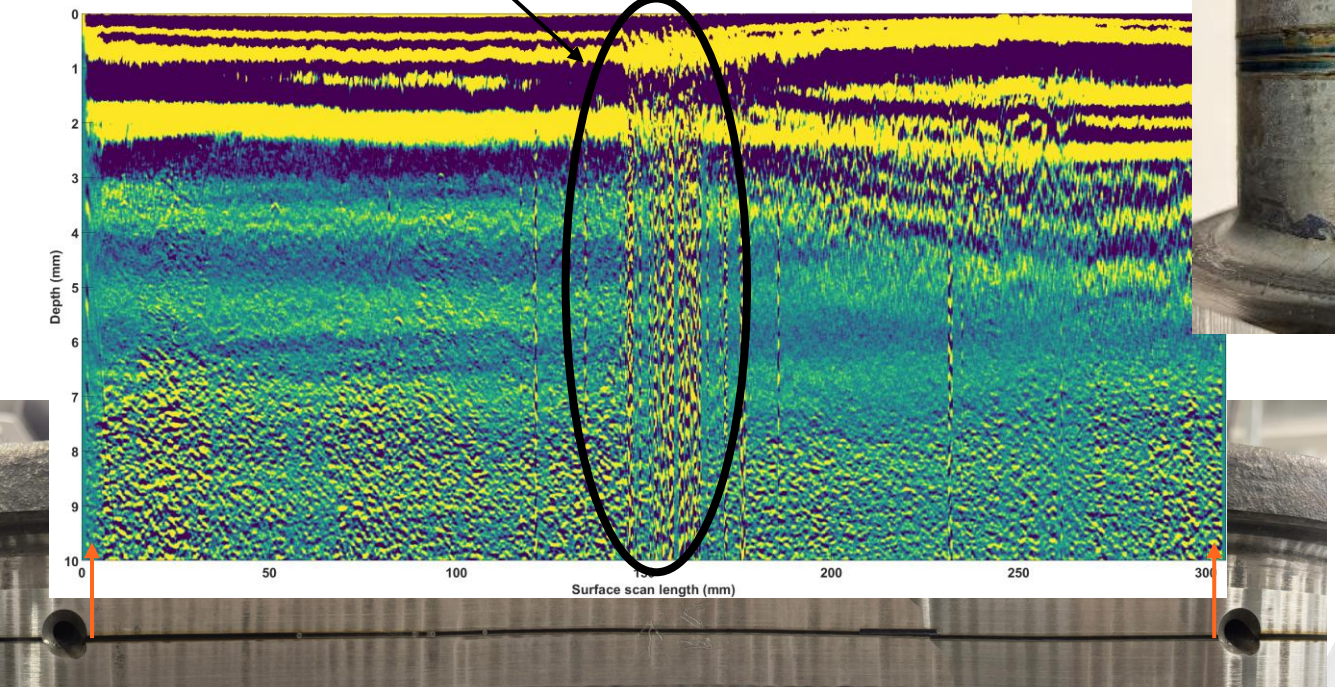


One measurement = hole edge to hole edge, ~350 degrees

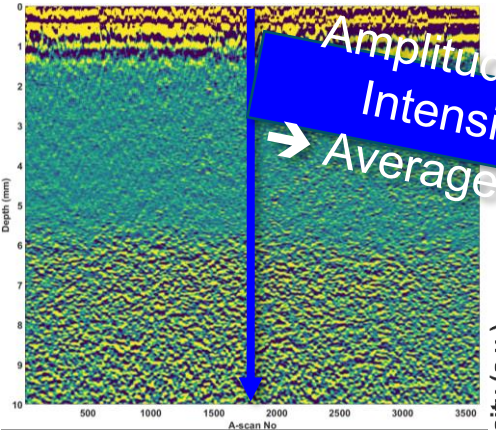
Results

Oxide scale deteriorates the LUS signals

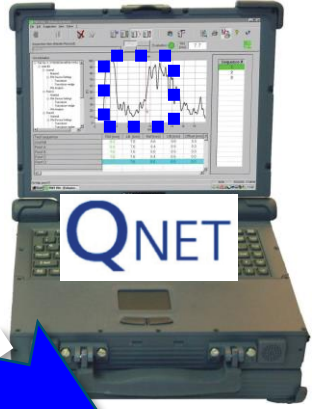


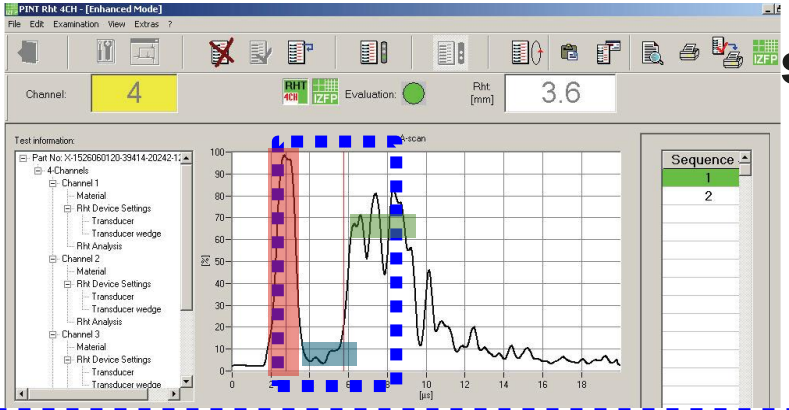


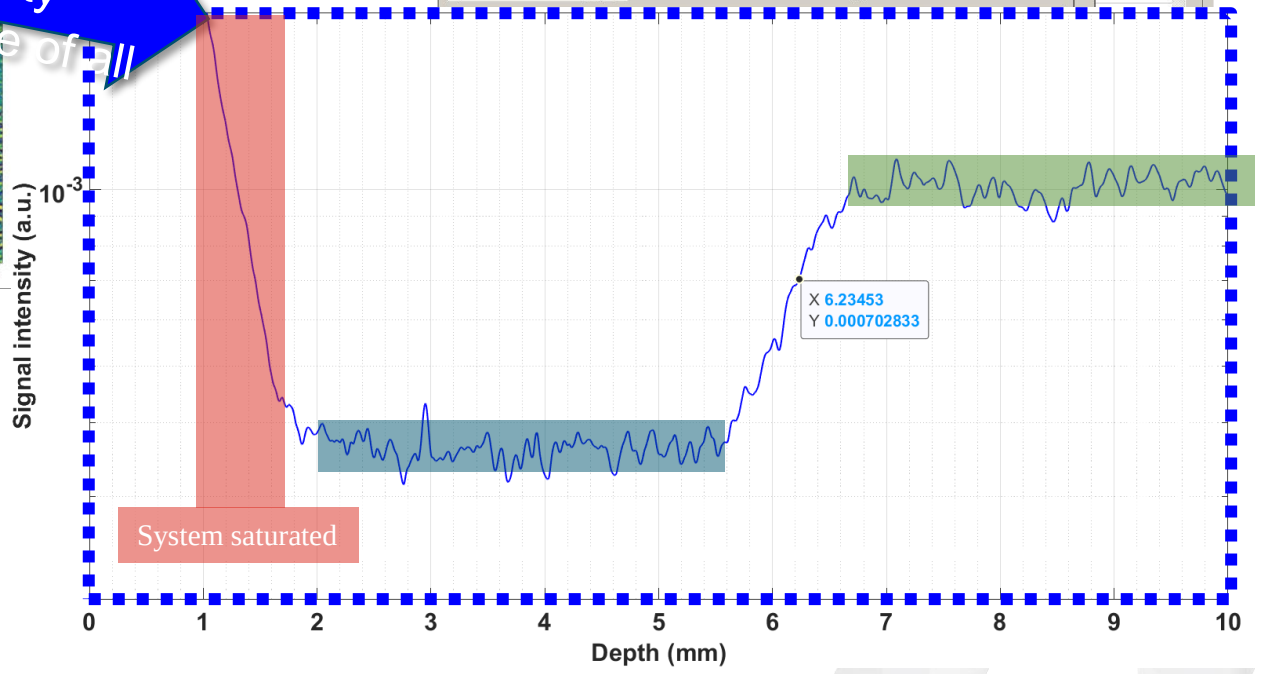
Algorithm



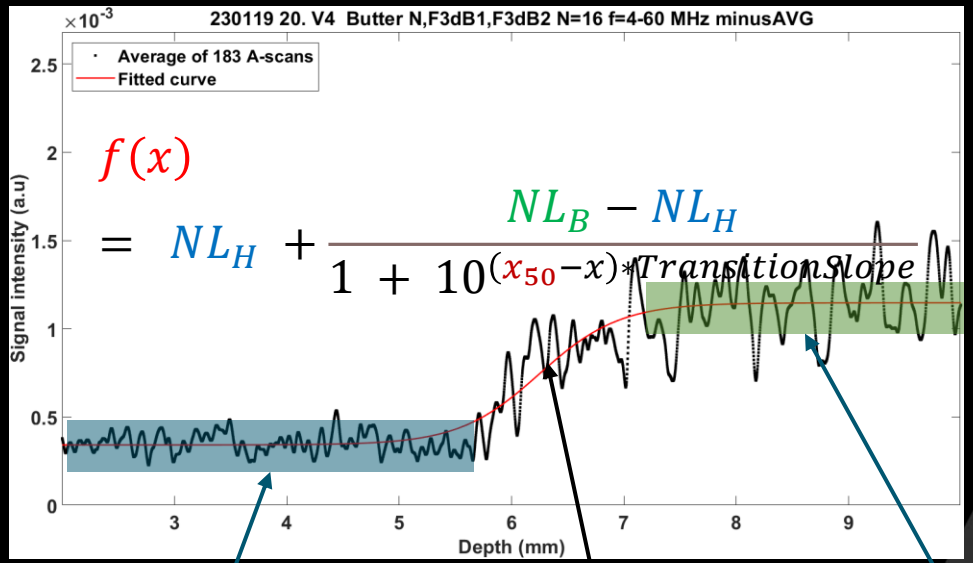
Amplitude
Intensity
Average of all



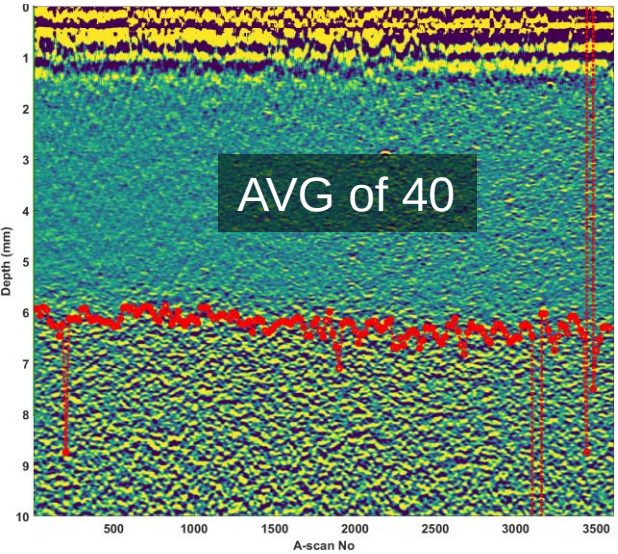


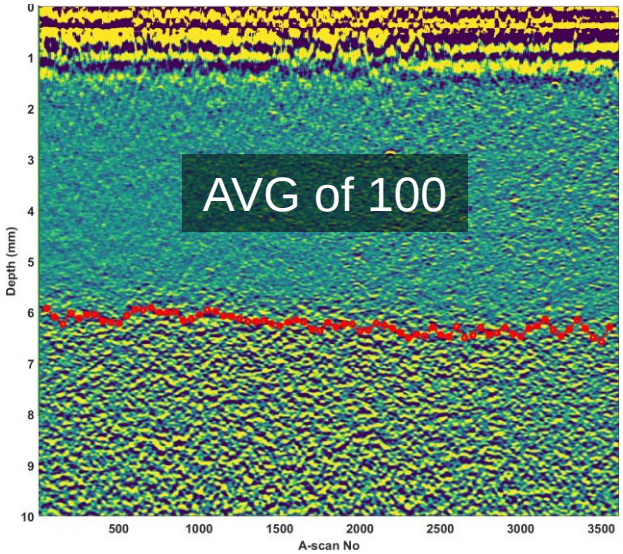


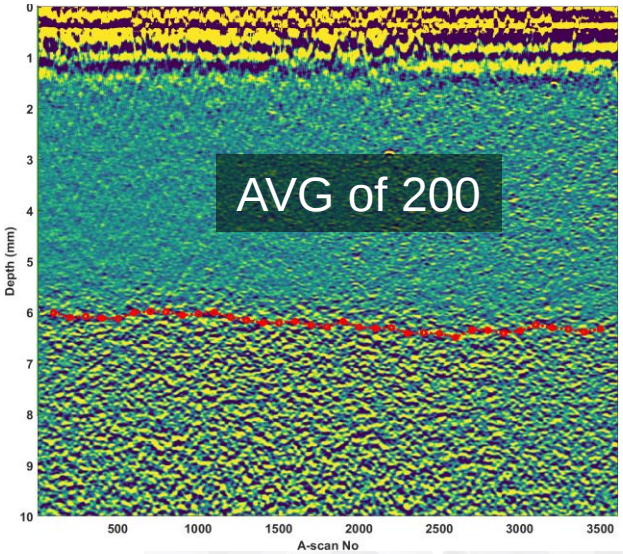
Fitting of sigmoid function



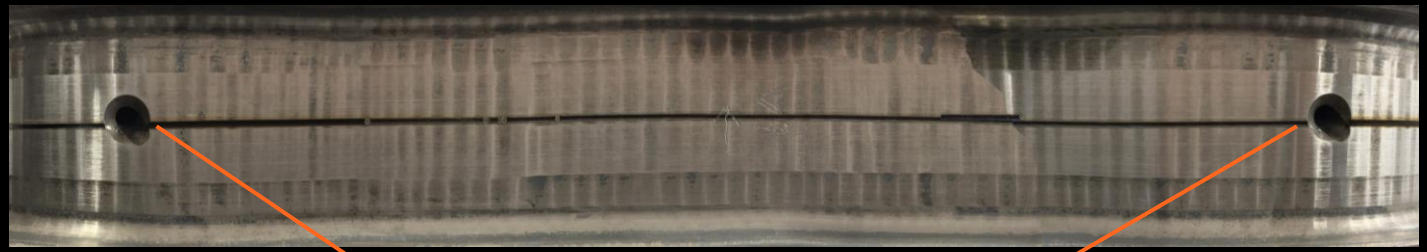
Finding the averaging settings

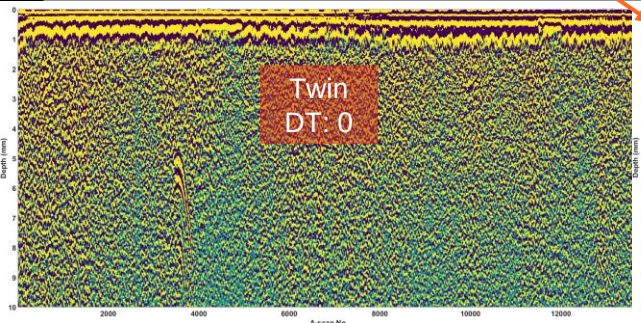


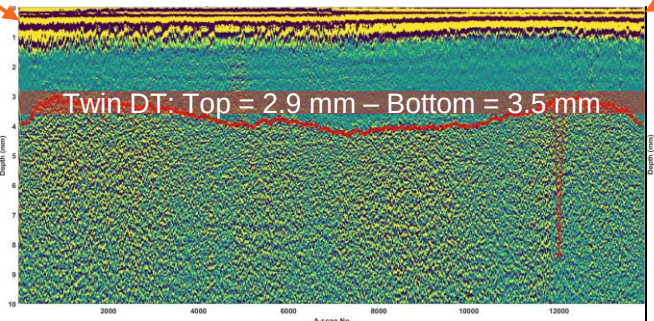


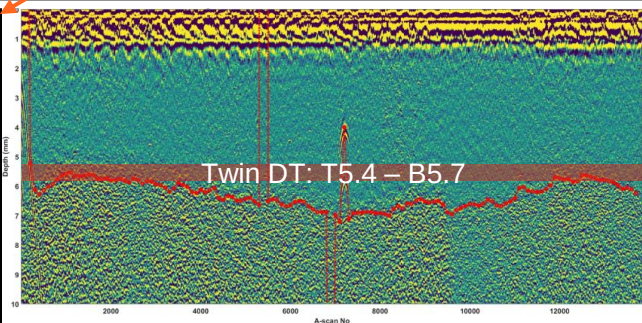


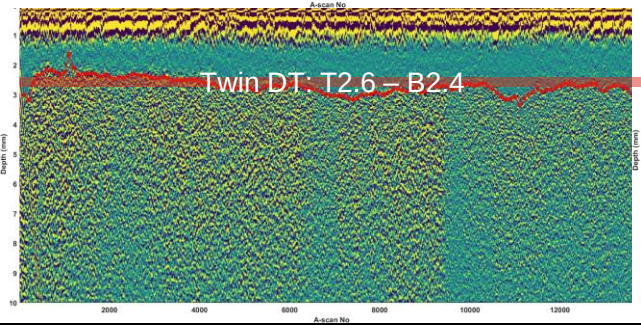
LUS vs destructive testing (DT) - Volvo

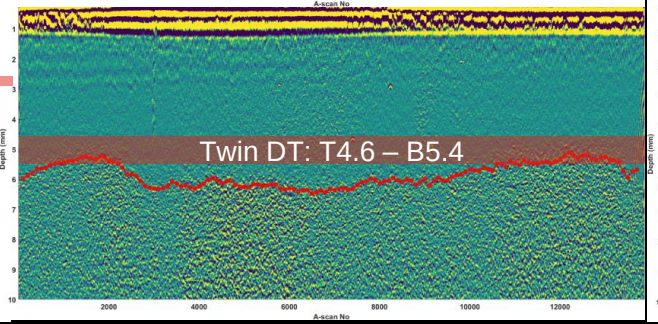


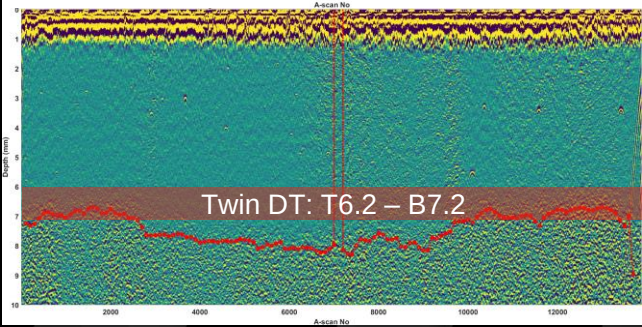




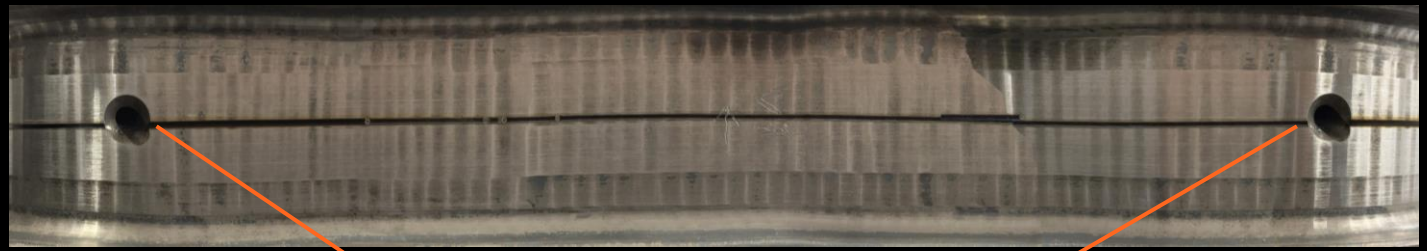


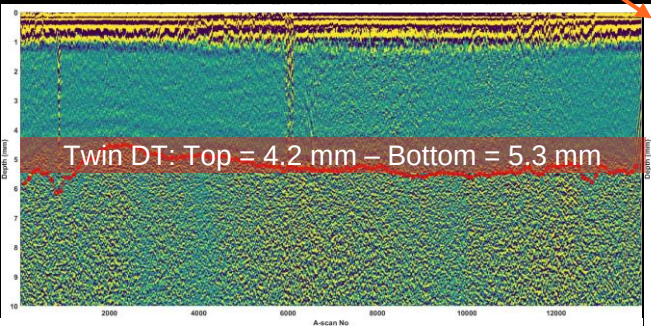


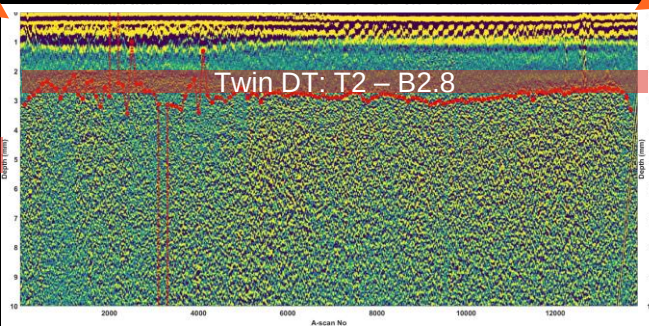


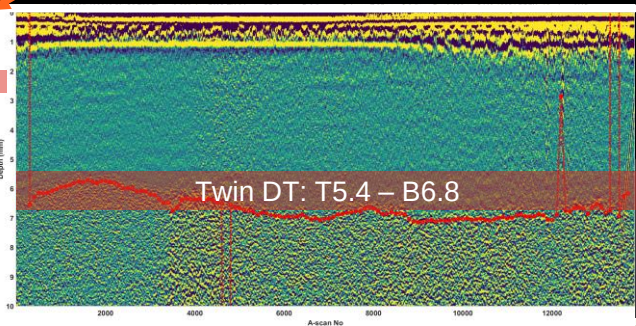


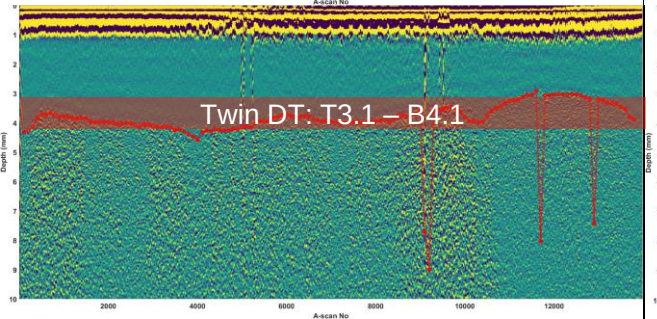
LUS vs destructive testing (DT) - Scania

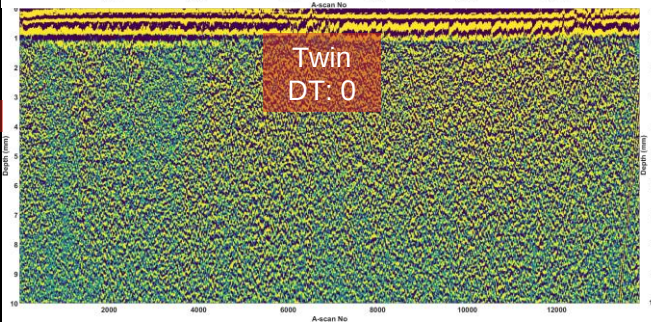


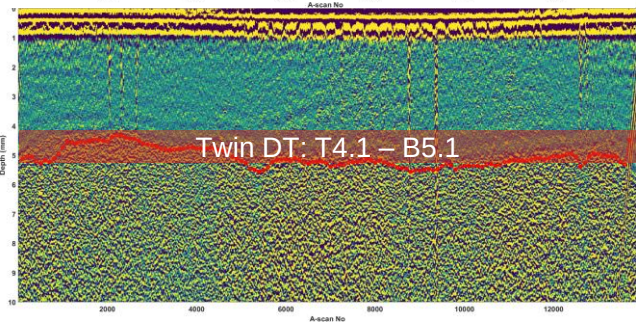




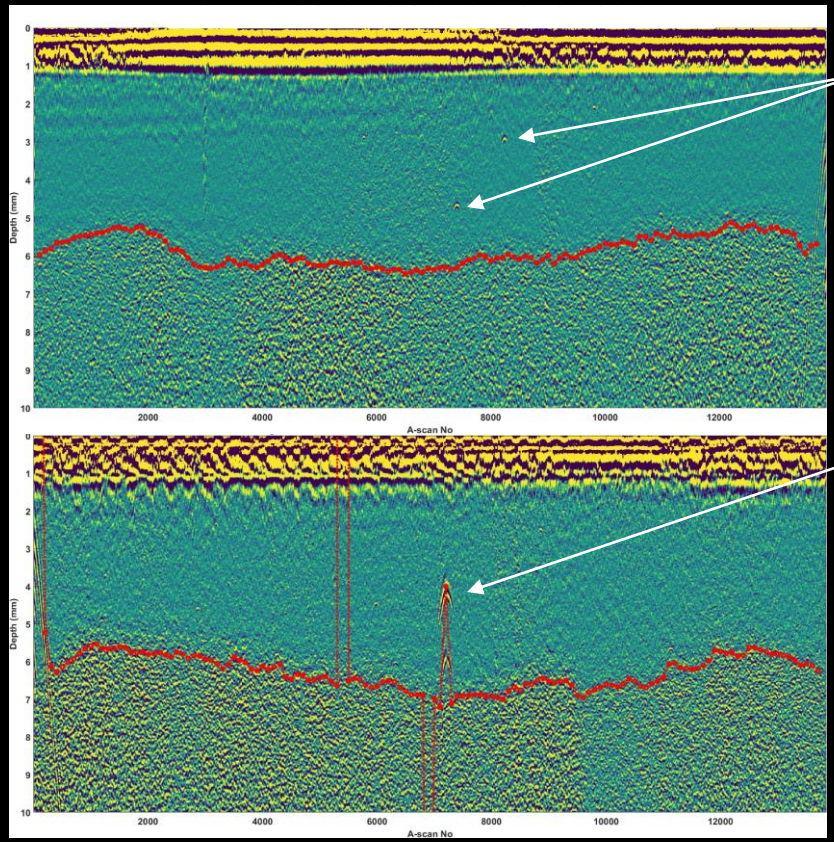




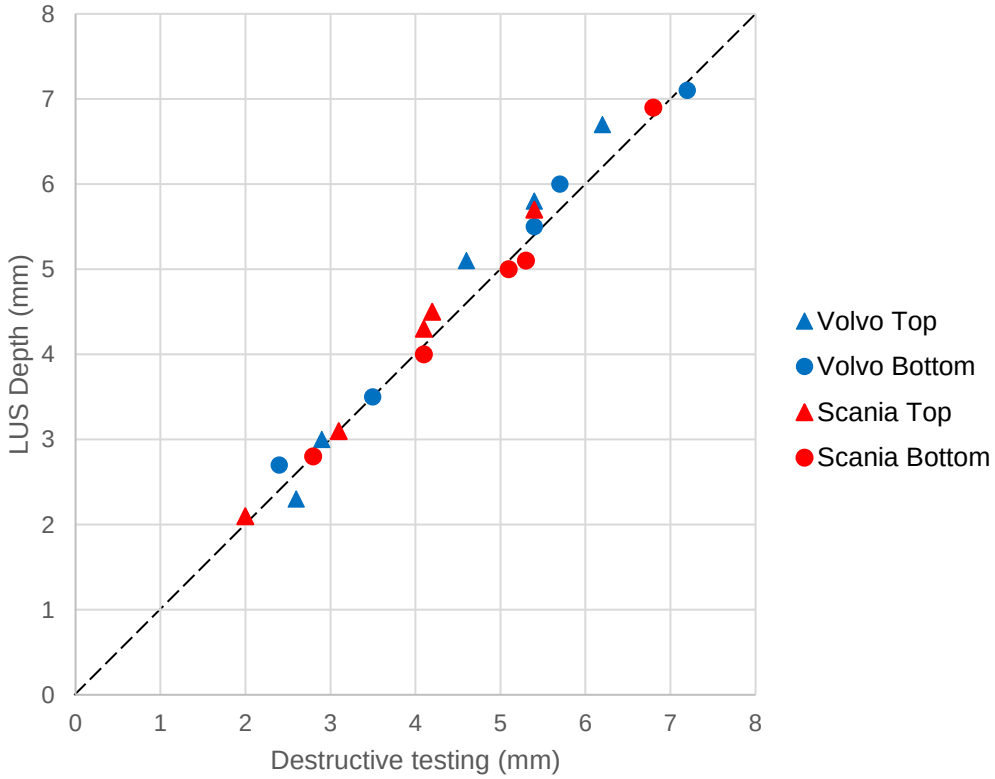




Defects


Depth (mm)
A-scan No
2000
4000
6000
8000
10000
12000
Defects
Defects

Results: LUS vs. Destructive testing



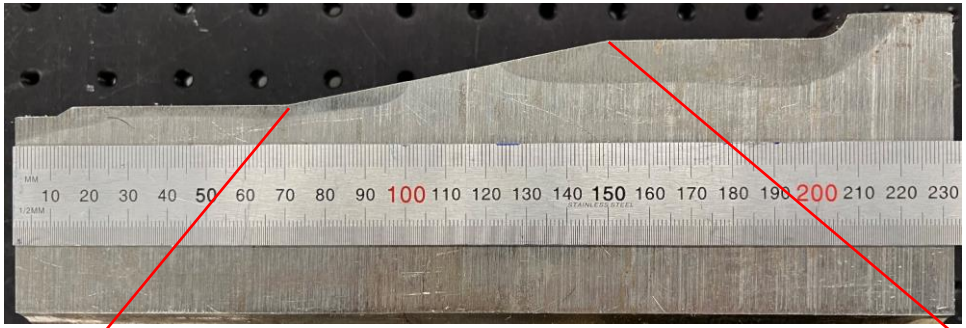
Conclusions and future work

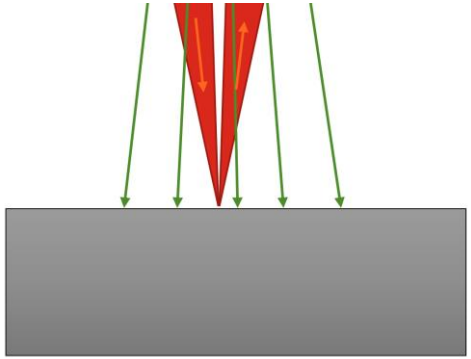
- The induction hardening depth can be measured/imaged by LUS
- Shown that the hardening depth can be measured with LUS in the interval ~ 1.5 - 8 mm
  - Excellent correlation with destructive testing
- It is somewhat sensitive to oxide scale on the surface

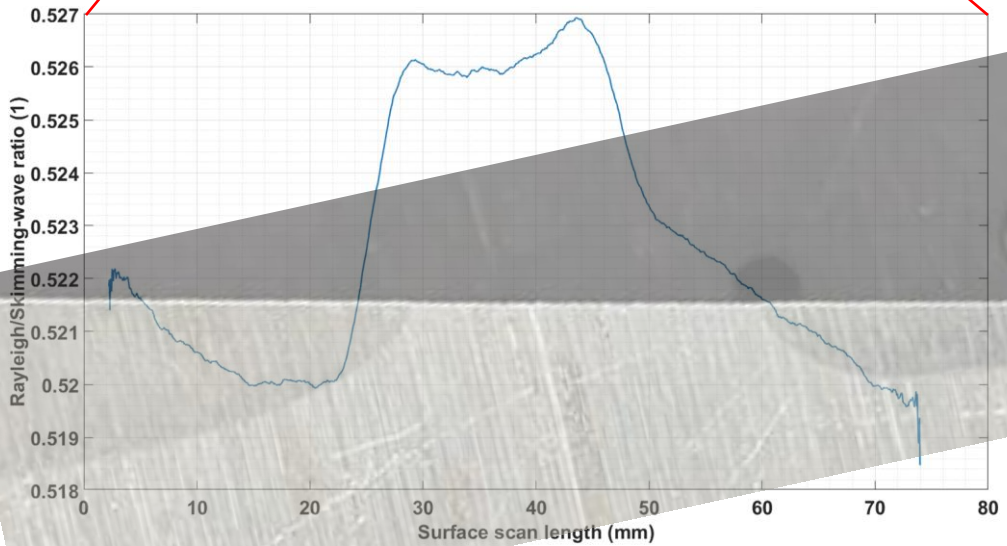
Future work

- Try to characterize microstructure in hardened zone
- Use surface waves to measure on quenched and tempered steel

Future work: QT steel







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