6th October 2014

“Laser guided inspection robot for the Non Destructive Testing in the shipping industry”

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Materials Joining and Engineering Technologies
Background

- Structural failure is a major cause of the loss of ships, resulting in loss of life and pollution of Europe waters.
- The European Union accounts for 27% of this traffic, with 90% of Europe’s oil arriving by sea.
- Tanker accidents account for 12% of all oil pollution.
- Each year over 400 ocean going ships sink, many as a result of weakened structures (corrosion, welding quality).
- Europe owns 40% of the world’s fleet of ships, which account for 90% of its external and 40% of its internal trade.
Industrial Need

- Technological problem
  - MPI is the most common technique used for surface defects
    - It needs a manual operator to apply the chemicals and visually check
    - Electromagnetic techniques like ACFM can remote access
  - Radiography is the mainstay technique used for volumetric defects
    - Dangerous radiation, needs special permission, also no other work is allowed at the same time
    - PAUT can provide a sustitude
Industrial Need

- Technological problem (cont.)
  - The inspection also involves
    - Scaffolding, cherry-pickers, rope access
  - Existing semi-automated inspection robot
    - Basic UT methods to perform thickness measurements
    - Manual identification of the weld prior to deployment

- Industrial need
  - Need for solution to gradually replace the use of radiography for the on-site inspection in the shipping industry
X-Scan Project Concept

- Concept
  - To combine advanced ultrasonic and electromagnetic techniques to fully inspect plate welds in one complete unit capable of guiding itself
  
  - The following technologies were developed
    - A wall climbing robot
    - A laser based seam tracking subsystem
    - Phased Array probe(s), methodology and technology
    - ACFM array probe(s), methodology and technology
Automation of weld inspection

Robot specifications:

- Wall climbing capability
- Weld seam automatic following
- Carry all needed equipment:
  - Control unit, motors, pneumatics and irrigation
  - Laser profile meter
  - NDT holder and probes
  - PAUT unit and splitter
  - ACFM splitter
  - Encoder splitter
  - Cabling and accessories
Laser profile meter seam tracking

Laser profile meter arrangement:

- Butt weld (top left)
- Fillet weld (bottom right)
- Tests on a coated butt weld using an x-y scanner (right)
- Curve fitting and threshold algorithms for both arrangements
Software interface of the seam tracker, not needed in automatic mode
PAUT system

- **Olympus Omniscan MX**
  - Proven system, VNC operation
- **Custom built probes after simulation**
  - Linear, 32 el, 7MHz
- **Rexolite wedge**
- **Water cavity wedge tested**
Inspection technique applied:
- Solid wedge / water wedge
- Encoded manual scan with string encoder (step size 1mm)
- Sector scan using 32 elements from 30° to 75° (angular step 0.5°)
- Focus in projection along the weld centreline
ACFM array system

Sensor holder shared with the PAUT system ~1.5kg

Lightweight cable ~30m 0.09kg/m

Splitter box 160x100x85 1.2kg

Array probe: 1 meter cable, 600g

Array probe: 1 meter cable, 600g

Single Probe: 2.5 meter cable, 750g

Encoder shared with the PAUT system

Near the operator on the control platform

On board of the X-Scan robot
ACFM array system

Probes and Splitter Box used for ACFM measurements
ACFM inspection
Probe holder

Butt weld configuration
Integration tests

3x3m 0.5ton custom build plate for testing

Butt weld scan (top)

Fillet weld scan (right)
4 meters up on the hull of a dry dock and going, rope for safety only
ACFM results
PAUT results
Conclusions

- Different inspection techniques focusing on different parts of the weld
- Combination of all techniques enable the whole coverage of the weld
- Scanning speeds of 30mm/sec achieved
- Results better for thicker than thinner plates
- Accurate positioning issues
Future work

Further funding being sought for:

- Miniaturizing
  - Smaller UT array controller
  - ACFM weld contour array probe
  - Splitters (4 on board) and accessory electronics, bottom up redesigned to fit

- Separation of fillet and butt configurations
  - Holder simplification

- Marinising
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Presentation prepared for ECNDT by TWI under Project No. 21493

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