Pulsed Eddy Current for Tile-Thickness Measurement on Victoria Class Submarines

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Motivation

- Circularity and surface condition of submarine hulls requires periodic condition assessment.
- The hulls of Victoria Class submarines are covered with special sound-absorbing tiles.
- The tiles are glued to the hull with epoxy over a thin primer layer.
- Shape and surface condition of the hulls can not be evaluated through the tile layer with standard techniques.
- Removal of tiles, the current procedure, is very costly and time consuming.
22,000 acoustic tiles are attached to the exterior of the hull. The tiles muffle sound emitted by the submarine, and absorb echoes from the surface and from active sonar [www.forces.gc.ca].
Hull-Shape Measurements

- Laser Tracker provides surface position measurement on outside surface of anechoic tile.
- Thickness of the tile layer fluctuates and is not known with required precision.
- Precise distance measurement from top of anechoic tile to steel hull surface is required, since this is key for evaluation of hull circularity without tile removal.
Primary Objective

- Develop probe that measures the linear stand-off distance along a vector collinear with the probe axis, to a point on an underlying metallic surface.
- Achieve ±1 mm resolution on about 40 mm stand-off distance measurement with < 20 mm lateral resolution.
Secondary Objective

Assess ability of probe to detect under-tile corrosion and weld regions like clad repairs and fabrication seams. Positioning of edge of such features should be within +/- 20 mm.

Corrosion arising at anechoic tile interfaces.
Experimental System with probe mounted on tile and steel plate.
Both probe types exhibit the required (1 mm) lift-off resolution while shielded probes show better resolution and signal to noise ratio.
Transient response of the reflection and shielded probes. The shielded probe is more sensitive to lift-off and less noisy.
Air-subtracted signal of the reflection probe for increasing lift-off (1 mm interval) from 26 to 45 mm.
Air-subtracted signal of the shielded probe for increasing lift-off (1 mm interval) from 26 to 45 mm, pre-amplified x10.
Response to Bent Submarine Hull Section

Comparison of peak of the signal difference, digital photograph of scanned area and mechanically measured lift-off interpolated over 1 cm.
Probe Calibration

Calibration functions are produced with polynomial fits to tables of maximum values of the subtracted signals versus probe lift-off values.

Reflection probe

Shielded probe

- Pre-amplified x10
- Cubic fit
- Quadratic fit
Comparison of stand-off distance between direct mechanical and electromagnetic measurements.

Comparison at 48 positions ⇒ root-mean-square difference of 0.5 mm.
Pulsed eddy current technology has been evaluated for:

- Sensitivity to lift-off at a 36 mm stand-off from the hull, as required for hull circularity measurements.
- Lateral resolution, for identification and characterization of hull surface condition.

- Requirement for sensitivity to lift-off (≤±1 mm) met.
- Lateral resolution/detection better than 25 mm achieved.

- The developed technique is not production ready at the current stage, it requires further improvements.
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