NON DESTRUCTIVE TESTING WITH MOBILE WALL CLIMBING AND SWIMMING ROBOTS

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ABSTRACT

This keynote paper will describe the application of mobile climbing and swimming robots to perform Non Destructive Testing (NDT) of large safety critical infrastructure. Tools are required for the integrity management of structures such as storage tanks, pressure vessels, aircraft, ships, mooring chains, wind and tidal turbine towers/blades, subsea oil and gas pipelines and flexible risers, etc.[1, 2, 3]. The mobile robots are designed to provide access and deploy a variety of NDT techniques to test sites located on these structures. They obviate the need to carry out lengthy and expensive preparation such as the erection of scaffolding or the dangerous deployment of rope abseiling and platform systems. The aim is to reduce planned outage times by speeding up inspection and wherever possible to perform the NDT on-line thus preventing costly outages. In addition, intrusive robotic inspection systems are usually the only means to perform NDT of structures located in hazardous or difficult to access environments.

The following mobile robots to perform NDT will be described:

- Inspection of welds on ship hulls and strengthening plates.
  Ultrasound NDT requires the provision of access to weld lines that run vertically and horizontally on the hull of cargo container ships. A wireless, permanent magnet adhesion wall-climbing robot will be described that performs phased array ultrasound NDT of large vertical steel structures [4].
- Inspection of aircraft wings and fuselage.
  The mandatory NDT of ageing civil aircraft wings and fuselage tests bond quality, corrosion, impact damage, and cracks around rivet fastener holes. A vacuum adhesion climbing robot [5] will be described that provides access to the top-side and under-side of aircraft wings and fuselage with a 18 kg payload of scanning arm and NDT sensors (acoustic camera, ultrasonic phased array, eddy current, thermography camera).
- The inspection of petrochemical storage tank floors for underside corrosion.
  Inspection of the floors of petrochemical storage tanks is performed by opening them after every ten years. The outage can be very lengthy (a crude oil tank outage can take 8-9 months to empty, clean, inspect and restore). Huge savings in cost and inspection times could be obtained by performing in-service inspection of tank floors and walls with robotic devices. The ROBTANK [6] robot can enter tanks through minimum manhole openings of 300 mm diameter to perform ultrasonic non-destructive testing (NDT) of top and bottom corrosion on the tank floor while submerged in liquids. It is equipped with four ultrasound wheel probes, four compression probes and two bulk-wave rotating probes look for corrosion thinning on the floor and walls up to half a metre ahead and under inaccessible floor areas.
- Inspection of Floating Production and Storage of Oil (FPSO) structures.
  The FPSO swimming and wheeled robot [6] is designed to inspect tanks in off-shore oil operations. It provides access to welds on stiffener plates inside oil storage tanks when the tank is either full of oil or emptied to the last few centimetres. It performs NDT of the

welds using ACFM and ultrasound for weld toe inspection (using creep waves) and for plate corrosion detection (using plate waves).

- Inspection of nuclear reactor pressure vessel welds.
  Reactor pressure vessels are inspected with an outage on average every 1-5 years. NDT is performed with Ultrasonic and eddy current techniques. The RIMINI wall climbing robot is designed to inspect shell welds from inside a nuclear reactor pressure vessel (RPV) while submerged in water.
- Inspection of concrete, brick and glass structures.
  Wheeled wall-climbing robots will be described that use a vortex to create adhesion forces and enable motion over rough surfaces such as brick walls.
- Inspection of wind turbine towers and blades.
  The largest wind turbines planned for the future will use fibre reinforced composite (FRP) blades up to 100m in length. FRP in safety critical structures located in such extreme environments is relatively new and it is likely that structural defects of a previously unknown nature may arise. Robotic in-situ blade inspection of offshore wind turbines is a promising solution [7] with radiography identified as the optimal if not the only solution for identification of safety critical defects in the thickest blade sections.
- Inspection of tidal stream generators and blades.
  Generation of energy from tidal streams located in regions of fast-moving tidal flow makes access for inspection purposes very hazardous. Inspecting turbine blades with robotics is a challenging task that has yet to be attempted but the need for it will grow in line with growth in their use.
- Inspection of platform mooring chains.
  The use of floating structures for oil and gas exploration and production, wind power generation and a subsea economy requires the regular inspection of mooring chains. MOORINSPECT is a chain climbing robot that can operate underwater, climb up through the splash zone to the first link in the chain which is located in air to test the link with ultrasound guided waves.
- Inspection of oil and gas flexible risers with digital radiography, ultrasound and eddy currents.
  To develop a sustainable subsea economy, it is necessary to test oil and gas flexible risers for annulus flooding, damaged outer sheaths and ruptured armour. Robotic solutions that deploy digital radiography and ultrasound testing will be described.

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