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Monitoring Average Wall Thickness of insulated or difficult to access objects with Pulsed Eddy Currrent

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Abstract

The method of Pulsed Eddy Current (PEC) has been successfully applied in corrosion detection for several years now. Whereas field experience on insulated objects has grown significantly, the technique's characteristics make it also highly suitable for other field situations where the object surface is rough or inaccessible. Because (surface) preparations can be avoided the tool provides a fast and cost-effective solution for corrosion detection. Due to the high repeatability accuracy PEC technology is specially of interest for monitoring purposes.

An overview of the fundamentals and the INCOTEST® pulsed eddy current tool for corrosion detection is presented and application ranges are discussed. Several field applications other than insulated objects are presented. These range from the inspection of objects covered fire proofing, to rough or corroded surfaces, coated objects and objects covered with marine growth.

These spin-offs offer interesting possibilities in many areas of industry such as sub sea piping, offshore jackets, civil engineering and FPSO ship hull inspection.

Introduction

Corrosion under insulation is a major concern for the owners and operators of almost all carbon steel installations and structures. Periodic or continuous inspection of objects for occurrence of corrosion or monitoring the extent and severity of known corrosion areas should ensure operation of the installation within the safe zone.

To operate the installation at minimum cost, new techniques can be applied to minimise the overall maintenance and inspection costs. Such techniques can aim at reducing the total number of activities either by reducing the number of selected areas to look after or by reducing the overall costs per inspected area. The latter, for instance, is possible by reducing the peripheral costs of inspection (preparation, cleaning, access etc.).

Fig 1: Example of insulated objects.

The INCOTEST pulsed eddy current tool can assist by bringing down both the number of selected areas and the peripheral cost in several applications.

This tool was developed for the detection of corrosion under insulation (CUI). It allows the detection of wall thinning areas without removing the insulation. Using this tool to indicate the affected areas can lead to significant cost reduction. Fewer areas need follow-up and less insulation needs to be removed. Also, in case of asbestos insulation the safety hazards are diminished.

INCOTEST applies pulsed eddy currents for the detection of corrosion areas. A pulsed eddy current technique uses a stepped or pulsed input signal, whereas conventional eddy currents use a continuous signal. The advantages of the pulsed eddy current technique are its larger penetration depth, relative insensibility to lift-off and the possibility to obtain a quantitative measurement result for wall thickness.

This leads to the characteristic which makes it suitable for the detection of CUI: no direct surface contact between the probe and the object is necessary. Also, this tool can be employed in other field situations where the object surface is rough or inaccessible. After a brief introduction of the theory, some of these applications are discussed.

Pulsed Eddy Currents for corrosion detection

The applied operating principle of pulsed eddy currents can vary from system to system. In order to obtain a quantitative reading for wall thickness INCOTEST uses a patented algorithm that relates the diffusive behaviour in time to the material properties and the wall thickness. It operates only on low alloy carbon steel.

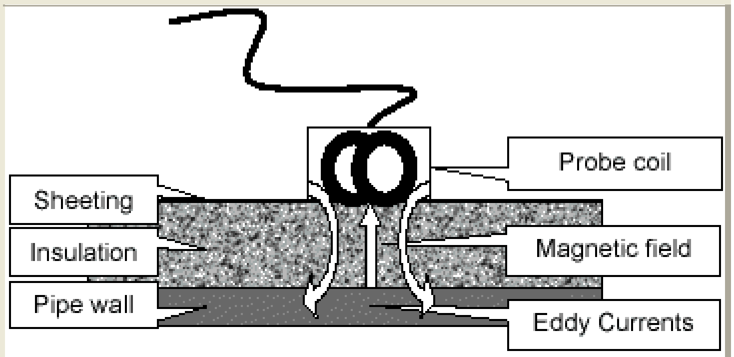

Fig 2: Principle of operation INCOTEST.

The principle of operation is illustrated in Figure 2. A pulsed magnetic field is sent by the probe coil. This penetrates through any non-magnetic material between the probe and the object under inspection (e.g. insulation material). The varying magnetic field will induce eddy currents on the surface of the object. The diffusive behaviour of these eddy currents is related to the material properties and the wall thickness of the object.

The detected eddy current signal is processed and compared to a reference signal. The material properties are eliminated and a reading for the average wall thickness within magnetic field area results. One reading takes a couple of seconds. The signal is logged and can be retrieved for later comparison in a monitoring approach.

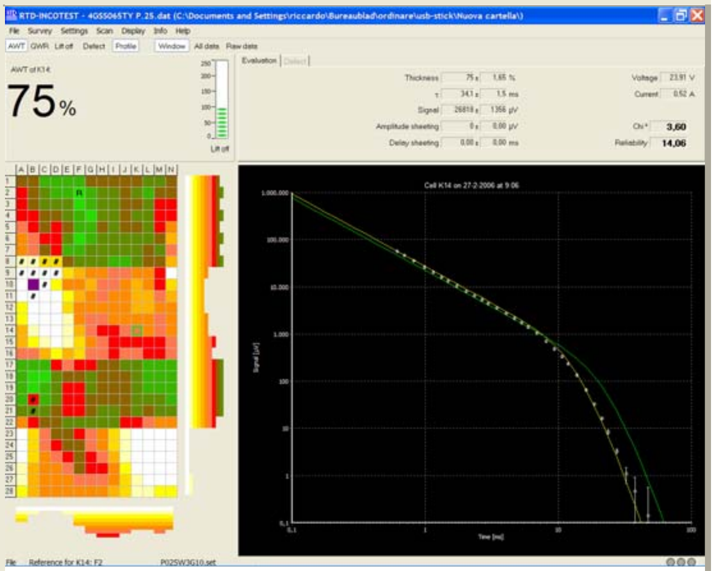

Fig 3: Display of INCOTEST showing AWT reading (top left), logged inspection grid (bottom left) and the decay of the eddy currents (bottom right).

The area over which a measurement is taken is referred to as the footprint. Probe design is such that the magnetic field focuses on an area on the surface of the object. The result of the measurement is a reading of the average wall thickness over this footprint area. The size of this area is dependent on the insulation and object thickness, as well as the probe design. Roughly, the footprint can be considered to be in the order of the insulation thickness. Due to the averaging effect, detection of highly localised defects types like pitting is not reliable with this tool. This effect is illustrated in Figure 4.

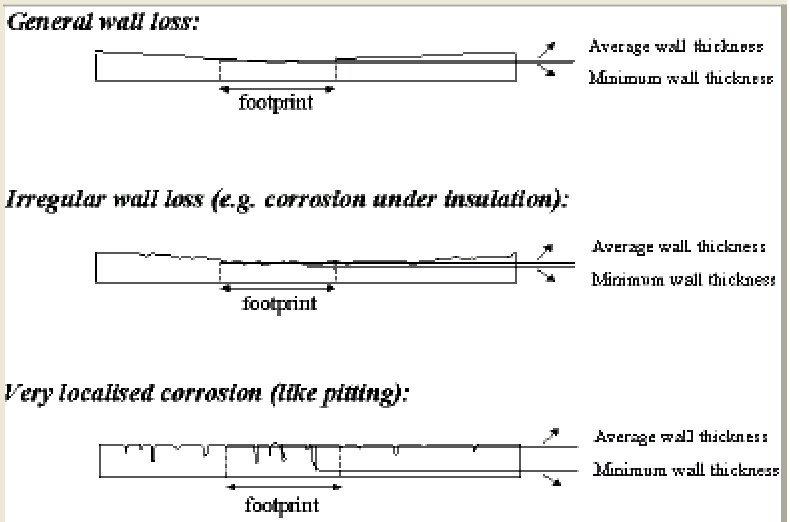

Fig 4: Difference between average and minimum WT within the footprint area.

Although the average wall thickness reading is not a direct replacement of the commonly used UT obtained minimum wall thickness a quantitative result is obtained that can be interpreted unambiguously.

The outer application ranges of the INCOTEST tool can be described by:

- Low alloy carbon steel
- Pipe diameter > 50 mm or 2"
- Nominal wall thickness between 6 mm and 65 mm
- Insulation thickness up to 200 mm
- Sheeting thickness up to 1 mm stainless steel, aluminum, galvanised steel
- Object temperature > -100ºC to < +500ºC

These ranges are determined on condition that a reliable signal can be obtained under regular field conditions.

Inspection approach

As with any other NDT technique, the pulsed eddy current technique has its own merits and cannot be a direct substitute for an existing NDT technique in an existing NDT inspection program. The characteristics of INCOTEST result in the application of the tool with various intentions. Firstly, the reduction of surface preparations may be an incentive to use the tool. No cleaning, grinding or removal of coating and insulation is required.

Secondly, on-stream screening for corrosion areas can be the objective. This means detecting defects is more important than sizing them accurately. It may be done to bring some ranking in a large number of structures or objects that would otherwise not get any attention because conventional inspection is too costly. Another application can be to select areas for follow-up. For instance, in a pre-shutdown inspection the items that need follow-up during a shutdown can be identified.

On-stream monitoring of corrosion areas using INCOTEST is another approach that is of interest because of intrusion on the process is kept to a minimum. The data of previous measurements can easily be retrieved and compared.

Finally, in a risk based inspection approach a choice is made for the level of information required and the necessary certainty for inspection of a particular object. This leads to a choice for a non-destructive testing approach in which pulsed eddy current can be one technique.

Field applications

Fire proofing

Many foundations in installations, such as skirts of process columns and the supports of spherical storage tanks, are covered with a layer of fireproofing for obvious safety reasons. Small cracks or damages to the fireproofing may cause ingress of water, resulting in corrosion underneath the covering. The deterioration process can not readily be detected from the outside. Failing adequate condition monitoring, the deterioration process may eventually cause the object foundation to collapse with disastrous results.

Fig 5: Application on concrete covered object: support legs of spherical storage tanks.

As these fire proofing materials are non-magnetic and non-conducting, the magnetic field can freely propagate between the probe and the object under inspection. Hence, pulsed eddy current can be used to detect corrosion areas without removing the fire proofing material.

To obtain a picture of the foundation's condition, measurements are taken in several points of a defined grid. On the supports of spherical tanks a rapid screening is done by taking readings on four wind directions distanced 100mm-150mm apart axially and starting 300mm from the foot. This results in about 100 readings per support leg. In one inspection day all eight support legs of a tank can be screened and reported.

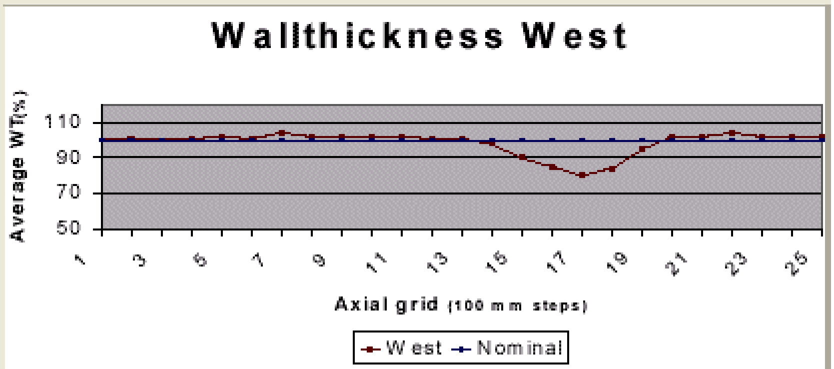

Fig 6: Graphical presentation of results on one sphere leg.

All average values measured are presented in a table together with a graph of the results indicating areas of interest for further action. These results can be used for strength calculations indicating the necessity whether or not to take action on the support leg.

Again, using INCOTEST the owners/operators of these structures can find out the current condition in a rapid and cost-effective manner.

Sub sea applications

Many bank-protections, ports and waterworks in areas with a soft soil consist of steel sheet pilings. These sheet pilings have only a very limited protection against the elements. As a result the unshielded steel surface will be attacked by various forms of corrosion, among Accelerated Low Water Corrosion (ALWC). Similar situations occur for instance at risers and the support pillars of jetties. In all these situations both time and money are saved by using the ability of pulsed eddy current to penetrate dirt and marine growth

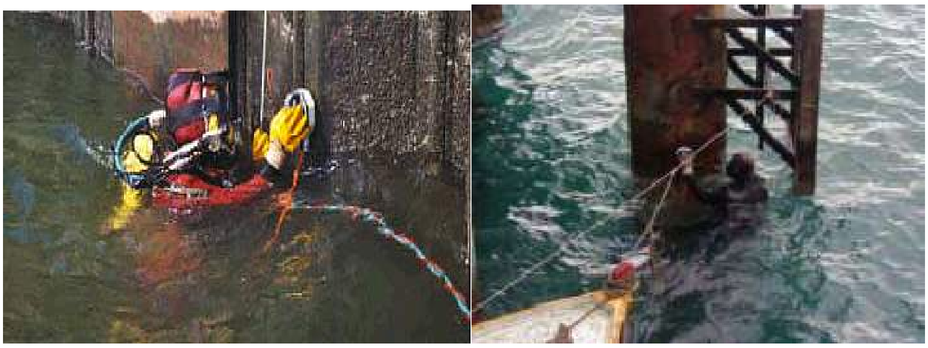

Fig 7: underwater and through marine growth: sheet piling and jetty

Maintenance including coating the surface is a costly action. The need to create a clean and dry environment below water level, and in the tide zone is, the most expensive .

The conventionally used methods of UT require extensive cleaning. Because no cleaning is necessary the use of INCOTEST in this situation leads to a faster inspection. The inspection can be carried out both above and below water level. Based on this result further maintenance can be done creating only localised clean and dry areas.

Even more inaccessible areas are sub sea piping and ship hulls of FPSO's. Many sub sea piping is covered with coatings or concrete. Inspection of these pipe lines is mainly done with intelligent pigs, however that requires that the line is taken out of service. Inspection of INCOTEST from the outside is possible with the use of divers or a ROV. Main aim it to obtain inspection data, without the associated inspection costs, in order to decide if immediate follow up is necessary or to determine the next inspection interval.

Fig 8: Inspection of FPSO ship hull.

Monitoring

Another advantage is also apparent in the relatively small lift-off ranges of several millimeters coating material or directly on the object itself. The repeatability of INCOTEST is 2% and thus an excellent tool for monitoring. Although UT is very accurate, it is commonly known that the repeatability of UT is relative poor.

Once a defect is identified, e.g. by mapping with UT to determine the weakest point, a INCOTEST probe is positioned and measures every day, week or month. At PEMEX, The "Ing. Antonio M. Amor" refinery in Salamanca, Mexico encountered an interesting application for INCOTEST;

Pemex performed a lot of experimental inspections in 2005. Inspection programs on insulated tank walls were established where, in the past, no inspections could be performed because of accessibility problems. During a shutdown a severe wall loss was detected in the shell of a heat exchanger containing Hydrochloric acid. Because a spare was not available, and in order to maintain safe production, Pemex found an interesting solution. "After basic repairs, Pemex decided to monitor the shell thickness by performing INCOTEST with an interval of 15 days. Due to the coating and operating temperature it was not possible to perform UT. A wall reduction of 16% was detected in only a few weeks. However, Pemex was able to continue production under safe conditions until a replacement was available. Pemex gained a lot of experience, which will be implemented in our inspection plans'', says Ing. Jorge Galvan Pena, Superintendente de Inspeccion Tecnica

Fig 9: Monitoring heat exchanger shells.

Conclusion

Beside insulated objects INCOTEST proves a suitable application for situations where access to or preparation of the object surface is hampered. The application of this pulsed eddy current technique can be done with several different inspection approaches. Because of its unique characteristics it can play an important role in the inspection strategy or RBI approach of an entire installation. Practical examples have been given for situations where dirt, corrosion, water, concrete or coating material hamper direct surface access. Because (surface) preparations can be avoided the tool can provide a fast and cost-effective solution for corrosion detection.

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Mr. Scottini earned his masters in material engineering at the University of Trento, Italy. Since 1997 Mr. Scottini is employed by RTD Group and has been actively involved in the technical development of INCOTEST and the development of new applications. Mr. Scottini is considered the leading technical expert on PEC.

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