

Paper No.
16466



Pulsed Eddy Current Advanced Data Analysis – Unlocking new possibilities for vessels inspection

Vincent Demers-Carpentier, Ph.D
Eddyfi Technologies
3425 Rue Pierre-Ardouin
Quebec City, Quebec, G1P 0B3
Canada

Andréanne Potvin
Eddyfi Technologies
3425 Rue Pierre-Ardouin
Quebec City, Quebec, G1P 0B3
Canada

Gabriel Cyr
Eddyfi Technologies
3425 Rue Pierre-Ardouin
Quebec City, Quebec, G1P 0B3
Canada

ABSTRACT

Pulsed Eddy Current (PEC) has proven to be an efficient NDT technique well suited for the detection and assessment of Corrosion Under Insulation (CUI) on pipes and vessels considering the recent technological advances enabling array of PEC with dynamic acquisition. Those breakthroughs now provide a productive solution to perform high-resolution inspection over large areas. Substantial high-resolution scan zones on complex components such as vessels highlight one of the main limitations of PEC which is the cross-sensitivity of the method regarding material properties variations. This limitation of PEC technology has led in the past to false positives. The objective of this paper is to present an information-rich alternative graphical representation called the Tau-scan which helps users make the correct call in complex situations. The various signatures on the Tau-scan are shown and explained for a variety of manufactured samples with machined defects as well as real field data related to corrosion on insulated vessels. It is shown that the novel graphical representation is efficient in overcoming one of PEC current limitations as it significantly helps reduce potential false positives, thereby greatly improving user confidence during data analysis and unlock new possibilities for vessels inspection.

Key words: Pulsed Eddy Current (PEC), Corrosion Under Insulation (CUI), Vessel Inspection, Non-Destructive Testing (NDT), Corrosion

INTRODUCTION

Pulsed Eddy current (PEC) is a versatile NDT technique that allows the detection of corrosion on ferromagnetic components^{1,2}. It works by projecting a magnetic field from a distance onto the inspected component and recording the evanescent eddy current response. As such it can work through insulation and does not require surface preparation. Depending on probe design and material thickness, PEC can detect the wall loss associated with corrosion at liftoffs of several tens of

centimeters. While the insulation needs to be non-conductive, the technique allows the penetration of a thin sheet of metal, often aluminum or steel, used as a weather-protective cladding. This has made PEC one of the preferred techniques for the detection of corrosion under insulation (CUI) on pipes and vessels in the oil and gas^{3,4} as well as the energy industry⁵.

Insulated vessels present a unique challenge for asset owners. Counting amongst the most important part of a refinery, working at high temperature and under pressure, the reliable monitoring of their integrity is paramount. Condensation or water ingress under the insulation can lead to the formation of corrosion, hidden from sight. The removal of the insulation to spot this corrosion is a pricey endeavor which may only be possible during a shutdown, depending on the vessel's condition and function. This makes a visual or ultrasonic (UT) inspection difficult. On the other hand, X-ray based techniques are also prohibited by the geometry of the vessel, namely the low curvature preventing a grazing angle examination. PEC is therefore an invaluable tool in its capacity to detect corrosion without stripping the insulation and while the vessel is in service. By monitoring the integrity of vessels year-round, PEC allows asset owners to be more judicious in their decision to strip and inspect with UT the most corrosion-affected vessels during their limited shutdown window.

One of the main remaining challenges of PEC is the technique's cross-sensitivity with material properties variations which can lead to false positives. A false positive occurs when a PEC analyst identifies a region of interest which turns out to present less severe corrosion than expected. While false positive rates are not prohibitively high, they are something that we aim to lower in order to increase user confidence and inspection accuracy. False positives can have one of several causes, including but not limited to: localized material property variation, interfering conductive component near the probe, temperature gradient, etc.

In order to make an accurate call, the analyst needs to consider three things: 1- look at the C-scan to find areas of interest while taking into account the varying baseline and noise level, 2- look at the signal shape from datapoints in the areas of interest 3-use context to make an informed call. This third factor falls squarely on the inspector. It is recommended that she gathers as much information as possible on the component in the form of as-built drawings, expected corrosion mechanism, morphology and position as well as any other relevant observation made during the inspection. The first two factors, on the other hand, depend mostly on the instrument manufacturer.

Providing a high-quality C-scan that helps analysts identify the potential areas of corrosion and differentiate with potential false positive requires a few key elements. Chief among them is the ability to have a high-resolution scan allowing to identify the shape and location of features. However, high resolution scans take more time to acquire, forcing inspectors to strike a balance between productivity and accuracy. To this end, recent leaps in technology have vastly improved the productivity of PEC inspection, allowing inspections to be carried out with much higher productivity without losing on accuracy. PEC array probes that acquire with six sensing elements simultaneously and dynamic scanning combine to improve inspection speed by a factor of up to ten times faster. This results in higher resolution scans and hence better detection capabilities.

The other main factor that goes with making an accurate call, as mentioned earlier, is the ability to look at the signal shape of datapoints in areas of interest to determine whether they correspond to a defect. This is also common to other inspection techniques such as UT and Eddy Current Testing (ECT) where looking at the A-scan or the butterfly plot helps the analyst confirm a call. This has long been a weakness of PEC where the A-scan, while rich in information, is hard to assess just by looking at it. Analyst have had to rely on the sizing algorithms and trust the outputted value. While sizing algorithms have gotten better in the past five years, the need for analysts to obtain clear information about a datapoint by looking at the A-scan remains a key factor in a successful inspection.

The lack of a proper representation for the PEC signal is evidenced by the fact that there are not one but two different ways to display it in commercial systems. PEC is a discrete measurement technique

where a magnetic pulse is first emitted from the probe and maintained until it fully penetrates the inspected component. The magnetic pulse is then abruptly cut-off, at which point eddy current form in the ferromagnetic component, generating a secondary magnetic field. This magnetic response is then recorded by the probe, filtered, analyzed, and displayed in the A-scan. Older PEC instruments have historically displayed the A-scan in a log-log scale, while more recent systems have opted for a log-lin representation. Both approaches have their advantages and limitations.

Herein we present a novel graphic representation of the A-scan, called the Tau-scan, which allows a better and simpler analysis of the PEC signal. The effect on the Tau-scan of several common features observed during PEC inspections will be discussed. The Tau-scan will then be used to analyze real-world data coming from the in-service inspection of an insulated vessel.

RESULTS

The Tau-scan

The Tau-scan is an alternative representation of the PEC signal. It is calculated from the following formula:

$$Tau [ms] = -1 / \left[\frac{d}{dt} \log(A-scan) \right]$$

This mathematical transformation allows a graphical representation of the information that better highlights the relevant elements it contains. Figure 1 shows the shape of a typical A-scan represented in the log-lin, log-log and Tau-scan representation.