CSI Tech Brief

CARBON STEEL INSPECTION, INC
VERSA INTEGRITY GROUP

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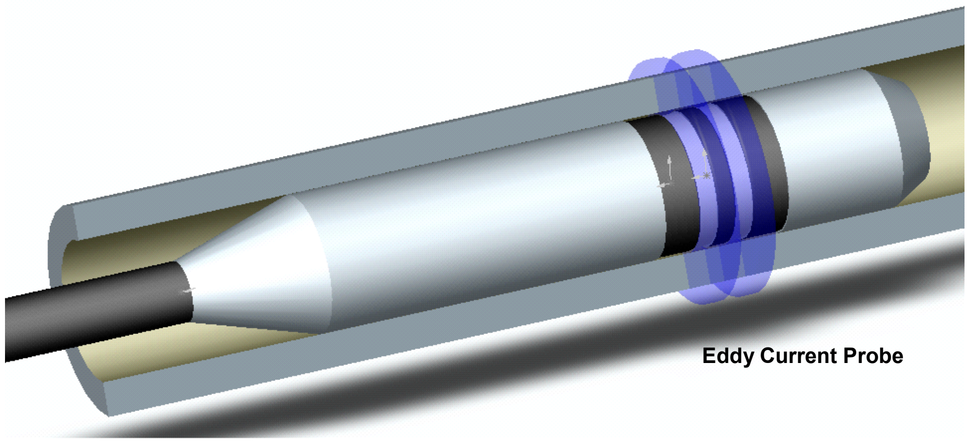
What's It All About?

At Carbon Steel Inspection we are often asked to provide a general description or background information on conventional Eddy Current Testing. There are many different manufacturers of Eddy Current testers, probes, and reference standards. This tech brief strives to maintain a clear and defined technical description of the ET method.



Eddy Current Probe

DEFINITION

The Eddy Current testing method is based on inducing electrical currents (eddy currents) in electrically conductive materials. Any changes in geometry, material, or discontinuities-such as cracks, pits, thinning, or other anomalies will disrupt the flow of the eddy currents and produce a signal.

ET GENERAL DESCRIPTION

Electrons in an object will flow when a conductive object is placed in a magnetic field that is continuously changing in polarity. This product is known as eddy currents. The eddy currents in turn generate a secondary magnetic field, which acts to oppose the source field. The opposing magnetic field can indicate a great deal about the nature of a conductive object. Qualities of the material, such as electrical conductivity, magnetic permeability, as well as geometry changes or discontinuity, will affect the primary and secondary fields.

The technique of eddy current testing takes advantage of this magnetic field by passing an alternating electric current through a coil of wire, then placing a conductive test object within this field. The opposing field generated in the test object will cause the current in the source coil to change. We can then electronically detect this change in current to draw conclusions about the object.

The eddy currents, which flow in the test object, are a function of the properties of the material AND of the frequency. The source field will cause rapid changes in the opposing magnetic field causing the penetration of the material by the source magnetic field to decrease as the frequency increases.

The signal that is developed across the probe coil is a voltage which results from the current that is driven through the coil by the eddy current instrument. The signal has both an amplitude and angular component based on the impedance change that develops across the coil. Therefore, the amplitude and angular values are dependent on the inductance of the coil.

This also occurs when a conductive object is brought into the vicinity of the coil; the opposing magnetic field changes the apparent inductance of the coil, resulting in a change in the amplitude and phase of the signal.

Variations in the electrical characteristics, anomalies, defects, or geometry changes within the test object will show up in this signal and can be evaluated by a trained operator.

There are two basic types of instruments available to detect and display eddy current signals. One is the metered type, which typically uses an analog meter read-out or strip chart to indicate and display a single dimension of the impedance change. Typically, it is the voltage or amplitude of the component. The second type incorporates a two dimensional representation that produces a pattern on an oscilloscope or computer screen. These X-Y plots are called impedance planes, vector displays, or phasor diagrams. All plot the sine and cosine of the change in voltage across the test coils. When used properly, the metered instrument is adequate for many tests conductivity and surface examinations. The X-Y plots allow the trained technician to categorize damage mechanism to patterns that can be recognized and lead to more informed evaluations and analysis.

ANALYSIS

In accordance with ASME Section V, Article 8 guidelines, the technology has the ability to display the resultant signal in a vector (X-Y) format. This form of two dimensional signal displays allows the data analyst to use pattern recognition for characterizing signals. This is a distinct advantage over single dimensional strip chart (amplitude only) analysis techniques.

Typically, the analysis parameters are established where the phase or angular relationship of the signal is measured relative to the X-axis, in degrees, which equates to flaw depth. The amplitude in volts or size of the signal relates proportionally to the volume loss in a material. However, the phase of the signal is volumetrically dependent. The ID and OD defect phase plans are distinguishable between the angular measurement. Most often a signal to noise ratio greater than three is required to provide sufficient information to discern flaws from the baseline or noise. Using this standard creates the ability to discern a small volume deep flaw from a large volume shallow flaw. Strip chart presentation cannot make this distinction.

RESOLUTION

Resolution is the phase separation between flaws of varying depths and will vary with excitation frequency. If lower operating frequencies are used, an increase in the depth of penetration results in an increase in magnitude of the resultant field. This causes a larger signal response with reduced resolution. Conversely, higher frequencies have less depth of penetration reducing the magnitude of the resultant field, but an increased flux density provides for greater resolution. Therefore, a multi-frequency tester provides greater capability for a broad range of tubing applications. Typically, the ID defect flaw plane has half the resolution as the OD defect flaw plane and is less accurate because it is more influenced by flaw geometry than the OD flaw plane.

SENSITIVITY

Sensitivity is dependent on the type of material, grade, dimensions, and wall thickness, residual stresses, operating conditions such as aging -- ambient temperature – tube cleanliness -- and location. Location affects the sensitivity due to the fact that as the field propagates outside of the tube wall, external materials can shunt or distort the field that will mask the indication.

Examples of shunting materials would include tube support plates, tube sheets, and welded attachments. Other examples, including tubes external to or encircling the tested tube and OD enhancements such as aluminum fins or integral fins. These OD enhancements have a limiting effect on the field strength.

Defect orientation, such as axial versus circumferential and location such as in the roll transition or at a land area, will determine the type or style of probe used. For instance, the general purpose style bobbin probe uses a pair of bobbin coils wired in a differential and absolute mode. These modes are good for detecting axially oriented discontinuities as well as general thinning. However, they have limited detection for circumferentially oriented anomalies and may be more influenced by geometric changes at roll or land transitions.

TRAVERSE SPEEDS

Probe traverse speeds are dependent upon the data sampling rates which can never be more than the lowest operating frequency. Selection of operating frequencies will be determined by the anticipated volumetric loss of anomalies and probe type used. Typically, the traverse speeds of 24 to 48 inches per second are attainable. However, if on-line analysis is required, the pull speed may be reduced or acquisition production rate decreases to monitor the data in real time versus post analysis.

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