producingresults

LOOK, BUT DON'T TOUCH

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Contributing Writer

INSPECTING WELDED TUBE INLINE WITH NONCONTACT RESONANCE-MODE TECHNOLOGY

Inspections fall into two broad categories: contact and noncontact. Typical characteristics measured through direct contact include a pipe or tube’s hardness and dimensions. Noncontact methods allow inspection of other qualities and even allow us to analyze defects below the surface.

Noncontact inspection by electromagnetic acoustic wave propagation is a new resonance-mode technology for inline quality control in welded tube production. This technology is suitable for any electrically conductive material and provides high measurement capability without adding complexity to the installation or altering normal mill operation.

How It Works

The term *resonance* refers to the natural, periodic vibrational patterns that occur in all matter. This traveling wave behavior is similar in concept to the vibrations generated when a tuning fork is struck. The tone emitted is the resonant acoustic signature that contains a complete physical description of the tuning fork, including material composition, dimensions, temperature, and quality.

The resonant waves used in this technology occur in the mid- to high-frequency ultrasonic spectrum. They remain localized in predictable regions both in the depth and length profiles of test specimens.

In principle, this is the equivalent of an acoustic CT scan, or a three-dimensional acoustograph of a solid metallic structure. As the material passes under the transducer, the resonant waves are constantly being excited in localized regions. The resonant frequency characteristics change only if the fundamental material properties differ in these localities.

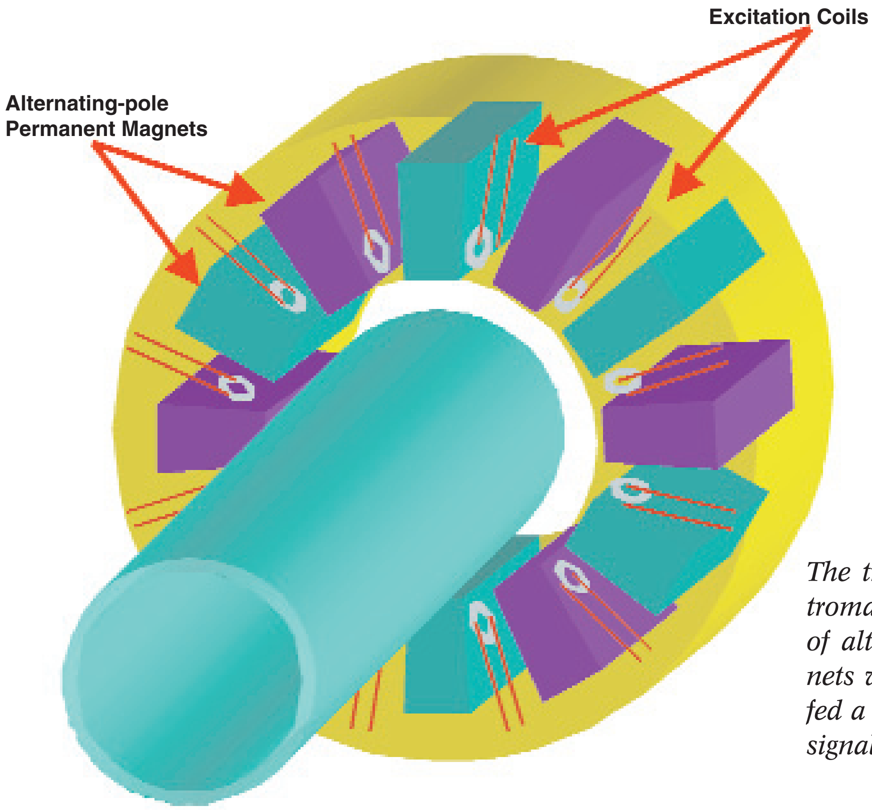
Because the transducer does not come into physical contact with the test sample, the resulting resonance is a pure signature of the material. Detection of an anomalous condition such as density, hardness, or diameter is then a process of monitoring the resonant frequency and looking for changes in frequency beyond a narrow, specific range of normal resonant vibrations particular to the given material.

Transducers and Acoustic Waveforms

The transducers used for resonance-mode electromagnetic acoustic inspection are composed of alternating-pole, high-strength ceramic magnets with bonded excitation coils (see **Figure 1**). The coils are fed a mid- to high-frequency waveform (selected by the operator or from a library from a previous setup) from the signal generator in the test unit power supply.

The excitation fields create a controlled, rapidly oscillating magnetic field, which imparts a matching acoustic waveform in the test material. The frequency of oscillation is adjusted to make the test material vibrate at its natural frequency. Paste welds, laminations, pinholes, and open seam conditions interrupt sound wave propagation and cause a frequency shift. This is similar to how a crack in a bell causes it to ring off -key.

Transducers are applied singly or in pairs for tube inspection, depending on the flaw condition to be monitored. The process control unit can handle up to four transducers in one array for more difficult tests.



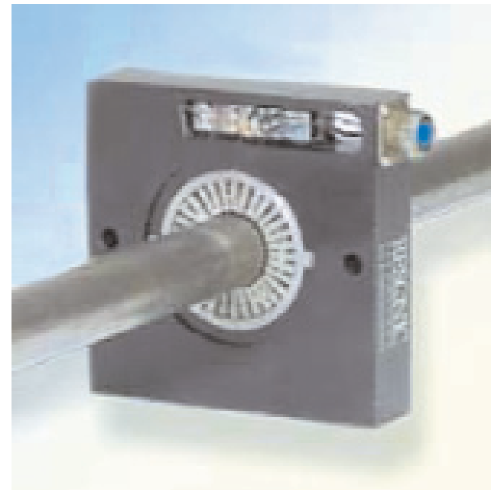


Figure 1

The transducers used for resonance-mode electromagnetic acoustic inspection are composed of alternating-pole, high-strength ceramic magnets with bonded excitation coils. The coils are fed a mid- to high-frequency waveform from the signal generator in the test unit power supply.

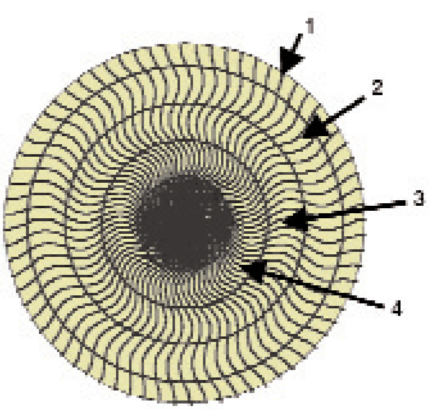
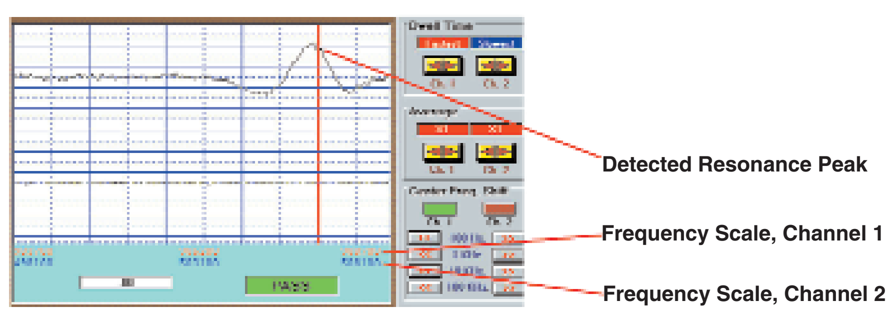


Figure 2

Resonance-mode electromagnetic inspection can detect vibrational patterns of first-, second-, third-, and fourth-order torsional mode in a solid cylinder.



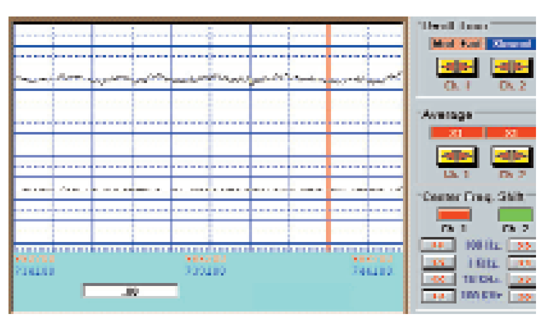


Figure 3

Top: *A peak is dectected on a sample with a good weld. Resonant frequency is about 987 kHz.*

Bottom: *No signal is detected at midsection of a tube with a marginal weld. This signal indicates a paste weld.*

Sound propagation through cylinders and solids follows the same rules employed in ultrasonic inspection. The transducer can be applied to amplify the first-, second-, third-, or fourth-order harmonics so the test can be focused on the near surface and interior surfaces (see **Figure 2**).

The test output is displayed on a VGA monitor much like an oscilloscope display (see **Figure 3**). Frequency of oscillation is shown as a waveform, so the operator may set upper and lower limits for alarms. The display on the top is for a good weld. The display on the bottom is for a cracked tube with no resonance, causing an alarm. Pinholes to 0.015 in., paste welds, laminations, and open seams all cause enough of a frequency shift to generate an alarm.

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