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AGMA Technical Paper

Crack Testing and Heat Treat Verification of Gears Using Eddy Current Technology

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Crack Testing and Heat Treat Verification of Gears Using Eddy Current Technology

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

While eddy current technology has long been used in the testing of bar, tube, and wire stock, advances in electronics, automation, and coil design have paved the way for a new generation of testers specifically designed for component testing applications. This includes the testing of gears and bearings which go into automotive and industrial applications. These testing systems easily integrate into production processes allowing for in-line testing at production line speeds. In addition to enabling 100% of production components to be inspected, it can help monitor upstream processes notifying operators that something is not functioning correctly. This greatly reduces scrap and warranty costs for gear and bearing manufacturers.

Eddy current crack testing is performed by passing a small pair of coil windings over a section of the component to be tested. These coil windings are small enough to test between gear teeth, and with multi-coil probes can test very complex shapes. Most crack test applications require only one test frequency since most tests require the detection of only surface flaws. Simultaneous testing with multiple frequencies allows for testing of both surface and sub-surface defects when inspecting non-ferromagnetic parts.

While not an absolute hardness test like a Rockwell test, eddy current heat treat verification can achieve sorting results on par with Rockwell testing. This has been demonstrated with both forged and powder metal gears. Eddy current heat treat inspection coils come in both standard encircling coil configurations and multi-coil custom configurations. The custom configurations allow for precise location testing verifying that induction heating parameters were correctly applied. Defects to be tested include misplaced case, shallow case, short quench, delayed quench, air cooled, non-heat-treat, and ground out conditions. When performing heat-treat inspection, multiple test frequencies are used to reliably detect these various heat-treat anomalies.

Eddy current testing offers fast, repeatable testing of gears and bearings. Testing data on each component can be stored electronically and re-analyzed off-line at a later date. Eddy current test instruments are designed to integrate with PLC's in material handling stations to set up real-time rejection capabilities. These are all features that complement modern QC requirements.

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While eddy current technology was initially developed for testing of bar, tube, and wire, advances in electronics, automation and coil design have paved the way for a new generation of systems specifically designed to test components such as gears that go into automotive and industrial applications. These eddy current systems not only detect cracks in components, but can also verify proper heat-treat conditions, proper alloy composition, and the presence or absence of features such as splines or teeth.

Eddy current systems are fast, clean, repeatable and easy to integrate into production processes allowing for in-line testing at production line speeds. In addition to enabling 100% of production components to be inspected, eddy current testing help monitor upstream processes notifying operators that something is not functioning correctly. This greatly reduces scrap and warranty costs for gear manufacturers. Eliminating or reducing off-line chemical testing such as dye penetrant, magnetic particle or acid etch allows companies to reduce waste and go green.

Eddy current 101

Eddy current testing works by inducing an electromagnetic field into a conductive material and then looking for anomalies in that field. Figure 1 shows an energized coil that induces eddy currents to flow in the material under test. Changes in the material due to cracks or “structure” changes such as heat treat variation, cause the eddy currents in the material to flow differently. This difference is detected by an eddy current instrument.

Figure 2 shows a block diagram of an eddy current test system. The eddy current instrument sends a single frequency or multiple frequencies out to a single coil or multiple coils. The real-time signal processing electronics compares the returned signals with the sent signals and determines whether an alarm condition has occurred. If an alarm condition has occurred, a signal is sent to a PLC within a material handling station to reject the part from the assembly line. Testing data can be sent to the factory MES or Quality System to track trends and store data. This data can be stored on-premise or in the cloud.

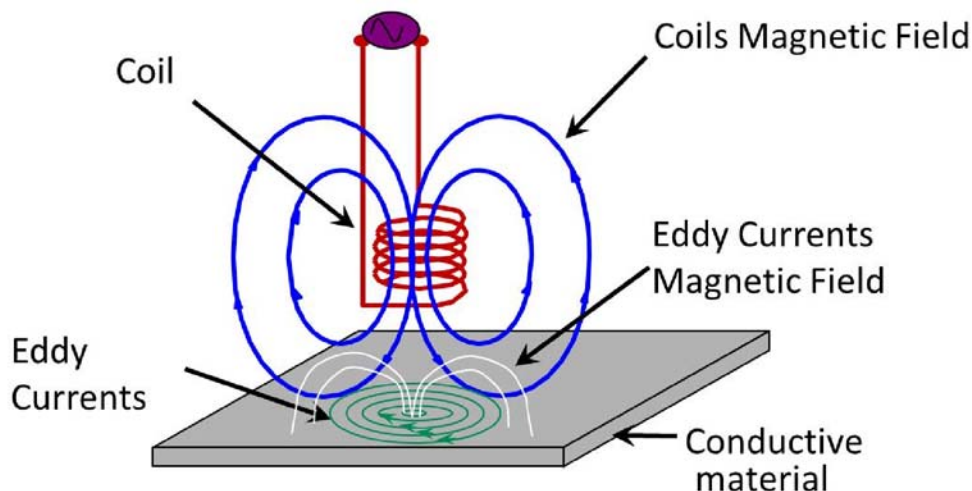


Figure 1. Eddy current flows