National Aeronautics and
Space Administration

technology solution

Instrumentation

Wide Bandwidth Magnetoresistive Eddy Current Probe

Magnetoresistive sensor-based probe for improved deep-flaw detection and surface characterization

NASA's Langley Research Center has developed a novel probe for eddy current sensor applications that improves detection depth and measurement resolution. Although the use of anisotropic magnetoresistive (AMR) sensors in eddy current probes to improve sensitivity at low frequencies and increase the detection depth is known, the high-frequency sensitivity and small size of these sensors is less explored. This new probe incorporates two induction sources (i.e., one high frequency and one low frequency) and an AMR sensor; the result is improved resolution in near surface material characterization, combined with simultaneous deep-flaw detection. Addition of a second high-frequency induction source, oriented to produce a magnetic field orthogonal to the first, allows for near surface anomaly detection in two dimensions.

BENEFITS

- Order of magnitude improvement regarding in-plane near-surface measurement resolution (from 1 mm to less than 0.1 mm)
- Bidirectional, near-surface material characterization at high resolution (approximately 0.1 mm)
- Simultaneous deep-flaw detection (exceeding 1 cm)

APPLICATIONS

- Aerospace - Detection of flaws in air and spacecraft fuselage and wings, as well as inspection of compression interfaces for high contact points
- Manufacturing - Thickness and surface property characterization in pipes, tanks, and reactors
- Materials - Detection of small particles and impurities in larger structures
- Energy - Inspection of reactor components, heat exchangers, and piping systems

THE TECHNOLOGY

Eddy current probes are well known in the realm of nondestructive testing. Traditionally, these probes encourage the formation of eddy currents in a conductive material, and measurement of the magnetic field generated by the eddy currents allows for detection of defects and changes in material properties. Unfortunately, resolution of this type of probe is limited by the probe diameter. Additionally, poor sensitivity at low frequency and the skin effect active in conductors at high frequency precludes inspection much below near-surface depths.

Incorporation of magnetoresistive materials as sensors in eddy current probes can improve instrument sensitivity. NASA researchers have developed a new probe, using a wide bandwidth AMR sensor capable of operating from direct current up to megahertz frequencies. The probe incorporates two induction sources, one low and one high frequency. A magnetizing coil (approximately 6 mm in diameter) is the low-frequency source. The coil is separated from the sensor by a mu-metal flux-focusing lens to minimize direct coupling between coil and sensor. Because the AMR sensor itself is quite small, spatial resolution of the instrument is limited by the dimensions of the induction source.

To improve measurement resolution, the high-frequency source is a single strand of fine gauge magnet wire located at the bottom of the sensor, positioned perpendicularly to the length of the probe. The large difference in operating frequency of the induction sources (low, approximately 500 Hz; high, approximately 1 MHz) allows for simultaneous operation. Incorporating a second high-frequency source, a wire positioned orthogonally to the first, allows for surface imaging along two axes at a resolution of up to 0.1 mm. The improved detection depth of this probe can eliminate the need for metal panels or other pieces to be removed from aircraft for inspection, and the higher resolution near-surface imaging allows for precise characterization of surface properties.

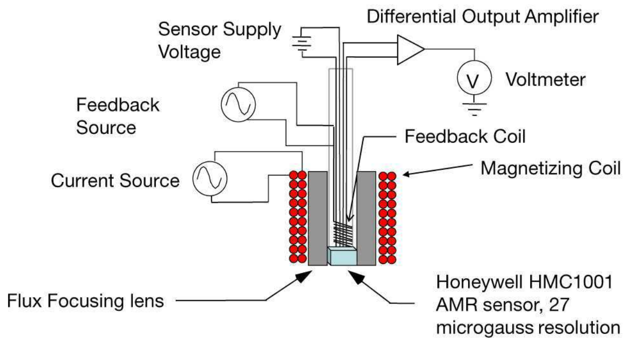

FIGURE 1 – Schematic diagram of an AMR sensor-based self-nulling probe.

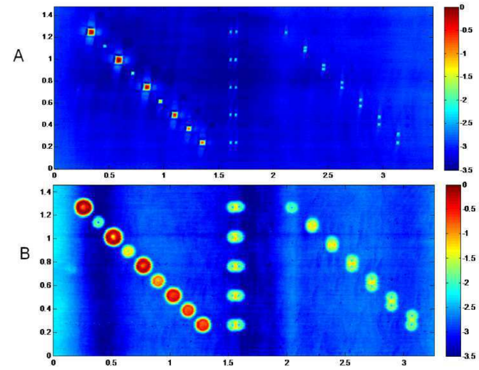

FIGURE 2 - Novel AMR probe imaging (A) compared to EC pencil probe imaging (B)

PUBLICATIONS

Patent No: 8,717,012

More Information

National Aeronautics and Space Administration

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