PREFERRED RELIABILITY PRACTICES

EDDY CURRENT TESTING OF AEROSPACE MATERIALS

Practice:

Eddy Current Testing (ECT) can be used on electrically conductive material for detecting and characterizing defects such as surface and near surface cracks, gouges, and voids. It can also be used to verify a material's heat treat condition. In addition, wall thickness of thin wall tubing, and thickness of conductive and nonconductive coating on materials can be determined using ECT.

Benefits:

Eddy Current Testing is a fast, reliable, and cost effective nondestructive testing (NDT) method for inspecting round, flat, and irregularly shaped conductive materials. Specific processes have been developed to determine the usability and integrity of threaded fasteners. In addition, ECT has the capability of being automated. With proper equipment and skilled test technicians readout is instantaneous.

Programs That Certified Usage:

Solid Rocket Motor (SRM) and Redesigned Solid Rocket Motor (RSRM).

Center to Contact for More Information:

Marshall Space Flight Center (MSFC)

Implementation:

Alternating Current (AC) flowing through a coil produces an alternating magnetic field about the coil. When the coil is positioned near to, or placed on, material that is capable of conducting electrical current, the magnetic field passes into the material and circular (eddy) currents are induced in the material near the coil. The flow of eddy currents in the material causes the excitation of a fluctuating magnetic field of its own. This magnetic field is always in opposition to the coil's magnetic field as illustrated in Figure 1. When the coil is placed on conductive material, the strength of the coil's magnetic field is reduced. This change in the magnetic field causes a change in the impedance of the coil, which causes a change in the current flowing through the coil. These changes are detected by an instrument placed in the circuit.

MARSHALL SPACE FLIGHT CENTER

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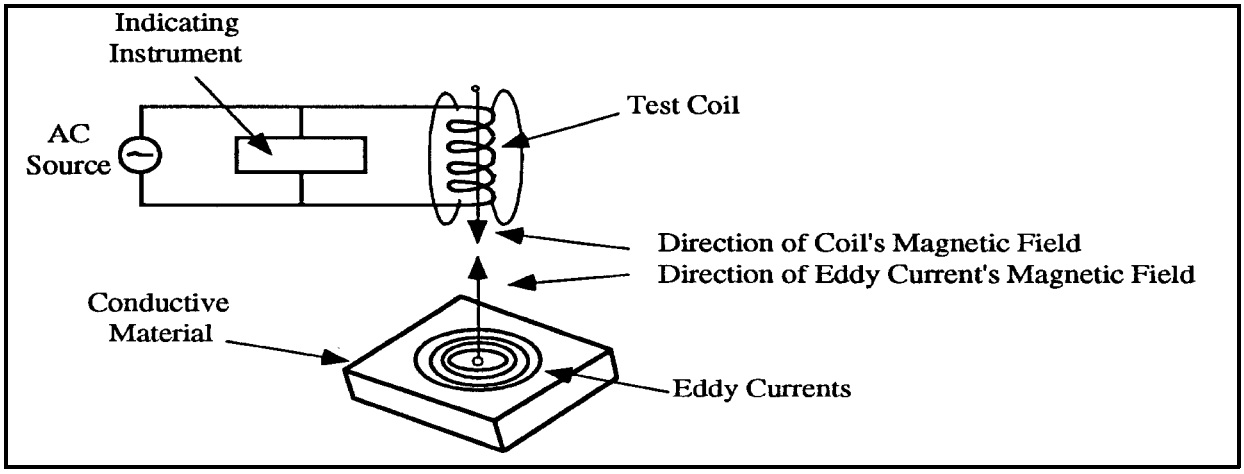

Figure 1. Basic Eddy Current Testing System

The flow of eddy current within the material is disrupted by the presence of discontinuities, such as, cracks, porosity, or inclusions. Discontinuities cause a decrease in the flow of current in the material by increasing the length of the path along which the current must flow as shown in Figure 2. This results in a reduction of current flow which causes a change in the impedance of the test probe coil.

There are three major factors that affect ECT. These are material conductivity, geometry, and permeability of the material being tested. In addition, there are contributors that affect the three major factors. These are shown in Table 1.

Table 1. Factors Affecting Eddy Current Testing

Conductivity	Geometry	Permeability
Alloy Hardness Temperature Residual stresses Coatings	Thickness Discontinuities Coil-to-Material Separation (liftoff)	Ferromagnetic*

* Material capable of being magnetized

The ECT signal is strongly related to the geometrical shape of the coil, i.e., the size, shape, and positioning of the coil; the relationship between the coil windings and suspected discontinuities; the effect of changes in liftoff or fill factors; the depth of penetration; and the edge effect.

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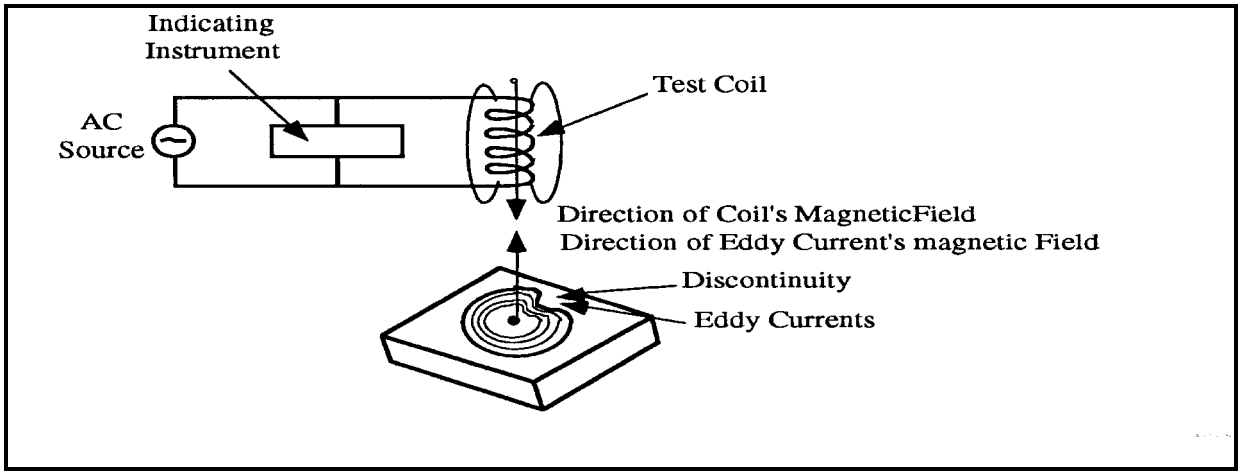

Figure 2. Distortion of Eddy Currents by a Discontinuity

Identifying the various factors causing impedance changes depends upon the knowledge and skill of the ECT technician. Thus, selecting the appropriate eddy current probe is an important part of eddy current testing.

Various types of test instruments available for ECT are: 1) conductivity testers, 2) crack detectors, 3) resistance and reactance measuring testers, 4) coating thickness testers, and 5) oscilloscopes and output devices such as strip chart recorders, printers, etc. when used as part of a test setup.

A standard test specimen with known flaw sizes must be fabricated for use in adjusting the sensitivity setting of the test instrument for accurate interpretation of the test results. The standard test sample should be sound and of the same alloy, temper, and geometry as the part to be tested. Flaws may be produced in the standard test specimen by drilling, electrical discharge machining, milling, or any other means that will not distort the standard. Any flaw size outside the predetermined acceptable flaw size for the object being tested shall be a noted defect for corrective action or rejection.

Table 2 lists advantages and disadvantages to be considered when selecting ECT. The most important elements required to maximize successful eddy current operations are dedicated personnel, training, proper equipment, and adequate standards. Also, at reasonable time intervals during ECT, routine checks should be made with the standard test specimen to insure equipment is operating properly.

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Table 2. Advantages and Limitations of Eddy Current Testing (ECT)

Advantages	Limitations
1. High speed testing (can be automated) 2. Accurate measuring of conductivity 3. Discontinuities at or near surface can be reliably detected 4. High-sensitivity to small discontinuities 5. Accurate coating thickness measurements 6. Direct Go/No Go answers can be quickly obtained 7. No physical contact required 8. Low cost 9. Portable	1. Limited penetration into test article 2. Several variables simultaneously affect output indication 3. Discontinuities are qualitative not quantitative indications 4. Material must be conductive 5. Requires skill when many variables are involved 6. False indications can result from edge effects and parts geometry

ECT is useful in the areas of material heat treat determination, coating thickness measurements, and flaw detection. A list of typical applications is shown in Table 3.

Table 3. Typical Applications of Eddy Current Testing

Material Property Determinations	Thickness Measurements	Flaw Detection
Heat treatment evaluations Hardness Fire damage Impurities Chemical compositions Corrosion damage Conductivity of ionized gas	Thin sheet metal Foil Paints Anodic coatings Lacquers Thin insulation Rocket motor linings	Sheet metal Foil Wire Bars Tubes Bolt holes Fasteners Welds Ball bearings

Technical Rationale:

For the past ten years, eddy current testing has been a necessary tool at MSFC for the inspection of bolts, (heads, grip length, and threads), nuts, and holes for defects. Standards are fabricated as required and special adapters have been fabricated which allows the probe (coil) to be

positioned at the correct angle and distance from surface. ECT is a fast, accurate, and highly reliable method for determining defects in surface and near surface areas of aerospace materials.

Impact of Nonpractice:

Failure to detect flaws in the surface or near surface areas of components could result in failure of the components and possibly failure of the mission. Failure to use ECT when applicable to aerospace materials could result in the use of a slower, less cost effective, and less reliable method for detecting surface and near surface flaws in aerospace materials.

References:

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