IMPROVED IMAGING OF MAGNETIC FLUX LEAKAGE FIELDS

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ABSTRACT

The present detection methods for imaging flux leakage are colored particle, fluorescent particle, Hall detectors and coils. These techniques are limited due to the need for the detector to be in close proximity to the material being inspected. Requirements exist in the Army for both remote sensing techniques and techniques which will allow easier analysis of the detected flux leakage.

ARMY PROBLEM

There exists a need for improved imaging of magnetic flux leakage fields.

Ferromagnetic materials can be inspected for surface and subsurface defects by utilizing the magnetic properties of the material. In this method, the test specimen is magnetized by sending an alternating or direct current through the specimen or by placing the specimen in the field produced by a permanent magnet or an electromagnet. Defects are detected by interrogating the test specimen surface with a probe which detects magnetic field inhomogeneities. If the tested material exhibits adequate magnetic retentivity, the specimen can be inspected after magnetization.

Various probes and support instrumentation are used to detect, sense, and image the magnetic field inhomogeneities at the specimen surface. Small ferromagnetic particles, such as iron oxide powder, are the simplest and most common detectors utilized. To improve visibility, the particles are coated with either a colored or a fluorescent substance. These particles are applied dry or dispersed in a liquid to the test item. The particles accumulate at the site of the magnetic leakage field and produce a visible outline of the discontinuity on the surface of the test item when properly viewed. Water and kerosene are the usual liquids the particles are dispersed in, but room temperature curing rubber is also used to provide a replica casting.

The use of small ferromagnetic particles for imaging magnetic flux leakage fields has the following shortcomings.

1. No quantitiative information is provided about the magnetic flux leakage field.
2. The technique is difficult to adapt to automatic inspection procedures.
3. The particles also accumulate at gravity favored sites.
4. Careful handling is required to not disturb the indication.
5. The interior of cylindrical items such as pipe, gun tubes, and projectile components are difficult to inspect using the magnetic particles as the imaging technique.
6. Indications on specimens with a rough surface finish are difficult to interpret.

Hall detectors, induction coils with and without cores, and some semiconductor devices are used as magnetic probes to sense the magnetic leakage field. These magnetic probes are hand-held or attached to a mechanical scanning mechanism. Coil type magnetic probes require rapid relative motion to the magnetic flux leakage field to generate adequate output signals. For crack detection both the magnetizing field and the probe scanning direction must have components normal to the crack orientation.

A significant amount of hardware has been constructed to examine ferromagnetic items with magnetic probes. Automated and semiautomated systems are used to inspect anti-friction bearings, pipe, gun tubes, projectiles, and similar items with cylindrical symmetry.

The use of magnetic probes to inspect items provides a characteristic signature concerning the flux leakage source. From the magnetic signatures obtained, flaw volume, flaw location, flaw depth from surface, flaw orientation, and flaw width can be determined.

The magnetic signatures can be imaged with an oscilloscope, peak and hold detectors to strip chart recorders, oscillographic recorders and scan converters for video display.

The use of magnetic probes to image magnetic flux leakage fields has the following shortcomings:

1. Some magnetic probes require rapid relative motion.
2. Magnetic probes must inspect very close to the specimen's surface (approximately 0.01").
3. Magnetic probes lend themselves to automated inspection but require complex hardware to follow specimen geometry.

With the advent of coherent single frequency light sources, are there other ways of imaging magnetic flux leakage fields? Do there exist any magneto-optical effects which would be useful for imaging magnetic flux leakage? The advantages of such a technique would be:

1. Remote sensing.
2. Quantitative flaw parameterization.
3. Easier automatic inspection.
4. Easier manual and automatic interpretation.