International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-3, Issue-3, March 2019
ISSN: 2395-3470
www.ijseas.com

The Dependence of Defect Percentage and Length on the Impedance of Magnetic Permeability for Eddy Current

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Abstract

Eddy currant nondestructive was used to find the defect percentage for Al, Zn, Fe, Sn and Pb. The samples were scratched such that the scratches have specific length. The changes of defect percentage with the sample impedance, magnetic permeability were studies. It was found that the defect percentage is inversely proportional to the magnetic permeability as well as defect length. These empirical relations one confirmed also theoretically.

Key wards: Eddy current, nondestructive test, impedance, magnetic permittivity.

Introduction

Nondestructive testing (NDT) has been defined as comprising those methods used to test part or material or system without impairing its future usefulness [1].
The term is generally applied to nonmedical investigations of material integrity.
Strictly speaking, this definition of nondestructive testing includes noninvasivemedical diagnostics. Ultrasound X-ray and endoscopes are used by both medical and industrial nondestructive testing. Medical noninvasive testing, however, has come to be treated by a body of learning so separate from industrial nondestructive testing that today most physicians do not use the word nondestructive. Nondestructive testing is used to investigate specifically the material integrity or properties of the test object. A number of other technologies

for instance, radio astronomy, voltage and amperage measurement and rheometer (flow measurement) are nondestructive but are not used specifically to evaluate material properties. Radar and sonar are classified as nondestructive testing when used to inspect dams, for instance, but not when they are used to chart a river bottom. Nondestructive testing when used asks "Is there something wrong with this material?" in contrast, performance and proof tests ask "Does this component work?" It is not considered nondestructive testing when an inspector checks a circuit by running electric current through it. Hydrostatic pressure testing is another form of proof testing, one that sometimes destroys the test object [2, 3, and 4]. Another gray area that invites various interpretations in defining nondestructive testing in future usefulness. Some material investigations involve taking a sample of the tested part for a test that is inherently destructive. A noncritical part of a pressure vessel may be scraped or shaved to get a sample for electron microscopy, for example. Although future usefulness of the vessel is not impaired by the loss of material, the procedure is inherently destructive and the shaving itself in one sense the true test object has been removed from service permanently. The idea of future usefulness is relevant to the quality control practice of sampling. Sampling (that is, less than 100 percent testing to draw inferences about the ensample lots) is nondestructive testing if the tested sample is returned to service. If the steel is tested to verify the alloy in some bolts that can then be returned to service, then the test is nondestructive. In contrast, even if spectroscopy used in the chemical testing of many fluids is inherently nondestructive, the testing is destructive if sample are poured down the drain after testing. Nondestructive testing is not confined to crack detection. Other discontinuities include porosity, wall thinning from corrosion and many sort of disband. Nondestructive material characterization is a growing field concerned with material properties including material identification and microstructural characteristics such as resin curing, case hardening and stress that have a direct influence on the service life of the test object [5, 6, 7, 8].The eddy current technique need to be improved so as to meet the new needs for building tests and other new areas. This requires determining the factors that affect its performance to do this an experimental work was done in this research to show how the defect percentage is affected by resistivity, mass number and valence.

Material and Methods

Defectometer model 2.837 was used in this inspection, some defected samples steel, aluminum, iron lead and tutia surface inspection probe.

Figure (4.1) shows types of samples used in the thesis and Defect meter model 2.837

Figure (2) types of probes used in the thesis

Method

The device was opened (switched on) and then the probe was raised to the upper position then it was placed in the standard sample which attached to the calibration device at the depth (1mm) the probe was then placed in the samples to be inspected and the probe was passed at a vertical angle (90 degrees) for all sample parts.

Specification

When the probe passes in the place of defect. There is complete signal in the device and an acoustic alarm at the same time. If the sensor passes in the area without defect it reads zero which indicate no defect in this region.

Eddy Current Specifications

Customer: TARCO
Method of inspection: eddy current
Type of inspection: Surface
Equipment used: Defectometer type 2837
Probe: Range 350 kHz up to 3MHz
Reference stander: PNN Fe2 (6955)
Cable: P/ N207050444709
Examination stander any discontinuity indication is too be considered as defect and reported Component identification steel, Al, Pb, Fe and tutia
Area to be inspected: different material holes and scratches
Technique No. used: 73-32-E
Inspection procedure: the sample cleaned and dried at 60 ^{0}C in circulating machine. The Defectometer checked (function check) usingthe reference stander p/N2-164-sss then the visual spectrum was carried out for inspected area.

Results

Table 1: relation between defect percentage D and dimension for linear scratches L

Sample	Thickness	Resistivity $\rho \times 10^{-7} \frac{\Omega}{m}$	Valance v	Atomic Number Z	Scratches Length L	Percentage D (%)	dimm
Al	0.41	0.282	3	13	60	82.09	1.68
Zn	0.44	0.590	2	30	50	24.63	2.87
Fe	2.87	1.000	3	26	80	52.77	2.03
Sn		1.090	2.4	50		27.95	
Pb	0.54	2.200	2.4	82	40	71.12	0.44

Table 2: relation between defect percentage D and dimension for holes L

Sample	Thickness	Resistivity $\rho \times 10^{-7} \frac{\Omega}{m}$	Valance v	Atomic Number Z	Holes Diameter L	Percentage D (%)	dimm
Al	0.41	0.282	3	13	60	82	1.68

Zn	0.44	0.590	2	30	100	52	2.87
Fe	2.87	1.000	3	26	50	24.6	2.03
Sn		1.090	2.4	50	30	27	
Pb	0.54	2.200	2.4	82	30	71	0.44

Discussion

The results in table (1) show that the defect percentage depends strongly on the resistivity as well as the magnetic properties of matter. The scratch length is also affecting the defect percentage. It is very clear that for scratch defects percentage for Al, Zn and Pb decreases as resistivity increases to take the values 60, 50 and 40% respectively this may be related to the fact that the defect percentage D is given by:

$$D = \frac{Z_d}{Z_b} = \frac{Z_{air}}{Z_b} (1)$$

Where

Z_d= Z_{air}= air impudence, since the crack is filled with air
Z_b=bulk matter impedance

Thus according to relation (1) the defect percentage decreases as the bulk matter impedance increases. For Fe the defect meters is very large compared to all other percentage increases abruptly. This increase is related to the fact that the defect impedance is related to the induction voltage which in turn is proper tonal to the magnetic permeabilityμ according to the relation

$$Z_d \sim \mu \frac{N}{i}\frac{di}{dt} = \sim \mu \frac{NdL_{n(i)}}{dt} \quad (2)$$

N= number of turns
I= currant

Thus the defect percentage is given by

$$D = \frac{Z_d}{Z_b} \sim \mu (3)$$

More over table (1) shows that the defect length L is about 4 times that of all other samples since

$Z_d \sim L$ (4)

Thus equations (3) and (4) show that the large observed defect percentage for Fe can be explained theoretically according to the two equations.

Conclusion

The defect percentage depends on many physical parameters. This percentage is inversely proportional to the sample impedance, while it is directly proportional to its magnetic permeabilityand defect length.

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