Tampere University of Technology
Institute of Materials Science

MOL-3116 Introduction to NDT techniques

Examination 1.3.2011

NO LITERATURE IS ALLOWED, RESETED CALCULATORS ALLOWED, DICTIONARIES ARE ALLOWED

ANSWER TO 5 QUESTIONS ONLY! / Vastaa viiteen kysymykseen kuudesta.
ANSWER EVERY QUESTION TO SEPARATE ANSWER PAPER! /vastaa jokainen kysymys omalle konseptipaperille!

1. Explain briefly:
   a) acoustic emission (AE)
   b) replica
   c) impedance plane
   d) MPI
   e) thermography
   f) wetting angle
   g) radiographic image quality
   h) electromagnetic yoke
   i) liquid penetrant
   j) borescope

2. What should be considered when choosing NDT methods in industrial applications?

3. Factors reducing the definition in radiographs?

4. Critical angles in ultrasonic inspection and how they influence to the inspection

5. Copper alloy (conductivity =5.96*10^7 S/m) rods are being inspected with eddy currents using encircling coil. Standard depth of penetration needs to be 1.0 mm, and flaw indications must be at least 10% of the empty coil impedance.

   a) What inspection frequency must be used?
   b) What is the phase angle for 0.5 mm deep calibration flaw?

6. Explain briefly NDT techniques which are based on magnetism or magnetic properties of test object, what are the limitations of the methods and the applicability for different materials and test objects.

Equations

$1 / d^2 = (h^2 + k^2 + l^2) / a^2$

$E = h \nu = h (c/\lambda)$

$\lambda L = R d_{hkl}$

$\mathbf{P} / \lambda = h \mathbf{a}^* + k \mathbf{b}^* + l \mathbf{c}^*$

$n \lambda = 2 d \sin\theta$

$\cos\varphi = (h_1h_2 + k_1k_2 + l_1l_2) / [(h_1^2 + k_1^2 + l_1^2)^{1/2} (h_2^2 + k_2^2 + l_2^2)^{1/2}]$

$DF = \varepsilon / \tan\alpha \approx \varepsilon / \alpha = d_{CRT} / (\alpha M)$

$1 / \lambda = k (Z - \sigma)^{1/2}$

$I / I_o = \exp [-(\mu/\rho) (\rho x)]$

$\delta = 0.61 \lambda / (\mu \sin\alpha)$

$d = \delta / \tan\alpha$

$D = M^2 d$

$C_i = (ZAF)_i (I_i / I_{(i)})$

$E_o / E_{ic} = U$

$\lambda = h \nu = 1.2398 / E \quad [nm] \quad ; \quad E \text{ in } [kV]$

$$f_\theta = \left[\left(me^2\right)/\left(2h^2\right)\right]\left[\lambda / \left(\sin\theta\right)\right]^2 \left(Z - f_x\right)$$

$$F_{hkl} = \sum_n f_n \exp\left\{2\pi i \left(hx_1 + ky_1 + lz_1\right)\right\}$$

$$\left|F\right|^2 = \sum_i f_i \cos\left\{2\pi i \left(hx_1 + ky_1 + lz_1\right)\right\} + \sum_i f_i \sin\left\{2\pi i \left(hx_1 + ky_1 + lz_1\right)\right\}$$

Structure	Reflection absent if
Simple cubic	All present
fcc	h, k, l, mixed odd and even
bcc	h+k+l odd
hcp	h+2k = 3n and l is odd

$$B = \mu H$$

$$X_L = \omega L = 2\pi f L$$

$$Z = \sqrt{\left(R^2 + X^2\right)}$$

$$J_x = J_o \exp(-x/\delta)$$

$$\delta = \left(\pi f \mu\sigma\right)^{-1/2}$$

$$\theta = \sqrt{\left(\pi f \mu\sigma\right)} = \frac{x}{\delta}$$

$$\nu = \mathrm{v}\,\lambda$$

$$\sin\alpha_i / \sin\beta_r = \mathrm{v}_i / \mathrm{v}_r$$

$Z_L = \rho V_L$: unit for ρ is g/cm^3 , and for V_L cm/μs

$$R = \mathrm{I}_r / \mathrm{I}_i = \left[\left(Z_2 - Z_1\right)/\left(Z_2 + Z_1\right)\right]^2 \qquad T = \mathrm{I}_t / \mathrm{I}_i = 4 Z_1 Z_2 / \left(Z_1 + Z_2\right)^2$$

μ = 4*10^-7 H/m for non-magnetic materials