Page No.
Date

Ultrasonic Sensors / Numericals on Sensors.

Q.1 $f = 20\,kHz$; $Y = 11.6 \times 10^{10}\ N/m^2$; $\rho = 7.23 \times 10^{3}\ kg/m^3$

$$f = \frac{1}{2L}\sqrt{\frac{Y}{\rho}} \Rightarrow L = \frac{1}{2f}\sqrt{\frac{Y}{\rho}}$$

$$= \frac{1}{2 \times 20 \times 10^3}\sqrt{\frac{11.6 \times 10^{10}}{7230}}$$

$$= 0.1\ m = 10\ cm.$$

Q.2. $l = 40\,mm$; $\rho = 7.25 \times 10^3\ kg/m^3$; $Y = 11.5 \times 10^{10}\ N/m^2$

$$f = \frac{1}{2l}\sqrt{\frac{Y}{\rho}} = \frac{1}{2 \times 40 \times 10^{-3}}\sqrt{\frac{115 \times 10^9}{7250}}$$

$$= 49.78\ kHz.$$

Yes, US waves can be produced by the magnetostriction oscillator as the frequency obtained here is 49.78 KHz which is more than 20 KHz.

Q.3. $t_1 = 1.8\ mm$; $Y = 8 \times 10^{10}\ N/m^2$; $\rho = 2650\ kg/m^3$

a) $$f_1 = \frac{1}{2t}\sqrt{\frac{Y}{\rho}} = \frac{1}{2 \times 1.8 \times 10^{-3}}\sqrt{\frac{8 \times 10^{10}}{2650}}$$

$$= 1.37\ MHz.$$

b) $$f_2 = \frac{1}{2t_2}\sqrt{\frac{Y}{\rho}} \Rightarrow t_2 = \frac{1}{2f_2}\sqrt{\frac{Y}{\rho}}$$

$$t_2 = \frac{1}{2 \times 2 \times 10^6}\sqrt{\frac{8 \times 10^{10}}{\ldots}}$$

∴ The required change in the thickness

$\Rightarrow t_2 - t_1 \Rightarrow 1.8 - 0.915 = 1.085$ mm

∴ Required change is 1.085 mm

Q.4. $t_1 = 4$ mm ; $f_1 = 400$ KHz

$t_2 = ?$; $f_2 = 500$ KHz

$$f_1 = \frac{1}{2t_1}\sqrt{\frac{Y}{\rho}} \quad ; \quad f_2 = \frac{1}{2t_2}\sqrt{\frac{Y}{\rho}}$$

$$\frac{f_1}{f_2} = \frac{1/2t_1\sqrt{Y/\rho}}{1/2t_2\sqrt{Y/\rho}} = \frac{t_2}{t_1}$$

$$t_2 = \frac{f_1 \times t_1}{f_2}$$

$$= \frac{4\cancel{00} \times \cancel{10^3} \times 4 \times 10^{-3}}{5\cancel{00} \times \cancel{10^3}}$$

$t_2 = 3.2$ mm.

Q.5. $T_N = 285°C$; $T_c = 0°C$

$T_i = ?$ if $T_c = -30°C$.

$$T_N = \frac{T_c + T_i}{2}$$

$$2T_N = T_c + T_i$$

$$T_i = 2T_N - T_c$$

$$= 2 \times 285 - (-30)$$

$$T_i = 600°C.$$

Q.6. $a_{Sb-Au} = a_{Sb-Pb} - a_{Au-Pb}$

$= 32.68\ \mu V/°C.$

$b_{Sb-Au} = b_{Sb-Pb} - b_{Au-Pb} = 0.137\ \mu V/°C.$

Page No.
Date

$$e = at + \frac{1}{2} bt^2$$

$$= 32.68 \times 100 + \frac{1}{2}(0.137) \times 10^4$$
$$= 3268 + 685$$
$$= 3953 \ \mu V$$

Q.7: Thermo emf $e = 2160 \mu V$ at $t_1 = 0^\circ C$
$t_2 = 250^\circ C$

$t_n = 330^\circ C.$

The thermoemf is given by $e = at + \frac{1}{2} bt^2$

$t = t_2 - t_1$

$\therefore$

$$2160 \times 10^{-6} = a(250) + \frac{1}{2} b(250)^2$$

$$\therefore 2160 \times 10^{-6} = 250a + 31250b$$

As $t_n = -a/b.$

$\therefore \quad a = -330b.$

Substituting a in the above eq^n

$$2160 \times 10^{-6} = 250(-330b) + 31250b$$
$$\therefore \quad b = -0.04214 \ \mu V/0^\circ C^2.$$

$$a = -330(-0.04214) = 13.906 \ \mu V/^\circ C.$$

Q.8: If a_1; b_1 are the coefficients for Fe-Pb thermocouple; while a_2, b_2 are the coeff. for ~~Cd~~ ~~thermo-couple~~. coeff. of Cd-Pb thermocouple.

As emf $e = at + \frac{1}{2} bt^2$

$$P = \frac{de}{dt} = a + bt$$

∴ for <u>Fe - Pb</u> thermocouple

$P_1 = a_1 + b_1 t$ — ①

& for Cd - Pb is $P_2 = a_2 + b_2 t$ — ②

∴ For Fe - Pb

$17.5 = a_1 + b_1 . 0$

∴ ~~a_1~~ $a_1 = 17.5 \mu V / °c$

at $t = 0°C$

Also $5 = a_1 + b_1 \times 125$

$\Rightarrow 5 = 17.5 + 125 b_1$

$\Rightarrow b_1 = \dfrac{5 - 17.5}{125} = -0.1 \mu V / °c^2$

For <u>Cd-Pb</u>

$3 = a_2 + b_2 . 0 \Rightarrow a_2 = 3 \mu V / °c^2$

$15 = a_2 + b_2 \times 150 \Rightarrow 15 = 3 + b_2 \times 150$

∴ $b_2 = \dfrac{15 - 3}{150} = 0.08 \mu V / °c^2$

∴ For Fe - cd thermocouple, we have the coefficients as

$a = a_1 - a_2$

$a = 17.5 - 3 = 14.5 \mu V / °c$

$b = b_1 - b_2 = -0.1 - 0.08 = -0.18 \mu V / °c^2$

∴ The neutral temperature for Fe - cd is

$t_n = -a / b = \dfrac{-14.5}{-0.18}$

$t_n = 80.55° c.$