ELECTRICAL ENGINEERING.

ASSIGNMENT-5

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A5
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MAGNETIC CIRCUITS.

ANS-1

$$\frac{di}{dt} = \frac{12}{0.01} = 1200 \text{ A/S.}$$

$$M = \frac{\mu_0 N_1 N_2 A}{l}$$

$$e = N\frac{d\phi}{dt} = 1000 \times \frac{\phi}{t} = 1000 \times \frac{6 \times 0.05}{10 \times 0.01}$$

$$M = \frac{\mu_0 \phi}{2} = 1000 \times \frac{60}{100} \times \frac{0.05 \times 10^{-3}}{5} = 6 \times 10^{-3} H$$

$$= 6 \text{ mH}$$

$$e = 6 \times 10^{-3}\left(\frac{12}{0.01}\right) = 7.2 \text{ V}$$

$$L = \frac{N\phi}{i} = \frac{1000 \times 0.05 \times 10^{-3}}{5} = 10^{-2} \cancel{\text{mH}} = 10 \text{ mH}.$$

ANS-2

$N_1 = 1500$, $l_1 = 60\text{cm}$

$N_2 = 500$, $A = 20 \times 10^{-4} m^2$

(a) $$M = \frac{\mu_0 N_1 N_2 A}{l} = \frac{4\pi \times 10^{-7} \times 1500 \times 1500 \times 20 \times 10^{-4}}{60 \times 10^{-2}}$$

$$= 3.14 \text{ mH.}$$

(b) $e = 3.14 \times 10^{-3} \times 250$
$= 0.75 \text{ V}$

ANS-3

$N_1 = 50$, $N_2 = 505$, $A = 2\times10^{-4}$
$l = 12 \text{ cm}$, $I = 0.2A$, $\nu = 5000$

$$M = \frac{4\pi\times10^{-7}\times 50 \times 505 \times 2\times10^{-4}}{5\times2\times10^{-2}} = 52.8\,\mu$$

$$e = M\frac{di}{dt} = 52.8\times10^{-6}\times 0.2\times 5000$$
$$= 0.0528 \text{ V}$$

ANS-4

$N = 1000$, $l = 100 \text{ cm} = 1 \text{ m}$
$l_1 = l_2$, $N_1 = N_2$
$d_1 = 3 \text{cm}$, $d_2 = 6 \text{ cm}$

$$M_1 = \frac{\mu N_1 N_2 A_1}{l_1} , \quad M_2 = \frac{\mu N_1 N_2 A_2}{l_2}$$

$$M_1 = \frac{4\pi\times10^{-7}\times10^{1}\times\pi\times9\times10^{-4}}{4\times100\times10^{-2}} = 0.888 \text{ mH}$$

$$M_2 = \frac{4\pi\times10^{-7}\times10^{6}\times\pi\times36\times10^{-4}}{4\times100\times10^{-2}} = 3.55 \text{ m}$$

$$M = \frac{\mu_0 N^2 A l}{L}$$

$$= \frac{4\pi \times 10^{-7} \times 10^{6} \times \pi \times 9 \times 10^{-4}}{4} = 0.888 \text{ mH}$$

$l_2 = 3.55 \text{ mH}$

$$K = \frac{M}{\sqrt{L_1 L_2}} = \frac{0.888}{\sqrt{0.888 \times 3.55}} = 0.5$$

ANS-5

$N_1 = 12000$, $I_1 = 5A$, $\phi_1 = 0.05 \text{ mWb}$

$N_2 = 15000$, $I_2 = 5A$, $\phi_2 = 0.075 \text{ mWb}$

(a) $M = \frac{N\phi}{i}$

$$M_{12} = \frac{N_2 \phi_{12}}{i}$$

$$= \frac{15000 \times \left(\frac{45}{100} \times 0.05\right)}{5}$$

$$= 0.0675 \text{ H}.$$

As 4.5% of flux produced by 1 link current.

$M_{12} = 0.0675 = 67.5 \text{ mH}$

$$K = \frac{M}{\sqrt{L_1 L_2}}$$

$$L_1 = \frac{N_1 \phi_1}{I_1} = \frac{12000 \times 0.05 \times 10^{-3}}{5} = 0.12 \text{ H}$$

$$L_2 = \frac{N_2 \phi_2}{I_2} = \frac{15000 \times 0.075 \times 10^{-3}}{5} = 0.225$$

$\sqrt{0.12 \times 0.225}$

$\boxed{ANS-6}$

$N_2 = 600$ $\qquad$ $A = 100 \times 10^{-4}\,m^2 = 10^{-2}\,m^2$

$N_1 = 30$ $\qquad$ $l = 150 \times 10^{-2}\,m = 1.5\,m$

(a) $M = \dfrac{\mu N_1 N_2 A}{l} = \mu_0 \mu_r \dfrac{N_1 N_2 A}{l} = \dfrac{4\pi \times 10^{-7} \times \overset{400}{\cancel{2000}} \times 30 \times 6}{\underset{5}{\cancel{150}} \times \cancel{10^{-2}}}$

$= \dfrac{4\pi}{5} \times 10^{-12} \times 10^{-2}$

$= 0.302\ H.$

(b) $e = M\dfrac{di}{dt} = 0.302 \times \dfrac{10}{10^{-2}} = 302\ V$

$\boxed{ANS-7}$ (i) $\dfrac{V_1}{V_2} = \dfrac{13.8}{11.5} = \dfrac{6}{5}$

$\dfrac{P_i}{P} = 1 - \dfrac{1}{n} = 1 - \dfrac{5}{6} = 1/6$

$P = 6P_i = 600\,KVA.$

(ii) $\dfrac{V_1}{V_2} = \dfrac{13.8}{2.3} = 6$

$\dfrac{P_i}{P} = 1 - \dfrac{1}{6} = \dfrac{5}{6}.$ $\Rightarrow$ $P = \dfrac{6}{5} P_i$

$= \dfrac{6}{5} \times 100 = 120\ KVA$

ANS-8 $N_1 = 90$, $R_1 = 0.067\Omega$

$N_2 = 100$ $R_2 = 0.232\Omega$.

(a) $R_1 = n^2 R_i'$

$n = \frac{N_2}{N_1} = 2$

$R_i = 4 \times 0.067$

$R_i = 0.268\,\Omega$

(b) $R_2' = \frac{R_2}{n^2} = \frac{0.232}{4} = 0.0582\,\Omega$

(c) Total $= R_1 + R_2 = 0.067 + 0.058$

$= 0.125\,\Omega$.

ANS-9

Voltage applied $= \frac{1}{10}$ rated voltage $= 60\,V$

$I_0 = 100\,A$

$P_{input} = 1.2\,KW = P_c$

$I_c = I_0^2 (R_1 + R_2)$

$R_1 + R_2 = \frac{1.2 \times 10^3}{10^4} = 0.12\,\Omega$.

$X_1 + X_2 = \sqrt{2^2 (R_1 + R_2)^2}$

$Z = \frac{V}{I} = \frac{60}{\quad} = 0.6\,\Omega$

$$x_1 + x_2 = \sqrt{0.36 - 0.0144} = 0.587\,\Omega$$

$\boxed{\text{ANS-10}}$ $R_1 = 1.15\,\Omega$, $R_2 = 0.155\,\Omega$

$$\frac{V_1}{V_2} = \frac{2000}{250}$$

(a) $$\eta = \frac{V_2}{V_1} = \frac{25}{200} = \frac{1}{8}$$

$$R_1' = \eta^2 R_1 = \frac{1}{64} \times 0.115 \times 10 = 0.0179$$

$$R_{net} = 0.0155 + 0.0179 = 0.0334\,\Omega$$

(b) Total drop on full load $= I_1 R_1 + I_2 R_2$.

$$I_1 = \frac{40 \times 10^3}{2000} = 20\text{ A}$$

$$I_2 = \frac{40 \times 10^3}{250} = 160\text{ A}$$

$\therefore$ Total drop $= 20 \times 1.15 + 160 \times 0.0155$

$= 25.48\text{ V}$.

(c) $$P_c = I_1^2 R_1 + I_2^2 R_2$$

$$= (20)^2 \times 1.15 + (160)^2 \times 0.0155$$

$$= 460 + 396.8 = 856.8\text{ W}.$$

ANS-11

$n = 6$ $\quad$ $\nu = 50\ Hz$

$R_1 = 0.9$ $\quad$ $R_2 = 0.3$

$X_1 = 5$ $\quad$ $X_2 = 0.13$

(a) $I = 200A$,

$$P_c = I^2(R_1+R_2) = (200)^2(1.2) = 48\ KW$$

$$P = VI$$

$$V = \frac{48 \times 10^3}{200} = 240\ V.$$

$$Z = \sqrt{(R_1+R_2)^2 + (X_1+X_2)^2}$$

$$= \sqrt{(1.2)^2 + (5.13)^2} = \sqrt{1.44 + 26.3}$$

$$= 5.26\ \Omega$$

$$V = IZ = 200 \times 5.26 = 1052\ V.$$

$$\tan\theta = \frac{R_1+R_2}{X_1+X_2} = \frac{1.2}{5.13} = 0.234$$

$$\phi = \tan^{-1} 0.234 = 13.17°$$

Power factor $= \cos\phi = \cos(13.17°) = 0.97$

Scanned by CamScanner

ANS-12 Ohmic loss = 1% of output.

$$\frac{IR}{V} = \frac{1}{100} = 0.01$$

Resistance drop = 5% of voltage.

$$IX = \frac{5}{100} V$$

$$\frac{IX}{V} = 0.05.$$

$$\text{Regulation} = \frac{IR\cos\theta}{V} \pm \frac{IX\sin\theta}{V}$$

(a) 0.8 lag

∴ % regulation = (0.01)(0.8) + (0.05)(0.6)

= 3.8%

(b) unity

$\sin\theta = 0$ (as $\theta = 0$)

∴ % regulation $= \frac{IR}{V}(1) = 1\%$

(c) 0.8 lead

∴ % regulation $= \left(\frac{IR}{V}\cos\theta - \frac{I\sin\theta X}{V}\right) \times 100$

= (0.01)(0.8) − (0.05)(0.6) ×

= 2.29 %

ANS -13

$P_c = 436 W$, $I = 10 A$, $V = 100 V$;

P.f. = 0.8(+)

$$R_1 + R_2 = \frac{P_c}{I^2} = \frac{436}{100} = 4.36 \Omega$$

$$Z = \frac{V}{I} = 10 \Omega \quad , \quad X = \sqrt{Z^2 - (R_1 + R_2)^2} = 9 \Omega.$$

$$\eta = \frac{E_2}{E_1} = \frac{6600}{330} = 20$$

$$\frac{V_2}{V_1} = 20$$

$$V_2 = 20 \times 330 = 6600 V$$

Regulation = $IR\cos\theta + IX\sin\theta$

$$I = \frac{100 \times 10^3}{6600} = 15.15 A$$

∴ Regulation = 15.15 (4.36 × 0.8 + 9 × 0.6)

= 134 V

∴ $V_2' = V_2 + 134$

= 6600 + 134 = 6734 V

ANS-15

$P_c = 1600 W$ at full load

$P_i = 1400 W$

a) Pf = 1

$$\eta = \frac{x VI\cos\theta}{x VI\cos\theta + P_i + P_c} \quad , \quad \cos\theta = 1$$

$$\eta = \frac{xVI}{xVI + P_i + P_c}$$

At 25% load output $= \frac{VI}{4} = \frac{150}{4} = 37.5$ K

$$P_c = \frac{P_i}{x^2} = \frac{1400}{16} = 87.5\,W$$

$$\eta = \frac{37.5 \times 10^3}{37.5\times10^3 + 1400 + 87.5} \times 100 = 96.18\%$$

At 33% load output $= 1500 \times \frac{33}{100} = 49.5$ KW

$$P_c = \frac{1400}{(3.03)^2} = 152.5\,W$$

$$\eta = \frac{49500}{49500 + 152.5 + 1400} \times 100 = 97\%$$

At full load

$$\eta = \frac{150\times10^3}{150\times10^3 + 1400 + 1600} \times 100 = 98\%$$

(b) $\cos\theta = 0.8$ lag.

At 25% load, output $= 150 \times 0.8 \times \frac{1}{4} = 3($

$$\eta = \frac{30\times10^3}{30\times10^3 + 1400 + \frac{1400}{x^2}} \times 100 = \frac{30\times10^3}{30\times10^3 + 1400 + 87.5} \times 100$$

$$\eta = \frac{30 \times 10^3}{31487.5} \times 100 = 95.27\%$$

At 33% load output $= 49.5 \times 0.8 = 39.6$ kW

$$\eta = \frac{39.6 \times 10^3}{39.6 \times 10^3 + 1400 + 152.5} \times 100$$

$$= 96.22\%$$

At full load

$$\eta = \frac{150 \times 0.8 \times 10^3}{150 \times 0.8 \times 10^3 + 1400 + 1600} \times 100$$

$$= 97.56\%$$

$\boxed{\text{ANS-16}}$ $P_i = 350$ W , $P_c = 400$ W

$$\eta = \frac{V_I}{V_I + P_i + P_c} \qquad \boxed{\cos\theta = 1}$$

(a) full load $= \eta = \dfrac{25 \times 10^3}{25 \times 10^3 + 350 + 400} \times 100 = 97.08\%$

(b) half load $= \eta = \dfrac{25 \times 10^3 \times 0.5}{25 \times 10^3 \times 0.5 + 350 + 87.5} \times 100 = 96.$

$\left(P_c = \dfrac{P_i}{n^2}\right)$

(c) load $= xP = \sqrt{\dfrac{P_i}{P_c}} \times P = \sqrt{\dfrac{350}{400}} \times 25\text{kVA} = 23.4$ kVA

At max efficiency = $P_i = P_c = 350$ W.

ANS-17

$$\eta = \frac{VI\cos\theta}{VI\cos\theta + P_i + P_c}$$

$$\eta_{max} = 0.98 = \frac{15K}{15K + 2x}$$

$\Rightarrow x = 153$ W

P_i constant = 153 W

P_c depends on loading = I^2R

12 hours $\rightarrow$ 2 KW at 0.5 pf

$$KVA = \frac{2}{0.5} = 4.$$

$$P_c = \frac{P_i}{x^2} = 153 \times \left(\frac{4}{15}\right)^2 = 10.88 \text{ W}$$

Next 6 hours $\rightarrow$ 12 KW at 0.8 pF

$$KVA = \frac{12}{0.8} = 15$$

$$P_c = 153\left(\frac{15}{15}\right)^2 = 153 \text{ W.}$$

Next 6 hours = 18 KW at 0.9 pF

$$KVA = \frac{18}{0.9} \times 1 = 20$$

$$P_c = 153 \times \left(\frac{20}{15}\right)^2 = 272 \text{ W.}$$

$$\% \eta = \frac{(12\times2 + 6\times12 + 6\times18)\times10^3}{10.88 + 12 + 153\times6 + 2 + 2\times6 + \frac{24\times153}{P_i} + 2.04} \times 100$$

$= 97.5\%$.

ANS-18

$P_c = 1000\ W$, $P_i = 1000\ W$

At full load.

$$\eta = \frac{VI\cos\theta}{VI\cos\theta + P_i + P_c}$$

(a) $$\eta = \frac{xVI}{xVI + P_i + \frac{P_i}{x^2}}$$

At half load

$$P_c = \frac{P_i}{x^2} = \frac{1000}{4} = 250\ W$$

$$\eta = \frac{100\times10^3\times0.5}{10^5\times0.5 + 1000 + 250} = 97.56\%$$

At full load $$\eta = \frac{10^5}{10^5 + 1000 + 1000} = 98.04\%$$

1.5 load output $P = 100\times1.5 = 150\ KVA$

$$\eta = \frac{150 \times 10^3}{150 \times 10^3 + 1000 + 2250} \times 100 = 97.87\%$$

b) $\cos\theta = 0.8$

half load , $\eta = \frac{50 \times 10^3 \times 0.8}{50 \times 10^3 \times 0.8 + 1000 + 250} \times 100 = 96.96\%$

full load , $\eta = \frac{50 \times 10^3}{10^5 \times 0.8 + 1000 + 1000} = 97.56\%$

1.5 load , $\eta = \frac{1.5 \times 10^5 \times 0.8}{1.5 \times 10^5 \times 0.8 + 1000 + 2250} = 97.3$