Question 1

6 pole, 240 V, 50 Hz,

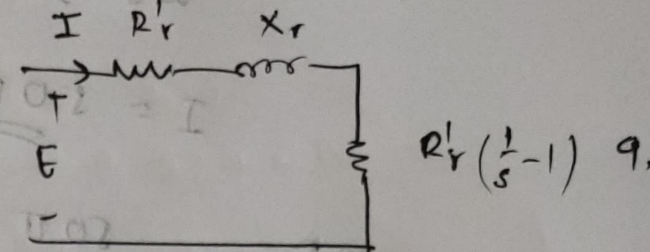
$R_r = 0.12\Omega$

$X_r = 0.85\Omega$

$N_s : N_r = 1.8$

$\frac{R_r}{s} = 0.97$

$s = 0.04$



$R_r' = 0.12 \cdot (1.8)^2 = 0.388\Omega$

$X_r' = 0.85 \cdot (1.8)^2 = 2.754\Omega.$

$\omega_s = \frac{120 \cdot 50}{6} = 100$

$= \frac{100\pi}{3}$

Torque

$= \frac{3}{\omega_s} \frac{E^2}{Z^2} \cdot \frac{R_r'}{s}$

$= \frac{3 \cdot 3}{100\pi} \cdot \frac{\left(\frac{240}{\sqrt{3}}\right)^2}{\left(\sqrt{\left(\frac{R_r'}{s}\right)^2 + (X_r')^2}\right)^2} \cdot \frac{0.388}{0.04}$

$= \underline{\underline{52.38 \text{ Nm}}}$

$HP = \underline{\underline{7.06 \text{ HP}}}$

for max torque $s = \frac{R}{X} = \frac{0.388}{2.754} = 0.14$

$N_r = (1 - s) N_s = (1 - 0.14)\, 1000 = 860 \text{ RPM}$

$T_{max} = \underline{99.84 \text{ NM}}$

Question 2

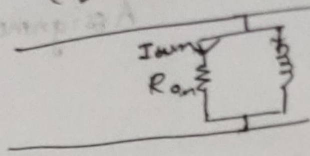
N.L. Test

$V_1 = 400V$

$I_o = 9.5A$

$P = 1400W$

eq circuit



assuming Y connected stator.

$V_{1\,perphase} = \frac{400}{\sqrt{3}}\,V$

$I_{o\,perphase} = 9.5A$

$R_{om\,perphase} = \frac{V_{1pph}}{I_{w\,pph}} = \frac{400}{\sqrt{3}\cdot 9.5\cdot\cos\phi} = \underline{\underline{114.66\,\Omega}}$

$\sqrt{3}\cdot V_1\cdot I_o\cos\phi = P$

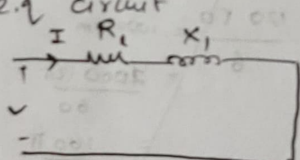
$\cos\phi = \frac{1400}{\sqrt{3}\cdot 400\cdot 9.5} = \underline{0.212}$

$X_{o\,pph} = \frac{V_{1pph}}{I_{\mu\,pph}} = \frac{400}{\sqrt{3}\cdot 9.5\sin\phi} = \underline{\underline{24.874\,\Omega}}$

~~Questions~~

S.C Test

e.q circuit



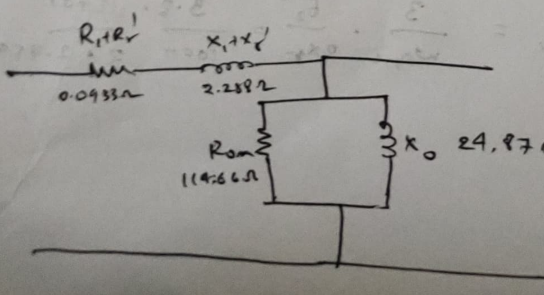
$\Rightarrow 700W = 3\cdot(50)^2\cdot R_1$

$\therefore R_1 = \underline{\underline{0.0933\,\Omega}}$

$\therefore \frac{V_{pph}}{I_{pph}} = \sqrt{R_1^2+x_1^2}$, $\frac{200}{\sqrt{3}\cdot 50} = \sqrt{R_1^2+x_1^2}$

$x_1 = \underline{2.288\,\Omega}$

$\Rightarrow$



Question 3

$P_{out} = 40 HP$

$Slip = 0.03$

$\text{mech losses} = \frac{1.5}{100} \cdot 40 HP = 0.6 HP$

$\therefore$ ~~gross mech power~~ Rotor ip power $= \frac{1}{1-s} \times (40 + 0.6) = \frac{40.6}{0.97} = 41.855 HP$

$0.95 \cdot (\text{Motor IP Power}) = 41.855$

$\text{Motor Power} = 44.058$

$\therefore \text{efficiency} = \frac{40}{44.058} = 0.9078 = 90.78\%$

$\Rightarrow 3 \cdot I^2 \cdot \frac{R}{s} = 41.855 \times 746$

$R_{\text{per phase}} = 0.154 \, \Omega$

Question 4

$$N_s \cancel{\omega_s} = \frac{120f}{P} = \frac{120 \cdot 50}{4} = 1500 \text{ rpm}$$

$$\omega_s = \frac{1500 \cdot 2\pi}{60} = 50\pi$$

$$\text{Power} = \underline{120 \cdot I \cdot \cos\phi} = 120 \cdot \frac{1}{2} \cdot I = 60I$$

$$\tau = \frac{60I}{\omega_s} = \frac{60I}{50\pi} = 60$$

$$I = 50\pi$$

$$\text{mmf} = 50\pi \cdot 120$$

$$= 18.849 \text{ kAN}$$

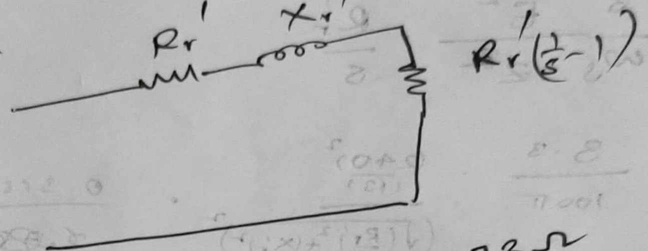
=

mmf =

$= 18.849$

Question 5

(a) $s = 1$



$R_r' = (3.8)^2 \cdot 0.012 = 0.173\,\Omega$

$X_r' = (3.8)^2 \cdot 0.8 \times 10^{-3} \times 2\pi \times 50 = 3.629\,\Omega.$

(a) rotor starting current $= \dfrac{V}{Z} = \dfrac{1100}{\sqrt{3}\left(\sqrt{(0.173)^2 + (3.629)^2}\right)}$

$= 174.8\ A$

(b) $pf = \cos \tan^{-1}\left(\dfrac{3.629}{0.173}\right) = 0.047$

(c) $\dfrac{1100}{\sqrt{3}\left(\sqrt{R^2 + (3.629)^2}\right)} = 100A$, $R = 5.211\,\Omega$

$\therefore$ Rextra $= 5.211 - 0.173$

$= 5.038\,\Omega$

(d) $i = \dfrac{1100/\sqrt{3}}{(3.8)^2\,(0.25J + 0.012/0.04)}$

$= 86.52 - 72.1J$

(e) $pf = \cos\left(\tan^{-1}\left(\frac{72.1}{86.52}\right)\right) = 0.768$

Question 6

4 pole, $N = 1425$

500V, 50Hz

$PF = 0.9$.

$\Rightarrow \quad \frac{120 \cdot 50}{4} = N_s = 1500$

(i) $\therefore s = \underline{\underline{0.05}}$

(ii) Rotor copper loss -

gross mech. power = $37 + 3 = 40HP$.

R_{cu} loss : gross mech power

$\Rightarrow s : 1-s$

$cu\ loss = \frac{s}{1-s} \cdot 40$

$= \frac{0.05}{0.95} \cdot 40 = 2.105\ HP$

(iii) Total power input $= 2500 + (2.105 + 40) \cdot 746$

$= 33.91\ KW$

(iv) efficiency $\eta = \frac{37 \times 746}{33910} = \underline{\underline{81.3\%}}$

(v) $\sqrt{3} V \cdot I \cdot \cos\phi = 42.105 \times 746$

$I = \cancel{36.26}\ A$

$40.29\ A$

(vi) $\frac{120 \cdot f}{P} = 75$

$f = \frac{75 \times 4}{120} = 2.5\ Hz$

$\therefore 60 \cdot f = \underline{\underline{150}}$

Question 7

50Hz,

P = 50 kW

Stator Loss = 800W

rotor emf frequency = $\frac{90}{60}$ = 1.5 Hz

→ slip = $\frac{1.5}{50}$ = 0.03

P_{ag} = 50 000 − 800 = ~~49800~~ 49200

∴ mechanical power = (1−s).49200
= 47.724 kW

perphase = 15.908 kW

rotor cu losses per p. = 492 W

Question 8

8 pole, 750 rpm

∴ $\frac{120.f}{8}$ = 750   ∴ f = 50 Hz

for motor, $\frac{120.50}{P}$ = 1000

P = 6 poles

slip = $\frac{1000-960}{1000}$ = 0.04

Question 9

S_1 = 0.04

S_2 = ~~0.04~~ 1 − 0.96 × 0.75 = ~~0.28~~ 0.28

$S_1 E_1^2 = S_2 E_2^2$

$\frac{E_1}{E_2}$ = ~~4.24~~ 2.64

$\frac{E_1 - E_2}{E_1}$ = ~~0.62~~ 0.62

Question 10

$\eta = 0.85$

load $= 60\,HP$

$P_{stator} = P_{rotor} = P_{core} = P$

$P_{mech} = \frac{1}{4}\left(P_{stator} + P_{core}\right)$

$= \frac{P}{2}$

$P_{IN} = P_{stator} + P_{rotor} + P_{core} + P_{mech} + 60\,HP$

$P_{IN} = \frac{7}{2}P + 60$

$\frac{2}{7}\left(\frac{60}{0.85} - 60\right) = P$

$P = 3.025\,HP$

60 s

$$P = \left(60 + \frac{P}{2}\right) \cdot \frac{s}{1-s}$$

$$\frac{s}{1-s} = 0.049$$

$$\underline{\underline{s = 0.0467}}$$