$$\frac{N_s - N}{N_s} = \frac{1500 - 1370}{1500}$$

$$T_{rated} = \frac{3}{\omega_s} \times I_2'^2 \times \frac{1}{s}$$

$$= \frac{3}{2\pi \times \frac{1500}{60}} \times I_2'^2 \times \frac{4.757}{0.08667}$$

$$I_{2\,rated}' = \frac{400/\sqrt{3}}{\sqrt{\left(\frac{4.757}{0.08667}\right)^2 + 3^2}} = 4.2$$

$$T_{rated} = 18.5 \text{ N-m}$$

load torque is directly proportional to speed

T_L at half the rated speed $= 9.25$ N-m

at half rated speed

$$= \frac{1500 - 685}{1500} = 0.54333$$

$$= \frac{3}{\pi \times \frac{1500}{60}} \times I_2'^2 \times \frac{4.757}{0.54333} = 9.25$$

2) $I_2' = 7.4377$ A

> I_{rated} the

run continuously the

6) a) Breakdown torque $= \frac{3}{\omega_s} \times \frac{0.5 V^2}{X_2'}$.

$$\frac{\text{SD Torque @ 100 Hz}}{\text{BD T @ 50 Hz}} = \frac{\frac{3}{2\omega_s} \times \frac{0.5 \times 480^2}{2 \times 4}}{\frac{3}{\omega_{s50}} \times \frac{0.5 \times 440^2}{4}}$$

$\omega_s' = 2\omega_s$

$\therefore$ ratio becomes $= \frac{1}{4} \times \left(\frac{400}{440}\right)^2$

$= 0.2066$, or 20.66%.

b) Ratio $= \frac{\frac{3}{\omega_{s75}} \times I_2'^2_{rated} \times r_2'/s_{75}}{\frac{3}{\omega_{s50}} \times I_2'^2_{rated} \times r_2'/s_{rated}}$

$= \frac{\frac{1}{75\ s_{75}}}{\frac{1}{50\ s_{rated}}} = \frac{2}{3} \times \frac{s_{rated}}{s_{75}}$

$\rightarrow s_{rated} = \frac{1000 - 945}{1000} = 0.055$

$I_{rated} = \frac{440}{\sqrt{\left(\frac{2}{.055}\right)^2 + 4^2}} = 12.027\ A$

and @ 75 Hz we have rated current

$\therefore \frac{V}{\sqrt{\left(r_2'/s_{75}\right)^2 + X_2'^2_{75}}} = 12.027$

$X_2'_{75} = 4 \times \frac{75}{50} = 6\Omega$.

$\frac{400}{\sqrt{\frac{4}{s^2} + 6^2}} = 12.027$.

$\Rightarrow s = 0.66114$.

$\therefore$ ratio $= \frac{2 \times 0.055}{0.66114} = 0.16$

6 c) Motor torque @ 30 Hz and slip of 650 rpm

N_s @ 30 Hz $= \frac{120 \times 30}{6} =$ 600 rpm.

$s_{30} = \frac{600 - 650}{600} = -0.08333$

V @ 30 Hz $= 440 \times \frac{30}{50} = 264$ V

X_r @ 30 Hz $= 2.4\Omega$.

$$\text{Torque} = \frac{3}{\frac{2\pi \times 600}{60}} \times \frac{264^2}{\left(\frac{2}{-0.08333}\right)^2 + 2.4^2} \times \frac{2}{-0.0}$$

T @ 30 Hz and 650 rpm $= -137.229$ Nm.

7 a) $T_{rated} = \frac{3}{\omega_s}\left[\frac{V_t^2 \; R_r'/s}{(R_s + R_r'/s)^2 + (X_s + X_r')^2}\right]$

$R_s = X_s = 0$

$= \frac{3}{104.72}\left[\frac{(440)^2 \times 2/0.055}{(2/0.055)^2 + (4)^2}\right]$

$T_{rated} = 150.69 \text{ N-m}$

$T_{half} = 75.34 \text{ N-m}$

$f = 35 \text{ Hz}$, $N_s = 700 \text{ rpm}$

$\omega_s = 73.3$

V/f Control

$50 \text{ Hz} \Leftrightarrow 440 \text{ V}$

$35 \text{ Hz} \Leftrightarrow 308 \text{ V}$

$T = \frac{3}{\omega_s}\left[\frac{V_t^2 \; R_r'/s}{(R_s + R_r'/s)^2 + (X_s + X_r')^2}\right]$

$75.34 = \frac{3}{73.3}\left[\frac{(308)^2 \times 2/s}{(2/s)^2 + 4^2}\right]$

$\therefore s = 0.0439$

$\therefore N = N_s(1-s)$

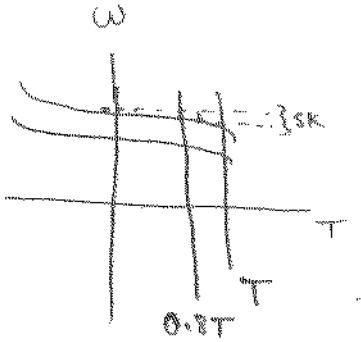
$= 672.7 \text{ rpm}$

7b)

$$0.8T = \frac{3}{104.72}\left[\frac{440^2 \times 2/5k}{(2/5k)^2 + 16}\right]$$

K

k=1
@ ω=



$\therefore S = 0.0438 \Rightarrow N_r = N_s(1-S) =$

$\therefore$ drop in speed = 43.8 rpm

@ 600 rpm, drop is same as 43.8 rpm

For any k, & 0.8T, drop is same as 43.8

$\therefore$ @ 600 rpm,

$N_s = 600 + 43.8$

$= 643.8$ rpm

$\therefore f = \frac{P \times N_s}{120}$

$= \frac{6 \times 643.8}{120}$

$f = 32.19$ Hz

$V = 283.27$ V

$k = 0.6438$, $S = 0.068$

$$I = \frac{283.27}{\sqrt{\left(\frac{2}{0.068}\right)^2 + 4^2}}$$

$I = 9.547$ A

7c)

$$N_s = \frac{120 \times 35}{6}$$

$$= 700 \text{ rpm}$$

$$s = [redacted] - 0.0714$$

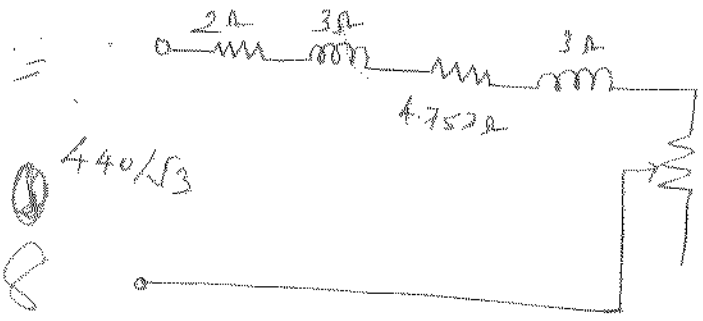
$$\omega_s = 73.3 \text{ rad/s}$$

$V/f \Rightarrow$ [redacted] $50 \text{ Hz} \rightarrow 440 \text{ V}$

$35 \text{ Hz} \rightarrow 308 \text{ V}$

$$T = \frac{3}{73.3} \left[\frac{308^2 \times 2 / -0.0714}{\left(\frac{2}{-0.0714}\right)^2 + 16} \right]$$

$$= [redacted] -135.83 \text{ N-m}$$



$$N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

(a)

$$\omega_s = \frac{2\pi N_s}{60} = 104.72 \text{ rad/sec}$$

At 50 Hz

Since we know that $T_b = \dfrac{3V_s^2}{2\omega_s\left[R_s + \sqrt{R_s^2 + (X_s + X_s')^2}\right]}$

So $T_{b\,@50Hz} = \dfrac{3 \times (440/\sqrt{3})^2}{2 \times 104.72 \times \left[2 + \sqrt{2^2 + 6^2}\right]} = 89.583 \text{ N-m}$

At 10 Hz

$$k = \frac{10}{50} = 0.2$$

$$T_{b\,@10Hz} = \frac{3kV_s^2}{2k\omega_s\left[R_s + \sqrt{R_s^2 + k^2(X_s + X_s')^2}\right]}$$

$$= \frac{3 \times 50.806^2}{2 \times 20.94 \times 4.30} = 42.70 \text{ N-m}$$

Hence $\boxed{T_{b(10)} = 0.4766 \text{ times of } T_{b(50)}}$

(b) $$T_{b(50)} = \frac{3 \times V_{10}^2}{2 \times k\omega_s \times 4.33} \Rightarrow V_{10} = 23.58 \text{ Volts}$$

$\boxed{V_{10} = \quad}$

Q9

At rated voltage and frequency

$$I_{st} = \frac{V/\sqrt{3}}{\left[(R_s + R_r')^2 + (X_s + X_r')^2\right]^{1/2}} = \frac{440/\sqrt{3}}{\left[6.757^2 + 6^2\right]^{1/2}}$$

$$I_{st} @ 50\,Hz = 26.11 \text{ Amp}$$

$$T_{st(50)} = \frac{3 \times 4.757}{1 \times 104.72} \times I_{st}^2 = 107.68 \text{ N-m}$$

Now during starting at 5 Hz.

$$K = 5/50 = 0.1 \qquad N_s = 10 \text{ rpm} \qquad \omega_s = 1.0472 \text{ rps}$$

$$I_{st}' = \frac{KV/\sqrt{3}}{\sqrt{(R_s + R_r')^2 + K^2(X_s + X_r')^2}} = 3.744 \text{ Amp}$$

$$T_{st(5)} = \frac{3 \times R_r' \times I_{st}^2}{\omega_{s1}} = \frac{3 \times 4.757}{1.047} \times 3.744^2$$

$$\boxed{T_{st(5)} = 51.032 \text{ N-m}}$$

$$\frac{I_{start(50)}}{I_{start(5)}} = \frac{26.11}{3.744} = 7.5$$

$$\frac{T_{st(50)}}{} = \frac{107.68}{}$$