EML Tut-6

1.

$K\phi = 1.44$ V/rad/s $R_a = 0.86\,\Omega$

$I_a = 40A$

Sol:-

$V_t = E_b + I_a r_a$

$E_b = K_e \omega = 1.44 * 150 = 216V$

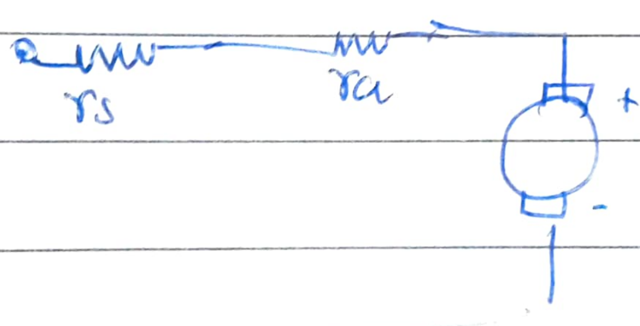
$= 216 + 40 \times 0.86 = 250.4V$

b) The no load speed

$\omega_{no\ load} = \frac{250.4}{1.44} = 173.88$

2, $R_a = 0.4\,\Omega$ $V = 200V$ $\omega = 500\,rpm = 52.35\,rad/s$

$I_a = 25A$



$400 = \frac{V - I_a R_a}{\omega}$

$\Rightarrow K_e = 3.62$

i) At full Load

$\hookrightarrow$ A curr = 25A

$\Rightarrow E_1 = V - I_a R_a'$

$\Rightarrow \; = \dfrac{130}{360} = 394.7364 rpm$

ii)

At stry Tm

$\omega = 1\;31.38 rpm$

(3) FL Tor $T = 100 Nm$

$V = 250V$

given $\omega_{no\ Load} = 1590 rpm = 167.08$

$\omega_{full\ Lo} = 1195 rpm = 125.14 rad s^{-1}$

at No Load

$$\omega = \frac{V}{K_e} \Rightarrow K_e = \frac{V}{\omega_{no\ lo}} = \frac{240}{167.0.}$$

$= 1.4319$

At full Load $\omega = 125.1401$

$\Rightarrow$ Back emf $= K_e \omega = 1.4319 \times 125.14$

$= 179.1769$

Armature circuit eq $\Rightarrow V = I_a R_a + E_b$

$$I_a = \frac{T}{K_t} = \frac{100}{1.43K} = 69.75$$

From $$R_a = \frac{V - E_b}{I_a} = \frac{240 - 179}{69.59} = 0.8658\Omega$$

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i) New vol $V = 0.833 \times 240 = 200V$

$R_a = r = 0.66 \quad 1.5 = 0.99 \,)$

4./

10kW, 250V, 1200 rpm

$R_a = 0.2\Omega$

$R_f = 125\Omega$

Full load = 80%

At full load = Output po = 10kW

⇒ Input power dh = 12.5kW

$P_{in} = 12.5 kW = VI$

Input line current = 50A

Feed cur = 2A

⇒ Armature current $I_a = I - I_f = 48A$

Speed torque equation

$$\omega = \frac{V}{K_e} - \frac{R_a T}{K_e K_t}$$

At

⇒ 75% of speed ⇒ $\omega = 0.75 \times 2\pi \times 1200$

$= 94.24$ rad/s $\times 60$

$V = 250V$

now, K_e

At rated condition,

$\omega = 1200 rpm = 125.6637$

$I_a = 48A$, $R_a = 0.2\Omega$

$\Rightarrow E_b = V - I_a R_a = 250 - (48 \times 0.2)$
$= 240.4 V$

$\Rightarrow K_e = \frac{E_b}{\omega} = \frac{240.4}{125.6637} = 1.9130$ V/rad

Re

5) DC shunt motor : $V = 250V$

$R_a = 0.2\Omega$

$R_f = 100\Omega$

While run at 600rpm, current drawn from supply = 60A

$I = 60A$

Field $I_f = \frac{V}{R_f} = \frac{250}{100} = 2.5A$

$\Rightarrow I_a = 60 - 2.5 = 57.5A$

At 600rpm,

$\omega = \frac{2\pi \times 600}{60} = 62.8318$ rad s^{-1}

$E_b = V - I_a R_a$
$= 250 - (57.5 \times 0.2) = 238.5V$

$K_e = \frac{E_b}{\omega} = \frac{238.5}{62.83} = 3.79585V$

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Torque $= K_t I_a = 3.7958 \times 57.7 = 218.2813\,Nm$
8.
Now speed needs to be increased to
$$\omega = \frac{2\pi \times 800}{60} = 83.7758\ \text{rad/s}$$
adding
extra resistance in field circuit
(Load torque = constant)
$$\omega = \frac{V}{K_e} - \frac{R_a}{K_e K_t} T$$
We know that, $K_e \propto I_f \Rightarrow K_e \propto \frac{V}{R_f}$

$K_t' = K_e'$

At 800 rpm

$$83.7758 = \frac{250}{K_t'} - \frac{0.2}{(K_e')^2} \times 218.2813$$

$\Rightarrow K_e' = 2.7979$

Now $\frac{R_f'}{R_f} = \frac{K_e''}{K_e'} \Rightarrow R_f' = 135.668$

Additional current $= 135.668 - 100$
$= 35.668\,\Omega$

6) 250V DC shunt motor

$T = 105\ Nm$

At $\omega = 750$ rpm,

current drawn $= 36A$

$FC = 1A$

$I_a = 35A$

at 750 rpm, $= 78.5398\ V$

$$K_e = \frac{V - I_a R_a}{\omega} = 3.0048\ V/rad$$

New speed

$$\omega = \frac{V}{K_e'} - \frac{R_a}{(K_e')^2} T$$

$$\frac{2\pi \times 1000}{60} = \frac{250}{K_e'} - \frac{0.3}{(K_e')^2} \times 35$$

$\Rightarrow K_e' = 2.2605\ V\ rads$

Percentage reduction $= \frac{K_e - K_e'}{K_e}$

$$= \frac{3.0048 - 2.2605}{3.0048}$$

$= 23.72\%$

$\therefore \frac{R_f'}{R_f} = \frac{K_e}{K_e'}$ & $R_f' = 332.3\ \Omega$

Extra $R_a = 332.318 - 250$

$= 82.3\ \Omega$

Tutorial-7

① For a ser. m/s : $V_a = I_a R_a + I_a R_f + K I_a \omega$

$\Rightarrow V_a = I_a(R_a + R_f + K\omega)$ ①

Torque $T_L = K I_a^2 \rightarrow$ ②

Given data : 200V DC ser motor

$N = 700\text{rpm} \Rightarrow \omega = 2\pi \times \frac{700}{60}$

$= 73.3038 \text{ rad s}^{-1}$

$I_a = 20A$

$R_a + R_f = 0.5\Omega$

From this data,

$V_a = I_a(R_a + R_f + K\omega)$

$\Rightarrow K = 0.1296 \ \Omega/\text{rad/s}$

a) When load torque incr by 1.44 times

$\Rightarrow T_L' = 1.44 T_L$

$\Rightarrow I_a' = 1.2 I_a$ from ②

$= 1.2 \times 20 = 24A$

① $\Rightarrow 200 = 24(0.5 + 0.1296 \times \omega)$

$\omega = 60.44$

$\Rightarrow$ rad $= 577.19\text{rpm}$

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[illegible]

(2) 220V DC [illegible] motor [illegible]

[illegible]

$R_a = 0.6\,\Omega$ [illegible]

$V_{brush} = 3V$

From given data

$V_a = I_a R_a + I_a R_f + K I_a \omega + V_{brush}$

$\Rightarrow V_a = I_a(R + K\omega) + V_{brush} \rightarrow (1)$

$\Rightarrow 220 = 38(0.6 + K \times 62.8\ldots) + 3$

$\Rightarrow K = 0.0813\ \Omega/\text{rad/s}$

a/ when $I_a = 19A$

$\Rightarrow 220 = 19(0.6 + 0.0813\omega) + 3$

$\Rightarrow \omega = 133.0\ \text{rad s}^{-1} = 12\ldots$ rpm

b/ $I_a = 1$

use (1) $\Rightarrow \omega = 2661.7466\ \text{rad s}^{-1} = 254\ldots$

c/ Developed power $= E_b I_a = K I_a \omega I_a =$

$K I_a^2 \omega$

Case (a) Developed power $= \frac{0.0813 \times \ldots}{746}$

①

$I_a' = 10A$

① $\Rightarrow 200 = 10(0.5 + 0.1256\omega)$

$\Rightarrow \omega = 150.3629 \text{ rad s}^{-1}$

④ $\approx 1336.83 \text{ rpm}$

② 220V DC series motor $I_a = 38A$

$N = 600 \text{ rpm} = 62.8318$

$R_a = 0.4\Omega$ $R_f = 0.2\Omega \Rightarrow R = 0.6\Omega$

$V_{brush} = 3V$

from given data

$V_a = I_a R_a + I_a R_f + k I_a \omega + V_{brush}$

$\Rightarrow V_a = I_a(R + k\omega) + V_{brush} \rightarrow$ (1)

$\Rightarrow 220 = 38(0.6 + k \times 62.8318) + 3$

$\Rightarrow k = 0.0813 \ \Omega/\text{rad/s}$

a/ when $I_a = 19A$

$\Rightarrow 220 = 19(0.6 + 0.0813\omega) + 3$

$\Rightarrow \omega = 133.0 \text{ rad s}^{-1} = 1271 \text{ rpm}$

b/ $I_a = 1$

use (1) $\Rightarrow \omega = 2661.7466 \text{ rad s}^{-1} = 25417.8 \text{ rpm}$

c/ Developed power $= E_b I_a = k I_a \omega I_a =$
$k I_a^2 \omega$

case (a) ~~Develo~~ Developed power $= \dfrac{0.0813 \times 19^2 \times 133}{746}$

$= 5.23 h_p$

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3/ Given data: 450V DC series motor;

$R_a + R_f = 0.8\Omega$

Rated speed $= 83.7758 \, rads^{-1}$

At rated torque $\Rightarrow I_a = 110A$

a/

$V_a = I_a R'$

$\Rightarrow R' = \frac{V_a}{I_a} = \frac{440}{110} = 4\Omega$

$R = 3.2\Omega$

b/ At 800rpm

$\Rightarrow 450 = 110(R' + 0.0382 \times 83.778)$

$R' = 1.6\Omega$

$R_{extra} = 0.8\Omega$

4) At no load, terminal voltage = Induced emf = E_b

$E_b = K_e \omega$

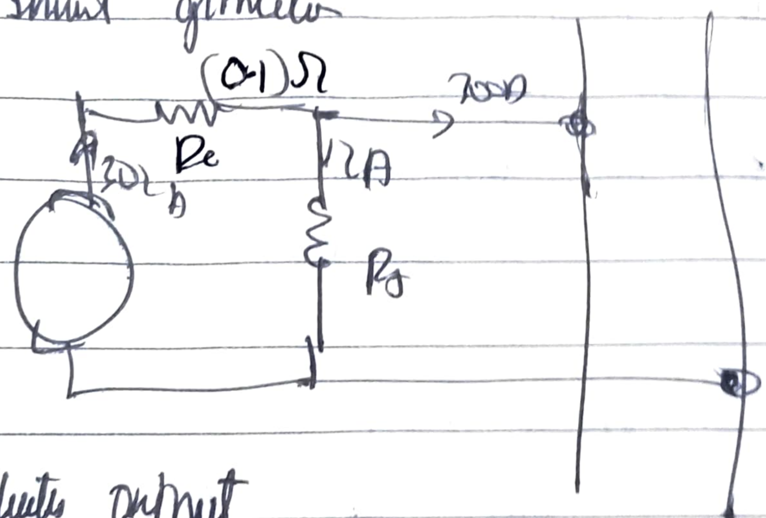
In other words $E_b \propto I_f \omega$

$$\frac{E_{b_2}}{E_{b_1}} = \frac{\omega_2}{\omega_1}\left(\frac{I_{f_2}}{I_{f_1}}\right) \Rightarrow E_{b_2} = E_{b_1}\left(\frac{\omega_2}{\omega_1}\right)\left(\frac{I_{f_2}}{I_{f_1}}\right)$$

a) $E_{b_2} = 120 \times \frac{2.5}{2} = 150V$

b) $E_{b_2} = 120 \times \left(\frac{1300}{1500}\right) \times \frac{2.83}{2} = 159.03V$

3) DC shunt generator



Delivered electric output power $= 60 KW @ 200V$

$$\Rightarrow I = \frac{60 \times 10^3}{200} = 300A$$

Field current $I_f = \frac{200}{100} = 2A$

Armature current $= I_a = 302$

Given brush drop = 2V

$\Rightarrow E_g = V + I_a R_a + V_{brush}$ (Generator equation)

$\Rightarrow E_g = 200 + (32 \times 0.1) + 2 = 232.2V = K_e\omega$

Therefore,

$$K_e = \frac{232.2}{2\pi \times \frac{500}{60}} = 4.434 V\,rad^{-1}s^{-1}$$

Now machine's prime moves input supply is removed while removed electrical terminals being connected to DC lines.

$\Rightarrow$ Field is energised & armature also

$\Rightarrow$ Operates as motor

P_m = Input power = VI

$\Rightarrow I = \frac{5 \times 10^2}{200} = 25A$

$I_f = 2A$

$I_a = I - I_f = 25A - 2A = 23A$

$V_a = I_a R_a + E_b + V_{brush}$

$\Rightarrow E_b = V_a - I_a R_a - V_{brush}$

$= 200 - (23 \times 0.1) - 2$

$= 215.7V$

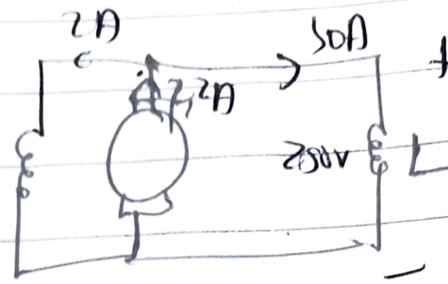
Speed $\omega = \frac{215.7}{4.4347} = 49.12\ rad\,s^{-1} = 421.4\,rpm$

1)

DC shunt generator supplies load power of
10kW at 250V,

$\Rightarrow VI = 10 \times 10^3$

$\Rightarrow I = \frac{10 \times 10^3}{250} = 40A$



$I_f = \frac{V_f}{R_f} = 2A$

$I_a = I + I_f = 52A$

Armature copper loss $= 1323W$

Iron + mech loss $= 600W$

$\Rightarrow$ In power loss $= 12523W$

$\Rightarrow$ Efficiency $\eta = 80.5\%$

7/ a) Given that field $I_f = 0.8A$

& $E_g = 113V$ (from table)

If $K_e\omega = 113V \Rightarrow K_e = \frac{113}{2\pi \times 1200 / 60} = 0.90$ V rad

$I_a = 51.88A$ supplied power $= 5370.25W$