Imp Stuff for numericals

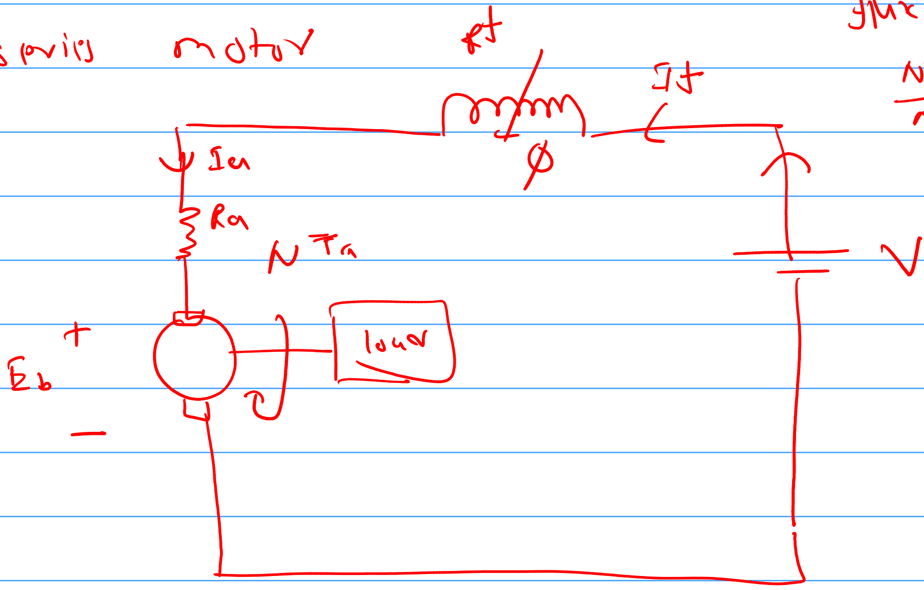
$N \propto \frac{E_b}{\phi} \propto \frac{E_b}{I_f}$ $\qquad T_a \propto \phi I_a$, $\phi \propto I_f$

$T_a \propto I_f I_a$

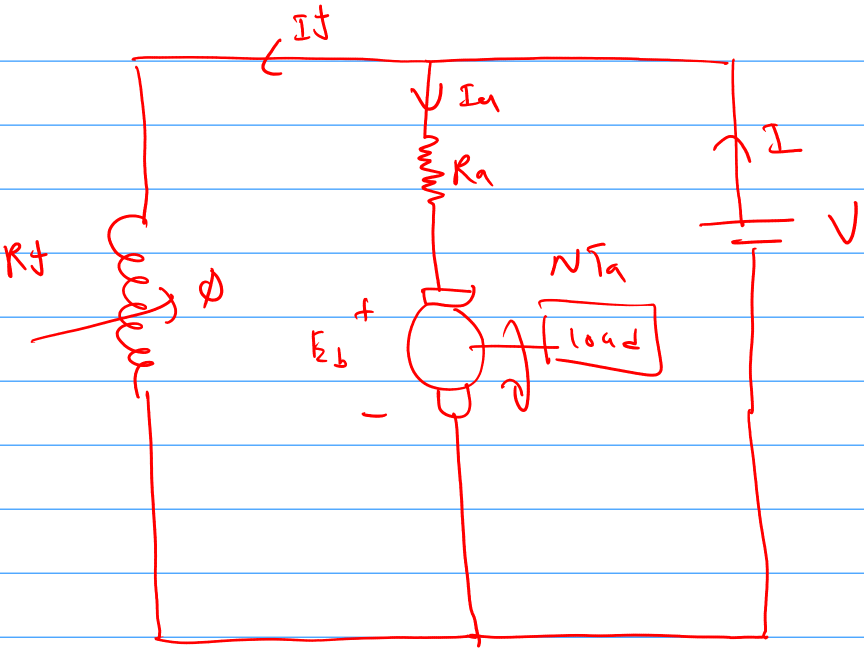
$\frac{N_2}{N_1} = \frac{E_2}{E_1} \times \frac{I_{f1}}{I_{f2}}$ $\rightarrow$ for both generator and motor

flux const then $\frac{N_2}{N_1} = \frac{E_2}{E_1}$

DC series motor



DC shunt motor



if winding type is not mentioned, then it's lap winding $(A = P)$

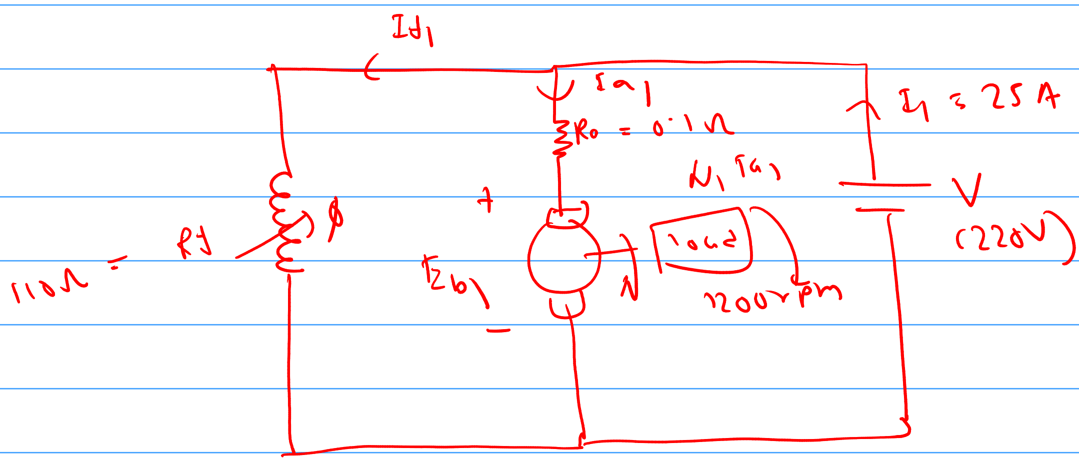
excitation → flux $\quad \phi \propto I_f$

$$\frac{N_2}{N_1} = \frac{E_2}{E_1} \times \frac{I_{f1}}{I_{f2}} \qquad \bigg| \qquad \frac{N_2}{N_1} = \frac{E_2}{E_1} \times \frac{\phi_1}{\phi_2}$$

① A 220V dc shunt motor draws a current of 25 A and runs at 1200 rpm with certain load on its shaft. The armature winding and field winding resistance are 0.1Ω and 110Ω respectively. If a resistance of 50Ω is connected in series with field winding and load torque on the shaft is reduced by 10%, calculate new speed.

soln :-

Case - I



Now

$$I_1 = I_{f1} + I_{a1}$$

$$25 = I_{f1} + I_{a1} \quad \text{—— (i)}$$

KVL on outer loop

$$V = I_{f1} R_f$$

or, $\boxed{I_{f1} = \frac{220}{110} = 2A}$

$\therefore \boxed{I_{a1} = 25 - 2 = 23A}$

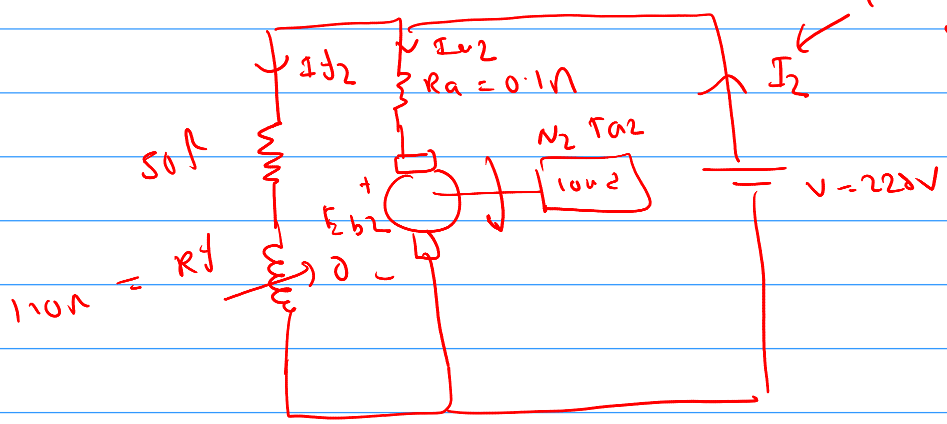
KVL on right loop

$$V = I_{a1} R_1 + E_{b1}$$

or $$220 = 23 \times 0.1 + E_{b1}$$

$\therefore$ $$\boxed{E_{b1} = 217.7\,V}$$

Case - II



current drawn will be different #

Now

$$T_a \propto \cancel{\phi} I_a \qquad \phi \propto I_f$$

$$T_a \propto I_f I_a$$

So, $$\frac{T_{a2}}{T_{a1}} = \frac{I_{f2} I_{a2}}{I_{f1} I_{a1}}$$

we know $$T_{a2} = T_{a1} - 0.1 T_{a1}$$
$$= 0.9 T_{a1}$$

or $\dfrac{0.9\,T_{a1}}{T_{a1}} = \dfrac{I_{f2}\,I_{a2}}{2 \times 23}$

or $I_{f2}\,I_{a2} = 41.4 \quad — (i)$

Now,

KVL in outer loop

$220 = I_{f2}\,(R + R_{f2})$

or $220 = I_{f2}\,(50 + 110)$

$\therefore$ $I_{f2} = 1.375\,A$

Now,

$I_{a2} = \dfrac{41.4}{1.375} = 30.10\,A$

KVL on right loop

$220 = I_{a2}\,R_{a2} + E_{b2}$

or $220 = 30.10 \times 0.1 + E_{b2}$

$\therefore$ $E_{b2} = 216.99\,V$

Now

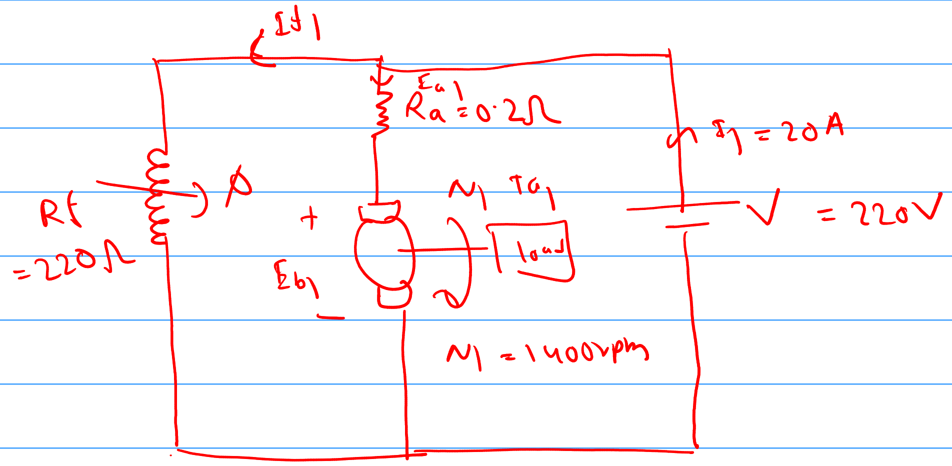
$\dfrac{N_2}{N_1} = \dfrac{E_{b2}}{E_{b1}} \times \dfrac{I_{f1}}{I_{f2}}$ $\left(N \propto \dfrac{E_b}{I_f} \right)$

or $\dfrac{N_2}{1200} = \dfrac{216.99}{217.7} \times \dfrac{2}{1.375}$ $\therefore$ $\boxed{N_2 = 1739.75\ \text{rpm}}$

A 220V dc shunt motor draws a current of 20A and runs at 1400 rpm with certain load on the shaft. The armature winding resistance and field winding resistance are 0.2Ω and 220Ω respectively. If a resistance of 0.1 is added in series with armature and load torque is increased by 10%. Calculate the new speed.

Soln ÷

Case I



Soln ÷

$$20 = I_{a1} + I_f \quad \text{—— (i)}$$

kvl on outer loop

$$V = I_{f1} R_f$$

$$\text{or, } \frac{220}{220} = I_{f1} \qquad \therefore \boxed{I_{f1} = 1A}$$

Now,

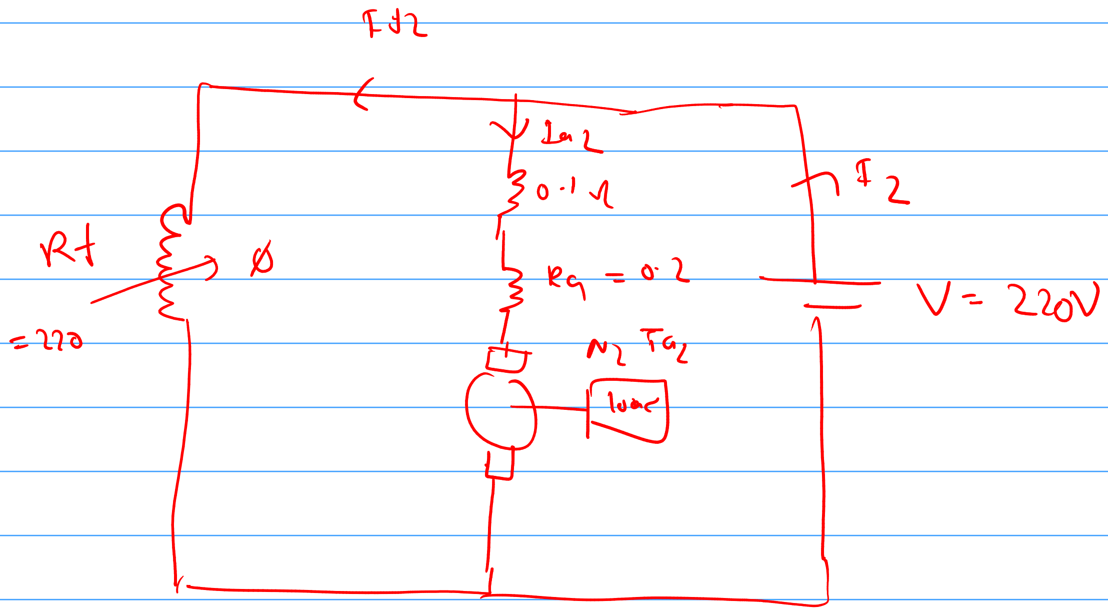
$$\boxed{I_{a1} = 20 - 1 = 19A}$$

KVL on right loop

$$V = I_{a_1} R_a + E_{b_1}$$

or $$220 = 19 \times 0.2 + E_{b_1}$$

∴ $$\boxed{E_{b_1} = 216.2\ V}$$



$$T_{a_2} = T_{a_1} + \frac{10}{100} \times T_{a_1} = 1.1\, T_{a_1} \qquad T_a \propto I_f I_a$$

$$\frac{T_{a2}}{T_{a_1}} = \frac{I_{f_2} I_{a2}}{I_{f_1} I_{a_1}}$$

or, $$\frac{1.1\, T_{a_1}}{T_{a_1}} = \frac{I_{f_2} I_{a2}}{1 \times 19}$$

∴ $$I_{f_2} I_{a2} = 20.9\ A \quad \text{— (ii)}$$

Now

$$V = I_{f2} R_f$$

or $220 = I_{f2} \times 220$

$\therefore$ $\boxed{I_{f2} = 1 \ A}$

$\boxed{I_{a2} = 20.9 \ A}$

KVL in right loop

$$V = I_{a2}(0.1 + 0.2) + E_{b2}$$

or $220 = 20.9 \times 0.3 + E_{b2}$

$\therefore$ $E_{b2} = 213.73 \ V$

Now

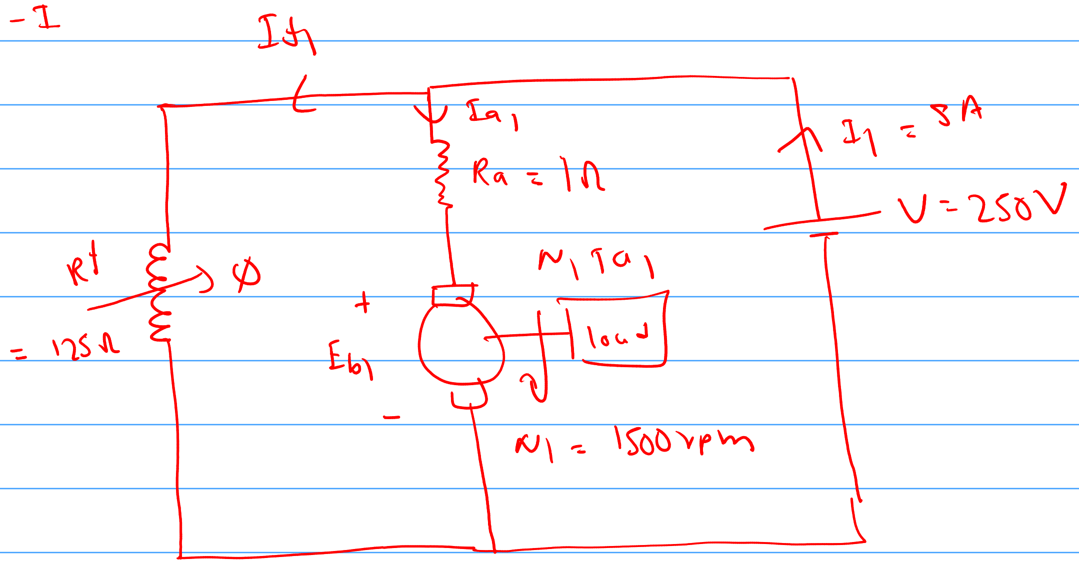
$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or $N_2 = 1400 \times \dfrac{213.73 \times 1}{216.2 \times 1}$

$\therefore$ $N_2 = 1384 \text{ rpm}$

#4 A 250V dc shunt motor has the armature and field winding resistance of 1Ω and 125Ω respectively. It takes a current of 5A and the speed is 1500 rpm. when the load is added on the shaft the motor draws a current of 25 Amp. Calculate the speed at this load.

Case - I



or $\quad 5 = I_{a1} + I_{f1} \quad$ ——(i)

$V = I_{f1} R_f$

or, $\quad 250 = I_{f1} \times 125$

$\therefore \quad I_{f1} = 2A$

$\therefore \quad I_{a1} = 5 - 2 = 3A$

Now

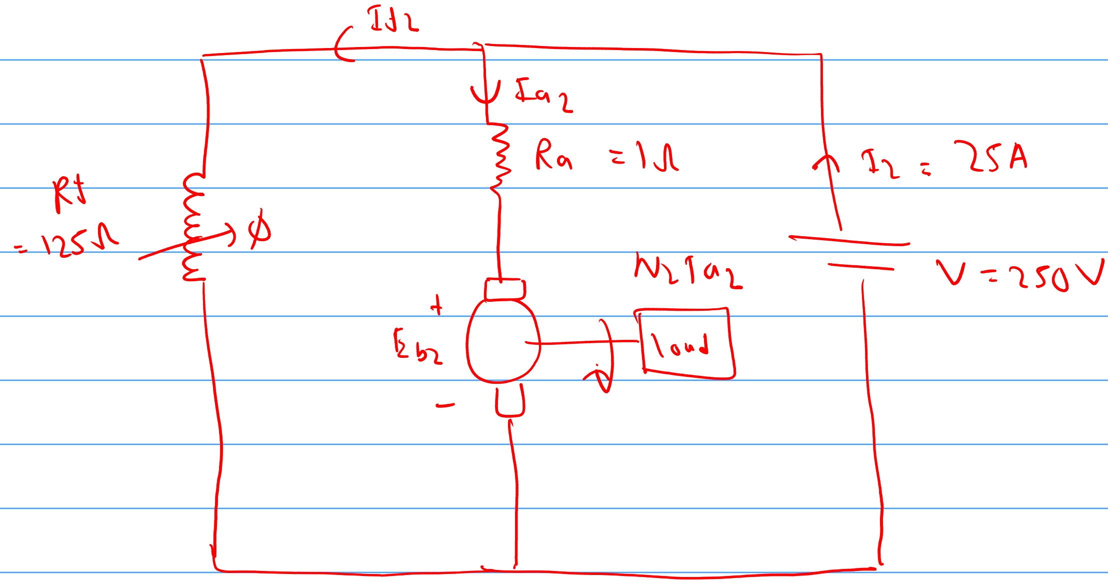
$250 = I_{a1} R_a + E_{b1}$

or $\quad 250 = 3 \times 1 + E_{b1}$

$\therefore \quad \boxed{E_{b1} = 247V}$

Case - II (load is added it draws a current of 25A)

$N_2 = ?$



now,

$$25 = I_{a2} + I_{f2} \quad \text{—(i)}$$

$$V = I_{f2} R_f$$

or, $250 = I_{f2} \times 125$

$\therefore I_{f2} = 2A$

$\therefore I_{a2} = 23A$

$$250 = I_{a2} \times R_a + E_{b2}$$

or, $250 = 23 \times 1 + E_{b2}$

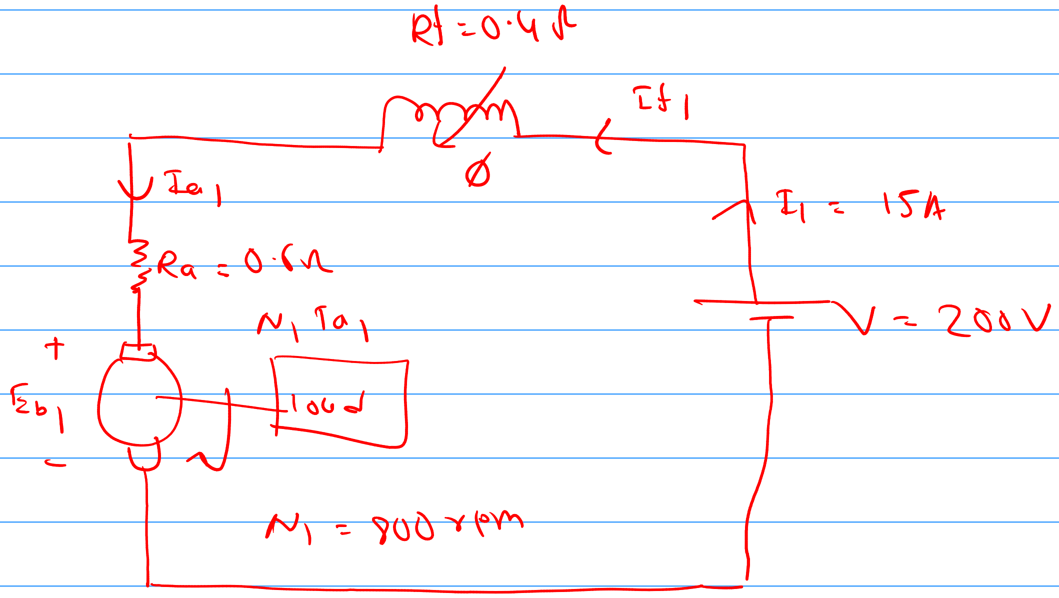
$\therefore \boxed{E_{b2} = 227V}$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or $\dfrac{N_2}{1500} = \dfrac{227}{247} \times \dfrac{2}{2}$ $\quad \therefore \boxed{N_2 = 1378.54 \text{ rpm}}$

A 200V dc series motor runs at 800 rpm when taking a line current of 15A. The armature and field resistances are 0.6 Ω and 0.4 Ω respectively. Find the speed at which it will run when connected in series with a 5Ω resistance and taking the same current at same voltage.

soln:-



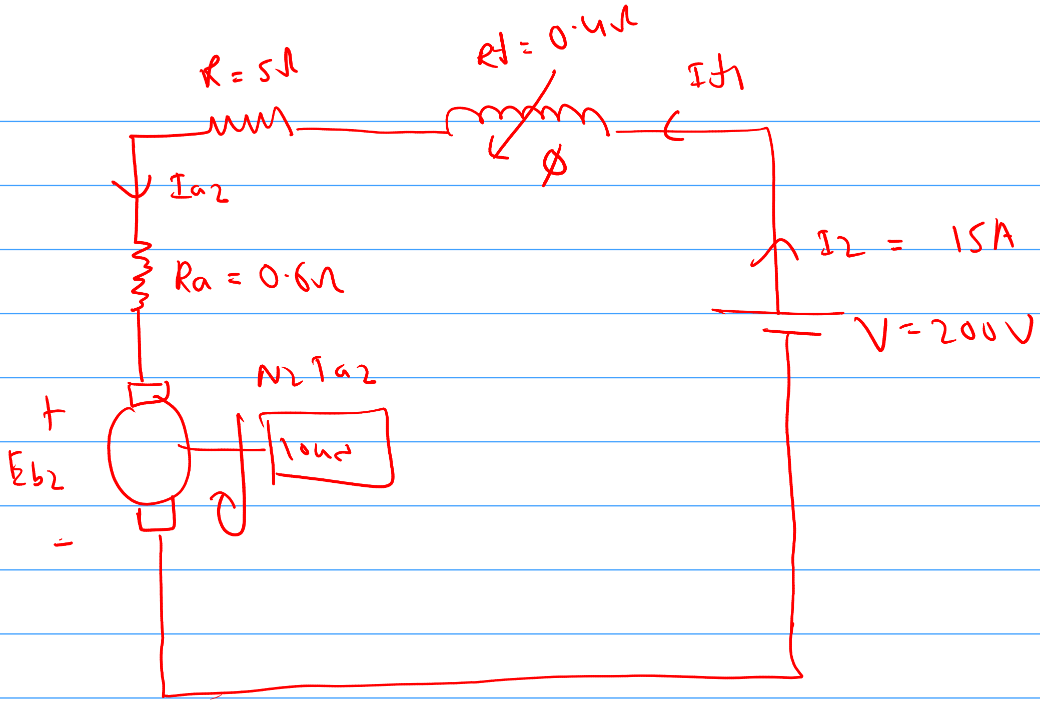
$I_1 = I_{a1} = I_{f1} = 15\,A$

$V = I_{f1} \times R_f + I_{a1} \times R_a + E_{b1}$

or, $200 = 15 \times 0.4 + 15 \times 0.6 + E_{b1}$

$\therefore E_{b1} = 185\,V$

Case - II (when connected in series with 5Ω resistance) taking same current at same voltage



$$I_2 = I_{f2} = I_{a2} = 15\,A$$

$$200 = 15\times0.4 + 15\times5 + 15\times0.6 + E_{b2}$$

$\therefore$ $$E_{b2} = 110\,V$$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}}\;\frac{I_{f1}}{I_{f2}}$$

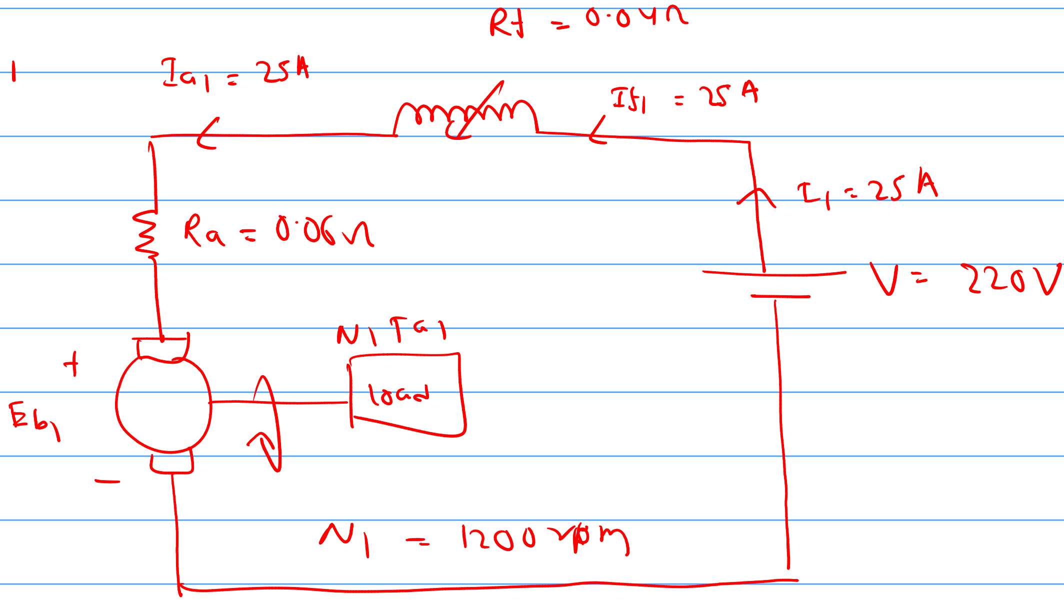
or $$\frac{N_2}{800} = \frac{110}{185} \times \frac{15}{15}$$

$\therefore$ $$\boxed{N_2 = 475.675\ \text{rpm}}$$

A dc series motor with armature resistance of 0.06Ω and field winding resistance of 0.04 Ω is supplied by a 220V supply. If the motor draws 25A

when running at 1200 rpm, calculate the current drawn by the motor when running at 800 rpm.

Solution,



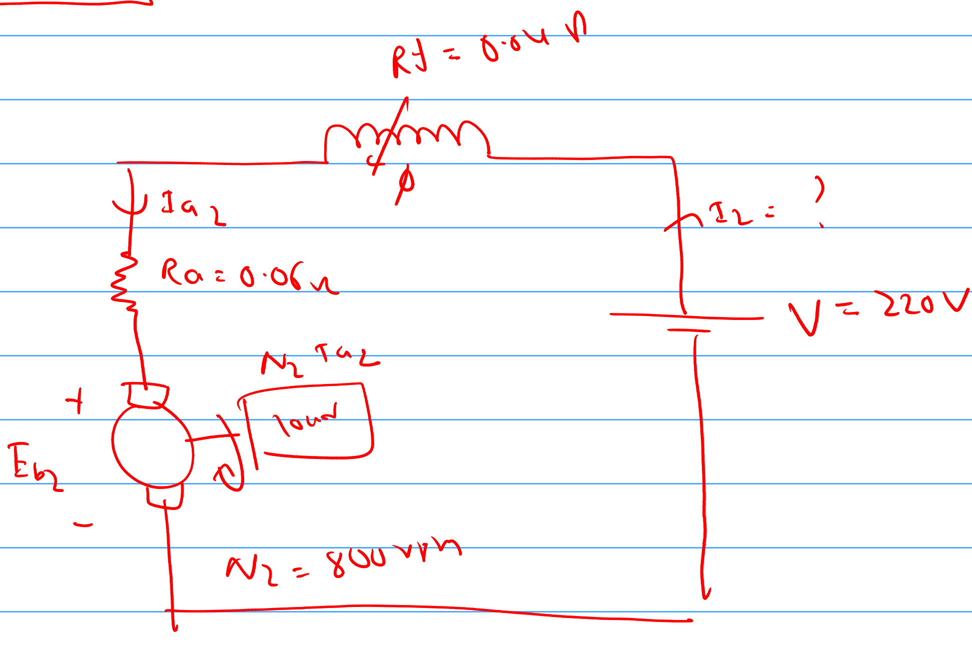
$I_{a1} = I_{f1} = 25\ A$

or, $V = I_{f1} R_f + I_{a1} \times R_a + E_{b1}$

or $220 = 25 \times 0.04 + 25 \times 0.06 + E_{b1}$

$\therefore \boxed{E_{b1} = 217.5\ V}$

Case - II



now, $(I_2 = I_{f2} = I_{a2})$

$$220 = I_{f2} \times R_f + I_{a2} \times R_a + E_{b2}$$

or $E_{b2} = 220 - 0.04\, I_{f2} - 0.06\, I_{f2}$

or, $E_{b2} = 220 - 0.1\, I_2$

now

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or $$\frac{800}{1200} = \frac{220 - 0.1\, I_2}{217.5} \times \frac{25}{I_2}$$

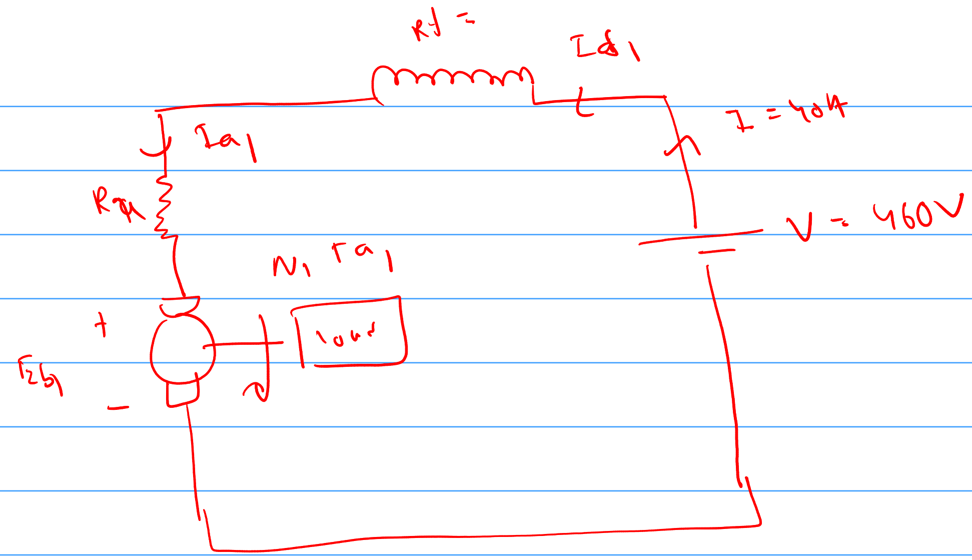
$\therefore$ $\boxed{I_2 = 37.28\, A}$

A 460 V dc series motor runs at 500 rpm taking a current of 40 amp at a certain load. Calculate the speed and % change in torque if the load is reduced so that the motor draws only 30 amp.

[Given that $R_f + R_a = 0.8$ ohm]

Soln:-

$(R_f + r_a) = 0.8\,\Omega$



$V = 460\,\Omega$, $N_1 = 500\,rpm$, $I_{a1} = I_{f1} = 40\,A$

$V = I_{a1} \times R_a + I_{f1} \times R_f + E_{b1}$

or $E_{b1} = 460 - 40\,(R_a + R_f)$

or $E_{b1} = 460 - 40 \times 0.8$

$\therefore E_{b1} = 428\,V$

Case II

$I_2 = I_{a2} = I_{f2} = 30\,A$

$V = I_{a2} \times R_a + I_{f2} \times R_f + E_{b2}$

or $E_{b2} = 460 - I_2\,(R_a + R_f)$

or $E_{b2} = 460 - 30 \times 0.8$

$\therefore E_{b2} = 436\,V$

$T_{a2} \propto I_f I_a$

$$\frac{T_{a2}}{T_{a1}} = \frac{I_{f2} I_{a2}}{I_{f1} I_{a1}} = \frac{30 \times 30}{40 \times 40} = \frac{900}{1600} = 0.5625$$

$T_{a2} = 0.5625\, T_{a1}$

% change in torque $= \dfrac{T_{a2} - T_{a1}}{T_{a1}} \times 100\%$

$$= \left| \frac{0.5625\, T_{a1} - T_{a1}}{T_{a1}} \right| \times 100\%$$

$$= 43.75\,\% \quad \#$$

Now

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or $$N_2 = 500 \times \frac{436}{428} \times \frac{40}{30}$$

$$\therefore \boxed{N_2 = 679.12 \text{ rpm}}$$

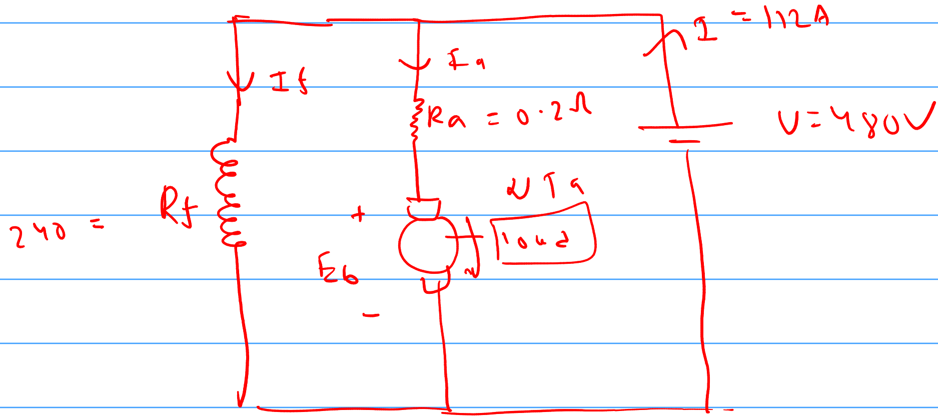
A dc shunt motor drains a current of 112 A from 480V dc source. The armature winding & field winding resistances are 0.2Ω & 240Ω respectively. The motor has 6 poles & the armature winding has 864 conductors. The flux per pole is 0.05 weber. Calculate:

a) Armature current

b) Speed

c) Torque developed by the armature

soln ÷



$P = 6$, $Z = 864$, $\phi = 0.05$

$V = I_f R_f$ (KVL on outer loop)

or $480 = I_f \times 240$

$\therefore$ $I_f = 2A$

$I = I_a + I_f$

or $112 = I_a + 2$

$\therefore$ $\boxed{I_a = 110\ A}$

$V = I_a R_a + E_b$

or $480 - 110 \times 0.2 = E_b$

$\therefore$ $E_b = 458V$

let the winding be lap winding if not mention. ($P \equiv A$)

$$E_b = \frac{Z \phi N}{60} \times \frac{P}{A}$$

or

$$458 = \frac{864 \times 0.05 \times N}{60} \times \frac{6}{6}$$

$\therefore$ $\boxed{N = 636.11 \text{ rpm}}$

Now,

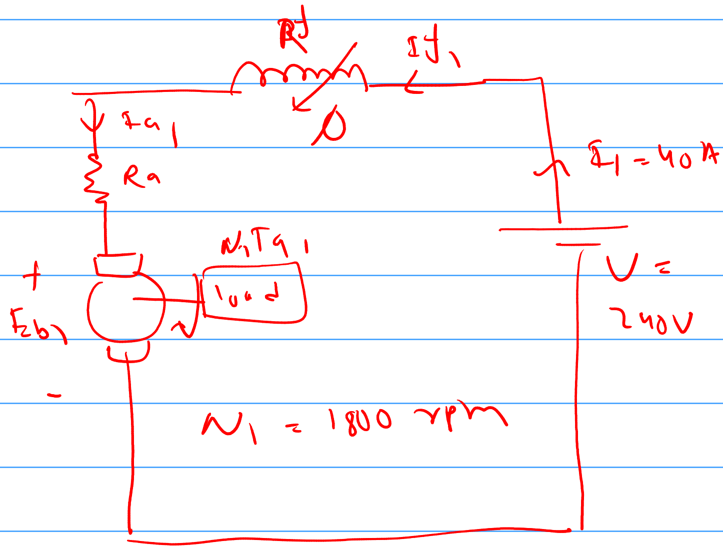
$$T_a = \frac{1}{2\pi} \frac{Z\phi P}{A} I_a$$

$$= \frac{1}{2\pi} \times 864 \times 0.05 \times \frac{6}{6} \times 110$$

$$= \boxed{756.30 \text{ N-m}}$$

A 240V dc series motor has a total resistance of 0.2Ω when the speed is 1800 rpm the motor drains a current of 40A. Calculate the value of resistance to be connected in series with the armature so, as to limit the speed to 3600 rpm when the line current is 10A.

Soln :-



$V = 240V$

$R_a + R_f = 0.2$

$N_1 = 1800 \text{ rpm}$

$I_1 = 40A$

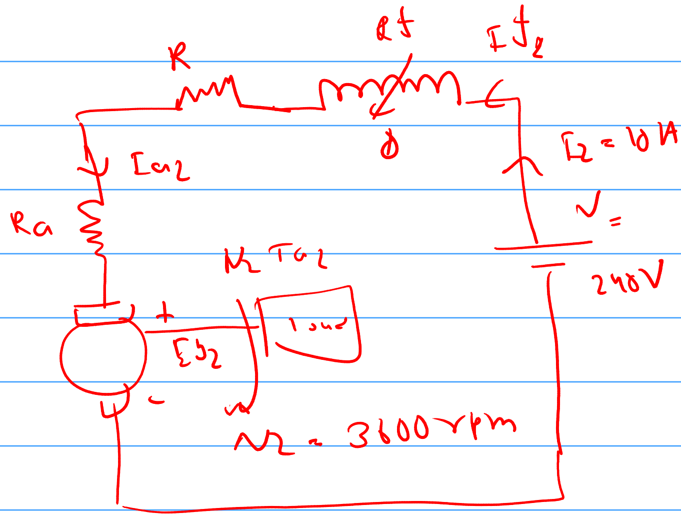
$I_1 = I_{f1} = I_{a1} = 40A$

$$V = I_{f1} \times R_f + I_{a1} \times R_a + E_{b1}$$

or $$240 = I_1 (R_f + R_a) + E_{b1}$$

or $$240 = 40 \times 0.2 + E_{b1}$$

$\therefore$ $$E_{b1} = 232\,V$$



Case II

$$I_2 = I_{f2} = I_{a2} = 10\,A$$

$$V = I_{f2} R_f + R I_{f2} + R_a I_{a2} + E_{b2}$$

or $$240 = 10 (R_f + R + R_a) + E_{b2}$$

or $$240 - 10 (0.2 + R) = E_{b2}$$

so $$E_{b2} = 238 - 10R$$

now

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or $$\frac{3600}{1800} = \frac{238 - 10R}{232} \times \frac{40}{10}$$

so $$\boxed{R = 12.2\,\Omega}$$

A 250V dc shunt motor has armature winding resistance of 0.5Ω & field winding resistance of 125Ω. It draws a current of 32A & runs at a speed of 1100 rpm. Calculate the value of resistance to be connected in series with the armature winding in order to reduce the speed to 750 rpm keeping the load torque constant.

...tion:

$$I_{s1} = 32A,\ N_1 = 1100 \text{ rpm}$$

$$I_{f1} = \frac{V}{R_f} = \frac{250}{125} = 2A$$

$$I_{a1} = I_{s1} - I_{f1} = 32A - 2A = 30A$$

$$\therefore E_{b1} = V - I_{a1} \times R_a = 250 - 30 \times 0.5 = 235V$$

$$\therefore E_{b2} = V - I_{a2}[R_a + R] = 250 - I_{a2}[R + 0.5]$$

$$N_2 = 750 \text{ rpm}$$

Now,

$$\frac{T_2}{T_1} = \frac{I_{a2}}{I_{a1}} \times \frac{I_{f2}}{I_{f1}}$$

Since the load torque is constant, so

$$\left[\text{Since } I_{f1} = I_{f2} = \frac{V}{R_f} = \text{constant}\right]$$

So,

$$\therefore I_{a2} = I_{a1} = 30A$$

And,

$$E_{b2} = 250 - [R + 0.5] \times 30 = 235 - 30R$$

Finally,

$$\frac{E_{b2}}{E_{b1}} = \frac{N_2}{N_1} \quad [\text{Since, } I_{f1} = I_{f2} = \text{constant}]$$

or, $$\frac{235 - 30R}{235} = \frac{750}{1100}$$

or, $$235 - 30R = 160.227$$

$$\therefore R = 2.49\Omega$$

A dc series motor with series field & armature resistance of 0.06Ω & 0.040 Ω respectively is connected across 220V mains. The armature takes 40A & its speed is 900 rpm. Determine its speed when the armature takes 75A & excitation is increased by 15% due to saturation.

soln ÷

$R_f = 0.06\Omega$, $R_a = 0.040\Omega$, $V = 220V$

$I_{a1} = 40A$ $N_1 = 900$ rpm

$I_{a2} = 75A$

excitation $(\phi_2) = \phi_1 + \frac{15}{100}\phi_1$

$= 1.15\phi_1$

Now,

$V = I_{a1}(R_f + R_a) + E_{b1}$

or, $220 = 40(0.06 + 0.040) + E_{b1}$

$\therefore E_{b1} = 216V$

$V = I_{a2}(R_f + R_a) + E_{b2}$

or, $220 = 75(0.06 + 0.040) + E_{b2}$

$\therefore E_{b2} = 212.5V$

Now

$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{\phi_1}{\phi_2}$ | $N_2 = 900 \times \frac{212.5}{216} \times \frac{\phi_1}{1.15\phi_1}$

$\therefore \boxed{N_2 = 770 \text{ rpm}}$

∴ N = 1450.2 rpm

A 1.25 kW, 250 V dc shunt motor on no load runs at 1000 rpm. The armature and field circuit resistance are 0.2 ohm and 250 ohm respectively. Calculate the speed of motor when it is loaded and draw current of 50 A. Assume armature reaction weakens the field by 3 %. [207]

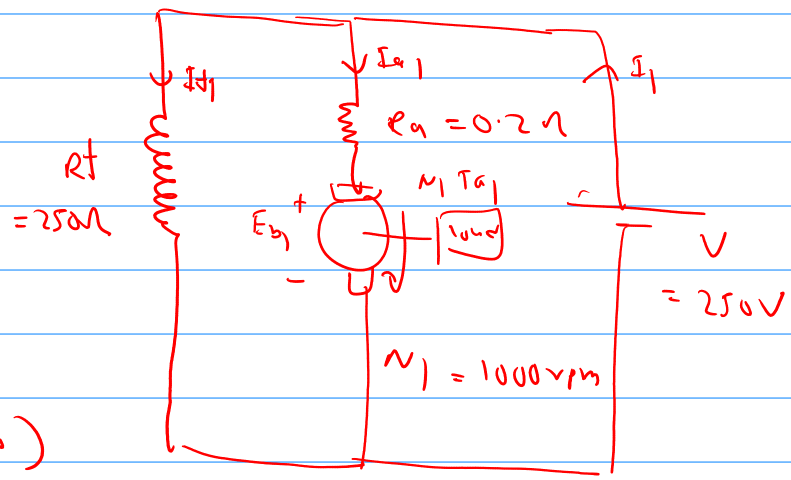
Soln÷

$\boxed{P_{in} = 1.25\,kW}$

$N_1 = 1000\,rpm$

$R_a = 0.2\,\Omega$

$R_f = 250\,\Omega$



$I_2 = 50A$

(field weakens by 3 %)

$\phi_2 = \phi_1 - \frac{3}{100}\phi_1$

$\phi_2 = 0.97\phi_1$, $N_2 = ?$

now case - I

$\boxed{P_{in} = VI_1}$

or, $1.25\times10^3 = 250 \times I_1$

∴ $I_1 = 5A$

$I_1 = I_{a1} + I_{f1}$

or $5 = I_{a1} + 1$

∴ $I_{a1} = 4A$

$V = I_{f1} R_f$

or, $250 = I_{f1} \times 250$

∴ $I_{f1} = 1A$

or, $V = I_{a1} R_a + E_{b1}$

or, $E_{b1} = 250 - 4\times 0.2 = 249.2\,V$

$I_2 = 50A$

$50 = I_{a2} + I_{f2}$

$\therefore I_{a2} = 49\,A$

$V = I_{f2} R_f$

or $250 = I_{f2} \times 250$

$\therefore I_{f2} = 1A$

$E_{b2} = 250 - 49 \times 0.2 = 240.2V$

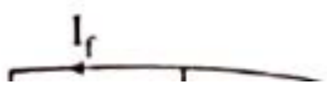
Now,

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{\phi_1}{\phi_2}$$

or $$N_2 = 1000 \times \frac{240.2}{249.2} \times \frac{\phi_1}{0.97\phi_1}$$

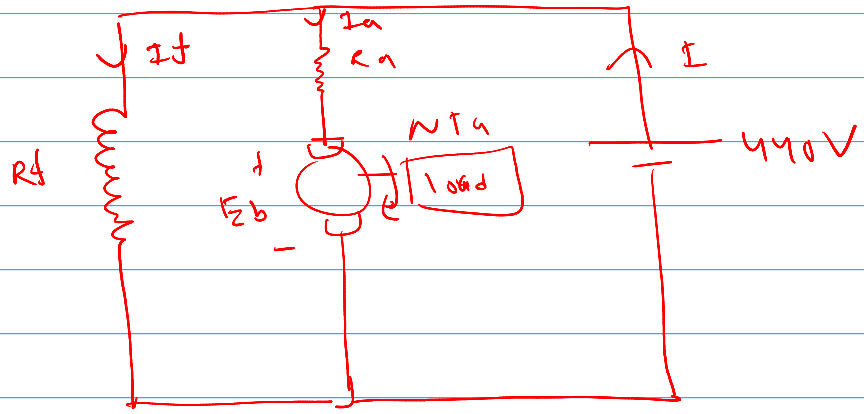
$\therefore \boxed{N_2 = 993.69\ rpm}$

A 440 V dc motor taking 5A at no load has armature and fi winding resistances are 0.5 ohm and 220 ohm respectiv Calculate the efficiency when the motor takes 50 A on full lo Also calculate the percentage change in speed from no load to f load. 1



soln:

p.T.O



on no-load

$I_1 = 5A$

$$If_1 = \frac{V}{Rf_1} = \frac{440}{220} = 2A$$

$5 = 2 + Ia_1$

$\therefore Ia_1 = 3A$

Now

$$Eb_1 = V - Ia_1 Ra_1$$

or $Eb_1 = 440 - 3 \times 0.5 = 438.5V$

$Pin = V \times I = 440 \times 5 = 2200 W$

$$\text{Cu-loss at no load} = Ia_1^2 Ra + If_1^2 \times Rf$$
$$= 3^2 \times 0.5 + 2^2 \times 220$$
$$= 884.5 W$$

rotational

other loss = Pin - Cu-loss

$= 2200 - 884.5 = 1315.5W$

at full load

$I_2 = 50A$, $I_{f2} = 2A$, $I_{a2} = 48A$

$P_{in} = V \times I_2 = 440 \times 50 = 22000$

Total cu-loss $= I_{a2}^2 \times R_a + I_{f2}^2 \times R_f$

$= 48^2 \times 0.5 + 2^2 \times 220$

$= 2032 W$

at no load same

Total loss at full load $=$ cu-loss $+$ Protational

$= 2032 + 1315.5$

$= 3347.5 W$

$P_{out} = P_{in} - P_{loss}$

$= 22000 - 3347.5$

$= 18652.5 W$

$\eta = \frac{P_{out}}{P_{in}} \times 100\% = \frac{18652.5}{22000} \times 100\%$

$= 84.78\%$

$E_{b2} = V - I_{a2} \times R_a = 440 - 48 \times 0.5 = 416V$

$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$ | $\frac{N_2}{N_1} = \frac{416}{438.5} \times \frac{2}{2}$

$N_2 = 0.948 N_1$

$$\% \text{ change} = \left| \frac{N_2 - N_1}{N_1} \right| \times 100\%$$

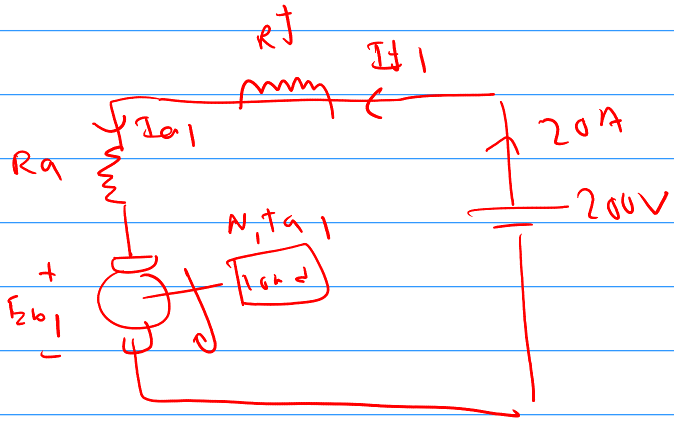
$$= \left| \frac{0.948 - 1}{1} \right| \times 100\%$$

$$= 5.2\%$$

A 200 V dc series motor runs at 1000 rpm taking 20 A. Combined resistance of armature and field is 0.4 Ω. A resistance is connected in series with the current and the speed was found to be reduced to 800 rpm. Assuming that torque varies at square of the speed. Find the value of resistance inserted. [207

Soln ÷

$R_f + R_a = 0.4$



$I_1 = I_{f1} = I_{a1} = 20A$

$N_1 = 1000$ rpm

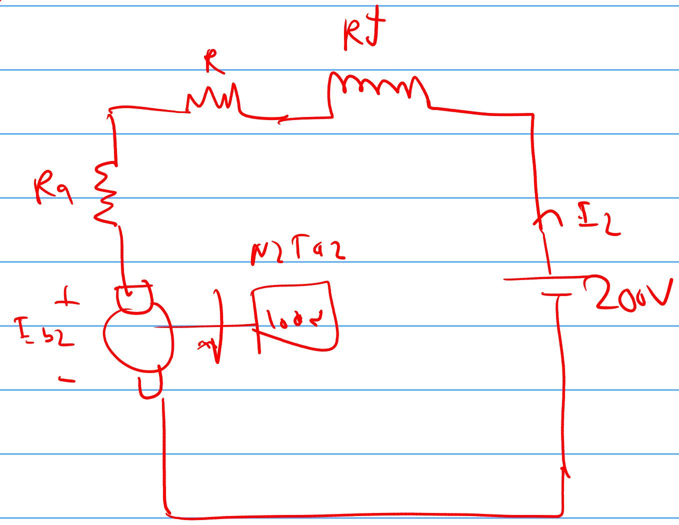
$V = I_1 (R_f + R_a) + E_{b1}$

or $200 - 20 \times 0.4 = E_{b1}$

$\therefore E_{b1} = 192V$

As case - II

Resistance R is inserted in series



$N_2 = 800$ rpm

$T \propto N^2$

$$\frac{T_{a2}}{T_{a1}} = \frac{N_2^2}{N_1^2}$$

or $$\frac{T_{a2}}{T_{a1}} = \left(\frac{800}{1000}\right)^2 = 0.64$$

$$T_{a2} = 0.64\, T_{a1}$$

Now

$$T_a \propto I_f I_a$$

$$\frac{T_{a2}}{T_{a1}} = \frac{I_{f2} I_{a2}}{I_{a1} I_{f1}}$$

or $$0.64 = \frac{I_{f2}^2}{I_{f1}^2}$$

or $$I_{f2}^2 = 0.64 \times 20^2 = 256$$

$\therefore$ $I_{f2} = 16$ A

Now

$$V = I_{f2}(R + R_f + R_a) + E_{b2}$$

or $$200 = 16(R + 0.4) + E_{b2}$$

or $$E_{b2} = 193.6 - 16R$$

Now,

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

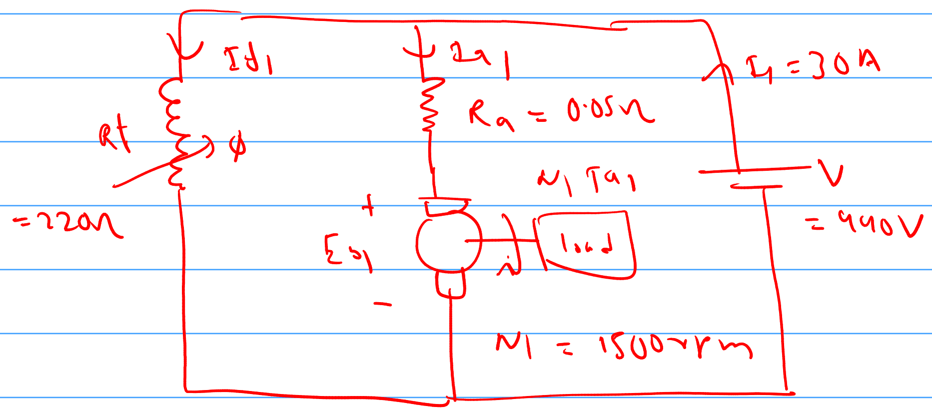
or $$\frac{800}{1000} = \frac{193.6 - 16R}{192} \times \frac{20}{16}$$

$\therefore$ $R = 4.42\,\Omega$

A 440 V dc shunt motor drains a current of 30 A and runs at speed of 1500 rpm. Given that the armature winding resistance is 0.05Ω and field winding resistance of 220 Ω. Calculate the values of resistance to be connected in series with the armature to operate the motor at a speed of 1300 rpm at constant load torque. [2071]

ution:

Soln:



Now

$$V = I_{f_1} R_f$$

or $$440 = I_{f_1} \times 220$$

$$\therefore \boxed{I_{f_1} = 2A}$$

$$30 = I_{a_1} + 2$$

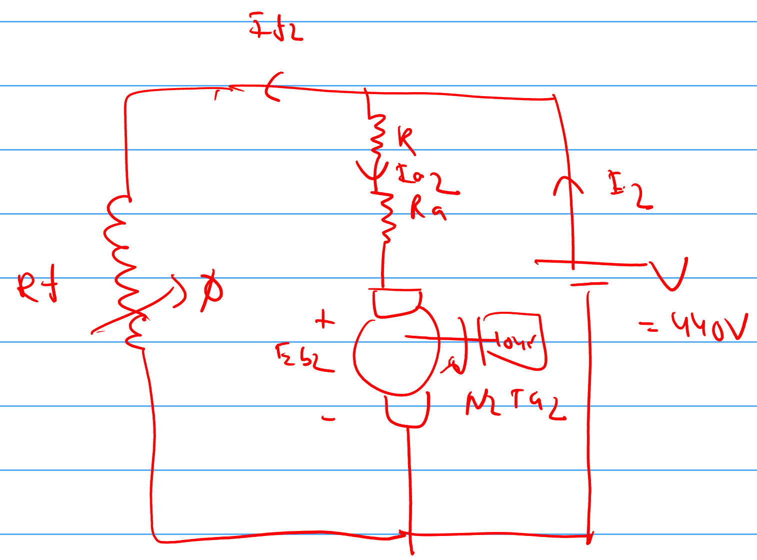
$$\therefore \boxed{I_{a_1} = 28\ A}$$

$$V = I_{a_1} R_a + E_{b_1}$$

or $$440 = 28 \times 0.05 + E_{b_1}$$

$$\therefore \boxed{E_{b_1} = 438.6\ V}$$

Case − II



$N_2 = 1300$ rpm

$(T_{a_1} = T_{a_2})$
Const torque

$$\frac{T_{a2}}{T_{a1}} = \frac{I_{f2} I_{a2}}{I_{f1} I_{a1}}$$

or $$1 = \frac{I_{f2} I_{a2}}{28 \times 2} \quad \therefore I_{f2} I_{a2} = 56 \quad \text{— (*)}$$

$$V = I_{f2} R_f$$

or $$440 = I_{f2} \times 220$$

$$\therefore I_{f2} = 2\,A$$

$$\therefore I_{a2} = \frac{56}{2} = 28\,A$$

$$V = I_{a2}(R + R_a) + E_{b2}$$

or $$440 = 28(R + 0.05) + E_{b2}$$

$$\therefore E_{b2} = 440 - 28(R + 0.05)$$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or $$\frac{1300}{1500} = \frac{440 - 28(R + 0.05)}{438.6} \times \frac{2}{2}$$

$$\therefore \boxed{R = 2.18\,\Omega}$$

A 250 V d.c. shut motor having an armature resistance of 0.25Ω carries an armature current of 50 A and runs at 750 r.p.m. if the flux is reduced by 10 %. Find the speed. Assume that the load torque remains the same.

[2072]

ution:

Solution,

$V = 250V$, $R_a = 0.25\Omega$, $I_{a_1} = 50A$ $N_1 = 750$ rpm

$\phi_2 = \phi_1 - \frac{10}{100}\phi_1 = 0.9\phi_1$

$T \propto \phi I_a$

$\frac{T_{a2}}{T_{a_1}} = \frac{\phi_2 I_{a2}}{\phi_1 I_{a_1}}$

$(T_{a2} = T_{a_1})$

or $1 = \frac{0.9\cancel{\phi_1} I_{a2}}{\cancel{\phi_1} \times 50}$ $\therefore I_{a2} = 55.55$ A

$V = I_{a_1} R_a + E_{b_1}$

$\therefore E_{b_1} = 250 - 50 \times 0.25 = 237.5$ V

$V = I_{a2} R_a + E_{b2}$

or $E_{b2} = 250 - 55.55 \times 0.25 = 236.1$ V

$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b_1}} \times \frac{\phi_1}{\phi_2}$, $\boxed{N_2 = 750 \times \frac{236.1}{237.5} \times \frac{1}{0.9} = 828 \text{ rpm}}$

. A 120 V d.c. shunt motor having an armature circuit resistance of 0.2 Ω, and fields circuit resistance of 60 Ω, draws a line of 40 A at full load. The brush voltage drop is 3 V and rated full-load speed is 1800 r.p.m. Calculate : (a) the speed at half load; (b) the speed at 125 percent full load. [2073]

Soln :-

$V = 120V$, $R_a = 0.2\Omega$, $R_f = 60\Omega$, $I_1 = 40A$

$V_b = 3V$ $N_1 = 1800 rpm$

$I_{f_1} = \frac{120}{60} = 2A$

$40 = 2 + I_a$

$\therefore I_{a_1} = 38 A$

$V = I_{a_1} R_a + V_b + E_{b_1}$

or $E_{b_1} = V - V_b - I_{a_1} R_a$

or $E_{b_1} = 120 - 3 - 38 \times 0.2 = 109.4 V$

half load

$I_2 = 0.5 \times I_1 = 0.5 \times 40$

$= 20A$

$I_{f_2} = \frac{120}{60} = 2A$

$I_{a_2} = 20 - 2 = 18 A$

$V = I_{a2} R_a + V_b + E_{b2}$

or, $120 = 18 \times 0.2 + 3 + E_{b2}$

$\therefore E_{b2} = 113.4\ V$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or, $$\frac{N_2}{1800} = \frac{113.4}{109.4} \times \frac{2}{2}$$

$\therefore N_2 = 1866$ rpm

at 125% load

$I_3 = 1.25 I_1 = 1.25 \times 40 \therefore = 50A$

$I_{f3} = 2A$

$I_{a3} = 48\ A$

$V = I_{a3} R_a + V_b + E_{b3}$

or, $120 - 48 \times 0.2 - 3 = E_{b3}$

$\therefore E_{b3} = 107.4\ V$

$$\frac{N_3}{N_1} = \frac{E_{b3}}{E_{b1}} \times \frac{I_{f1}}{I_{f2}}$$

or $$\boxed{N_3 = 1800 \times \frac{107.4}{109.4} = 1770 \text{ rpm}}$$