2018 Fall

6.a

Two D.C. traction motors run at speeds 700 RPM and 750 RPM respectively when each takes a current of 50 A from 500 V mains. Each motor has an effective resistance of 0.3 ohm. Calculate the speed and voltage across each machine when mechanically coupled and electrically insulated in series and taking a current of 50 A from 500 V mains, the resistance of each motor being unchanged.

~~$N_1 = 700$ rpm, $N_2 = 750$ rpm~~

Let the two motors be 1 and 2 of speed $N_1 = 700$ rpm & $N_2 = 750$ rpm.

Applied voltage across each motor = 500 V

Current taken by each motor = 50 A

Resistance of each motor, $R_m = 0.3\,\Omega$

Now,

~~Back emf of motor 1 when taking a current of 50 A, $E_{b1} = V - IR_m = 500 - 50\times0.3 = 485$ V.~~

~~Back emf of motor 2 when taking a current of 50 A, $E_{b2} = 500$.~~

Back emf developed by each motor when taking a current of 50 A, $E_{b1} = E_{b2} = V - IR_m$

$= 500 - 50\times0.3 = 485$ V

When the machines are mechanically coupled and connected in series, the speed of each motor will be same, say N, current will be same and equal to 50 A and the sum of voltage across the two motors will be equal to 500 V.

Let the voltage across motors 1 and 2 be V_1 & V_2 respectively.

Now, $V_1 + V_2 = 500$ --- (1)

Back emf of motor 1, $E'_{b1} = E_{b1} \times \frac{N}{N_1} = \frac{485}{700} \times N$

voltage across motor 1,

$$V_1 = E_{b1}' + IR_m = \frac{485}{700} N + 50 \times 0.3$$

$$= \frac{485}{700} N + 15$$

Back emf of motor 2, $E_{b2}' = E_{b2} \times \frac{N}{N_2} = \frac{485}{750} \times N$

Voltage across motor 2, $V_2 = E_{b2}' + IR_m$

$$= \frac{485}{750} N + 15$$

Substituting V_1 and V_2 in eqn ① we get

$$\frac{485}{700} N + 15 + \frac{485}{750} N + 15 = 500$$

$$\text{or} \left(\frac{485}{700} + \frac{485}{750} \right) N = 470$$

$$\text{or, } N\left(\frac{1}{700} + \frac{1}{750} \right) = \frac{470}{485} \quad 0.969$$

or, $N = 357$ rpm

Voltage across motor 1, $V_1 = \frac{485}{700} N + 15 = \frac{485 \times 357}{700} + 15$

$$= 258.0 \text{ V}$$

Voltage across motor 2, $V_2 = \frac{485}{750} N + 15$

$$= \frac{485 \times 357}{750} + 15$$

$$= 242.0 \text{ V}$$

2016 Fall

4.a

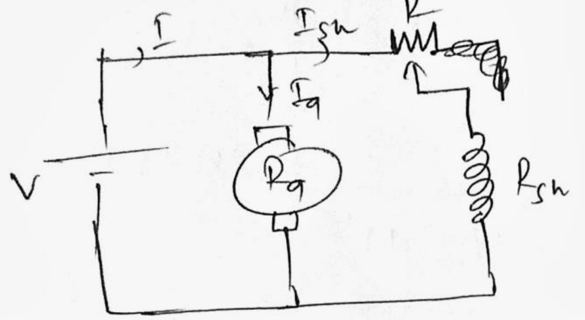
Q. A 250 V dc shunt motor has an armature resistance of 0.4Ω and field resistance of 250Ω. When driving a load of constant torque at 600 rpm the armature current is 20A. It is desired to raise the speed from 600 to 800 rpm. What resistance is to be inserted in the field circuit. Assume the magnetic field is unsaturated

Sol^n:- Given, $V = 250\ V$

$R_a = 0.5\ \Omega$, $R_{sh} = 250\ \Omega$

$I_a = 20\ A$

$N_1 = 600$ rpm, $N_2 = 800$ rpm



Resistance to be inserted in the shunt field circuit R

we know that, $\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{\phi_1}{\phi_2}$

Since the magnetic field is unsaturated,

$\phi \propto I_{sh}$

$\therefore \frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{sh1}}{I_{sh2}}$ ------ (i)

Since torque remains constant,

$\phi_1 I_{a1} = \phi_2 I_{a2}$ $\quad [\because T \propto \phi I_a]$

or, $I_{a2} = \frac{\phi_1 I_{a1}}{\phi_2} = I_{a1} \times \frac{I_{sh1}}{I_{sh2}}$ ------ (ii)

Now, $I_{sh1} = \frac{250}{250} = 1A$

And, $I_{sh2} = \frac{250}{R_t}$

where R_t is total resistance of shunt field circuit

$\therefore I_{a2} = 20 \times \frac{1}{250/R_t} = 0.08 R_t$

Also, $E_{b1} = V - I_{a1} R_a = 250 - 20 \times 0.5 = 240\,V$

and, $E_{b2} = V - I_{a2} R_a = 250 - (0.08 R_t \times 0.5)$

$= 250 - 0.04 R_t$

Substituting these values in eq ① we get

$$\frac{800}{600} = \frac{250 - 0.04 R_t}{240} \times \frac{1}{250/R_t}$$

or, $\frac{4}{3} = \frac{250 - 0.04 R_t}{240} \times \frac{R_t}{250}$

or, $R_t (250 - 0.04 R_t) = \frac{4}{3} \times 240 \times 250$

or, $250 R_t - 0.04 R_t^2 = 80000$

or, $0.04 R_t^2 - 250 R_t + 80000 = 0$

$\therefore R_t = \frac{250 \pm \sqrt{250^2 - 4 \times 0.04 \times 80000}}{2 \times 0.04}$

$= \frac{250 \pm 222.9}{0.08}$

Taking +ve sign, $R_t = \frac{250 + 222.9}{0.08}$

$= 5911.25\,\Omega$

Taking −ve sign, $R_t = \frac{250 - 222.9}{0.08}$

$= 338.7\,\Omega$

If we take the +ve sign we get very high R_t

So taking the negative sign,

$$R_t = 338.75\,\Omega$$

$\cancel{\therefore R + R_s}$ Now, $R_t = R + R_{sh}$

$$\therefore R = R_t - R_{sh} = 338.75 - 250$$

$$= 88.75\,\Omega$$

Hence additional resistance required in shunt field circuit $= 88.75\,\Omega$

2018 Fall

5.b

b) A 440 V, 50 Hz, 6 pole, Y-connected wound rotor induction motor has 8
following parameters referred to stator.

R_s= 0.5 ohm, R_r'= 0.4 ohm, X_s=X_r'=1.2 ohm, X_m=50 ohm

An external resistance is inserted into the rotor circuit so that maximum torque is produced at S_m = 2. The motor, which was initially operating on no-load is being braked by 1-phase ac dynamic braking with three lead connection. Calculate the braking current and torque as a ratio of their full load values at 950 rpm.