2019 Fall

4.b

A 37.5 kw, 500rpm shunt motor is used for a shop. The stored energy of the machinery average 660 kgm per kw. Assuming the load torque during starting to be equal to the full load torque and the starting current to be twice the full load current. Calculate the time taken to start the motor.

Solⁿ:-

Given, output power $(P) = 37.5$ KW

Speed $(N) = 500$ rpm

Stored energy $(K.E) = 660$ kgm per KW

$= 660 \times 37.5 \times 9.81$

$= 242800$ N-m

Now, Load torque during starting $T_{L(st)}$ = Full load torque of motor (T_f)

So, $T_{L(st)} = T_f = \frac{P \times 1000}{2\pi N/60} = \frac{37.5 \times 1000 \times 60}{2\pi \times 500}$

$= 716.2$ Nm

In dc shunt motor,

$T_{m(st)} \propto I_a \propto I_{st}$

or, $T_{m(st)} = K I_{st}$ — (1)

Also,

$T_f \propto I_f \Rightarrow T_f = K I_f$ — (2)

From eq^{ns} ① and ②

$$\frac{T_{m(st)}}{T_f} = \frac{I_{st}}{I_f}$$

$$\Rightarrow T_{m(st)} = \frac{I_{st}}{I_f} \times T_f$$

$$= \frac{2 I_f}{I_f} \times T_f \quad [\because \text{ from the given cond}^n,\ I_{st} = 2I_f]$$

$$= 2 \times 716.2$$

$$= 1432.4 \text{ N-m}$$

Torque available for acceleration is

$$T_a = T_{m(st)} - T_L = 1432.4 - 716.2 = 716.2 \text{ N-m}$$

We have,

$$\text{K.E stored} = \tfrac{1}{2} J \omega^2$$

$$\text{or, } 242800 = \tfrac{1}{2} J \left(\frac{\pi N}{30}\right)^2$$

$$\Rightarrow J = \frac{242800 \times 2}{\left(\frac{\pi \times 500}{30}\right)^2} \Rightarrow J = 177 \text{ Kg-m}^2$$

= MOI of rotating system

Angular acceleration $(\alpha) = \frac{d\omega}{dt} = \frac{T_a}{J}$ $\left[\because T_a = J\frac{d\omega}{dt}\right]$

$$= \frac{716.2}{177} = 4.04 \ rad/sec^2$$

$\therefore$ Starting time can be calculated as

$$t = \frac{\omega}{\alpha} = \frac{\pi N/30}{4.04} = 12.95 \text{ seconds.}$$

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2019 Fall

5.b.

The rotor of a 4-pole,50 HZ, slip ring induction motor has a resistance of 0.25W per phase and runs at 1,440 rpm at full-load. Calculate the external resistance per phase which must be added to lower the speed to 1,200 rpm, assuming that the torque remains same.

Sol^n:-

Given, no. of poles (p) = 4

frequency (f) = 50 Hz

Rotor resistance (R_2) = 0.25 Ω per phase

Full load rotor speed (N) = 1440 rpm

Reduced speed (N') = 1200 rpm

Now,

$$N_s = \frac{120f}{p} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

$$\text{Full load slip } (s) = \frac{N_s - N}{N_s} = \frac{1500-1440}{1500}$$

$$= 0.04$$

After inserting resistance (say R ohms per phase) in rotor circuit

rotor speed (N') = 1200 rpm

$$\text{slip } (s') = \frac{N_s - N'}{N_s} = \frac{1500 - 1200}{1500} = 0.2$$

for same torque,

$$s \propto R_2$$

or, $\dfrac{s'}{s} = \dfrac{R_2 + R}{R_2} \Rightarrow \dfrac{0.2}{0.04} = \dfrac{0.25 + R}{0.25}$

$\therefore R = 1\ \Omega$ #

2019 Fall

3.b

A 230v-dc series motor has an armature resistance of 0.08Ω and field resistance of 0.05Ω. The magnetization characteristic of the machine at 700 rpm is as follows

Field Current	30	60	90	120	150
EMF	70	125	180	210	230

The motor run on a 230v supply. An additional resistance of 1.5Ω is connected in series with the armature. Determine the torque and speed when the motor draws a current of 90 A.

Soln:

Given, $V = 230\,V$

motor resistance $(R_m) = R_a + R_f = 0.08 + 0.05$

$= 0.13\,\Omega$

Additional resistance $(R) = 1.5\,\Omega$

Line current $(I_L) = 90\,A$

speed $(N) = 700$ rpm

for the magnetization characteristic at 700 rpm

for $I_f = I_L = 90\,A$.

emf $(E) = 180\,V$

After additional resistance is added, the current being same

$I_L' = I_L = I_f = 90\,A$

so, Back emf developed $(E') = V - I_L'(R + R_m)$

$= 230 - 90(1.5 + 0.13)$

$= 83.3\,V$

We have,

$\cancel{\frac{N_L}{N_1}} = \cancel{E}$ $\frac{N'}{N} = \frac{E'}{E} \times \frac{\phi}{\phi'}$ [$\because \phi = \phi'$ field current being same

or, $\frac{N'}{N} = \frac{E'}{E}$

or, $N' = \frac{E'}{E} \times N = \frac{83.3}{180} \times 700 = 324$ rpm #

And,

torque developed $(T') = \frac{9.55 \cdot E' I_L'}{N'}$

$= \frac{9.55 \times 83.3 \times 90}{324}$

$= 221$ N-m #