Dc motors

1. A 20hp, 250V shunt motor with $R_a=0.22\ \Omega$, $R_f=170\ \Omega$. At no-load and rated voltage, the speed is 1200 rpm and the armature current is 3 A. At full-load and rated voltage, the line current is 55A. What is the full-load speed?

Solution

At No-load

$$I_{f\,n.l} = \frac{V_t}{R_f} = \frac{250}{170} = 1.47\ A\ ,$$

$$N_{n.l} = 1200\ \ r.p.m$$

$$E_{n.l} = V_t - I_a R_a = 250 - (3)(0.22) = 249.34\ V$$

At Full-load

$$I_{f\,f.l} = \frac{V_t}{R_f} = \frac{250}{170} = 1.47\ A\ \ , N_{f.l} = \ ??$$

$$E_{f.l} = V_t - I_a R_a = 250 - (55)(0.22) = 238.22\ V$$

$$\frac{E_{n.l}}{E_{f.l}} = \frac{I_{f\,n.l} N_{n.l}}{I_{f\,f.l} N_{f.l}}$$

$$\frac{249.34}{238.22} = \frac{1200}{N_{f.l}}$$

$$N_{f.l} = 1146.5\ \ r.p.m$$

2. A separately excited motor runs at 1045rpm, with a constant field current, while taking an armature current of 50A at 120V. The armature resistance is 0.1 Ω if the load on the motor changes such that it now takes 95A at 120V, determine the motor speed at this load.

Solution

$$E = K_a \phi \omega = K \phi N$$

$$\frac{E_1}{E_2} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$\because$ *the field current is constant and the core is assumed unsaturated*

$$\therefore \ \phi_1 = \phi_2$$

$$\therefore \ \frac{E_1}{E_2} = \frac{N_1}{N_2}$$

$$E = V_t - I_a R_a$$

$$E_1 = 120 - (50)(0.1) = 115\ V$$

$$E_2 = 120 - (95)(0.1) = 110.5\ V$$

$$\frac{115}{110.5} = \frac{1045}{N_2}$$

$$N_2 = 1004.1 \ \ r.p.m$$

3. A separately excited DC motor has the following specifications: Terminal voltage = 250 V, field voltage = 250 V, armature resistance = 0.03 Ω, field resistance = 250 Ω. Initially the motor was running at speed = 1103 rpm while supplied by the rated terminal voltage and the armature current = 120 A. While supplying constant torque, what is the speed of the motor if the terminal voltage is reduced to 200 V?

Torque is constant and V_f is not changed (the field flux will be constant)

$$T = K_a \phi I_a$$

$$T_1 = T_2$$

$$\phi_1 I_{a1} = \phi_2 I_{a2}$$

$$I_{a1} = I_{a2} = 120\ A$$

$$E = K_a \phi \omega = K \phi N$$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

$$E_1 = V_{t1} - I_{a1} R_a = 250 - (120)(0.03) = 246.4\ V$$

$$E_2 = V_{t2} - I_{a2} R_a = 200 - (120)(0.03) = 196.4\ V$$

$$N_2 = \frac{E_2}{E_1} N_1$$

$$= \frac{196.4}{246.4} * 1103$$

$$= 879.5\ \ r.p.m$$

4. A 20 hp, 250 V DC shunt motor drives a load that requires a constant torque regardless the speed of operation. The armature resistance is 0.1 Ω. When this motor is running at full load, the armature current is 65 A at a speed of 1100 rpm. If the flux is reduced to 75% of its original value, find the armature current and the speed of the motor at this new condition?

Solution

Torque is constant

$$T_1 = T_2$$

$$\phi_1 I_{a1} = \phi_2 I_{a2}$$

$$\phi_1 I_{a1} = 0.75\phi_1 I_{a2}$$

$$I_{a1} = 0.75 I_{a2}$$

$$65 = 0.75\ I_{a2}$$

$$I_{a2} = 86.6\ A$$

$$E = K_a \phi \omega = K\phi N$$

$$\frac{E_1}{E_2} = \frac{\phi_1 N_1}{\phi_2 N_2} = \frac{\phi_1}{0.75\phi_1}\frac{N_1}{N_2} = \frac{1}{0.75}\frac{N_1}{N_2}$$

$$E = V_t - I_a R_a$$

$$E_1 = V_{t1} - I_{a1} R_a = 250 - (65)(0.1) = 243.5\ V$$

$$E_2 = V_{t2} - I_{a2} R_a = 250 - (86.6)(0.1) = 241.4\ V$$

$$\frac{243.5}{241.4} = \frac{1}{0.75}\frac{1100}{N_2}$$

$$N_2 = 1454\ \ r.p.m$$