Problems:

of Electrical Actuators

Problem 1 (LP3): A constant speed lap wound machine is chosen as an actuator for its application in robotics. Design constraints of machine allows 4 parallel paths for armature current, Number of conductors in the machine are 540, flux per pole of 30m Wb, 1A constant current through field when connected across rated voltage. Several batteries are connected in series and parallel to form a source of 220 V (rated) and current of 32 A (rated) for the application. If the output power is 5.6kW and number of poles is 4,determine the speed of the machine and hence the torque. Assume armature resistance (ra) **0.1Ω**.

Solution :

The described motor is Lap Wound Machine (A = P)

Given data: P= A = 4, Z=540, r_a =0.1Ω, Φ=30mWb, I_f = 1A,

V_{DC}= 220, I_{DC}= 32 A, $P_{o/p}$= 5.6kW

(LP3) Solution :

Governing equations:

$$I_a = I_{DC} - I_f$$

$$E_b = V - I_a R_a$$

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

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

$$T_a = \frac{0.159 \phi I_a P Z}{A}$$

Answers:

Ia = 31A, Eb=216.9V, N=803.33, T=79.84N-m

Problem 2 (LP4): An electric train is powered by machine which takes the supply from 220 V DC rail running above the train throughout. Machine draws current of 100 A from the DC rail to account for high torque during starting and runs at 700 r.p.m initially. Calculate the new speed of the train once it picks up the speed where the torque output required is only 70% of starting torque. Assume the motor has a resistance of 0.1Ω across its terminals

Solution :

The described electric train requires series motor:

Given data: V_{DC}= 220, I_{DC1}= 100 A, N_1=700rpm T_2= 0.7 T

R_a+R_{se} = 0.1Ω

(LP4) Solution :

Governing equations:

$T_1 \propto I_1^2$, $T_2 \propto I_2^2$, $\frac{T_1}{T_2} \propto \frac{I_1^2}{I_2^2}$, $E_b = V - I_a R_a$,

$$\frac{E_{b1}}{E_{b2}} = \frac{\phi_1 N_1}{\phi_2 N_2} = \frac{I_1 N_1}{I_2 N_2}$$

Answers:

I_2= 83.66A, E_{b1}=210V, E_{b2}=211.63V,

N_2=843.23rpm

Problem 3 (LP5): A wireless battery powered drilling machine operates on 24 V DC with constant speed and negligible field current. Initially when the machine is powered it runs at 1200 rpm and draws 0.5 A from the battery. Further when the drill bit starts drilling the hole, the speed reduces to 1120 rpm. Determine power requirement from the battery for drilling application if the armature resistance value is 0.2Ω.

Solution :

The described wireless drilling machine with negligible field current requires shunt motor:

Given data: V_{DC}= 24V, I_{a1}= 0.5 A, N_1=1200rpm N_2= 1120rpm

R_a = 0.2Ω

(LP4) Solution :

Governing equations: PMDC motor is also constant speed motor

$$E_{b1} = V - I_{a1} R_a \qquad \frac{E_{b1}}{E_{b2}} = \frac{N_1}{N_2}$$

$$I_{a2} = \frac{V - E_{b2}}{R_a}$$

Power Input to the drilling machine = $V * I_{a2}$

Answers:

I_{a2}= 8.5A, E_{b1}=23.9V , E_{b2}=22.30V,

P_{in}=204W

Thank You