ELEMENTS OF ELECTRICAL ENGINEERING
Course Code : UE25EE141A/B

PES UNIVERSITY

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ELEMENTS OF ELECTRICAL ENGINEERING

TORQUE EQUATION OF A SEPARATELY EXCITED DC MOTOR & ITS EQUIVALENT CIRCUIT

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Torque Equation of a DC Motor - Derivation

Let P = Number of poles in the stator

ϕ = Flux per pole in Weber

Z = Total number of conductors in the Armature winding

A = Number of parallel paths in the armature winding

I_a = Armature winding current in Amperes

l = length of each conductor in meters

r = radius of the rotor (or) armature in meters

Number of parallel paths depends on the type of armature winding.

For a lap wound armature winding, A = P

For a wave wound armature winding, A = 2

Torque Equation of a DC Motor – Derivation (Contd..)

Force experienced by one conductor, $F_C = B * I_C * l * \sin\theta$ (1)

B = Flux Density $= \dfrac{Total\ flux\ of\ all\ the\ Poles}{Total\ Surface\ area\ of\ all\ the\ Poles}$

$= \dfrac{P\emptyset}{2\pi rl}$

Conductor current, $I_C = \dfrac{Ia}{A}$

& since conductor & magnetic field are perpendicular, θ = 90 degrees

Torque Equation of a DC Motor – Derivation (Contd..)

Substituting for B, I_C & θ in equation (1),

$$F_C = \frac{P\emptyset Ia}{2\pi rA} \quad \text{Newton}$$

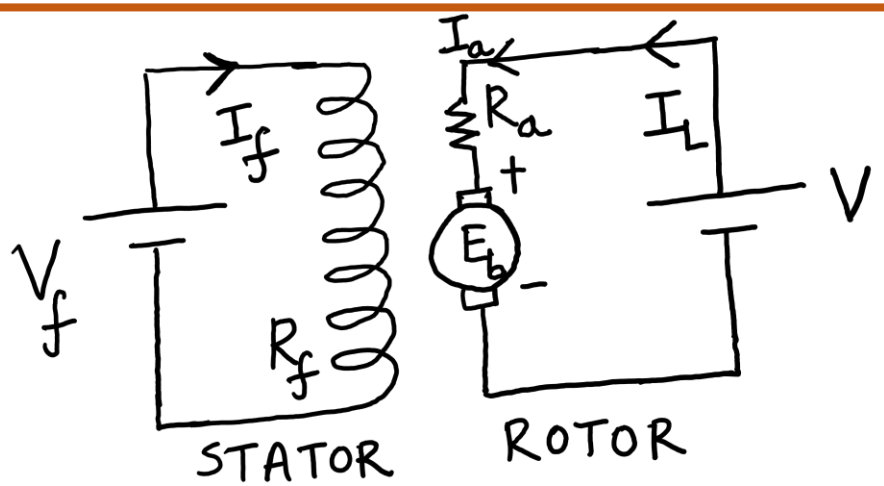
Torque experienced by each conductor, $T_C = F_C * r$

Hence, $$T_C = \frac{P\emptyset Ia}{2\pi A} \quad \text{Newton-Meter}$$

Torque developed in the Motor, $T_e = T_C * Z$

Hence, $$T_e = \frac{\emptyset ZIa}{2\pi} * \frac{P}{A} \quad \text{Newton-Meter}$$

Equivalent Circuit of a Separately excited DC Motor



$$I_f = \frac{V_f}{R_f}$$

$$I_a = I_L$$

$$E_b = V - I_a R_a$$

Electrical Power Input $= VI_L$

Mechanical Power developed $= E_b I_a$

Armature cu loss $= I_a^2 R_a$

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Numerical on Separately Excited DC Machine

The armature of a DC Machine has a resistance of 0.1Ω and is connected to a 250V DC supply. Calculate the generated EMF when running

i) As a generator giving 80A

ii) As a motor drawing 60A

Soln :

i) As a Generator,

$$E_g = V + I_a R_a = 250 + 80 * 0.1$$

$$= 258\,V$$

ii) As a Motor,

$$E_b = V - I_a R_a = 250 - 60 * 0.1$$

$$= 244\,V$$

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Text Book & References

Text Book:

1. "Basic Electrical Engineering" S.K Bhattacharya, 1st Edition Pearson India Education Services Pvt. Ltd., 2017
2. "Basic Electrical Engineering", D. C. Kulshreshta, 2nd Edition, McGraw-Hill. 2019
3. "Special Electrical Machines" E G Janardanan, PHI Learning Pvt. Ltd., 2014

Reference Books:

1. "Engineering Circuit Analysis" William Hayt, Jack Kemmerly, Jamie Phillips and Steven Durbin, 10th Edition McGraw Hill, 2023

2. "Electrical and Electronic Technology" E. Hughes (Revised by J. Hiley, K. Brown & I.M Smith), 12th Edition, Pearson Education, 2016.

THANK YOU

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