EEE363

Electrical Machines

(DC Motor)

Lecture # 8

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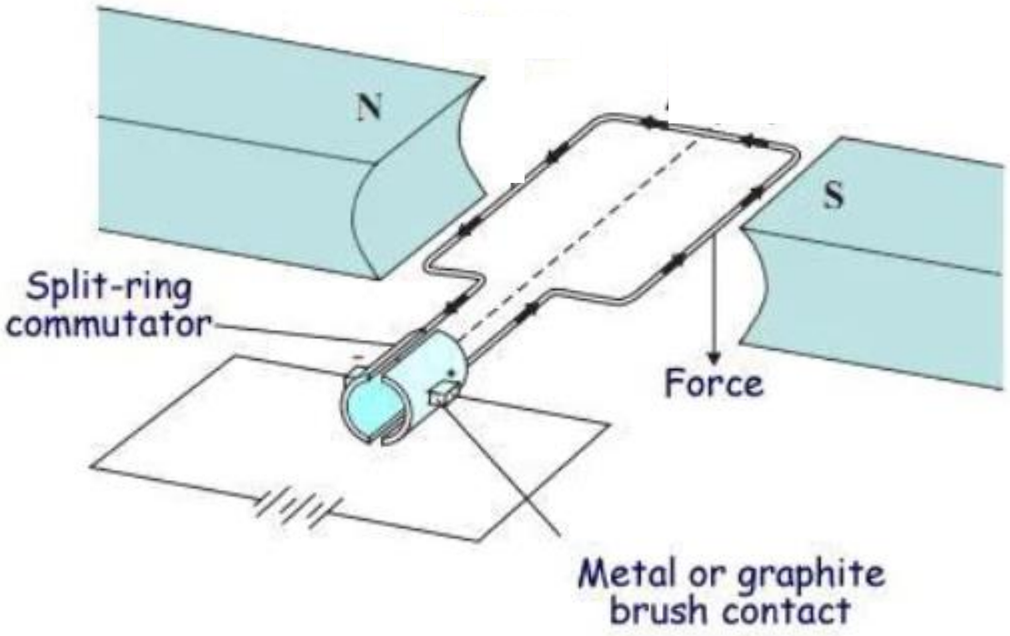
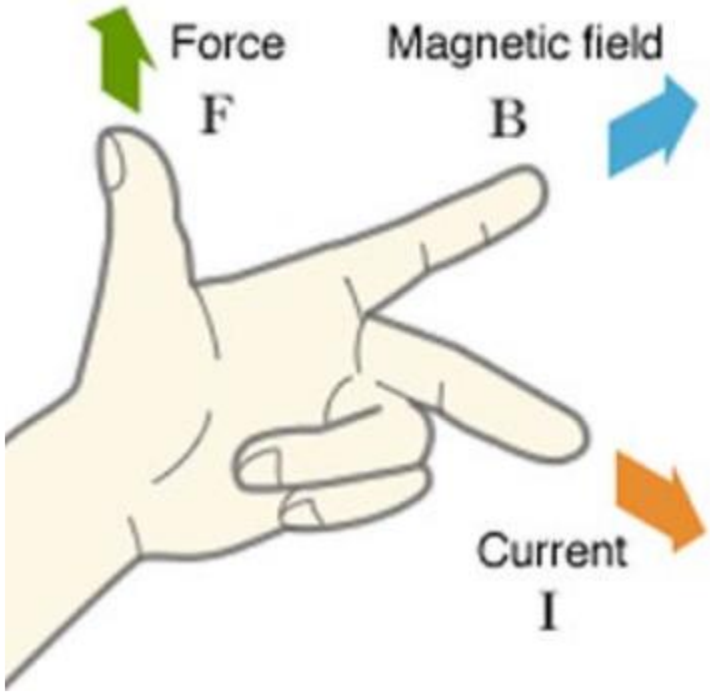
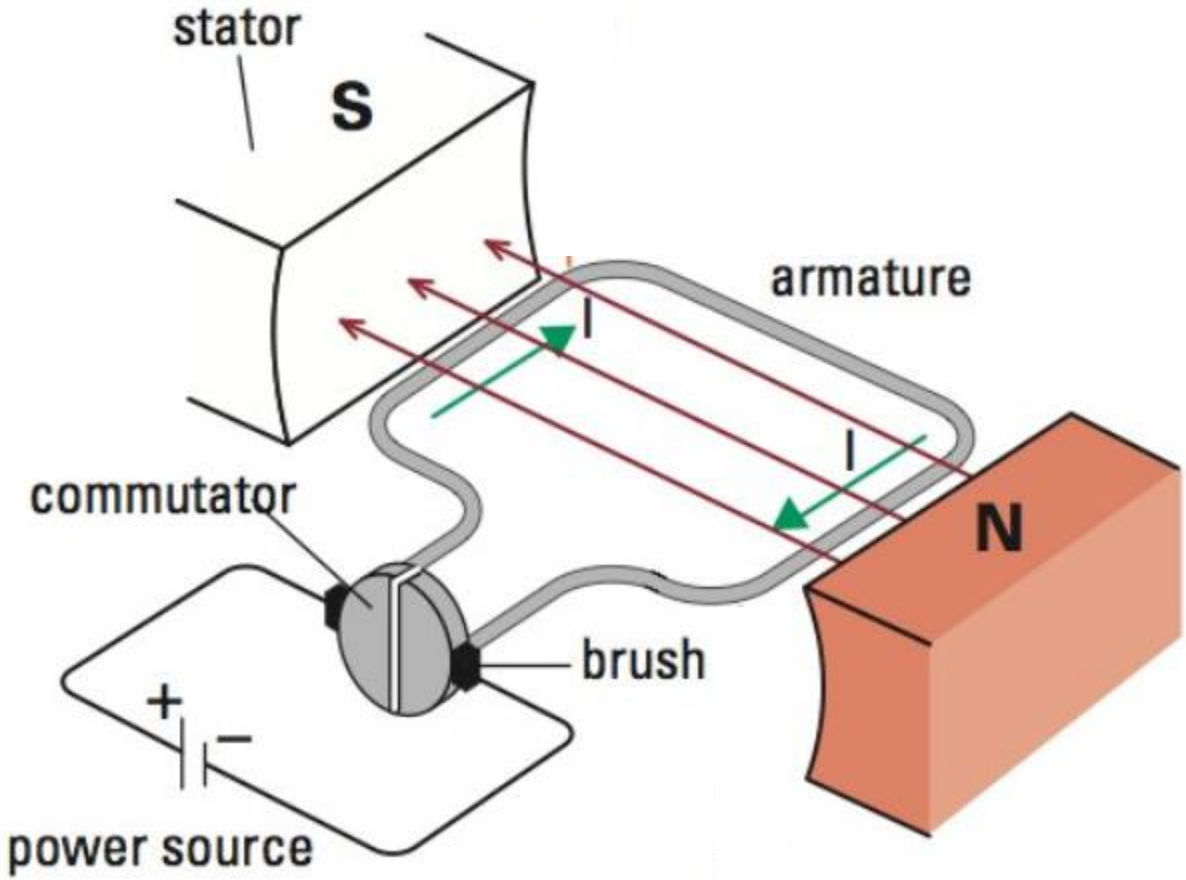
Motor

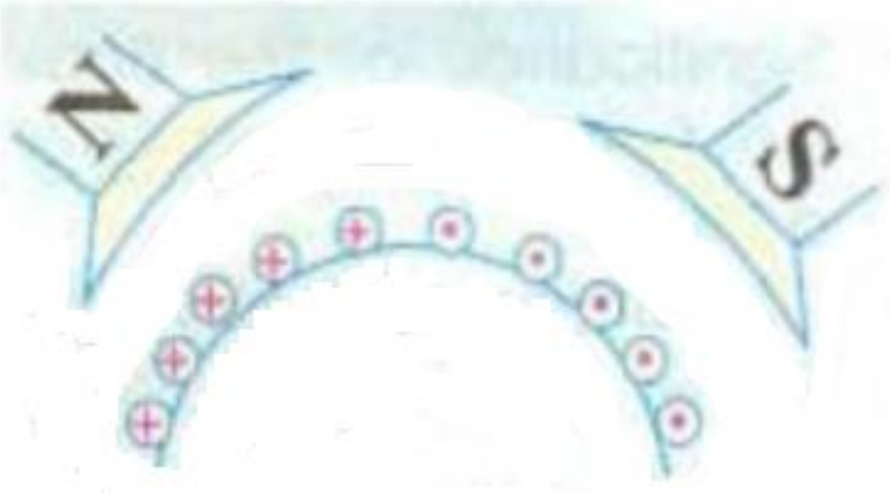
- An electric motor is a machine that converts electrical energy into mechanical energy.
- In terms of construction, there is no basic difference between a generator and a motor.
- It should be noted that the function of commutator in a motor is same as in a generator.



Fleming’s Left-hand Rule



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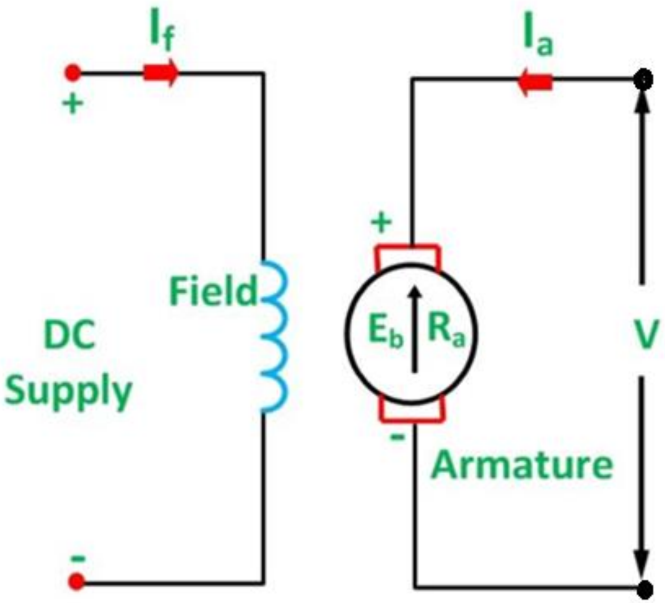
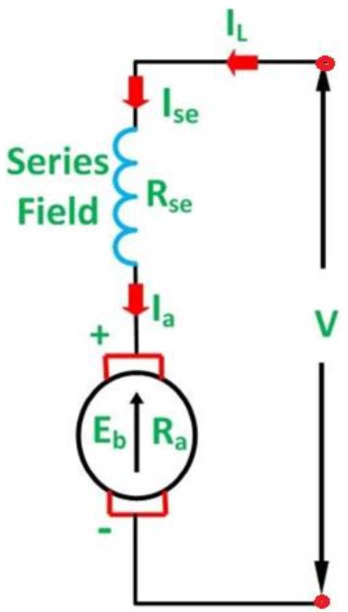
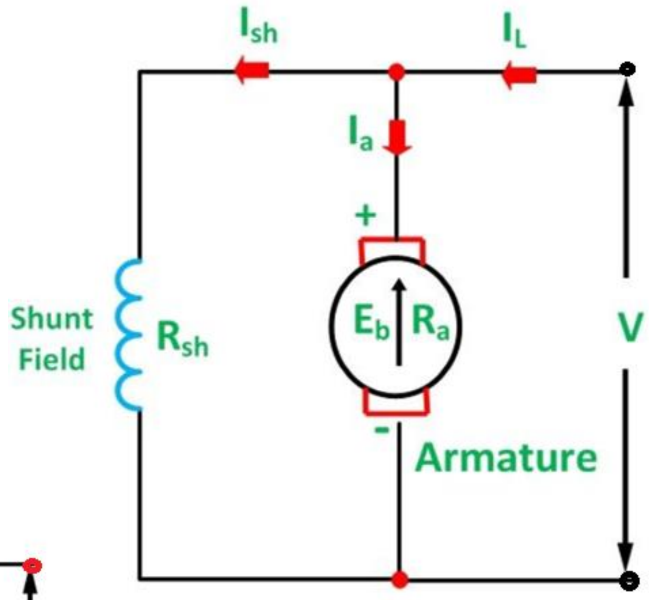
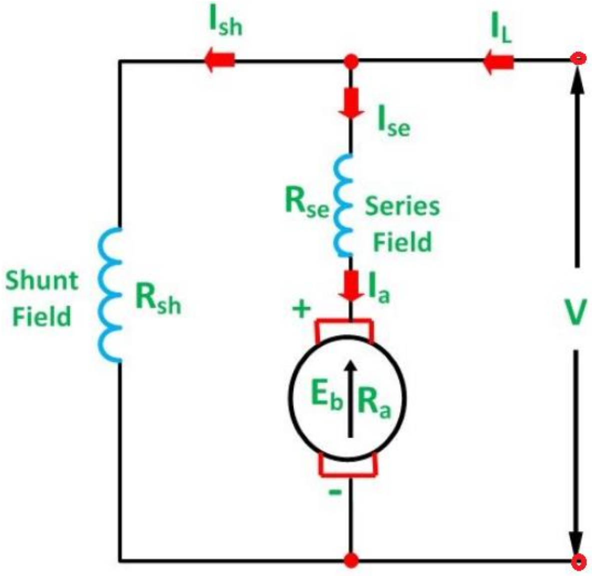
Classification

- Same as DC generator

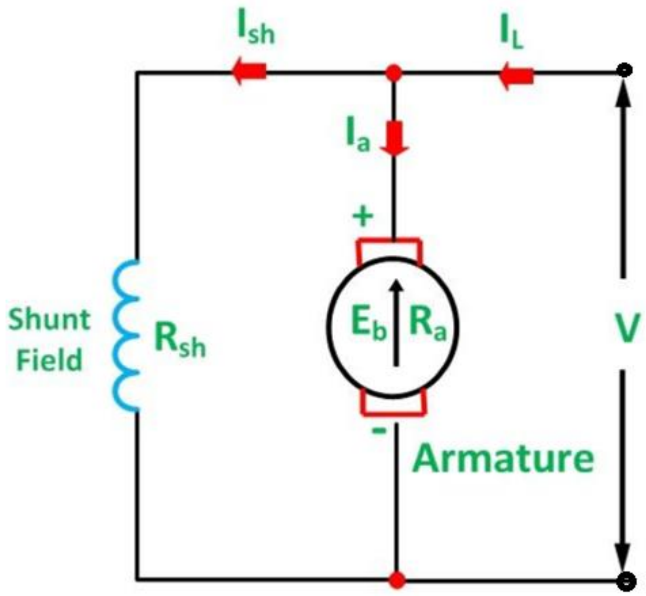


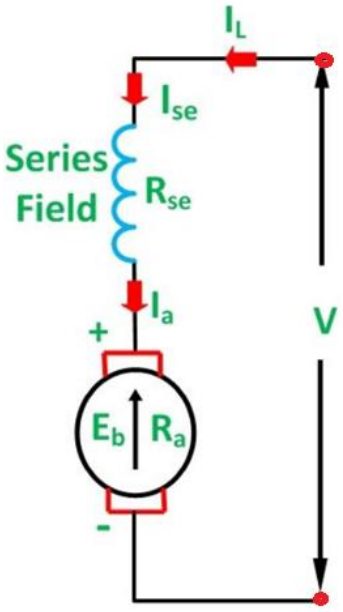


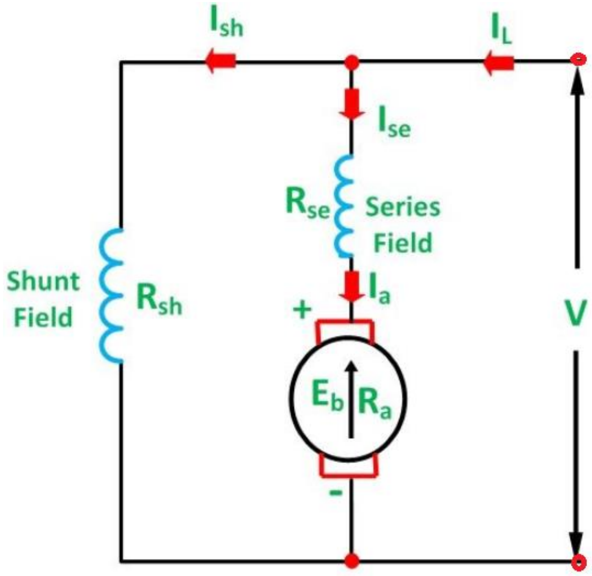




Motor equation







$$V = E_b + I_aR_a$$

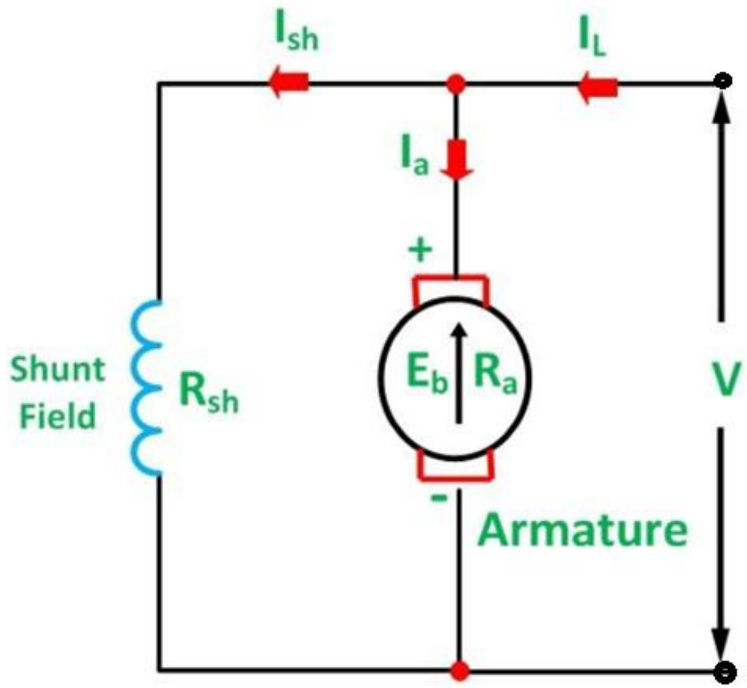
$$V = E_b + I_aR_a + I_aR_{se}$$

$$V = E_b + I_aR_a + I_aR_{se}$$

- E_b is called ‘back emf’ or ‘counter emf’

Back EMF

- Induced emf in the armature due to the rotation.
- Its polarity is such that it opposes the applied voltage (Lenz's rule).
- V has to drive I_a against the opposition of $E_{b.}$



Importance of back emf

$$V = E_b + I_a R_a$$

Multiplying both sides with I_a

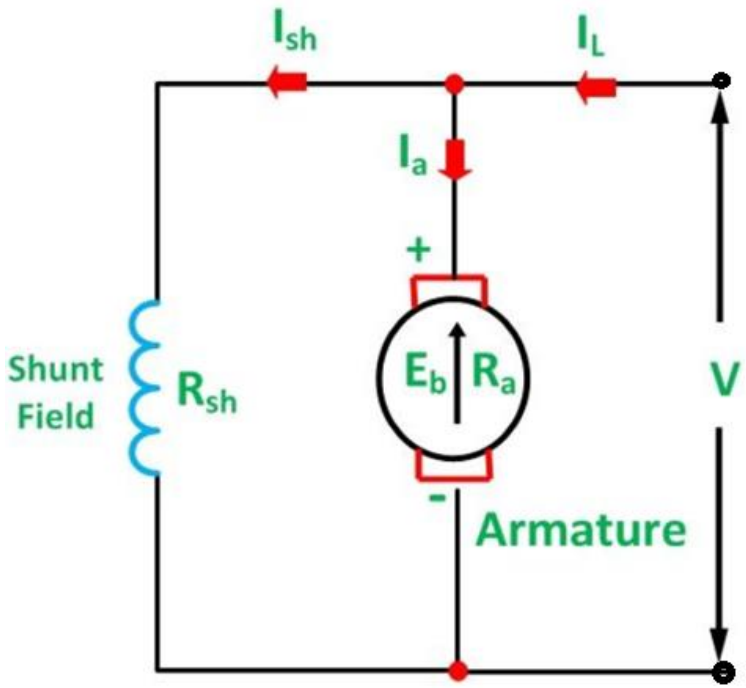
$$VI_a = E_b I_a + I_a^{\,2} R_a$$

Input power

Mechanical power developed

Loss

Conversion efficiency = $\dfrac{E_b I_a}{V I_a} = \dfrac{E_b}{V}$



Condition for maximum efficiency

Armature developed power, $P_m = E_b I_a = VI_a - I_a^2 R_a$

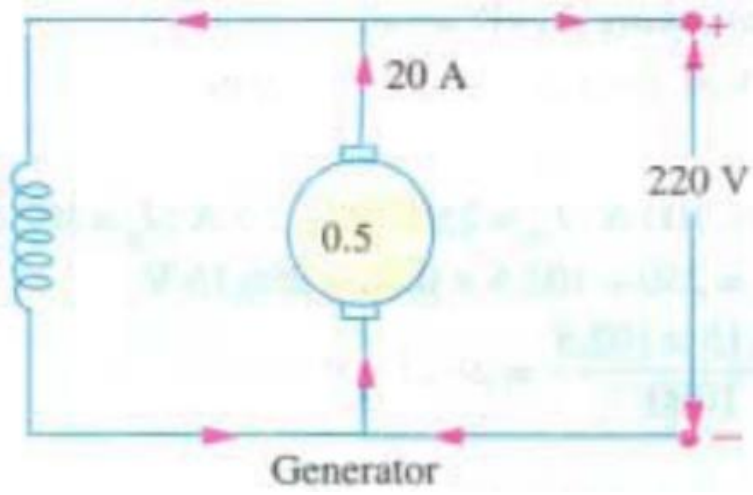
For Maximum efficiency $\frac{dP_m}{dI_a} = V - 2I_a R_a = 0 \Rightarrow I_a R_a = V/2$

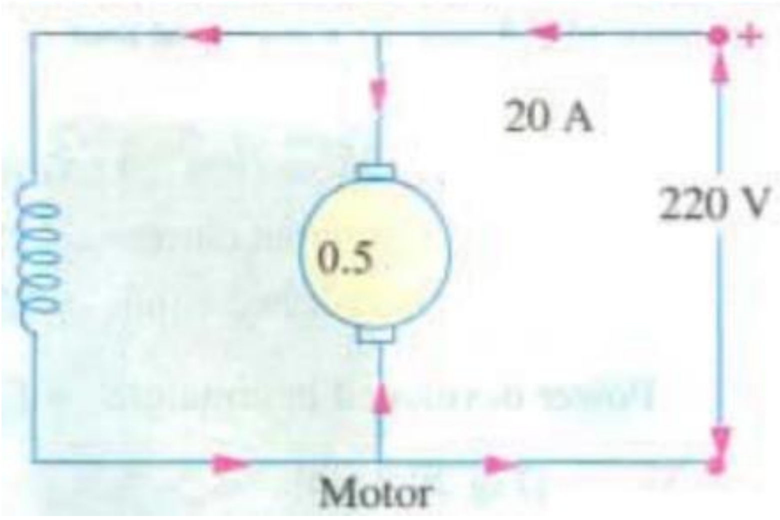
Substituting $I_a R_a$ in the following expression gives

$V = E_b + I_a R_a \Rightarrow \boxed{E_b = V/2}$

Maximum conversion efficiency $= \frac{E_b}{V} = \frac{V/2}{V} = 50\%$

A 220-V d.c. machine has an armature resistance of 0.5 Ω. If the full-load armature current is 20 A, find the induced e.m.f. when the machine acts as (i) generator (ii) motor.





(a) As Generator $E_g = V + I_a R_a = 220 + 0.5 \times 20 = 230\text{ V}$

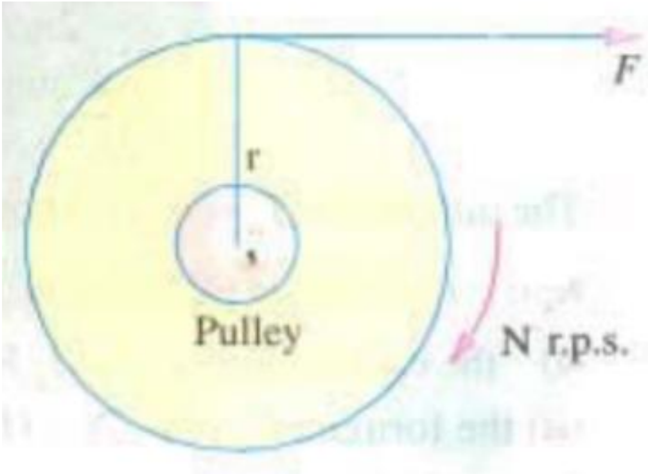
(b) As Motor $E_b = V - I_a R_a = 220 - 0.5 \times 20 = 210\text{ V}$

Torque

torque $T = F \times r$

Work done by this force in one revolution

$= $ Force $\times$ distance $= F \times 2\pi r$ Joule



Time for one revolution = $\frac{60}{N}$ sec

Power developed = $\frac{F \times 2\pi r}{60/N}$ $= F \times r \times (2\pi \times \frac{N}{60})$

$= T \times \omega$

Armature torque

Armature developed power $= T_a \times \omega = E_b I_a$

$$T_a = \frac{E_b I_a}{\omega} = \frac{1}{\omega} \times \frac{\varphi Z N}{60} \times \frac{P}{A} \times I_a = \frac{1}{2\pi} \varphi Z I_a \cdot \frac{P}{A}$$

Shaft torque

$$T_{sh} = \frac{\text{Output in watts}}{2\pi N / 60} = \frac{P_{out}}{\omega}$$