Total emf induced in the DC M/c is

$$\boxed{e = \frac{P \phi N}{60} \times \frac{Z}{A}}$$

There are two type of winding

i) Lap winding $\Rightarrow$ A = no. of parallel path
= P (Poles)

ii) wave winding $\Rightarrow$ A = 2 (always)

PROBLEM:-

4 Pole DC Generator
wave winding
51 slots & each slot contains 20 conductors
Flux per pole is 7.0 mwb
Generator is driven at 1500 rpm.

Ans:-

$$E_g = \frac{\phi Z N}{60} \cdot \left(\frac{P}{A}\right)$$

$Z = ?$

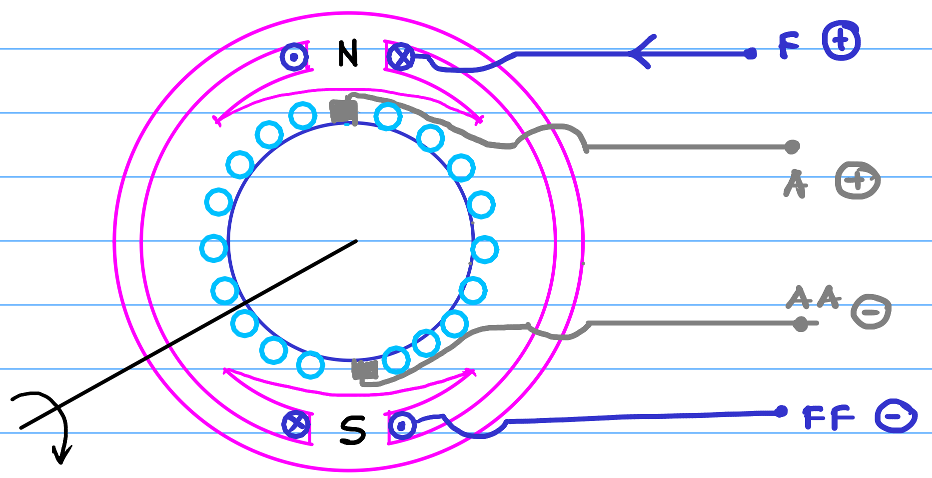
$\phi = 07.0$ mwb

$A = ?$ $\qquad\qquad$ $E_g = ?$

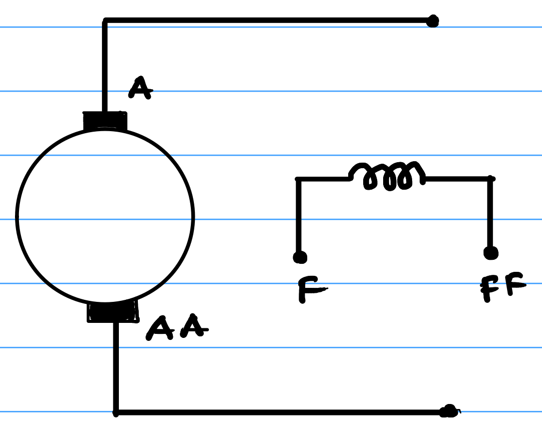
$P = 4$

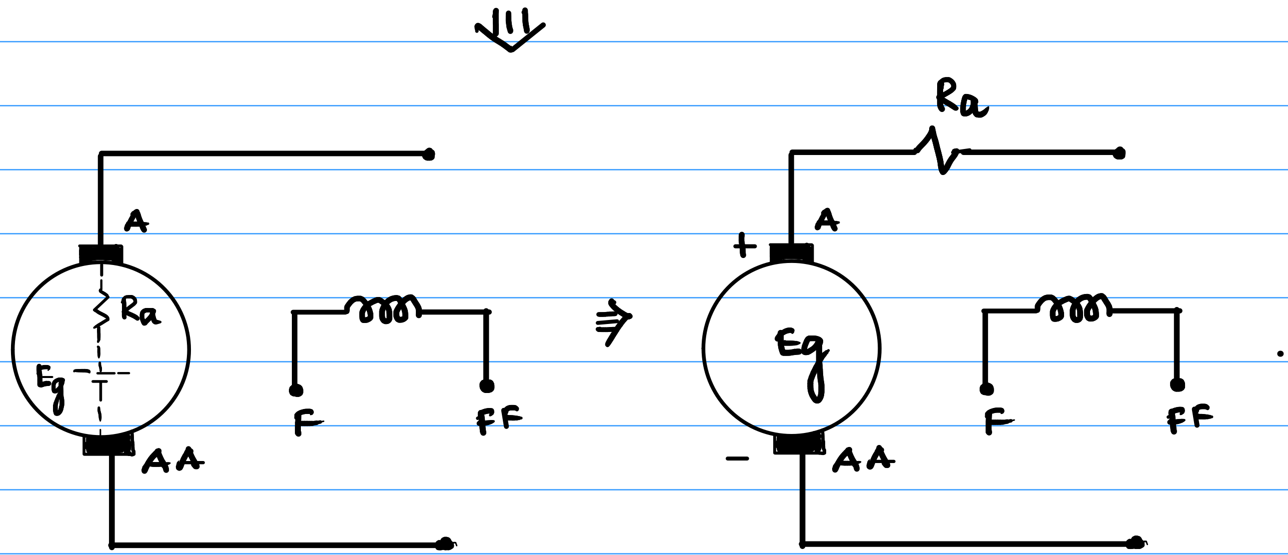
$N = 1500$ RPM

Different types of DC Generators :-



Symbolically the generator can be represented by





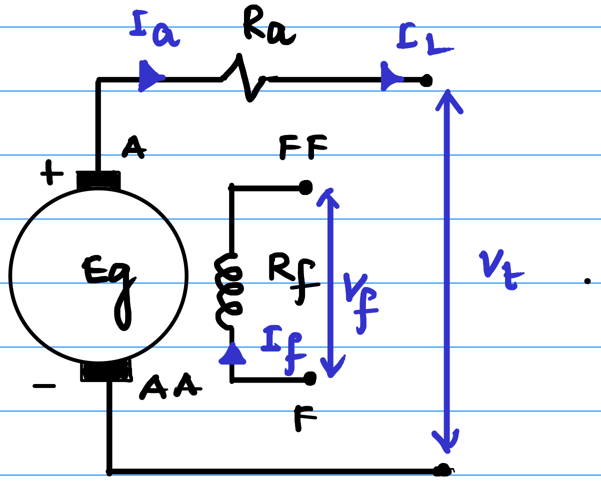
Depending on the Connection of the field coil to the armature different DC generators are possible

i) Separately excited DC generator

ii) Shunt excited DC generator

iii) Series excited DC generator.

Separately excited DC Gen :-



$V_f = I_f R_f$

$V_t = E_g - I_a R_a - 2V_{brush}$

$E_g = \frac{\phi Z N}{60}\left(\frac{P}{A}\right)$

$I_a = I_L$

Electrical power generated $P_g = E_g I_a$

$(P_{cu})_a = I_a^2 R_a = I_L^2 R_a$

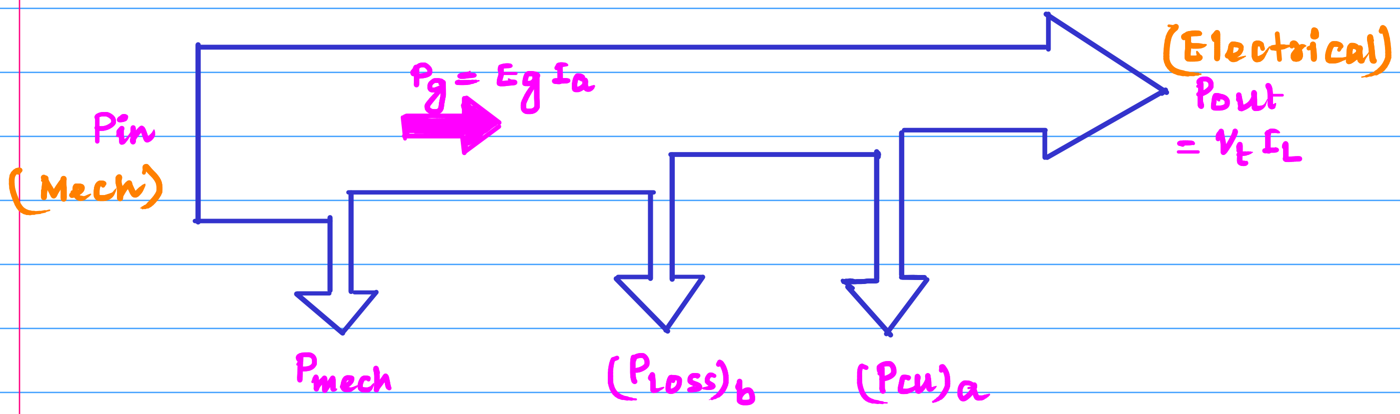
$(P_{cu})_f = I_f^2 R_f = V_f^2 / R_f$

$\omega = \frac{2\pi N}{60}$ rad/sec

N = Speed in RPM

$(P_{loss})_b = 2V_{brush} I_a$

P_{mech} = Friction and windage loss



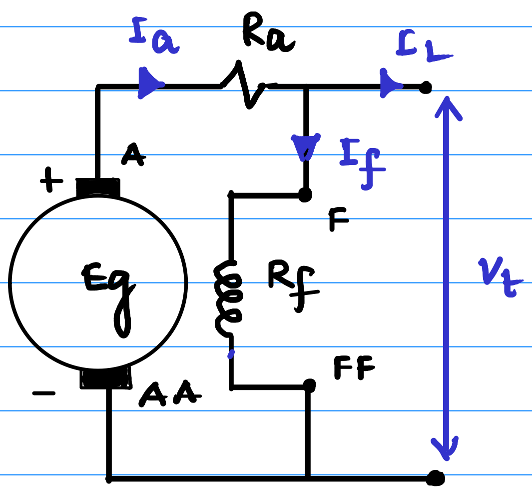
Power flow diagram of separately excited DC Generator.

Efficiency for DC generator

$$= \frac{P_{out}}{P_{in}} \times 100$$

$$= \frac{P_{out}}{P_{out} + (P_{cu})_a + (P_{loss})_b + P_{mech}} \times 100\ \%$$

Shunt Excited DC Generator :-



$V_t = E_g - I_a R_a - 2V_{brush}$

$E_g = \frac{\phi Z N}{60}\left(\frac{P}{A}\right)$

$I_a = I_f + I_L$

Electric Power Generated $= P_g = E_g I_a$

$(P_{cu})_a = I_a^2 R_a$

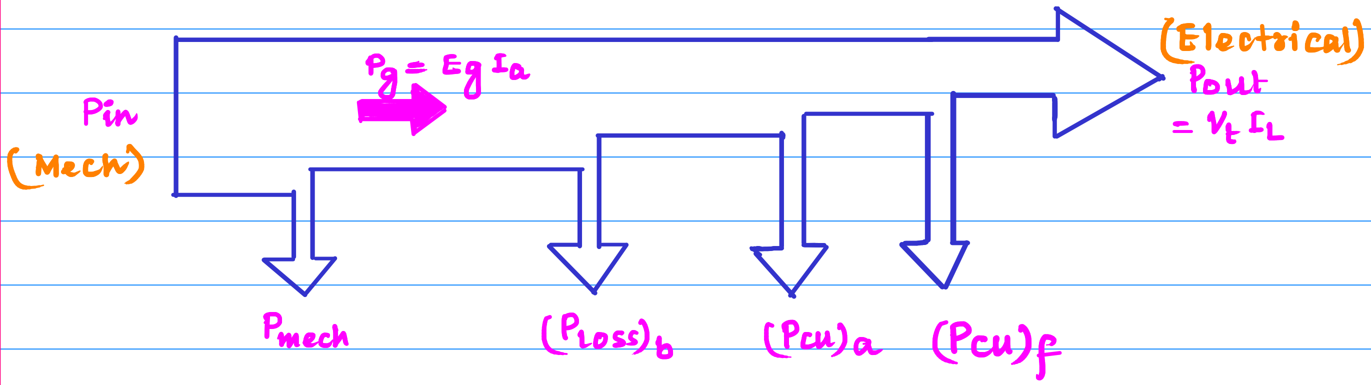
$(P_{cu})_f = I_f^2 R_f = V_t^2 / R_f$

$(P_{loss})_b = 2 V_{brush} I_a$

P_{mech} = Friction and windage loss

$\omega = \frac{2\pi N}{60}$ rad/sec

N = Speed in RPM



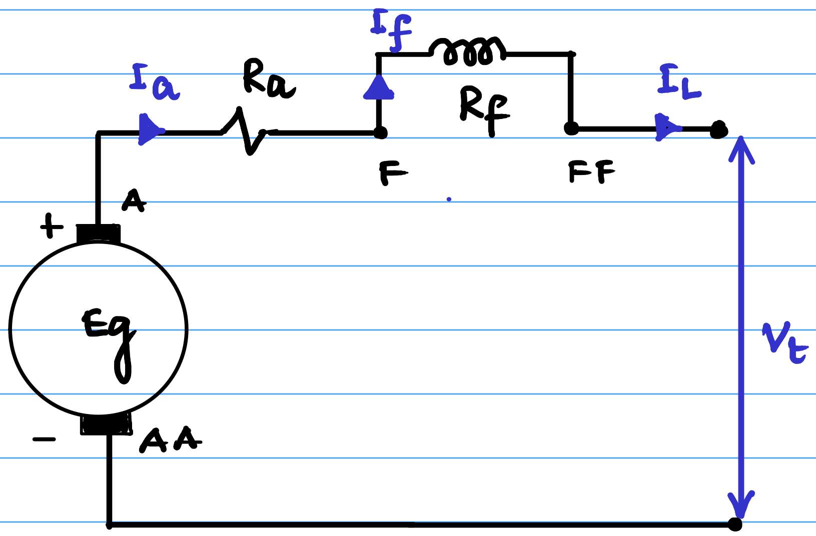
Power flow diagram of Shunt excited DC Generator.

Efficiency for DC generator

$$= \frac{P_{out}}{P_{in}} \times 100$$

$$= \frac{P_{out} \times 100}{P_{out} + (P_{cu})_a + (P_{loss})_b + P_{mech} + (P_{cu})_f} \%$$

Series Excited DC Generator :-



$$V_t = E_g - I_a(R_a + R_f) - 2V_{brush}$$

$$E_g = \frac{\phi Z N}{60}\left(\frac{P}{A}\right)$$

$$I_a = I_f = I_L$$

Electric Power Generated = $P_g = E_g I_a$

$$(P_{cu})_a = I_a^2 R_a$$

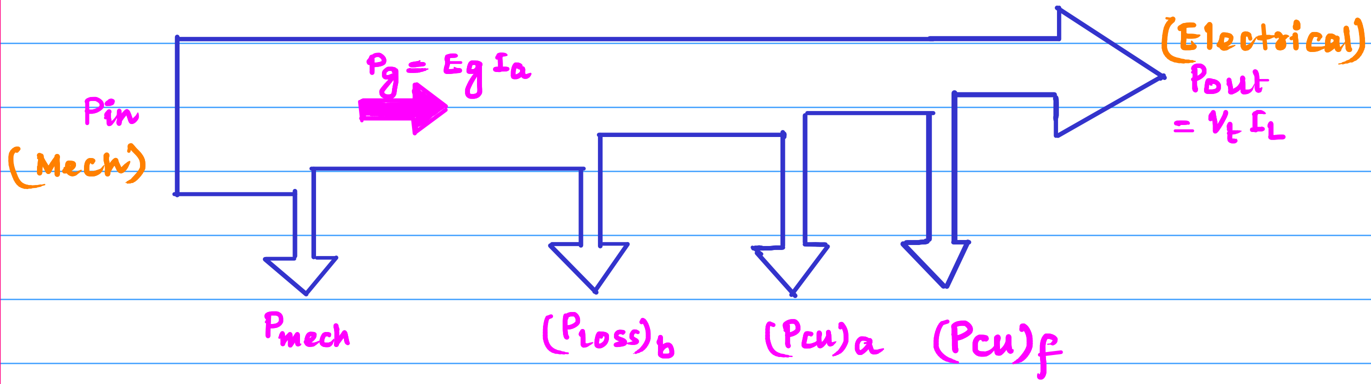
$$(P_{cu})_f = I_f^2 R_f = I_a^2 R_f$$

$$(P_{loss})_b = 2V_{brush} I_a$$

P_{mech} = Friction and windage loss

$\omega = \frac{2\pi N}{60}$ rad/sec

N = Speed in RPM



Power flow diagram of Series excited DC Generator.

Efficiency for DC generator

$$= \frac{P_{out}}{P_{in}} \times 100$$

$$= \frac{P_{out} \times 100}{P_{out} + (P_{cu})_a + (P_{loss})_b + P_{mech} + (P_{cu})_f} \%$$

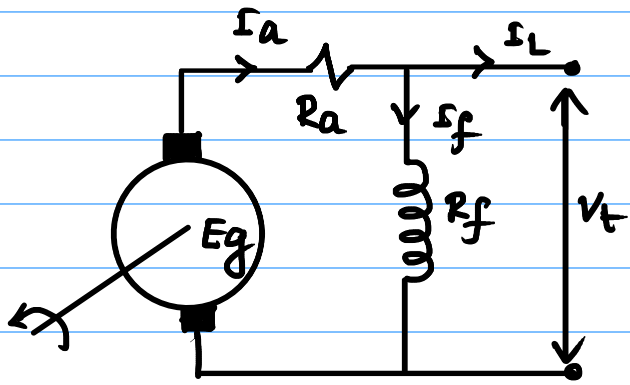
PROBLEM:-

A shunt generator delivers 450 A at 230 V

$R_f = 50\,\Omega$ $\quad R_a = 0.3\,\Omega$

$P_{mech} = 2000$ watt

Sol^n:



$V_t = ?$

$I_L = ?$

$I_f = ?$

$I_a = I_L + I_f = ?$

$E_g = V_t + I_a R_a = ?$

$P_g = E_b I_a = ?$

$(P_{cu})_f = ?$

$(P_{cu})_a = ?$

$P_{in} = P_g + P_{mech} = ?$

$P_{out} = ?$

$$\text{efficiency } \eta = \frac{P_{out}}{P_{in}} \times 100 = ?$$

Problem :-

Separately excited DC generator delivers 150 A to a const. resistive load at 400V and 1000 rpm. $R_a = 0.12\,\Omega$

Current reduced to 100 A.

Determine Speed.

[Total Brush Contact Drop = 2 V]

Sol^n^

$$E_g = V_t + I_a R_a = ?$$

Load Resistance is constant

$$R_L = ?$$

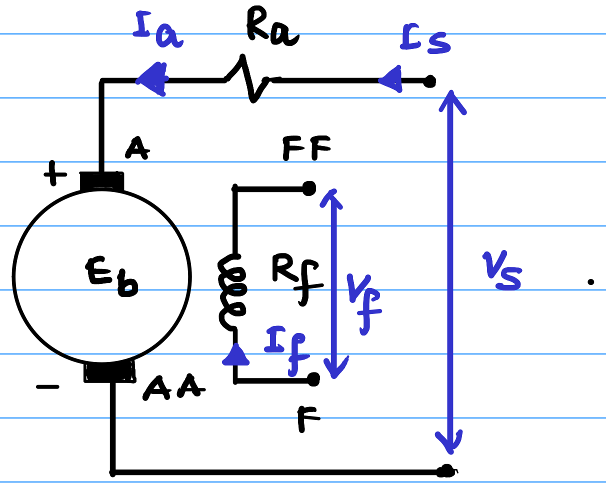
$$V_t' = R_L \times I_L' = ?$$

$$E_g' = V_t' + I_a' R_a = ?$$

$$\frac{E_g}{E_g'} = \frac{N_1}{N_2} = \frac{1000}{N_2}$$

$$N_2 = ?$$

Separately excited DC Motor:-



$$V_f = I_f R_f$$

$$V_s = E_b + I_a R_a + 2V_{brush}$$

$$E_b = \frac{\phi Z N}{60}\left(\frac{P}{A}\right)$$

$$I_a = I_s$$

Gross mechanical power developed = $P_{gross} = E_b I_a$

$$(P_{cu})_a = I_a^2 R_a = I_L^2 R_a$$

$$(P_{cu})_f = I_f^2 R_f = V_f^2 / R_f$$

$$\omega = \frac{2\pi N}{60} \text{ rad/sec}$$

N = Speed in RPM

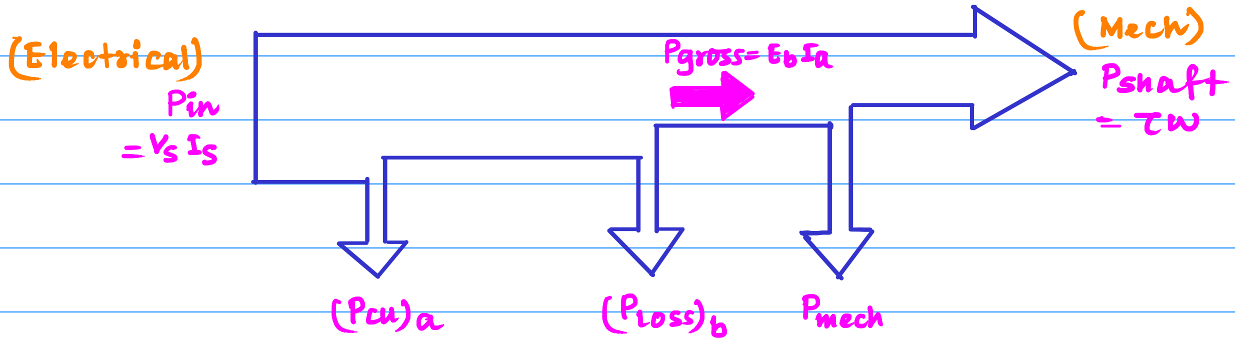
$$(P_{loss})_b = 2V_{brush} I_a$$

P_{mech} = Friction and windage loss

Shaft power developed → $P_{shaft} = P_{gross} - P_{mech}$

$$\tau_{gross} = \frac{P_{gross}}{\omega} \qquad \tau_{shaft} = \frac{P_{shaft}}{\omega}$$

$$\omega = \frac{2\pi N}{60} \text{ rad/sec.}$$



Power flow diagram of separately excited DC Motor

Efficiency for DC Motor

$$= \frac{P_{out}}{P_{in}} \times 100$$

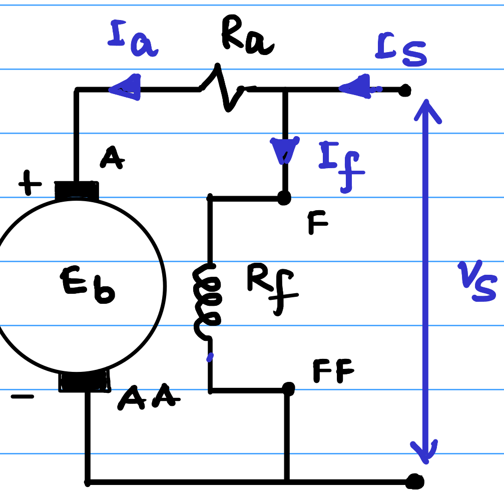
$$= \frac{P_{out}}{P_{out} + (P_{cu})_a + (P_{loss})_b + P_{mech}} \times 100\ \%$$

Shunt DC Motor :-

$$V_s = E_b + I_a R_a + 2V_{brush}$$

$$E_b = \frac{\phi Z N}{60}\left(\frac{P}{A}\right)$$

$$I_s = I_f + I_a$$

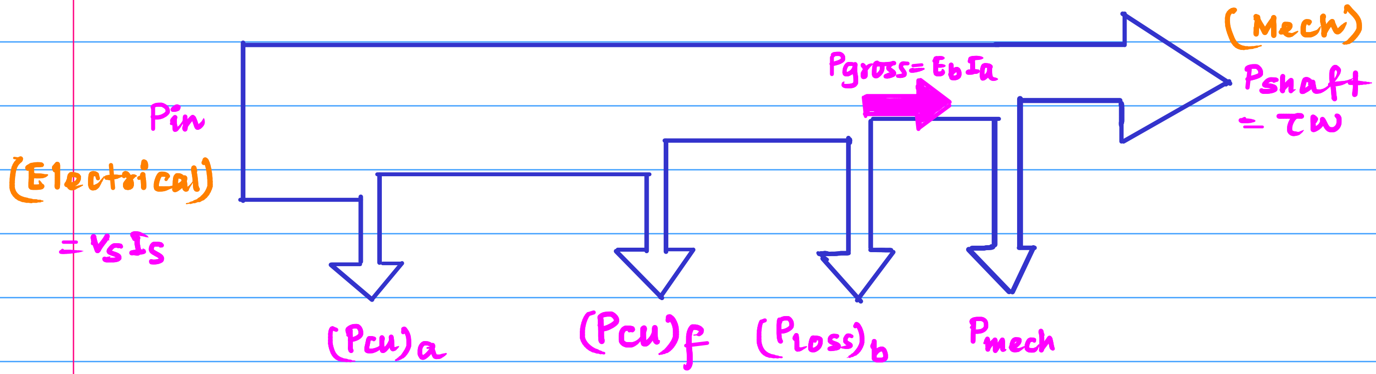


Gross Mechanical Power Developed ⇒ $P_{gross} = E_b I_a$

Shaft power developed → $P_{shaft} = P_{gross} - P_{mech}$

$$\tau_{gross} = \frac{P_{gross}}{\omega} \qquad \tau_{shaft} = \frac{P_{shaft}}{\omega}$$

$$\omega = \frac{2\pi N}{60} \text{ rad/sec.}$$



Power flow diagram of DC shunt Motor

Efficiency for DC Motor

$$= \frac{P_{out}}{P_{in}} \times 100$$

$$= \frac{P_{out}}{P_{out} + (P_{cu})_a + (P_{loss})_b + (P_{cu})_f + P_{mech}} \times 100\ \%$$