DC machines – Electromechanical Energy conversion

Commutator
Brushes
wave windings
lap windings

shunt machines
series machines
separately excited machines

armature coil (coil in which voltage is induced)

E (EMF induced) $= (\bar{V} \times \bar{B}) \cdot l$

$E = 2BlV \cos\theta$ ← position of the coil

when current was injected in the loop then,

$\tau = BIl \sin\theta$

and also was sinusoidally varying

↓

sinusoidally varying quantity on the rotor

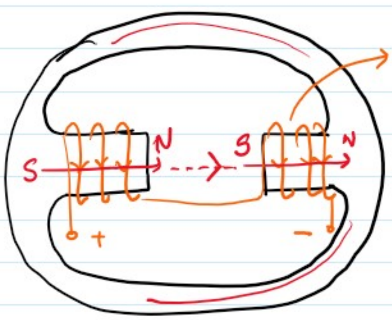
↓

For DC machines we want DC quantity on the rotor

↓

How do we get this?

↓

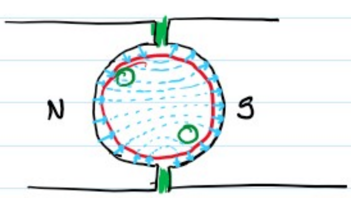


field coil

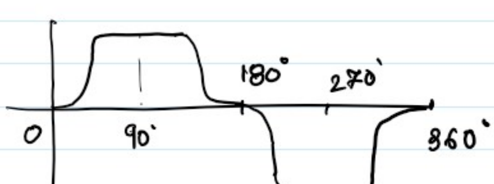
∵ it is setting up the constant magnetic field in which rotor rotates

↓

setup constant magnetic field that is created by injecting DC current

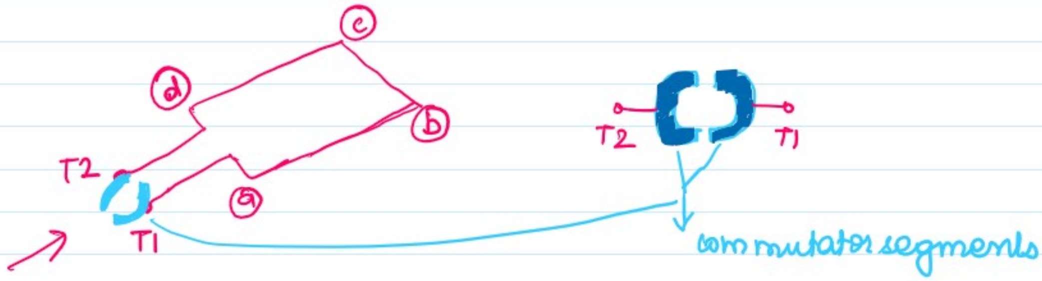


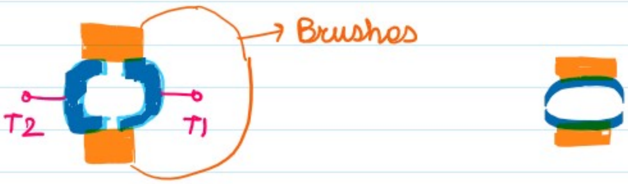
- The magnetic poles on the field coil and structure of the rotor are circular (3D – cylindrical)
- field is perpendicular to pole face & rotor and goes through the air gap



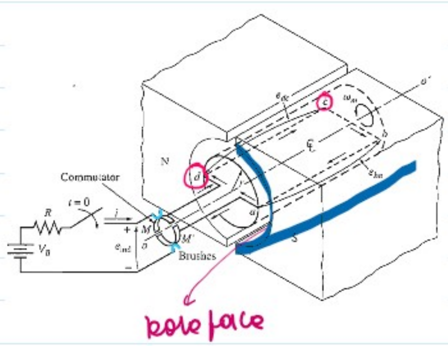
EMF

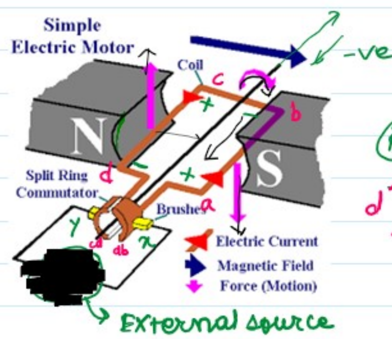
Commutator along brushes $\left[\text{Rectifiers} \rightarrow \text{AC to DC}\right]$
↓
mechanical rectifiers

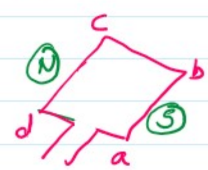




Commutator + Brushes = Rectification Action





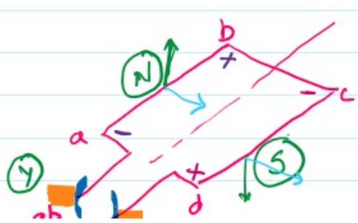


$E = (\underbrace{\bar{V} \times \bar{B}}) \cdot L$ $\qquad E_{cd} = BLV$

$E_{bc} = 0$ $\qquad E_{ab} = (\bar{V} \times \bar{B}) \cdot L = -BLV$

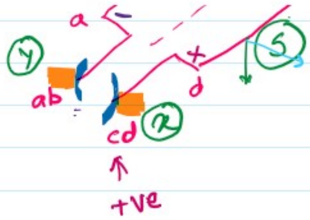
Brushes	polarity of brushes	polarity of commutator segments
x	+ve	ab – $\boxed{x}$ – +ve
y	–ve	cd – y – –ve

Brushes are fixed (they cannot rotate/move)
Commutator segments are moving



180° rotation

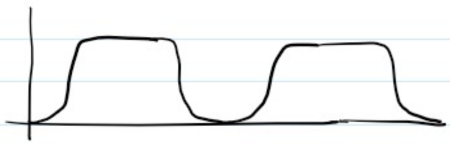
Brushes	polarity of brushes	polarity of commutator segments
x	+ve	cd – x – +ve potential
y	–ve	ab – $\boxed{y}$ – –ve potential



x +ve
Y −ve

cd − (x) − +ve potential
ab − $\boxed{Y}$ − −ve potential

DC signal coming out of the brushes.



average of this is DC value

$E = 2BLV$ ← $B = \phi/A$

we have two magnetic poles which are cylindrical

cross section is circular $A_c = \pi r^2$

The armature is cylindrical also the field coils have cylindrical
there is very small air gap

The surface of the field coil = $2\pi r l$

length of the coil

radius of the pole face
↓
radius of the rotor
↓
∵ airgap is small
$R = 10cm$
$l_g = 2mm$

the area per pole = $\frac{2\pi r l}{2}$

$$\boxed{A_p = \frac{2\pi r l}{P}}$$

$E = 2BLV$,

$B = \Phi_P/A_P$ $\Phi_P = A_P B$

$E = 2 \cdot l r \omega \cdot B$

$= 2 l r \omega \cdot \left(\frac{2\pi}{2\pi}\right) \cdot \frac{P}{P} \cdot B$ $V = r\omega$

$= 2 \cdot \left(\frac{2\pi r l}{P}\right) \cdot \frac{P}{2\pi} B \cdot \omega$

$= 2 \cdot \left(\frac{P}{2\pi}\right) \omega \cdot \boxed{\left(\frac{2\pi r l}{P}\right) B} \longrightarrow \Phi_P$ = flux per pole

$$\boxed{E = 2 \cdot \left(\frac{P}{2\pi}\right) \omega \cdot \Phi_P}$$

$$E = \frac{Z \cdot P}{2\pi} \phi_p \omega$$

$$\boxed{E = k' \phi_p \omega}$$

ϕ_p - flux per pole
ω - speed of rotation
k' - geometry

$$\tau = \underline{\underline{B}} I l$$

$$\rightarrow \tau = k \phi_p I$$

k - geometry
ϕ_p flux per pole
I - current