DC MACHINE

A Common name given 2- types of machine — (1) DC Generator

(2) DC motor

There Construction is identical & they also Operate on DC Supply. A Generator Can be Operated as motor as well as motor Can be Operated as a Generator.

DC Generator - A device which takes the Advantages of electromagnetic Induction.

In order to Convert mechanical movement into electricity.

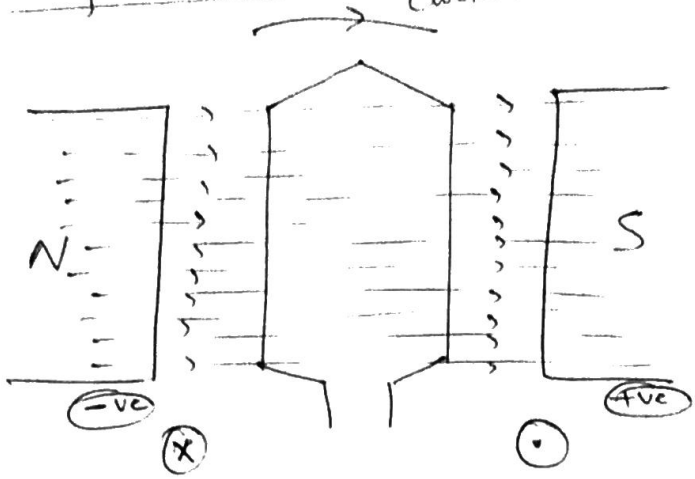
A Generator Cannot generate Voltage by itself. But it only Converts given mechanical Input into electrical output.

According FLEMI 3 things are required. to depicted in DC Generator.

(1) Flux (2) Conductor (3) Prime mover.

FLEMI → Faraday law of electro magnet Induction.

Principle of operation



Consider a pair of poles, South & North.
and a single turn coil rotating clockwise.
B/w the poles.

In gen.

(known)
M ⟶ E

(Flemings R.H. Rule)

Thumb ⟶ motion
fore finger ⟶ flux
middle ⟶ V & I

In motor

E ⟶ M (known)

(f. L.H. Rule)

Flux linkage (λ)

$$\lambda = N \cdot \phi$$

$$e = \frac{d\lambda}{dt} = N\frac{d\phi}{dt} \text{ volt}$$

Emil lenz:

Resultant oppose Cause.

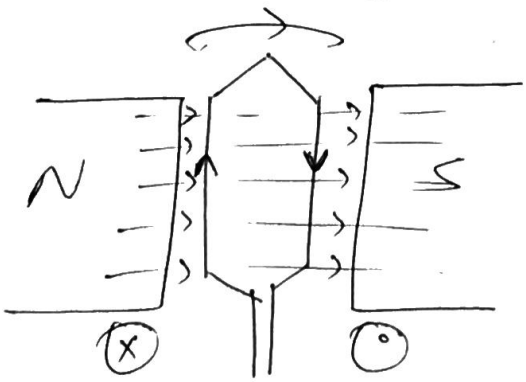
$$\left[e = -N \cdot \frac{d\phi}{dt} \right]$$

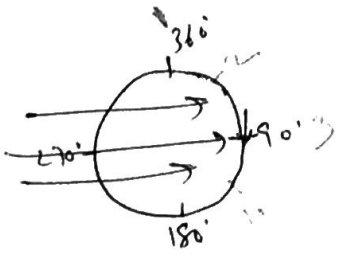
to represent lenz law, (resultant opposes cause)

-ve sign used

$$e = N \cdot \frac{d\phi}{dt} \cdot \frac{di}{di} = N \cdot \frac{d\phi}{di} \cdot \frac{di}{dt}$$

$$\boxed{e = L \cdot \frac{di}{dt}}$$

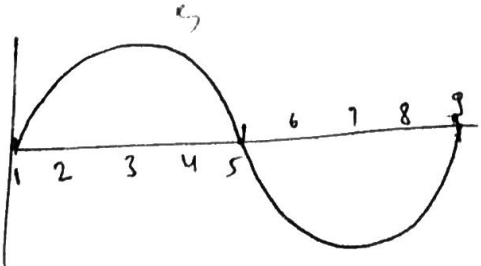




$$e = B \, l \, v \sin\phi$$

(length, velocity)

$$\boxed{e = N \cdot \frac{d\phi}{dt}}$$



Consider Conductor Complete a cycle of 360° mech. degree from Position 1 to 5.

the Conductor in the influence of South pole. & Position 1 & 5 the Conductor is rotating adjectly Parallel to the flux lines therefore no flux linkage. and the emf induce become zero as the rate of flux linkage become zero.

At Position 3, the Conductor moves ⊥ to (P. Perd.) the flux line which results in max. flux linkage, max. induce emf.

$$e = B l v \sin\theta$$

'θ' → is angle B/w Conductor rotation & the flux lines. [$\sin 0 = 0$, (At 1 & 5) & $\sin 90 = 1$ (At P. 3)]

As the Conductor is under the influence of South Pole. a +ve Cycle is Considered. the same Conductor in the next half cycle of rotation. Comes under the influence of north pole.

therefore opposite Polarity emf is induced.

In one Complete mech. rotation there is +ve or -ve ½ Cycle. known as alternating Current or Voltage. which is in periodic nature.

therefore in a DC generator AC is induced this should be rectified.

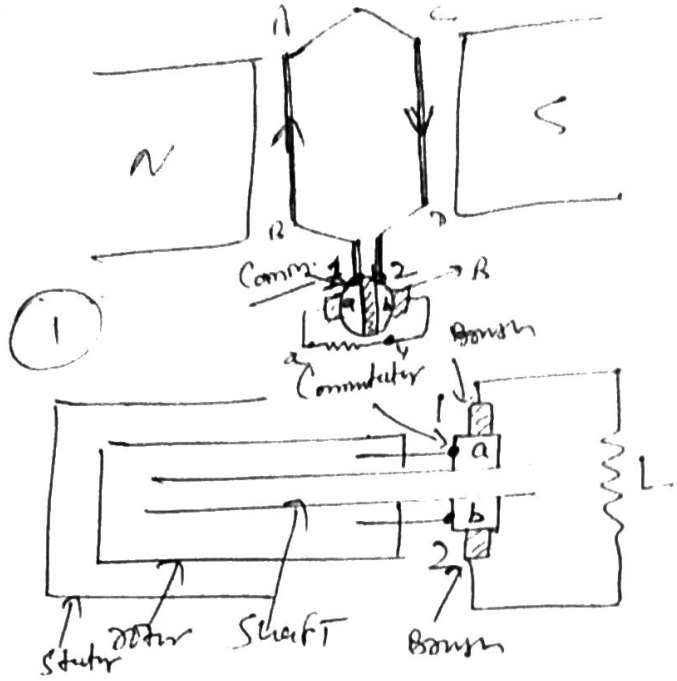
Rotating Commutator

(0 – 180°) →

BACDb2YX1a

→ diren of flow current

(If Comm. rotated)

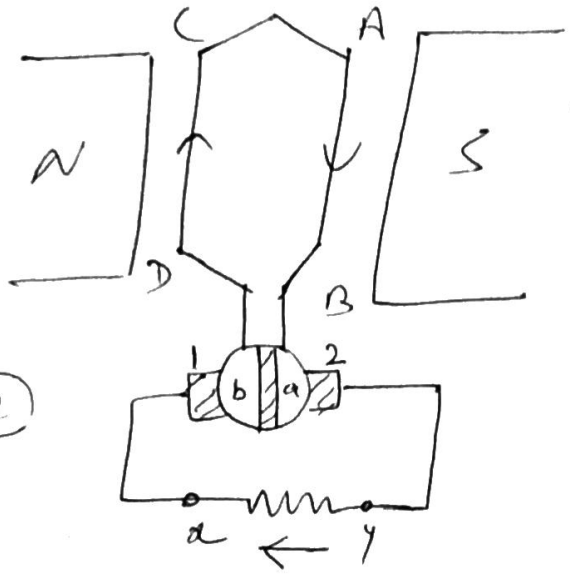


(180 → 360°) →

DCABa2YX1b

(diren of flow of current)

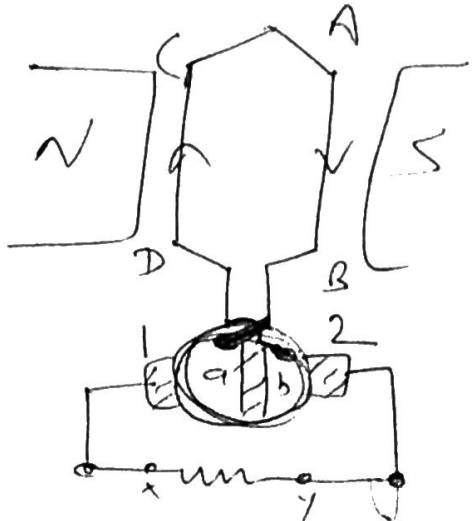
(If Commutator rotated) with Coil



(180 – 360)

When Comm. not rotate with Coil

DCAB.a1XY2b →



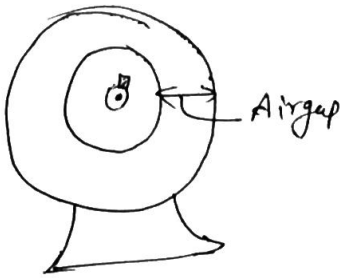
The Commutator Converts bidirectionaly induced emf into unidirectional. based on its rotation.

. therefore it is called as mechanical rectifier.

This is the basic reason why the Conductors in DC machine are rotating in a stationary field.

Construction Details (Imp. for exams.)

range of Air gap
(.4 mm to 4 mm)



Common features of rotating el. machines

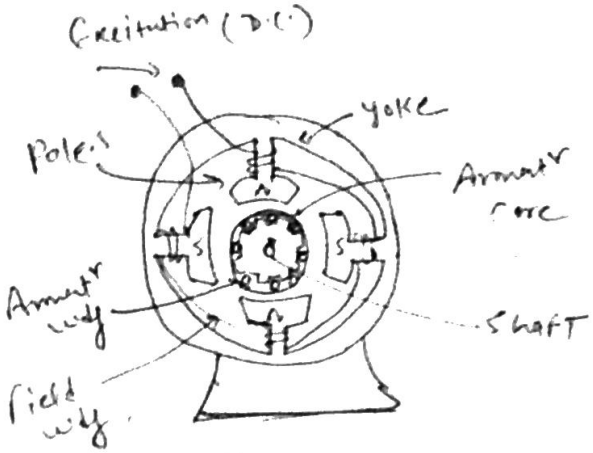
(1) Consist of Stationary Part known as Stator. and a rotating Part known as rotor with an air gap between them. ranging from (.4mm to 4 mm)

the rotor is mounted on a shaft in order to give mechanical I/P or to Collect to it.

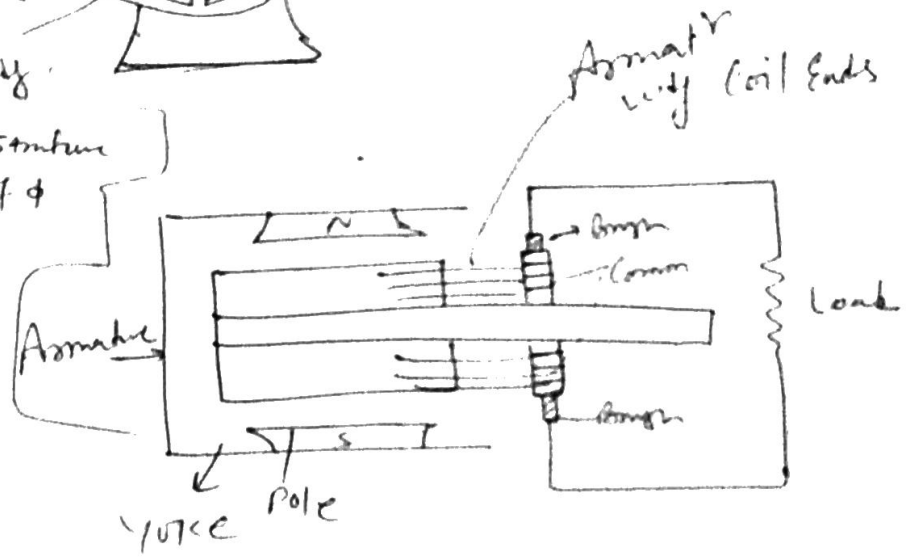
(2) there is a magnetic Circuit where field Current flows and a electrical circuit where load Current flows.

(3) They follow Heteropolar structure (alternate North or South Poles of even No.)

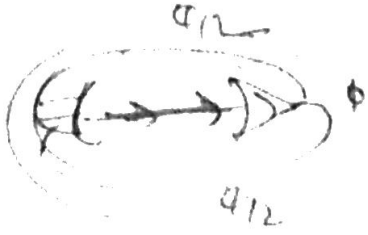
(4) Excitation Voltage is always D.C.

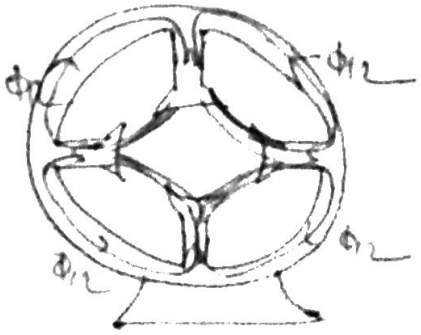


According to heteropolar structure in P- pole m/c ∴ of ϕ flux per pole the flux flowing through yoke will be only $\phi/2$



Yoke:→





The Basic fun. of yoke is the mech. Covering of entire machine also support the Poles.

Another imp. fun. is it offers flux path Completion.

Therefore yoke should be a good magnetic material. for small machines Cast iron is used.

for large machines Steel yokes are used.

⇒ When the DC machines are operating under Power electronic Converter Circuit the yoke should be laminated

Pole

① The function of a Pole is to produce working flux in m/c. the fundmental Source of flux is P. magnet.

These are naturally obtained and uncontrollable in nature.

Only Small m/c P.m. is used.

② The flux should be Controllable (variable), to control the machine.

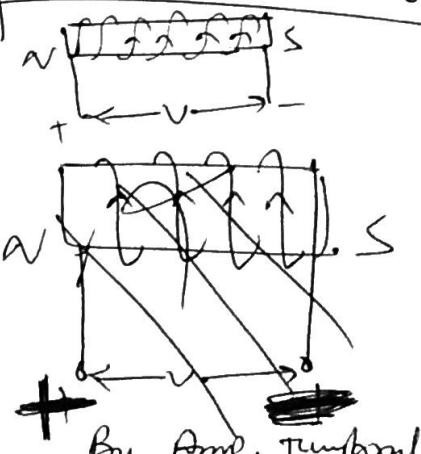
The generator induced emf is directly proportional to the flux. the torque of a motor is directly proportional to flux.

Erected

gives — Current Carry Conductor Surround by mag. field.

P.magnet → uncontrollable

Electromagnet → Control able



By. Amp. Tumbrule or R.H. Rule

and it's speed inversely proptional to flux. Therefore electromagnets are used which are controllable in nature.

Electromagnet

According to ORested a current carrying conductor is surrounded by a magnetic field in concentric circuits. direction given by R.H. Thumb Rule. or Amp. Thumb Rule.

Faraday observ that this current carrying conductor is wound on ferromagnetic material in N No. of turns. The current flowing in them electromagnetise the material and it act's like a magnet. Called as electromagnet.

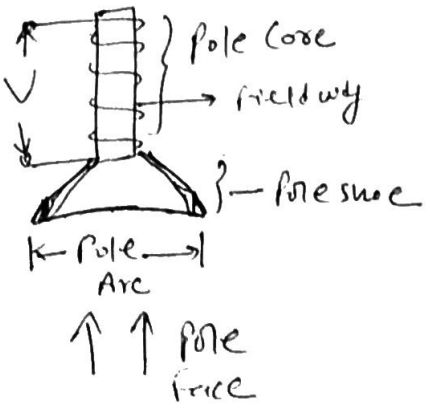
The Principle Cause of flux is (Ampere-turn's) also called as MMF.

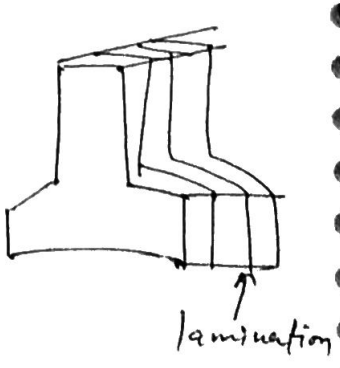
$$(mmf = N \cdot I)$$

$$\Phi = \frac{MMF}{Rel.}, \quad Rel = \frac{mmf}{\Phi} = \frac{NI}{Wb}$$

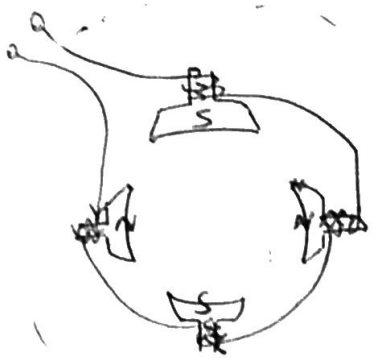
The voltage given across turns is known as excitation voltage. By varying excitation current or No. of turns flux can be varied

Pole:





Excitation:- It is essentially D.C. In order to have a definite a North & South Pole the Polarity of the Pole depends on the direction of current as well as orientation of field wdg. Technically called as Sense of winding.



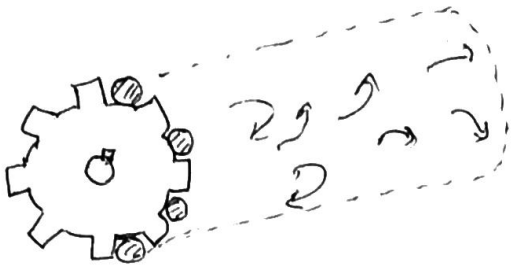
(orientation) OR Sense

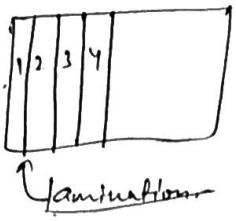
A pole is Nothing but electromagnet. made up of Silicon Steel Lamination. It Consist of a Pole Core where field wdg is done and the Pole shoe to Spread out Flux uniformly on the armature. It reduce the reluctance of area.

The orientation of the field wdg will be alternately opposite. In order to have heteropolar structure.

The No. of turns on Pole Core of the all Poles will be equally designed. the Cross Sectional area of the field wdg depends on the type of DC Machine.

Armature Core





The Core material ~~Conductor~~ should Contain Superior magnet Property. bcoz it's basic fun. is to hold the armature Conductor's. the emf is induced in the Conductor's and all the mechanical to electrical Conversion occurs in the armature. which is a rotating part. therefore it requires a good mechanical Property also.

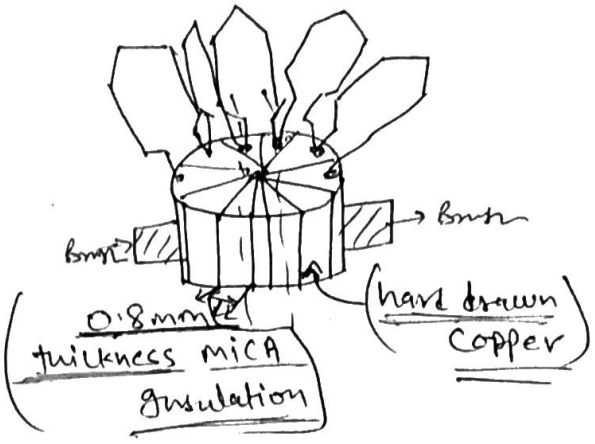
Steel is most ~~Pref~~ferd material bcoz of its Superior magnetic & mechanical Properties but it Contains high Conductivity. when the Core Rotates it cuts the flux & emf is induced. which produce undesirable Current's. which have No definite direction. Circulating within the Core Called as eddy Currents.

these give rise to eddy Current loss associated with temp. rise. which damage the insulation. to reduce these eddy Current —

laminated core is designed.

In place of a single core thin sheets which are insulated are joined together. they are electrically isolated each lamination act as an individual core to form a single core. which reduce eddy currents.

Commutator



the Commutator segments are made up of hard drawn Copper with an insulation of (0.8 mm) thickness of mica.

It is also mounted on shaft along with armature core, therefore called as rotating Commutator

It is an image of armatr coil inside the armature Core.

No. of Commutator segment = No. of Coils.

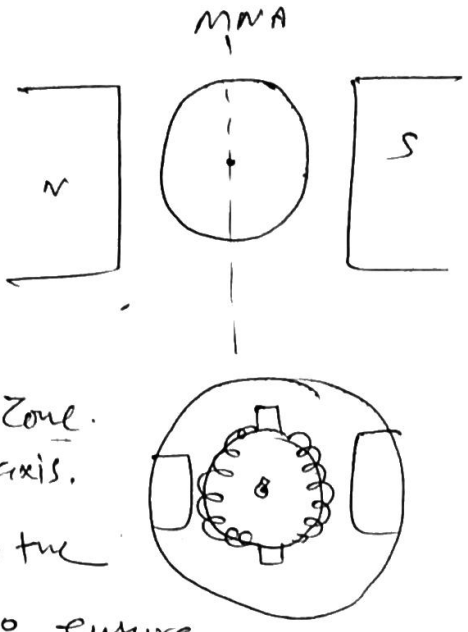
Brushes

These are stationary sliding Contacts which are placed on the Commutator, which ensure electrical Connection B/w rotating Commutator & stationary load.

They play an important role in the operation of DC machine. By collecting -

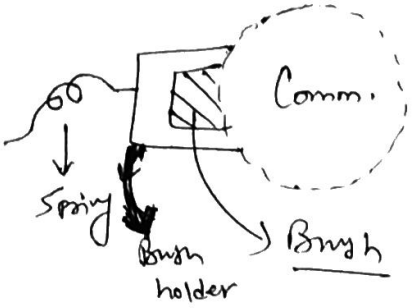
current from the rotating commutator & armatr coil.

If the Brushes collect current without any sparking then the commutation is known as successful commutation.



The Best location of Brushes to be placed on Commutator is in the neutral zone. known as magnetic neutral axis. (MNA). It is generally B/w the Poles. The Brushes has to ensure good mechanical conditions with the Commutator. they should not be tightly held or lossly held

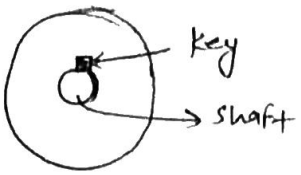
therefore they are placed in Brush holders. through spring. known as spring Pig tail.



generally used Brush material are Copper, *Carbon & *graphite.

SHAFT & Bearings

The armature is key to the shaft. which is used to supply mechanical input. (Prime move is coupled) in case of a generator. & also to collect Mechanical o/p. (loading is done across the shaft.) in a motor.

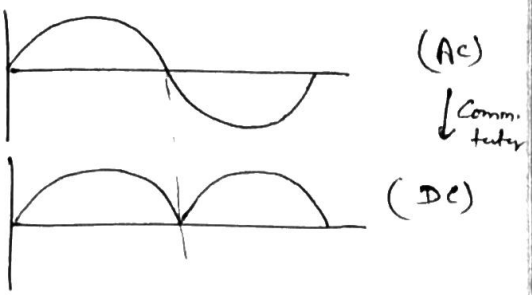


Bearings

Ball	Roller
	

There are 2 - types of Bearings. Small machines Contain Ball Bearings. & large machine Contain Rotter Bearings.

*Armature Winding (imp.)



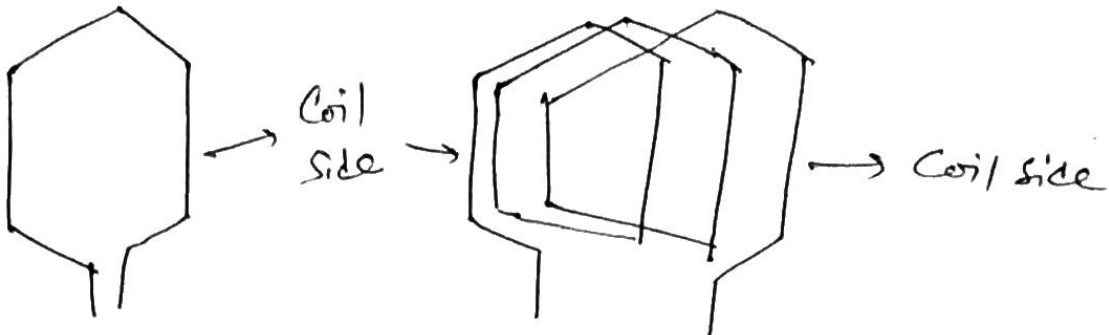
The emf induced in a simple coil is pulsating DC (after commutation) across the brushes. which is not suitable for commercial applications. therefore the waveform shape needs to be improved or the ripple content has to be reduced. this is achieved by using armature winding. armature wdg is no. of coils arranged in series distributed uniformly. throughout the entire peripheral of the armature.

Conductor:- The active length, lying in the magnetic field. which cut the flux & emf is induced

Turn → 2-Conductors make a turn.

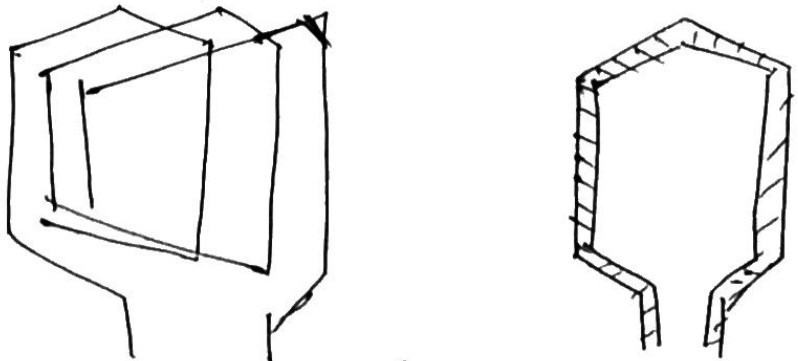
If turn are Z Cond^{r}

then turn = Z/2



Coil — A Coil Can be 1-turn or multiturn Coil.

If the Coil Consist of only one turn it is known as Sigle turn Coil. Generally armature wdg's are designed in multiple turn Coil's only as the voltage of the multiple turn coil is more. all the conductors are Punched together or Strapped ~~Stacked~~ together. to form two Coil Sides.



these Coil Sides are Plaled in the Slot's.