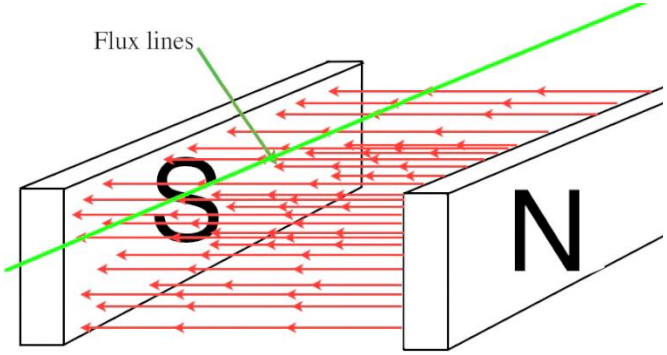
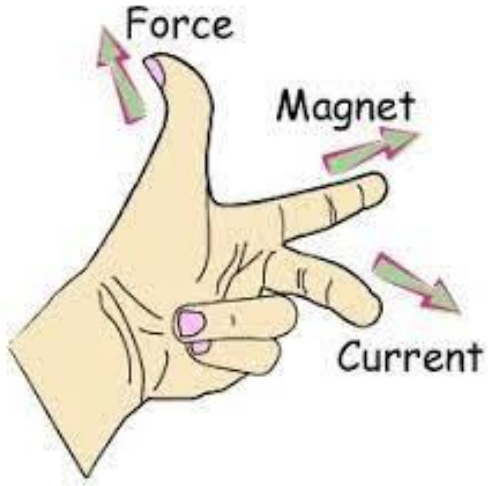
Course Code - EEE-401
Course Title – Energy Conversion and Special Machine
Lecture- Universal Motor

Basic Law

Four basic principles describe how magnetic fields are used in different devices

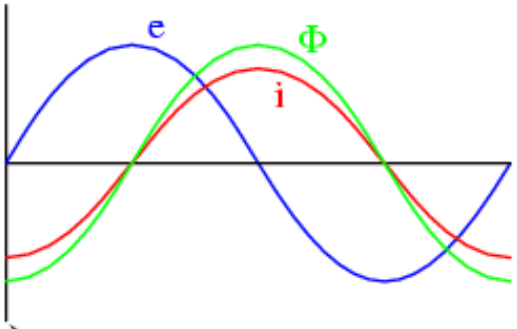


- A current-carrying wire produces a magnetic field in the area around it.
- A time-changing magnetic field induces a voltage in a coil of wire if it passes through that coil. (**This is the basis of transformer action**.)
- A current-carrying wire in the presence of a magnetic field has a force induced on it. (**This is the basis of motor action**.)
- A moving wire in the presence of a magnetic field has a voltage induced in it. (**This is the basis of generator action**.)

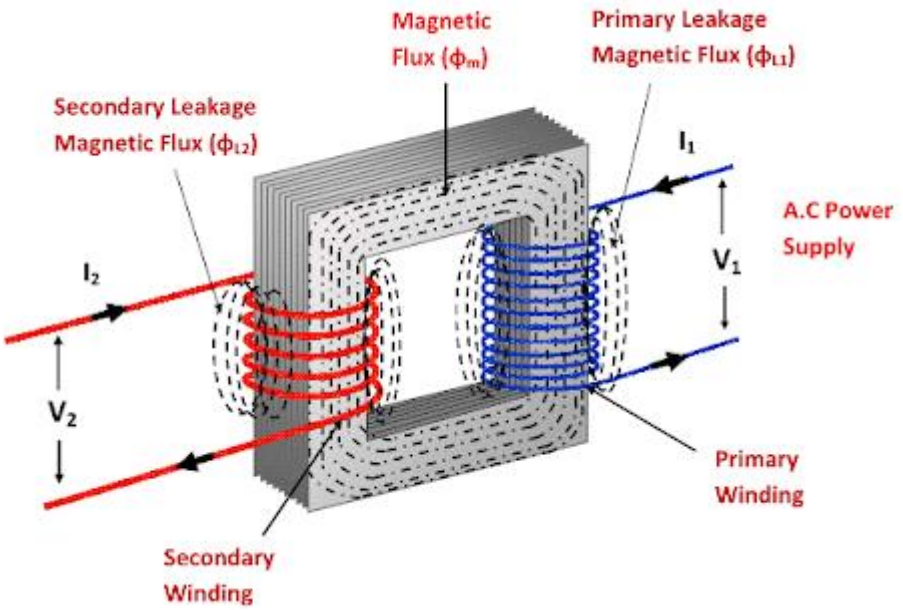


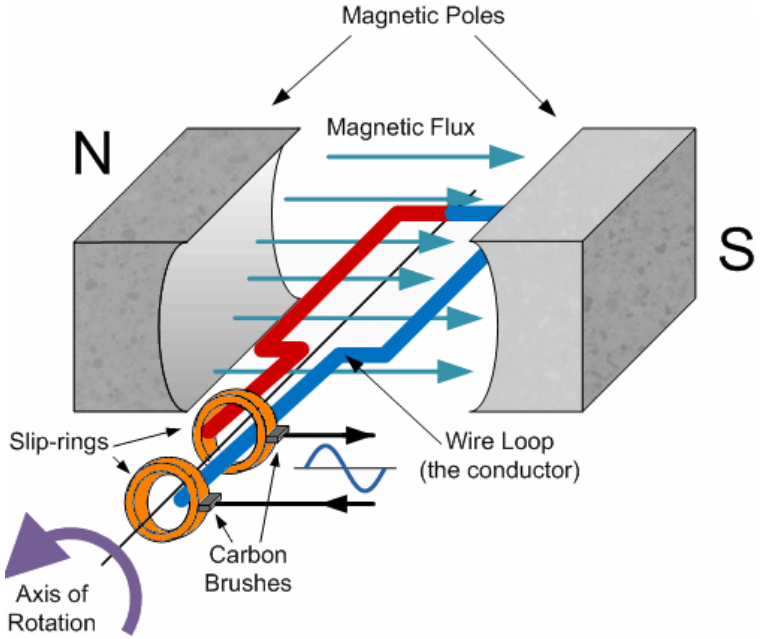
Basic Law

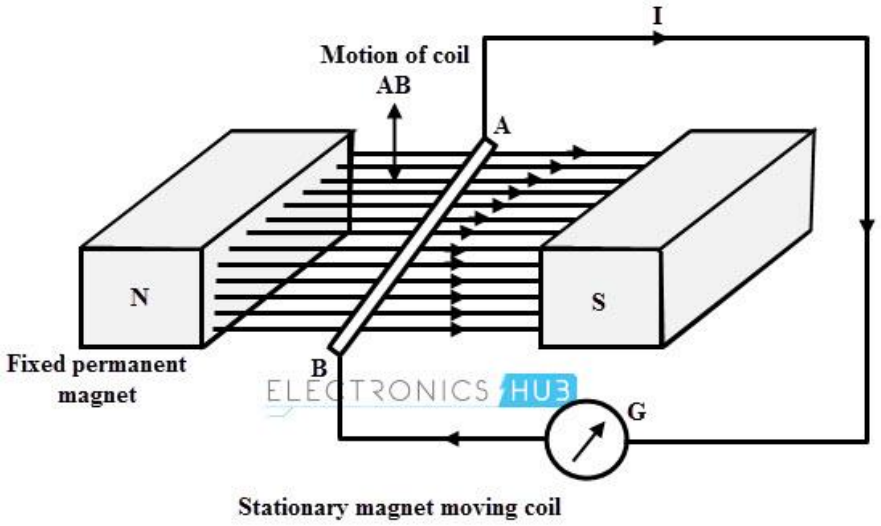
e = voltage
Φ = magnetic flux
i = coil current



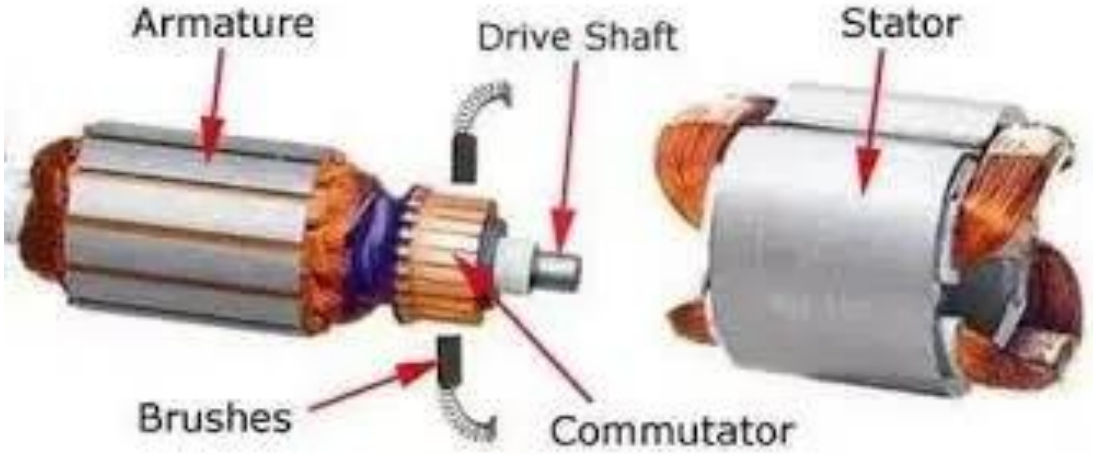
Instant in time when voltage is zero, during continuous operation.

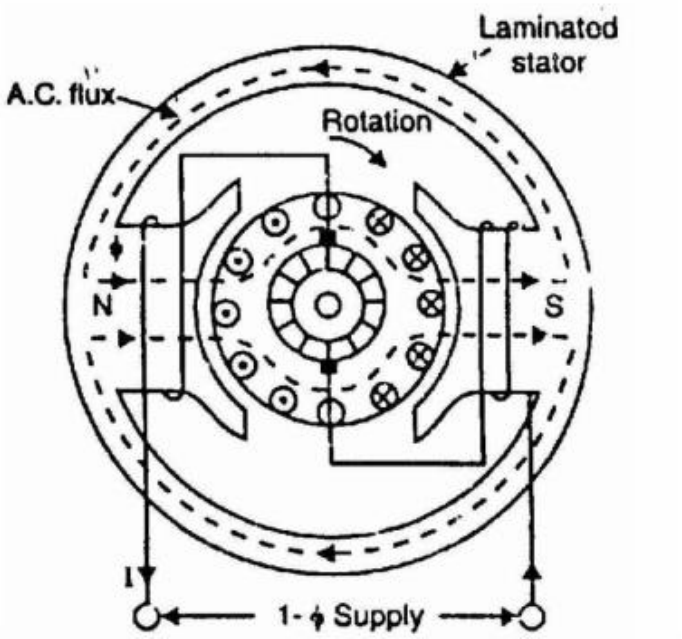


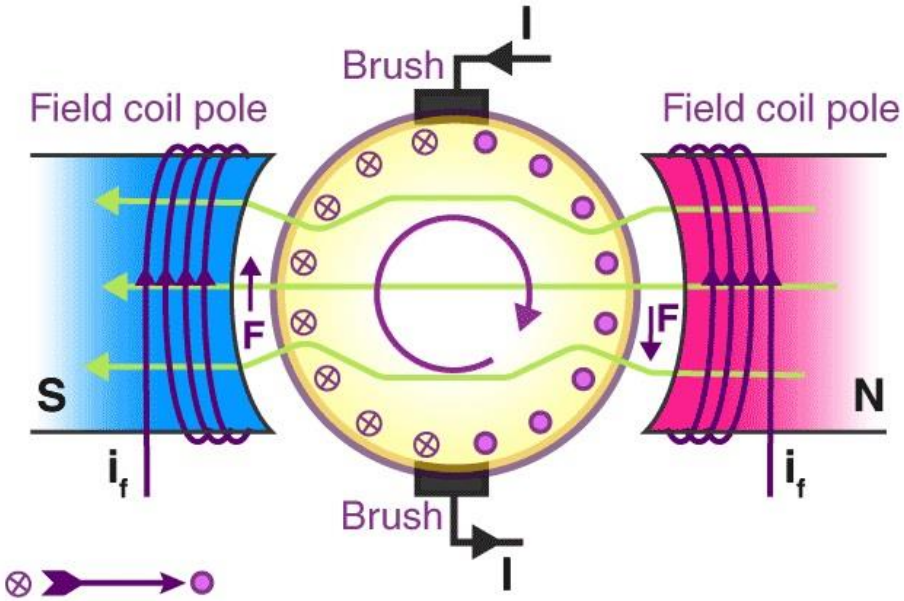


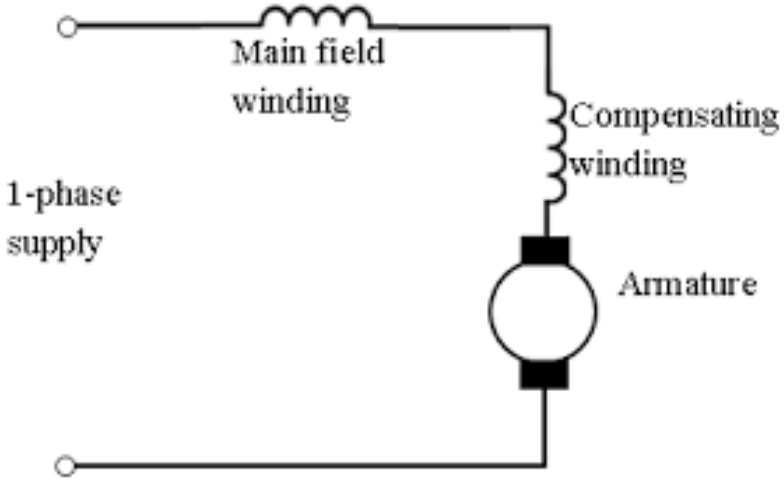


Basic of motor









Single Phase Motor

Single Phase Motor

- Single phase motor is designed to operate from a single- phase supply,
- These are manufactured in a large number of types to perform a wide variety of useful services in home, offices, factories, workshops and in business establishments etc.

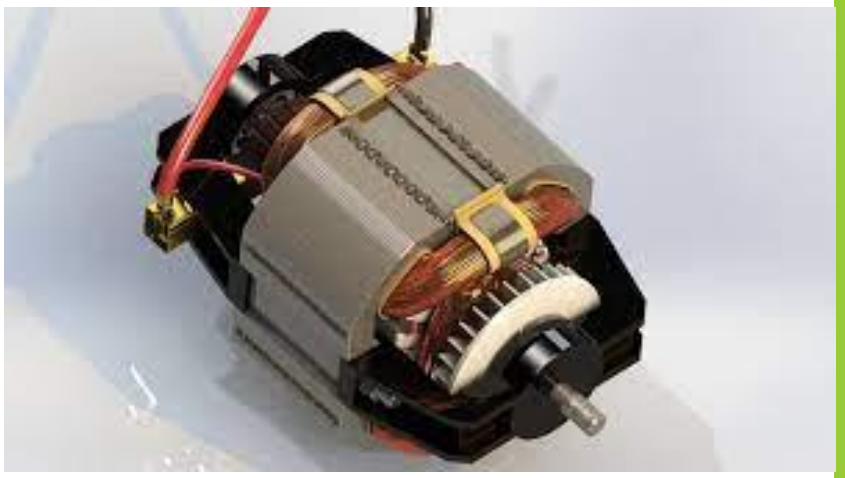
Types of Single Phase Motor

1. Induction Motors (split-phase, capacitor and shaded-pole etc.)
2. **Repulsion Motors** (sometime called Inductive-Series Motors)
3. **A.C. Series Motor**
    i. **Universal Motor**
4. Un-excited Synchronous Motors
    i. **Reluctance Motor**
    ii. **Hysteresis Motor**

Universal Motor

Universal Motor

- A universal motor is a special type of motor which is designed to run on either DC or single phase AC supply.
- These motors are generally series wound (armature and field winding are in series), and hence produce high starting torque.



Application of Universal Motor

- Universal motors find their use in various home appliances like vacuum cleaners, drink and food mixers, domestic sewing machine etc.
- The higher rating universal motors are used in portable drills, blenders etc.

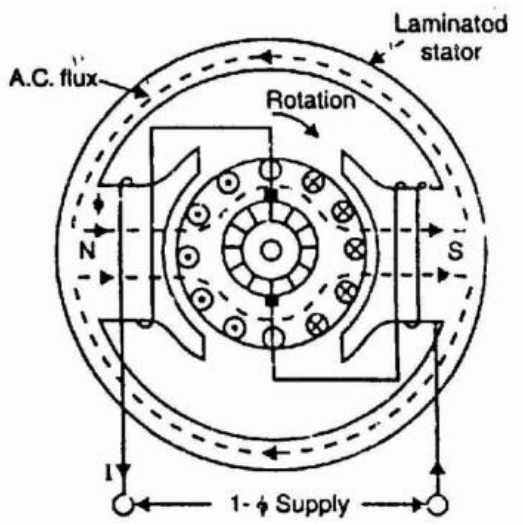
Types of Universal Motor

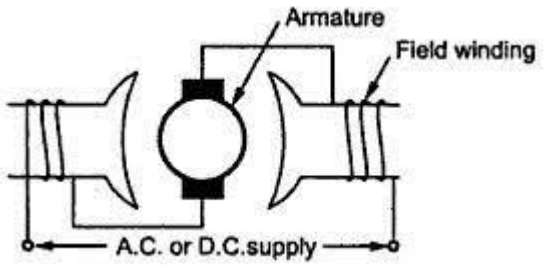
- **Non-Compensated type**(concentrated pole, low power rating)
- **Compensated type**(distributed field, high power rating)

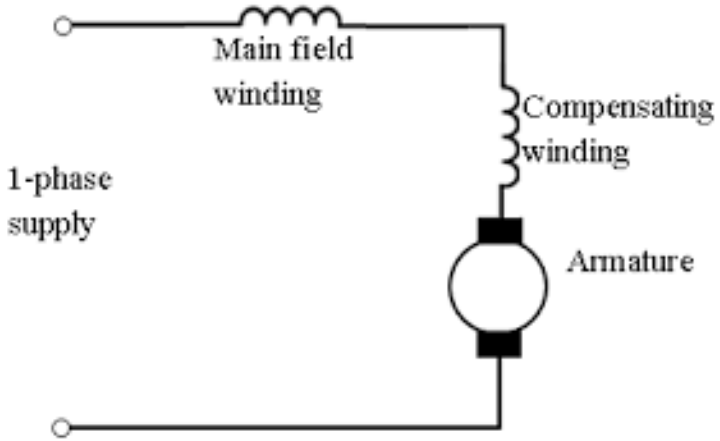
Construction of Universal motor

Construction

- It consists of a **stator** on which field **poles** are mounted.
- **Field coils** are wound on the **field poles**.
- The whole **magnetic path** (stator field circuit and also armature) is laminated. **Lamination** is necessary to minimize the eddy currents which induce while operating on AC.
- The **rotary armature** is of wound type having **straight slots** and **commutator** with **brushes** resting on it.
- The **commutation** on AC is poorer than that for DC. because of the current induced in the armature coils. For that reason **brushes** used are having high resistance.







Working principle of Universal motor

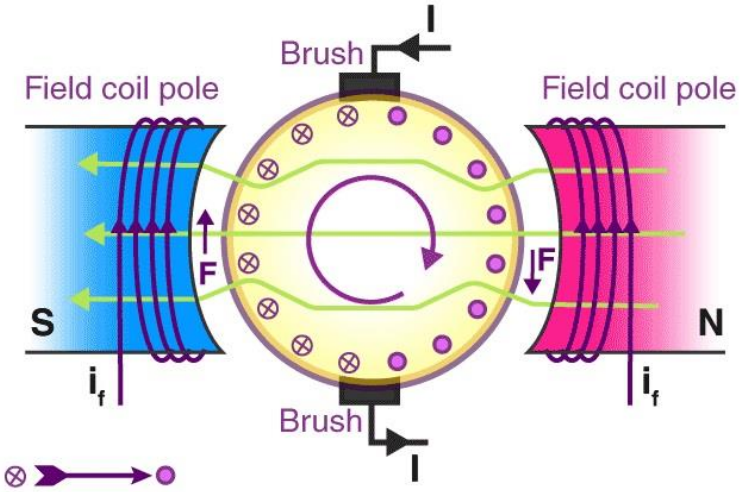
Working principle(DC)

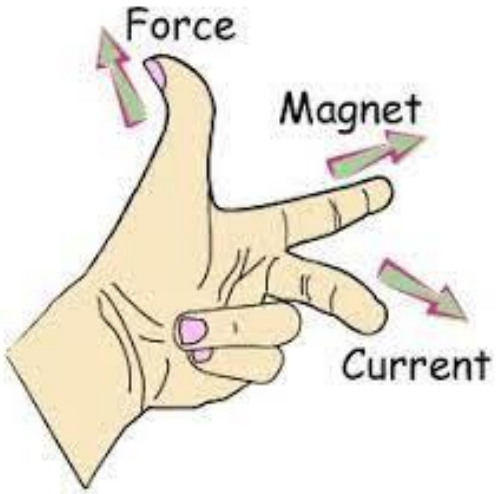
- A universal motor works on either DC or single phase AC supply. When the universal motor is fed with a DC supply, it works as a DC series motor.

- When current flows in the field winding, it produces an electromagnetic field. The same current also flows from the armature conductors. When a current carrying conductor is placed in an electromagnetic field, it experiences a mechanical force.

- Due to this mechanical force, or torque, the rotor starts to rotate. The direction of this force is given by Fleming's left hand rule.

https://www.youtube.com/watch?v=0PDRJKz-mqE

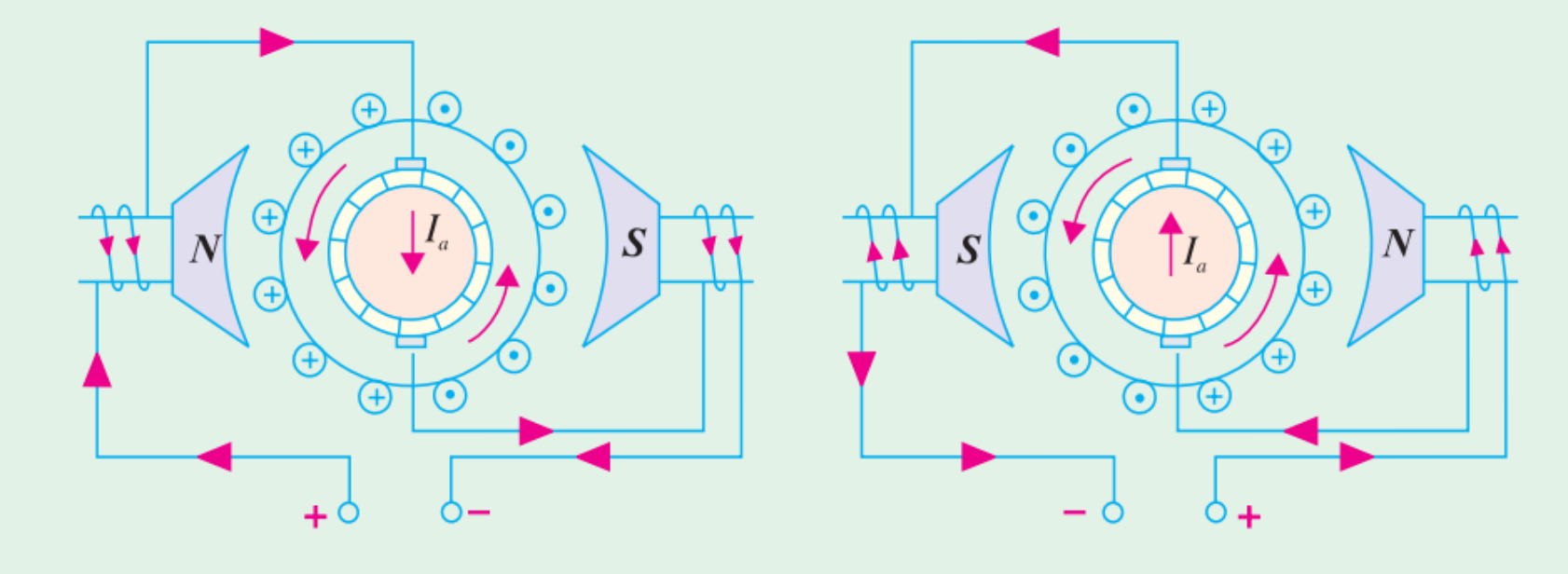




Working principle of Universal motor

Working principle(AC)

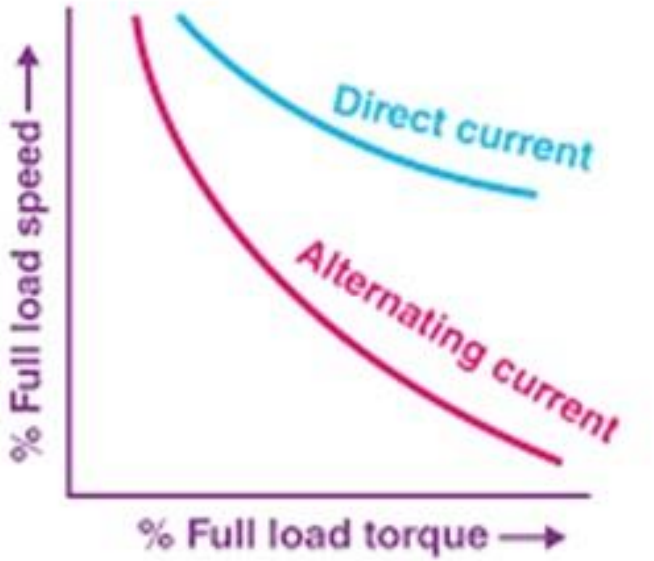
- When fed with AC supply, it still produces unidirectional torque. Because, armature winding and field winding are connected in series, they are in same phase.
- Hence, as polarity of AC changes periodically, the direction of current in armature and field winding reverses at the same time.
- Thus, direction of magnetic field and the direction of armature current reverses in such a way that the direction of force experienced by armature conductors remains same.
- Thus, regardless of AC or DC supply, universal motor works on the same principle that DC series motor works.



Speed/load characteristics

Speed/load characteristics

- The speed of a universal motor is low at full load and very high at no load.
- Usually, gears trains are used to get the required speed on required load.



Speed control of Universal Motor

- **Resistance method**
- **Tapping field method**
- **Centrifugal method**

Resistance method

- The motor speed is controlled by connecting variable resistance in series with the motor.
- Use in sewing machines

Tapping field method

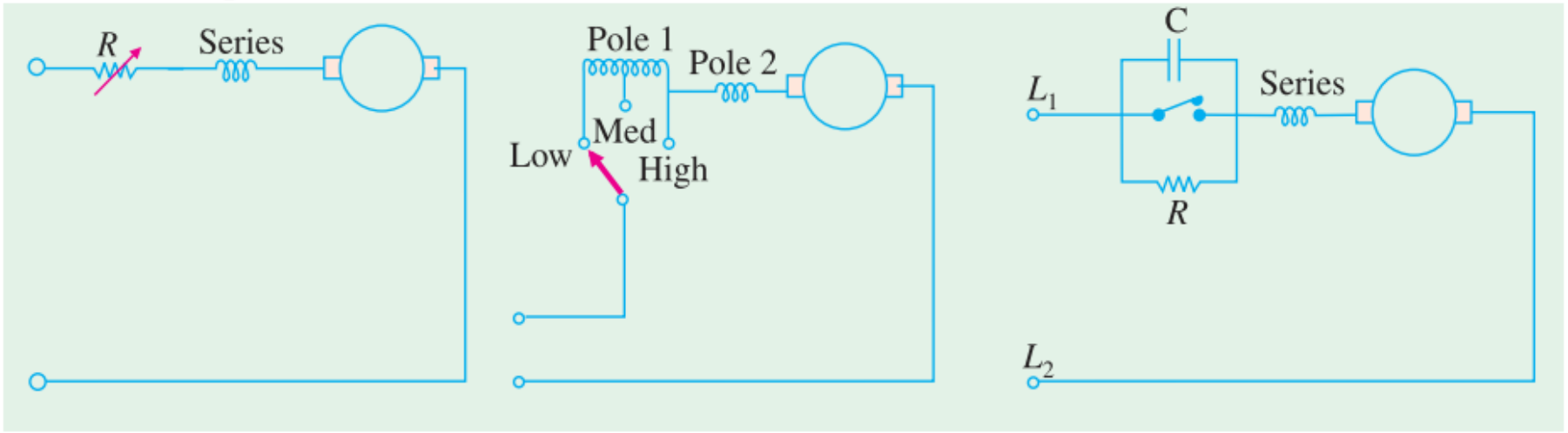
- Field pole is tapped at various point and speed is controlled by varying the field strength.

Speed control of Universal Motor

- They are commonly used in portable power tools and equipment, as well as many household appliances.

Centrifugal method

- Centrifugal switch is located inside the motor.
- This centrifugal switch can be controlled by means of an external lever.
- When motor runs too slowly, the centrifugal device will close the two contacts and when runs too fast then open the two contacts.
- A capacitor C is used across the contact points in order to reduce sparking produced due to the opening and closing of these points.
- Use in food and drink mixers.



Advantages and Disadvantages of Universal Motor

Advantages

- Universal motor can be operated from both DC and AC voltage sources.
- Cost-effective and no requirement of permanent magnets.
- Capable to provide good torque at low speed.
- Field winding and armature winding is connected in series so it can rotate at very high speed.
- Small size and less weight.
- High power ratings ranging from 5W to 500W.
- The universal motor also has the capability to run at adjustable speeds.

Disadvantages

- Higher noise and the sound of noise also increases with the increase in the speed of the universal motor.
- Difficult to reverse the universal motor to run in the opposite direction.
- Slight unbalancing can cause severe vibrations possibly damaging motor or surroundings.
- At no load very high current will flow causing the motor to attain dangerously high speed so starting mechanism is required.
- Require frequent service and maintenance for carbon brushes and commutators.
- Overheating and usually require an environment with fresh air to avoid heating and cooling down.

Mathematical problems of Universal motor

Problem-01

A 250-W, single-phase, 50-Hz, 220-V universal motor runs at 2000 rpm and takes 1.0 A when supplied from a 220-V dc. supply. If the motor is connected to 220-V ac supply and takes 1.0 A (r.m.s), calculate the speed, torque and power factor. Assume Ra = 20 ohm and La = 0.4 H.

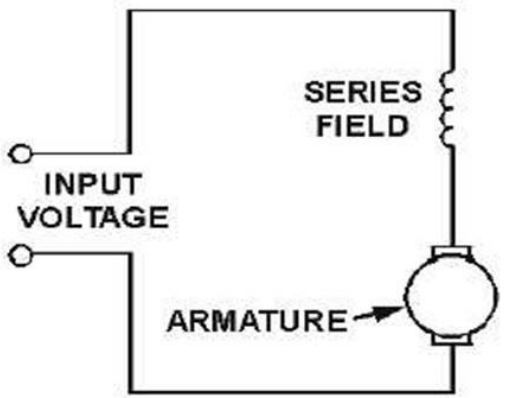
Here

Motor

Motor rating=250W, 50Hz, 220V

Motor armature resistance Ra=20 ohm

Motor armature Inductance La=0.4 H



Supply DC

DC supply voltage = 220V

Motor armature current Ia=1 A

Motor speed= 2000rpm

Supply AC

AC Supply frequency, f= 50Hz

AC Supply Voltage= 220V

Motor armature current Ia=1 A(rms)

Calculate

Speed(**N**) , Torque(**T**) and power factor(**φ**) at AC

Equations

$$Eb = V - IaRa$$

$$\frac{Eb,dc}{Eb,ac} = \frac{N,dc}{N,ac}$$

$$P,mech = Eb*Ia$$

$$T = 9.55* \frac{P,mech}{N,ac}$$

$$Cos\varphi = \frac{Eb,ac + IaRa}{V}$$

Solution

For DC input:

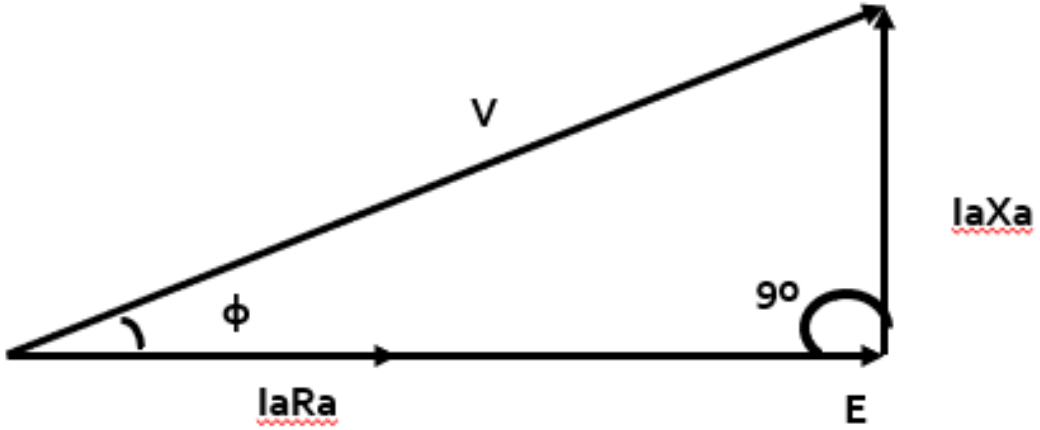
Eb,dc = V – IaRa = 220-1*20 = **200V**

For AC input:

Xa = 2*π*f*La = **……**

$V^2=(IaRa+Eb,ac)^2+(IaXa)^2$

Eb,ac = ……



Speed

$$\frac{Eb,dc}{Eb,ac} = \frac{N,dc}{N,ac}$$

N,ac = ……

Power Factor

$$Cos\varphi = \frac{Eb,ac + IaRa}{V}$$

φ = ……

Torque

P,mech = Eb*Ia = **……**

$$T = 9.55* \frac{P,mech}{N,ac}$$

T = ……

Ans……

Mathematical problems of Universal motor

Problem-02

A universal series motor has resistance of 30 ohm and an inductance of 0.5 H. When connected to a 250 V DC supply and loaded to take 0.8 A, it runs at 2000 r.p.m. Estimate its speed and power factor, when connected to a 250-V, 50-Hz AC supply and loaded to take the same current.