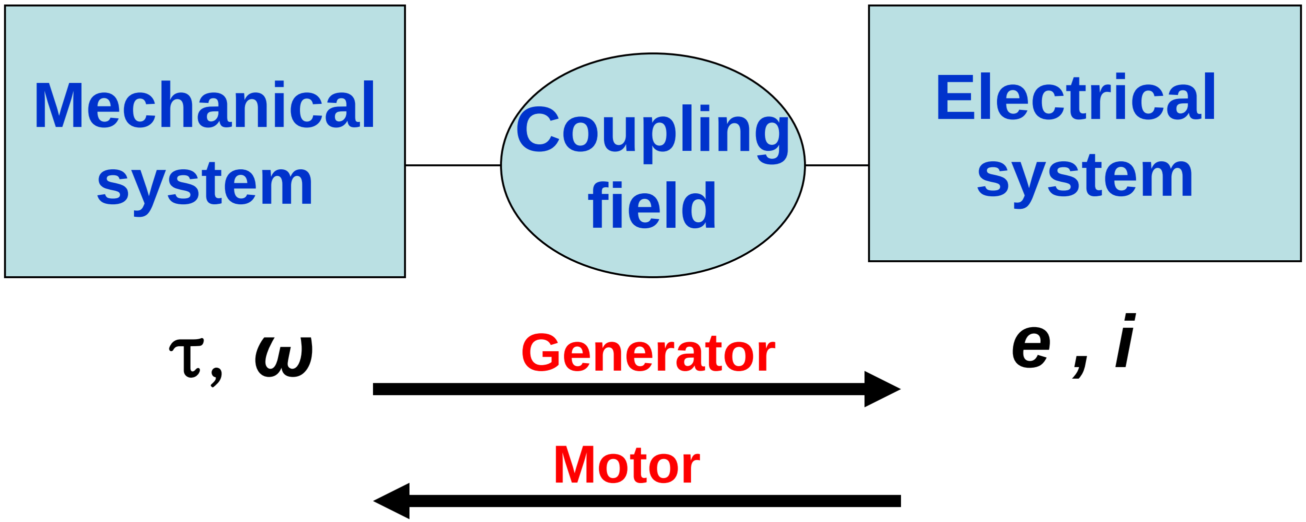
DC MACHINES

- These are electromechanical energy-conversion devices or machines.
  - The direct current (DC) machine can be used as a motor or as a generator.
  - DC machine is most often used for a motor.
  - The major advantages of DC machines are the easy speed and torque regulation.
  - However, their application is limited to mills , mines and trains. As examples, trolleys and underground subway cars may use DC motors.
  - In the past, automobiles were equipped with DC dynamos to charge their batteries.
  - Even today the starter is a series DC motor.
  - However, the recent development of power electronics has reduced the use of DC motors and generators.
  - The electronically controlled ac drives are gradually replacing the dc motor drives in factories.
  - Nevertheless, a large number of DC motors are still used by industry and several thousand are sold annually.

Elementary Concepts

- Induced *emf* in a Conductor (Speed emf): $e = Blv$
- Induced *emf* in a Coil (Transformer emf): $e = NBA\omega \sin \omega t$

Thus, $E_m = NBA\omega$



Electromechanical Energy Conversion

Developed Electrical and Mechanical Power

- Emf developed in a single coil is 2Blv. If there are n coils on the rotor, the total emf becomes **e = 2nBlv**

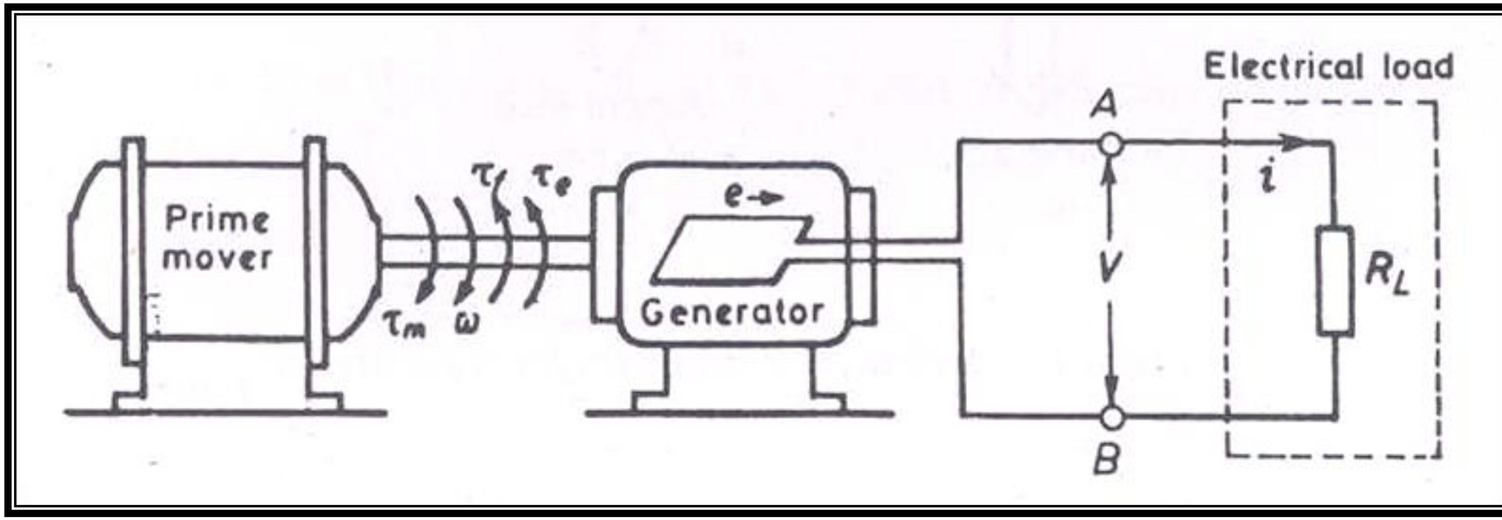
- The force developed on a single conductor is F = Bli. For n coils, the total force developed is **F = 2nBli**. If r is radius, the resulting torque developed is

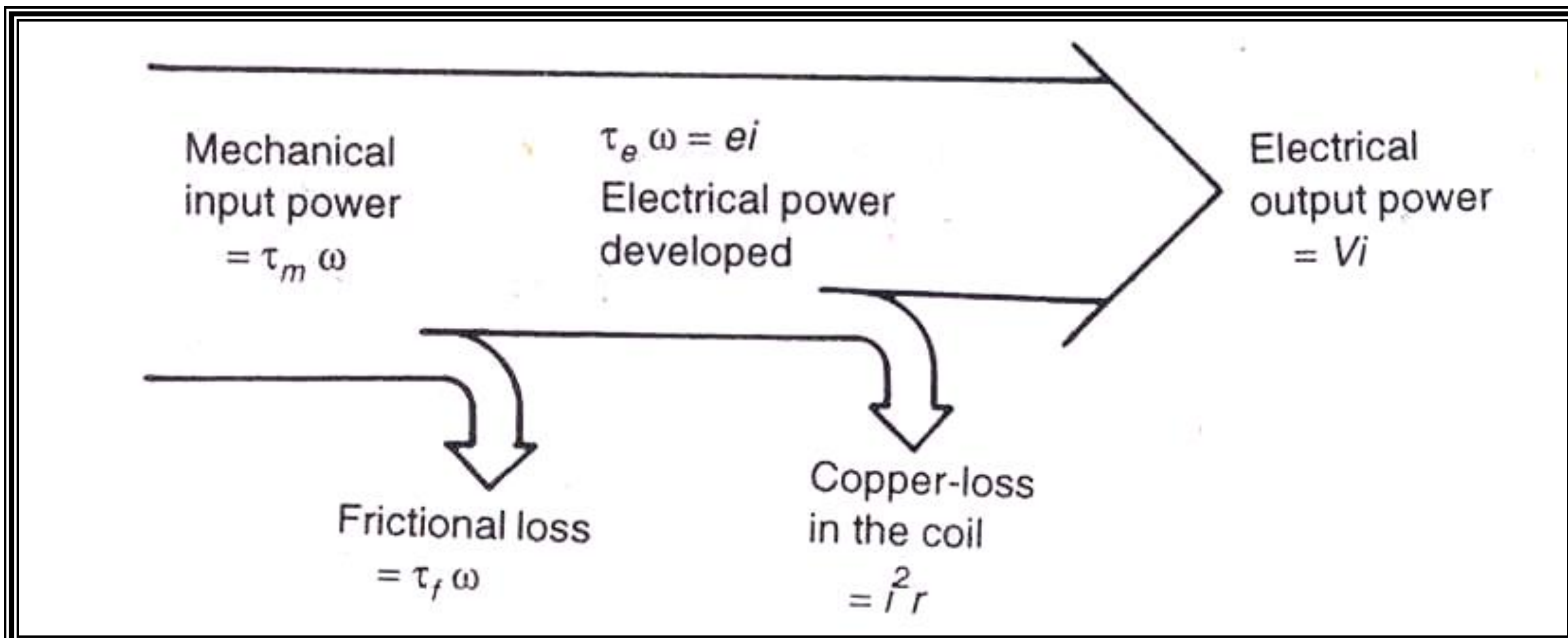
  $$\boldsymbol{\tau_e = Fr = 2nBlir \quad (= BinA)}$$

  Note that both are dependent on B. <u>One is action, the other is reaction; depending on whether it is a motor or generator.</u>

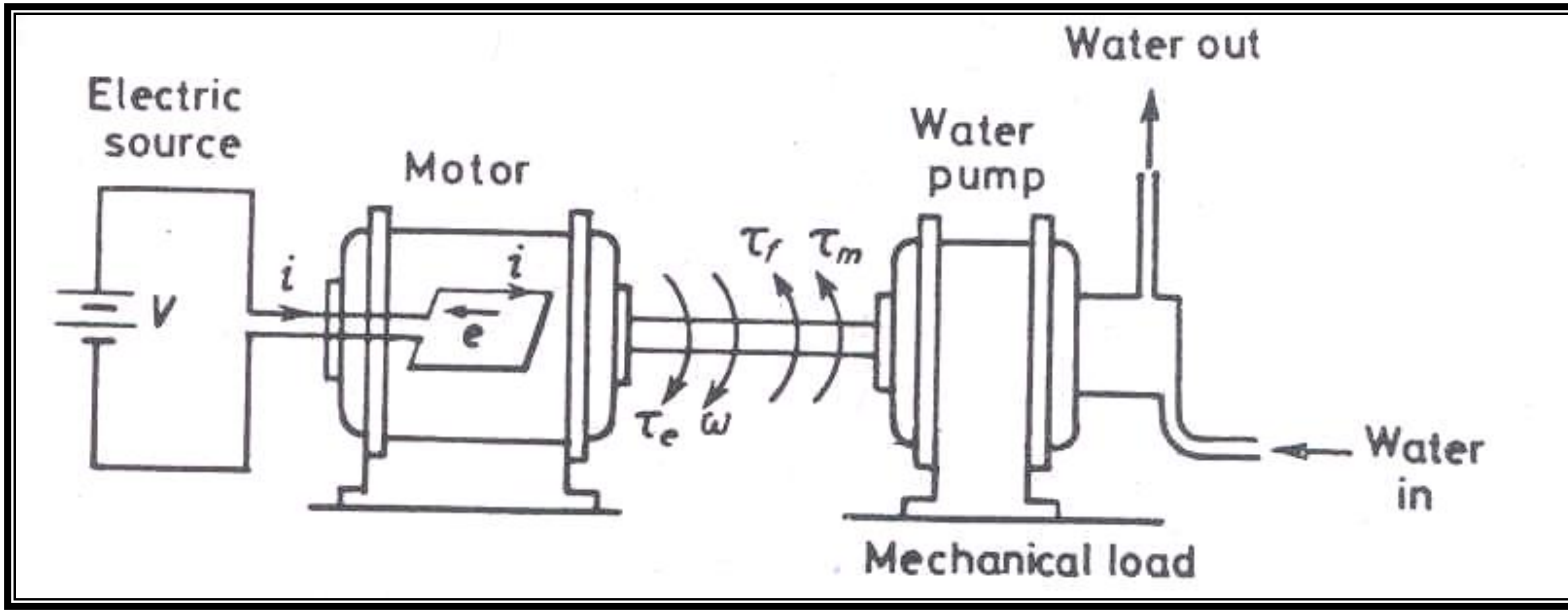
  Dividing the two, we get $\boxed{ei = \tau_e\,\omega}$

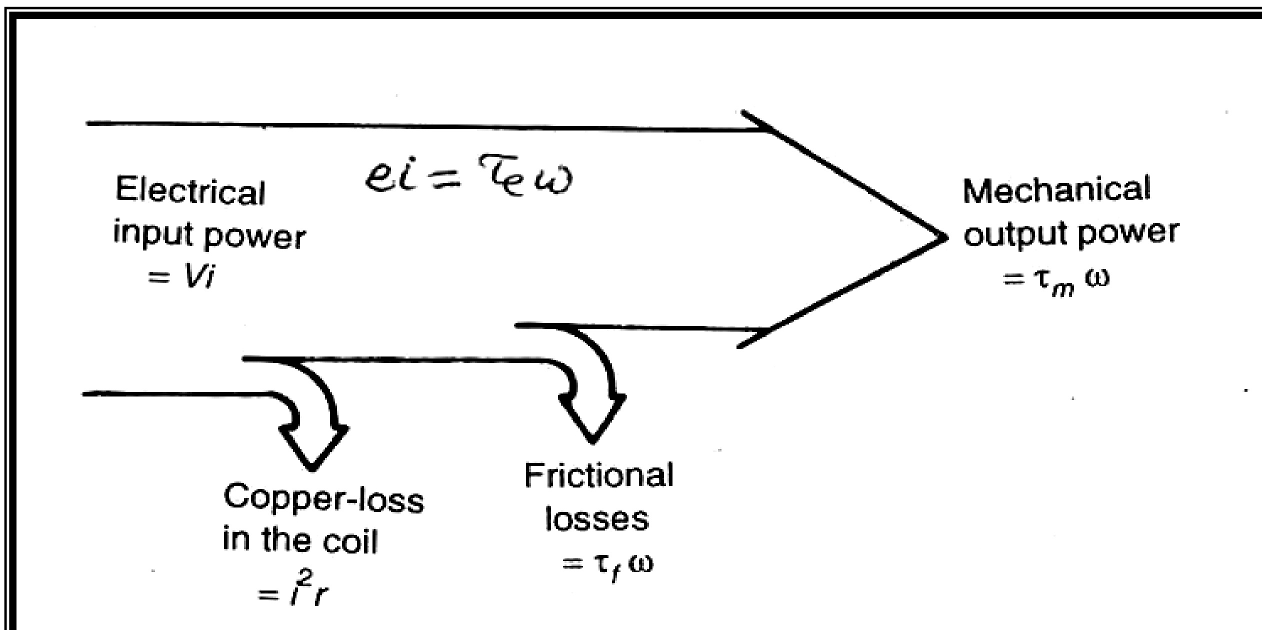
Power Flow in GENERATOR





Power Flow in MOTOR





How a Generator differs from a Motor

1. The directions of e and i are same in a generator; but are opposite in a motor.

2. The directions of τ_e and ω are opposite in a generator; but are same in a motor.

3. In both, the frictional torque is opposite to the direction of rotation.

4. In both, Ohmic loss is opposite to the direction of power supply or emf induced.

Construction of DC Machine

Two main parts of all rotating machines are Stator (Stationary) and Rotor (rotating).

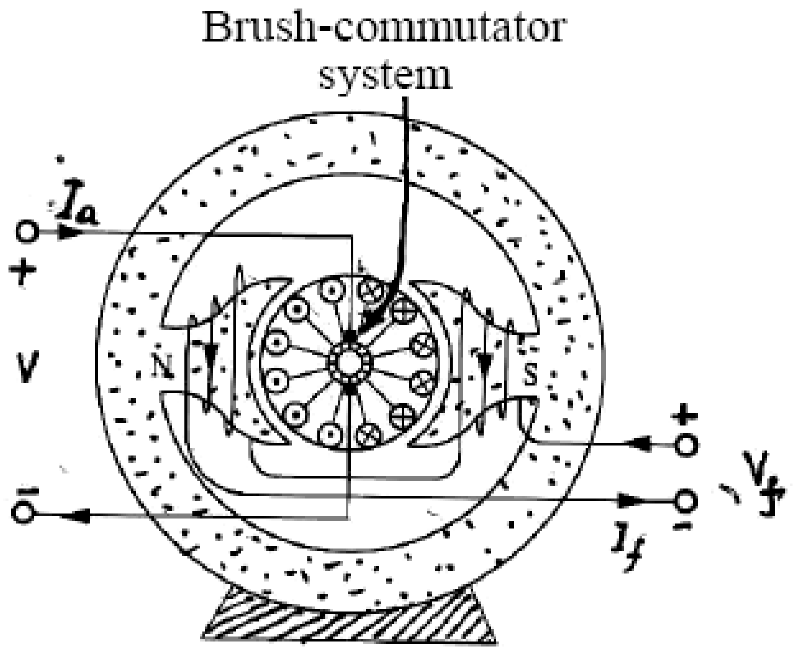
The main parts of a dc machine are :

1. On Stator-

- **i. Yoke**
- **ii. Poles, pole shoes.**
- **iii. Field Coils.**

2. On Rotor-

- **i. Armature.**
- **ii. Commutator.**
- **iii. Brushes.**



A two-pole dc motor with a brush-commutator system.

STATOR OF DC MACHINE

DC Machine Construction

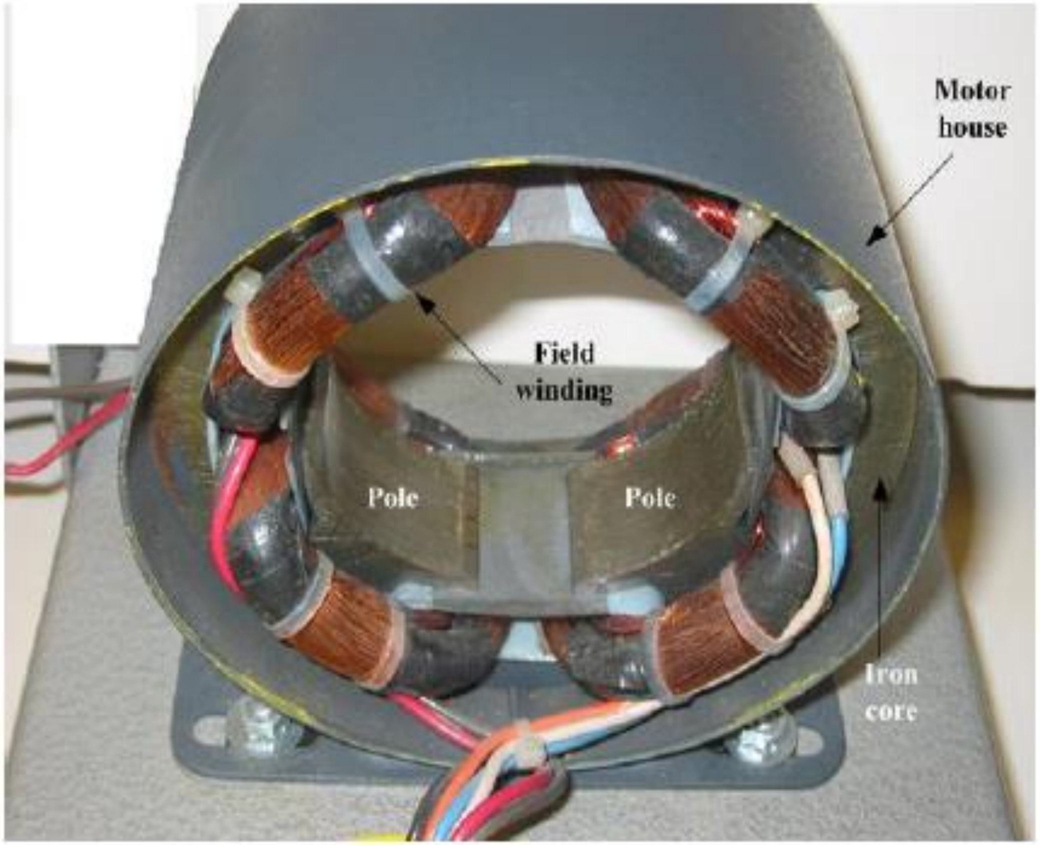


Figure 4 DC motor stator with poles visible.

ROTOR OF DC MACHINE

DC Machine Construction

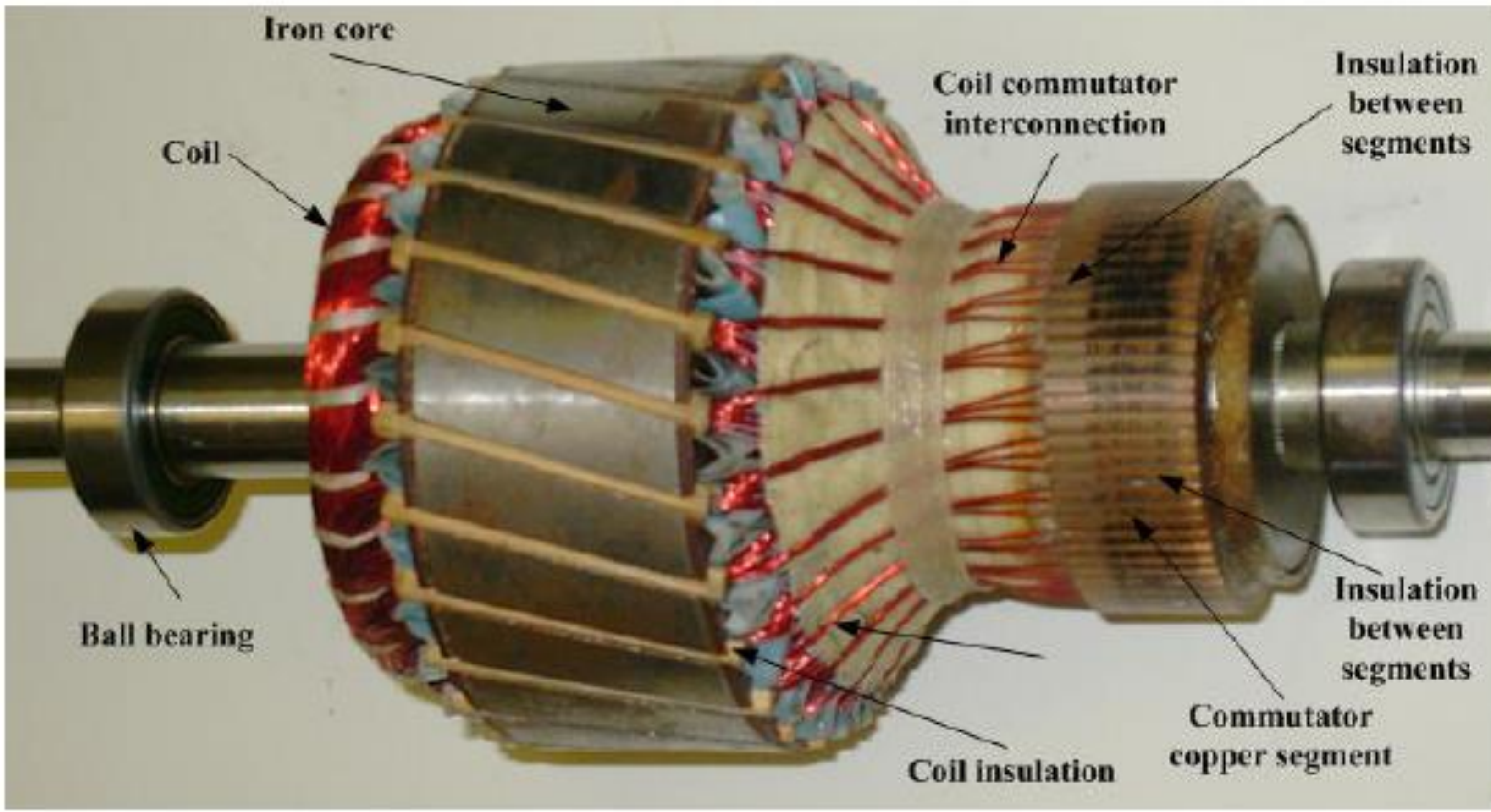


Figure 5 Rotor of a dc motor.

EMF Equation of a DC Generator

- Let the speed of rotation = *N* rpm = *N*/60 rps. Therefore, time taken in one revolution is

$$\Delta t = \frac{60}{N}$$

- If Φ is the magnetic flux per pole and there are *P* poles, the total flux traversed by one conductor in one rotation,

$$\Delta\Phi = P\Phi$$

$$\therefore \qquad e = \frac{\Delta\Phi}{\Delta t} = \frac{P\Phi}{60/N} = \frac{NP\Phi}{60}$$

•**The net emf *E* is same as the total emf in one parallel path. If there are total *Z* conductors and *A* parallel paths, we get**

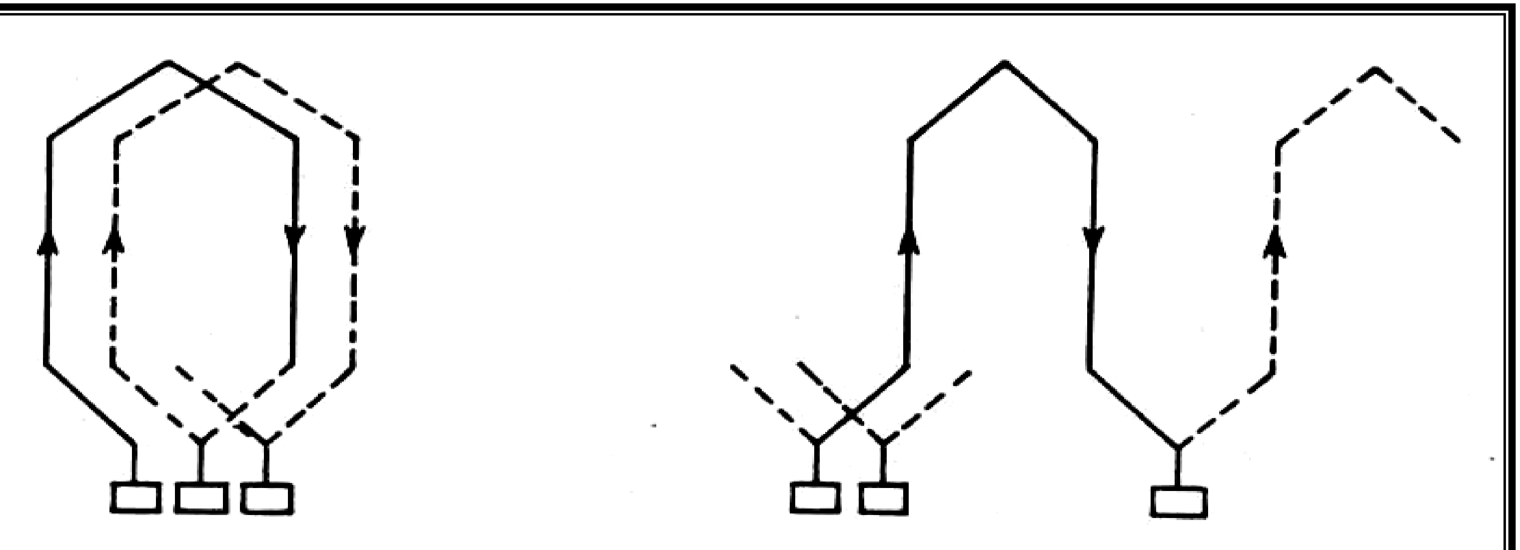
$$E = e\left(\frac{Z}{A}\right) = \frac{NP\Phi}{60}\left(\frac{Z}{A}\right) = \frac{\Phi ZNP}{60A}$$

$$\text{where,} \quad A = P \qquad \text{(for lap winding).}$$

$$A = 2 \qquad \text{(for wave winding).}$$

For large current rating, Because it gives more power

Suitable for small generators and gives more emf(500-600)v



(a) Lap winding

(b) Wave winding

Ex-2.The induced emf in a dc generator running at 750 rpm is 220 V. Calculate

(a) the speed at which the induced emf is 250 V (assume the flux to be constant), and

(b) the required percentage increase in the field flux so that the induced emf is 250 V, while the speed is only 600 rpm.

Solution : (*a*) if the flux is constant, we have

$$E = KN$$

where K is a constant. Thus,

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} \quad \text{or} \quad N_2 = \frac{E_2}{E_1} N_1 = \frac{250}{220} \times 750 = \mathbf{852 \text{ rpm}}$$

(*b*) Here, neither the speed N nor the flux is remaining constant. Therefore,

$$E = K'\Phi N$$

where K' is a constant. Thus,

$$\frac{E_2}{E_1} = \frac{\Phi_2 N_2}{\Phi_1 N_1} \quad \text{or} \quad \frac{\Phi_2}{\Phi_1} = \frac{E_2}{E_1} \times \frac{N_1}{N_2} = \frac{250}{220} \times \frac{750}{600} = 1.42$$

Therefore, the required percentage increase in flux is

$$(1.42 - 1.00) \times 100 = \mathbf{42\ \%}$$