

Reviewing The Construction And Electromotive Force Equation Of DC Generators

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Abstract

A DC generator is an essential electrical machine that converts mechanical energy into direct current electrical energy. This device operates on the principle of Faraday's electromagnetic induction, where the relative motion between a magnetic field and a conductor generates an electromotive force (EMF) in the conductor. DC generators find applications in various industries and are critical components in power generation and electric motor systems.

This abstract provides an overview of the key components and principles underlying the operation of a DC generator. It discusses the essential components, including the armature, field windings, commutator, and brushes, which play crucial roles in its functionality. The constant direction of current flow in a DC generator distinguishes it from an alternating current (AC) generator

Generators

There are two types of generators, one is ac generator and other is dc generator. Whatever may be the types of generators, it always converts mechanical power to electrical power. An ac generator produces alternating power.

A DC generator produces direct power. Both of these generators produce electrical power, based on same fundamental principle of Faraday's law of electromagnetic induction. According to this law, when a conductor moves in a magnetic field it cuts magnetic lines force, due to which an emf is induced in the conductor. The magnitude of this induced emf depends upon the rate of change of flux (magnetic line force) linkage with the conductor. This emf will cause an current to flow if the conductor circuit is closed. Hence the most basic two essential parts of a generator are

1. Magnetic field
2. Conductors which move inside that magnetic field.

The Input is mechanical energy (from the prime mover), and the output is electrical energy.

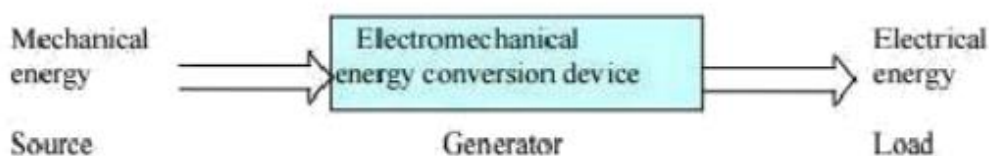


Fig 1: Electromechanical energy conversion

Constructional Features

A DC generator has the following parts

1. Yoke
2. Pole of generator
3. Field winding
4. Armature of DC generator
5. Brushes of generator
6. Bearing

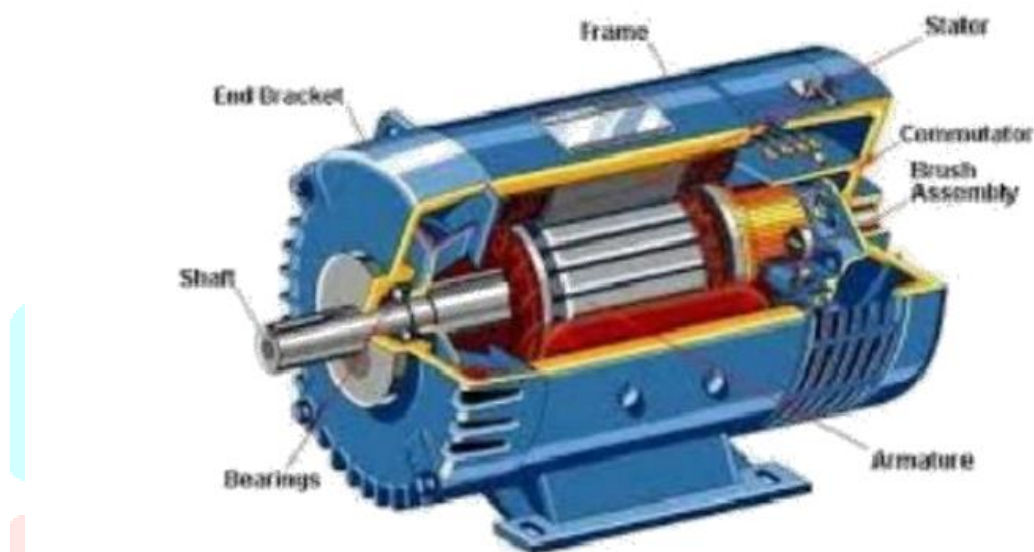


Fig 2.: A Cut Away View of Practical DC Generator

Yoke of DC Generator

Yoke of DC generator serves two purposes,

1. It holds the magnetic pole cores of the generator and acts as cover of the generator.
2. It carries the magnetic field flux.

In small generator, yoke are made of cast iron. Cast iron is cheaper in cost but heavier than steel. But for large construction of DC generator, where weight of the machine is concerned, lighter cast steel or rolled steel is preferable for constructing yoke of DC generator. Normally larger yokes are formed by rounding a rectangular steel slab and the edges are welded together at the bottom. Then feet, terminal box and hangers are welded to the outer periphery of the yoke frame.

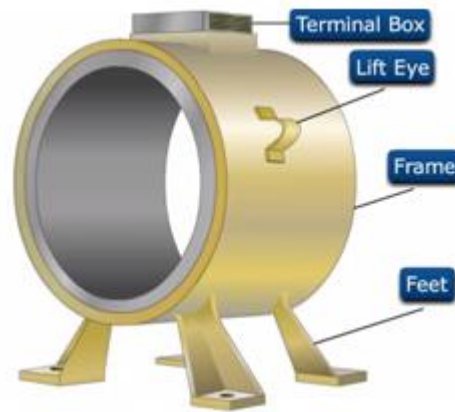


Fig 3.: Yoke

Armature Core of DC Generator

The purpose of armature core is to hold the armature winding and provide low reluctance path for the flux through the armature from N pole to S pole. Although a DC generator provides direct current but induced current in the armature is alternating in nature. That is why, cylindrical or drum shaped armature core is buildup of circular laminated sheet. In every circular lamination, slots are either die - cut or punched on the outer periphery and the key way is located on the inner periphery as shown. Air ducts are also punched or cut on each lamination for circulation of air through the core for providing better cooling.

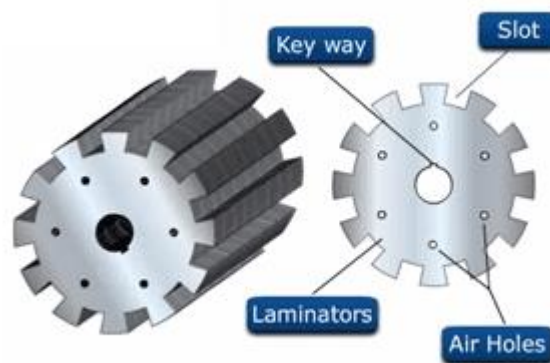


Fig 4.: Armature Core

Armature Winding of DC Generator

Armature winding are generally formed wound. These are first wound in the form of flat rectangular coils and are then pulled into their proper shape in a coil puller. Various conductors of the coils are insulated from each other. The conductors are placed in the armature slots, which are lined with tough insulating material. This slot insulation is folded over above the armature conductors placed in it and secured in place by special hard wooden or fiber wedges.

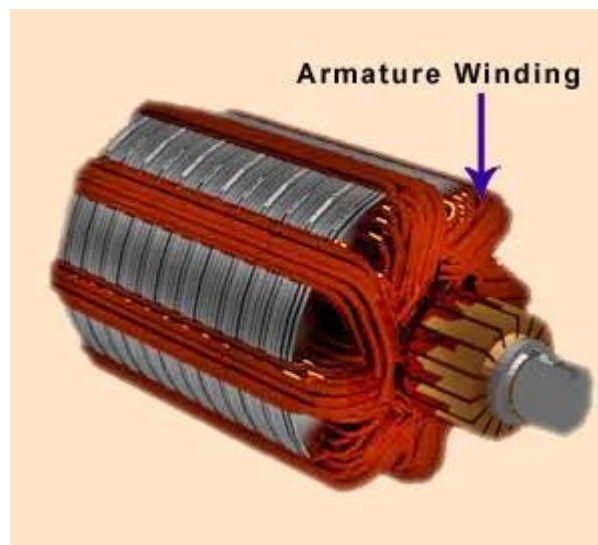


Fig 5.: Armature Winding

Commutator of DC Generator

The commutator plays a vital role in dc generator. It collects current from armature and sends it to the load as direct current. It actually takes alternating current from armature and converts it to direct current and then send it to external load. It is cylindrical structured and is buildup of wedge - shaped segments of high conductivity, hard drawn or drop forged copper. Each segment is insulated from the shaft by means of insulated commutator segment shown below. Each Commutator segment is connected with corresponding armature conductor through segment riser or lug.

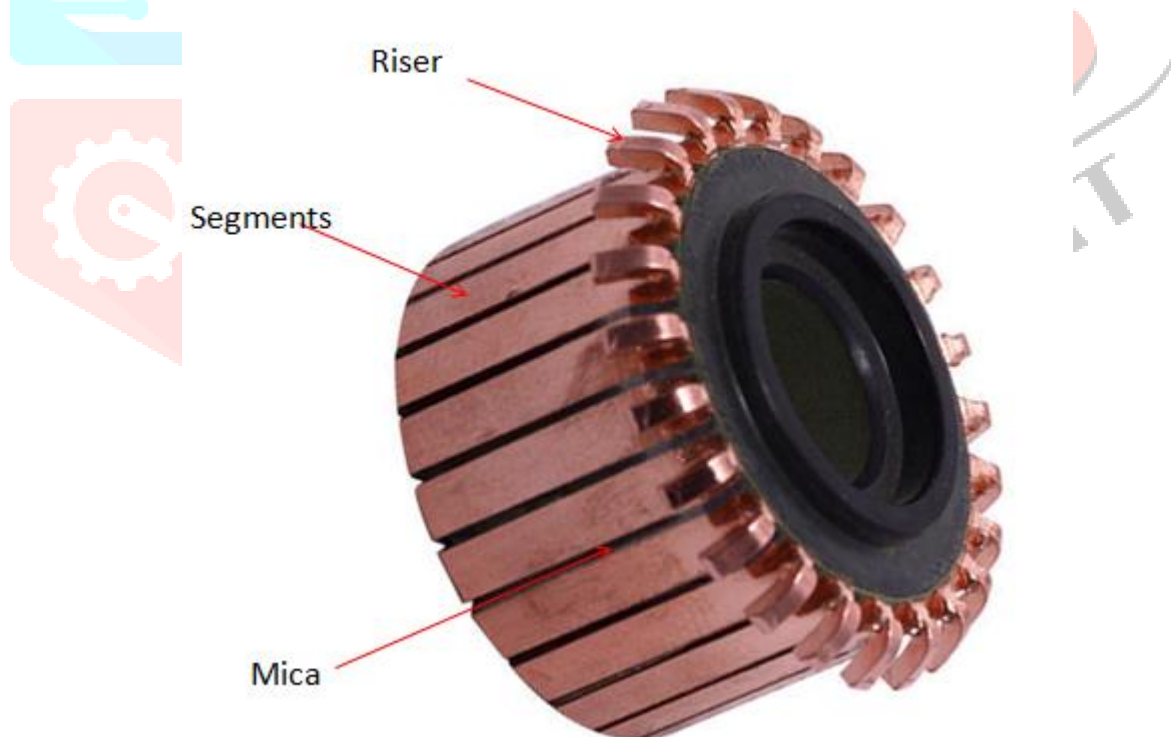


Fig 6: Commutator

Brushes of DC Generator

The brushes are made of carbon. These are rectangular block shaped. The only function of these carbon brushes of DC generator is to collect current from commutator segments. The brushes are housed in the rectangular box shaped brush holder. As shown in figure, the brush face is placed on the commutator segment with attached to the brush holder.



Fig 7: Brushes

Bearing of DC Generator

For small machine, ball bearing is used and for heavy duty dc generator, roller bearing is used. The bearing must always be lubricated properly for smooth operation and long life of generator.



Fig 8: Bearing

Emf equation for dc generator

The derivation of EMF equation for DC generator has two parts:

1. Induced EMF of one conductor
2. Induced EMF of the generator

Derivation for Induced EMF of One Armature Conductor

For one revolution of the conductor,

Let,

Φ = Flux produced by each pole in weber (Wb) and

P = number of poles in the DC generator. therefore,

Total flux produced by all the poles = $\phi * p$

And,

Time taken to complete one revolution = $60/N$

Where,

N = speed of the armature conductor in rpm.

Now, according to Faraday's law of induction, the induced emf of the armature conductor is denoted by "e" which is equal to rate of cutting the flux.

Therefore,

$$e = \frac{d\phi}{dt} \text{ and } e = \frac{\text{total flux}}{\text{time take}}$$

Induced emf of one conductor is

$$e = \frac{\phi P}{\frac{60}{N}} = \phi P \frac{N}{60}$$

Derivation for Induced EMF for DC Generator

Let us suppose there are Z total numbers of conductor in a generator, and arranged in such a manner that all parallel paths are always in series.

Here,

Z = total numbers of conductor

A = number of parallel paths

Then,

Z/A = number of conductors connected in series

We know that induced emf in each path is same across the line Therefore,

Induced emf of DC generator

E = emf of one conductor \times number of conductor connected in series

Induced emf of DC generator is

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

Simple wave wound generator

Numbers of parallel paths are only 2 = A

Therefore,

Induced emf for wave type of winding generator is

$$\frac{\phi P N}{60} \times \frac{Z}{2} = \frac{\phi Z P N}{120} \text{ volts}$$

Simple lap-wound generator

Here, number of parallel paths is equal to number of conductors in one path i.e. P = A

Therefore

Induced emf for lap-wound generator is

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

Conclusion:

In conclusion, the DC generator is a fundamental electrical device with diverse applications, ranging from powering small electrical devices to serving as a backup power source in critical systems. Understanding its components and operation is essential for engineers and technicians working in the field of electrical engineering and power generation.

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