Acknowledgement

Acknowledgement is the most beautiful page in any project ‘s file page.More than formality ,this appears to be the best opportunity to express my gratitude

With due respect I express my sincere gratitude to my teacher Mr. Kedar Nath singh for the kenn support and continuous effort in the preparation of this ptoject.

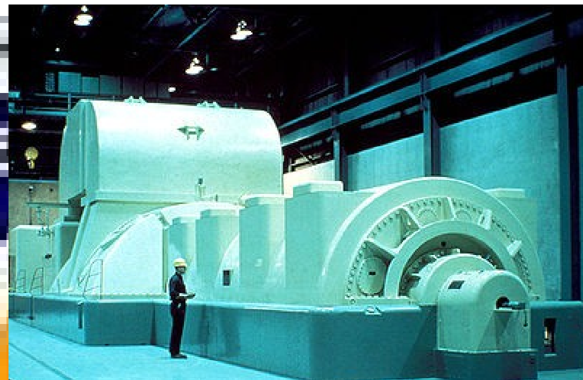
I can’t end this list without thinking the esteemed parents and friends for giving their honest openion , suggestion , encouragement.

I also thank all mighty GOD who make all this possible..

Thank you..

Electric generator

This project is about electromagnetic power generation. For electrostatic generators like the Van de Graff machine,



U.S. NRC image of a modern steam turbine generator (STG).

In electricity generation, a generator is a device that converts mechanical energy to electrical energy for use in an external circuit. Sources of mechanical energy include steam turbines, gas turbines, water turbines, internal combustion enginesand even hand cranks. The first electromagnetic generator, the Faraday disk, was built in 1831 by British scientist Michael Faraday. Generators provide nearly all of the power for electric power grids.

The reverse conversion of electrical energy into mechanical energy is done by an electric motor, and motors and generators have many similarities. Many motors can be mechanically driven to generate electricity and frequently make acceptable manual generators.

Terminology

- Dynamos generate direct current, usually with voltage or current fluctuations, usually through the use of a commutator
- Alternators generate alternating current, which may be rectified by another (external or directly incorporated) system.

Mechanically a generator consists of a rotating part and a stationary part

- Rotor: The rotating part of an electrical machine

- Stator: The stationary part of an electrical machine, which surrounds the rotor

Electrically, generators contain two sets of wire windings

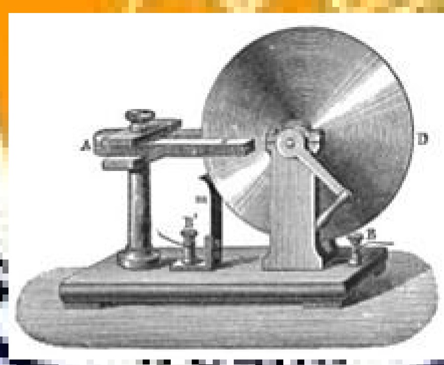
- Armature: The power-producing component of an electrical machine. In a generator, alternator, or dynamo the armature windings generate the electric current. The armature can be on either the rotor or the stator.

- Field: The magnetic field producing component of an electrical machine. The magnetic field of the dynamo or alternator can be provided by either wire windings called field coils or permanent magnets, mounted on either the rotor or the stator.

History

Before the connection between magnetism and electricity was discovered, electrostatic generators were invented. They operated on electrostatic principles, by using moving electrically charged belts, plates, and disks that carried charge to a high potential electrode. The charge was generated using either of two mechanisms: electrostatic induction or the triboelectric effect. Such generators generated very high voltage and low current. Because of their inefficiency and the difficulty of insulating machines that produced very high voltages, electrostatic generators had low power ratings, and were never used for generation of commercially significant quantities of electric power. Their only practical applications were to power early X-ray tubes, and later in some atomic particle accelerators.

Faraday disk generator



The Faraday disk was the first electric generator. The horseshoe-shaped magnet (A) created a magnetic field through the disk (D). When the disk was turned, this induced an electric current radially outward from the center toward the rim. The current flowed out through the sliding spring contact m, through the external circuit, and back into the center of the disk through the axle.

The operating principle of electromagnetic generators was discovered in the years of 1831–1832 by Michael Faraday. The principle, later called Faraday's law, is that an electromotive force is generated in an electrical conductor which encircles a varying magnetic flux.

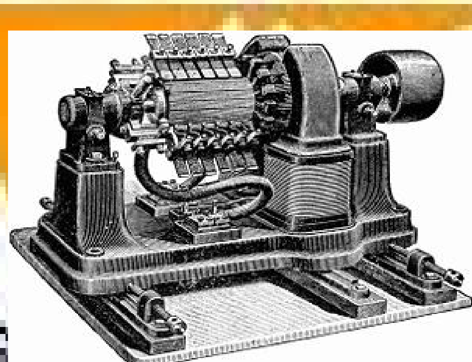
He also built the first electromagnetic generator, called the Faraday disk, a type of homopolar generator, using a copper disc rotating between the poles of a horseshoe magnet. It produced a small DC voltage.

This design was inefficient, due to self-cancelling counterflows of current in regions that were not under the influence of the magnetic field. While current was induced directly underneath the magnet, the current would circulate backwards in regions that were outside the influence of the magnetic field. This counter flow limited the power output to the pickup wires, and induced waste heating of the copper disc. Later homopolar generators would solve this problem by using an array of magnets arranged around the disc perimeter to maintain a steady field effect in one current-flow direction.

Another disadvantage was that the output voltage was very low, due to the single current path through the magnetic flux. Experimenters found that using multiple turns of wire in a coil could produce higher, more useful voltages. Since the output voltage is proportional to the number of turns, generators could be easily designed to produce any desired voltage by varying the number of turns. Wire windings became a basic feature of all subsequent generator designs.

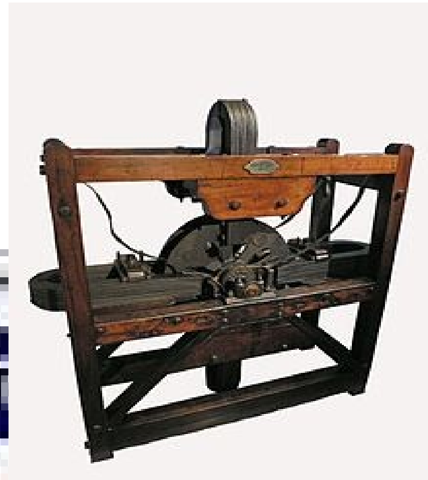
Independently of Faraday, the Hungarian Anyos Jedlik started experimenting in 1827 with the electromagnetic rotating devices which he called electromagnetic self-rotors. In the prototype of the single-pole electric starter (finished between 1852 and 1854) both the stationary and the revolving parts were electromagnetic. He also may have formulated the concept of the dynamo in 1861 (before Siemensand Wheatstone) but didn't patent it as he thought he wasn't the first to realize this.

Direct current generators



This large belt-driven high-current dynamoproduced 310 amperesat 7 volts. Dynamos are no longer used due to the size and complexity of the commutator needed for high power applications.

The dynamo was the first electrical generator capable of delivering power for industry. The dynamo uses electromagnetic induction to convert mechanical rotation into direct current through the use of a commutator. An early dynamo was built by Hippolyte Pixii in 1832.



Woolrich Electrical Generator in Thinktank, Birmingham

The Woolrich Electrical Generator of 1844, now in Thinktank, Birmingham Science Museum, is the earliest electrical generator used in an industrial process. It was used by the firm of Elkingtons for commercial electroplating.

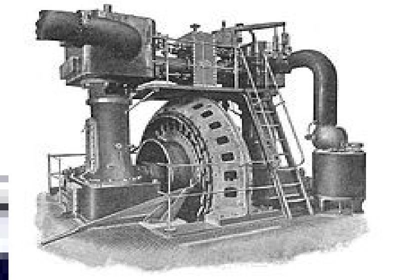
The modern dynamo, fit for use in industrial applications, was invented independently by Sir Charles Wheatstone, Werner von Siemens and Samuel Alfred Varley. Varley took out a patent on 24 December 1866, while Siemens and Wheatstone both announced their discoveries on 17 January 1867, the latter delivering a paper on his discovery to the Royal Society.

The "dynamo-electric machine" employed self-powering electromagnetic field coils rather than permanent magnets to create the stator field.Wheatstone's design was similar to Siemens', with the difference that in the Siemens design the stator electromagnets were in series with the rotor, but in Wheatstone's design they were in parallel. The use of electromagnets rather than permanent magnets greatly increased the power output of a dynamo and enabled high power generation for the first time. This invention led directly to the first major industrial uses of electricity. For example, in the 1870s Siemens used electromagnetic dynamos to power electric arc furnaces for the production of metals and other materials.

The dynamo machine that was developed consisted of a stationary structure, which provides the magnetic field, and a set of rotating windings which turn within that field. On larger machines the constant magnetic field is provided by one or more electromagnets, which are usually called field coils.

Large power generation dynamos are now rarely seen due to the now nearly universal use of alternating current for power distribution. Before the adoption of AC, very large direct-current dynamos were the only means of power generation and distribution. AC has come to dominate due to the ability of AC to be easily transformed to and from very high voltages to permit low losses over large distances.

Alternating Current Generator



Ferranti alternating current generator, c. 1900.

Through a series of discoveries, the dynamo was succeeded by many later inventions, especially the AC alternator, which was capable of generating alternating current.

Alternating current generating systems were known in simple forms from Michael Faraday's original discovery of the magnetic induction of electric current. Faraday himself built an early alternator. His machine was a "rotating rectangle", whose operation was heteropolar - each active conductor passed successively through regions where the magnetic field was in opposite directions.

Large two-phase alternating current generators were built by a British electrician, J.E.H. Gordon, in 1882. The first public demonstration of an "alternator system" was given by William Stanley, Jr., an employee of Westinghouse Electric in 1886.

Sebastian Ziani de Ferranti established Ferranti, Thompson and Ince in 1882, to market his Ferranti-Thompson Alternator, invented with the help of renowned physicist Lord Kelvin. His early alternators produced frequencies between 100 and 300 Hz. Ferranti went on to design the Deptford Power Station for the London Electric Supply Corporation in 1887 using an alternating current system. On its completion in 1891, it was the first truly modern power station, supplying high-voltage AC power that was then "stepped down" for consumer use on each street. This basic system remains in use today around the world.\

A small early 1900s 75 kVAdirect-driven power station AC alternator, with a separate belt-driven exciter generator.

After 1891, polyphase alternators were introduced to supply currents of multiple differing phases. Later alternators were designed for varying alternating-current frequencies between sixteen and about one hundred hertz, for use with arc lighting, incandescent lighting and electric motors.

Self-excitation

As the requirements for larger scale power generation increased, a new limitation rose: the magnetic fields available from permanent magnets. Diverting a small amount of the power generated by the generator to an electromagnetic field coilallowed the generator to produce substantially more power. This concept was dubbed self-excitation.

The field coils are connected in series or parallel with the armature winding. When the generator first starts to turn, the small amount of remanent magnetismpresent in the iron core provides a magnetic field to get it started, generating a small current in the armature. This flows through the field coils, creating a larger magnetic field which generates a larger armature current. This "bootstrap" process continues until the magnetic field in the core levels off due to saturationand the generator reaches a steady state power output.

Very large power station generators often utilize a separate smaller generator to excite the field coils of the larger. In the event of a severe widespread power outage where islanding of power stations has occurred, the stations may need to perform a black start to excite the fields of their largest generators, in order to restore customer power service.

<u>Specialized types of generator</u>

Direct current

Homopolar generator

A homopolar generator is a DC electrical generator comprising an electrically conductive disc or cylinder rotating in a plane perpendicular to a uniform static magnetic field. A potential difference is created between the center of the disc and the rim (or ends of the cylinder), the electrical polarity depending on the direction of rotation and the orientation of the field.

It is also known as a unipolar generator, acyclic generator, disk dynamo, or Faraday disc. The voltage is typically low, on the order of a few volts in the case of small demonstration models, but large research generators can produce hundreds of volts, and some systems have multiple generators in series to produce an even larger voltage. They are unusual in that they can produce tremendous electric current, some more than a million amperes, because the homopolar generator can be made to have very low internal resistance.

MHD generator

A magnetohydrodynamic generator directly extracts electric power from moving hot gases through a magnetic field, without the use of rotating electromagnetic machinery. MHD generators were originally developed because the output of a plasma MHD generator is a flame, well able to heat the boilers of a steam power plant. The first practical design was the AVCO Mk. 25, developed in 1965. The U.S. government funded substantial development, culminating in a 25 MW demonstration plant in 1987. In the Soviet Union from 1972 until the late 1980s, the MHD plant U 25 was in regular commercial operation on the Moscow power system with a rating of 25 MW, the largest MHD plant rating in the world at that time. MHD generators operated as a topping cycle are currently (2007) less efficient than combined cycle gas turbines.

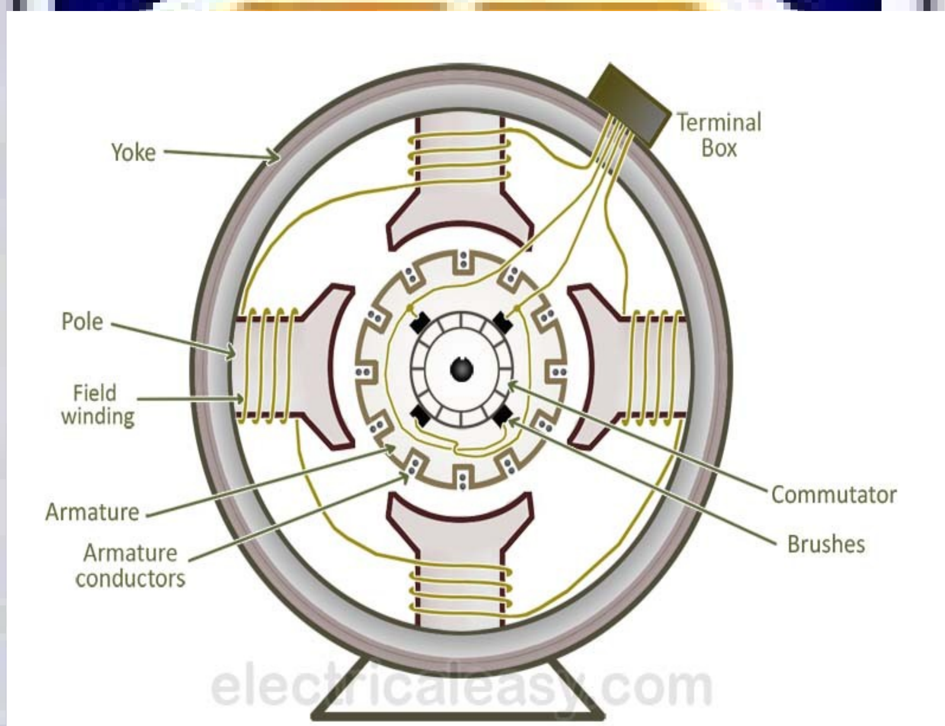
<u>Basic Construction And Working Of A DC Generator.</u>

DC Generator

A dc generator is an electrical machine which converts mechanical energy into direct current electricity. This energy conversion is based on the principle of production of dynamically induced emf. This article outlines basic construction and working of a DC generator.

Construction Of A DC Machine:

Note: A DC generator can be used as a DC motor without any constructional changes and vice versa is also possible. Thus, a DC generator or a DC motor can be broadly termed as a DC machine. These basic constructional details are also valid for the construction of a DC motor. Hence, let's call this point as construction of a DC machine instead of just 'construction of a dc generator'.



The above figure shows the constructional details of a simple 4-pole DC machine. A DC machine consists two basic parts; stator and rotor. Basic constructional parts of a DC machine are described below.

1. Yoke: The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It not only provides mechanical strength to the whole assembly but also carries the magnetic flux produced by the field winding.

2. Poles and pole shoes: Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes; (i) they support field coils and (ii) spread out the flux in air gap uniformly.

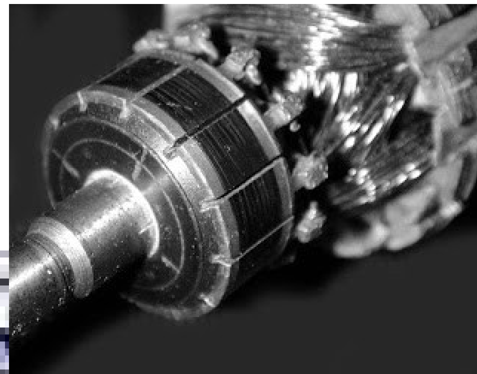
3. Field winding: They are usually made of copper. Field coils are former wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles.

Armature core (rotor)

4. Armature core: Armature core is the rotor of the machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.

5. Armature winding: It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding. Double layer lap or wave windings are generally used. A double layer winding means that each armature slot will carry two different coils.

6. Commutator and brushes: Physical connection to the armature winding is made through a commutator-brush arrangement. The function of a commutator, in a dc generator, is to collect the current generated in armature conductors. Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. The number of segments is equal to the number of armature coils. Each segment is connected to an armature coil and the commutator is keyed to the shaft. Brushes are usually made from carbon or graphite. They rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

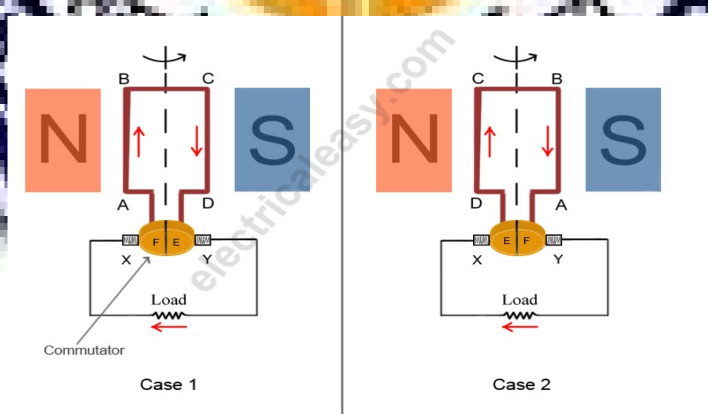


Commutator

Working Principle Of A DC Generator:

According to Faraday's laws of electromagnetic induction, whenever a conductor is placed in a varying magnetic field (OR a conductor is moved in a magnetic field), an emf (electromotive force) gets induced in the conductor. The magnitude of induced emf can be calculated from the emf equation of dc generator. If the conductor is provided with the closed path, the induced current will circulate within the path. In a DC generator, field coils produce an electromagnetic field and the armature conductors are rotated into the field. Thus, an electromagnetically induced emf is generated in the armature conductors. The direction of induced current is given by Fleming's right hand rule.

Need of a Split ring commutator:



According to Fleming's right hand rule, the direction of induced current changes whenever the direction of motion of the conductor changes. Let's consider an armature rotating clockwise and a conductor at the left is moving upward. When the armature completes a half rotation, the direction of motion of that particular conductor will be reversed to downward. Hence, the direction of current in every armature conductor will be alternating. If you look at the above figure, you will know how the direction of the induced current is alternating in an armature conductor. But with a split ring commutator, connections of the armature conductors also gets reversed when the current reversal occurs. And therefore, we get unidirectional current at the terminals.

Types Of A DC Generator:

DC generators can be classified in two main categories, viz; (i) Separately excited and (ii) Self-excited.

(i) **Separately excited:** In this type, field coils are energized from an independent external DC source.

(ii) **Selfexcited:** In this type, field coils are energized from the current produced by the generator itself. Initial emf generation is due to residual magnetism in field poles. The generated emf causes a part of current to flow in the field coils, thus strengthening the field flux and thereby increasing emf generation. Self excited dc generators can further be divided into three types -

(a) Series wound - field winding in series with armature winding

(b) Shunt wound - field winding in parallel with armature winding

(c) Compound wound - combination of series and shunt winding

Alternating current Generator

Induction generator

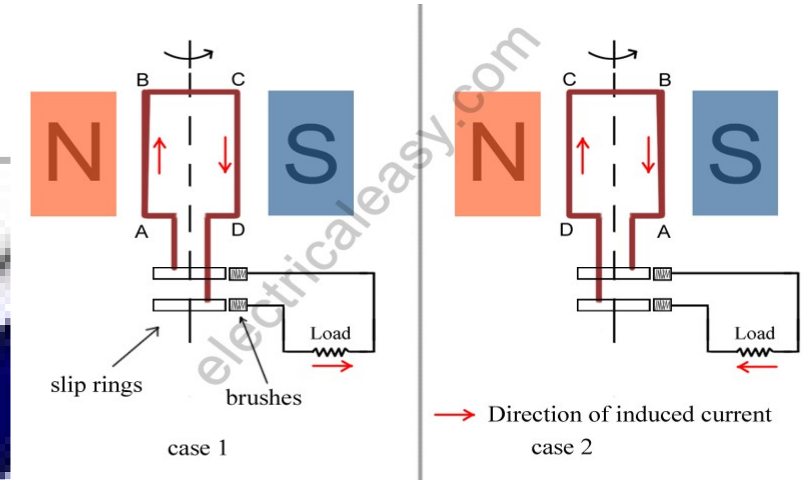
Some AC motors may be used as generators, turning mechanical energy into electric current. Induction generators operate by mechanically turning their rotor faster than the synchronous speed, giving negative slip. A regular AC asynchronous motor usually can be used as a generator, without any internal modifications. Induction generators are useful in applications such as minihydro power plants, wind turbines, or in reducing high-pressure gas streams to lower pressure, because they can recover energy with relatively simple controls.

To operate, an induction generator must be excited with a leading voltage; this is usually done by connection to an electrical grid, or sometimes they are self-excited by using phase correcting capacitors.

AC Generator (Alternator) - Construction And Working

How Does An AC Generator Work?

The working principle of an alternator or AC generator is similar to the basic working principle of a DC generator.



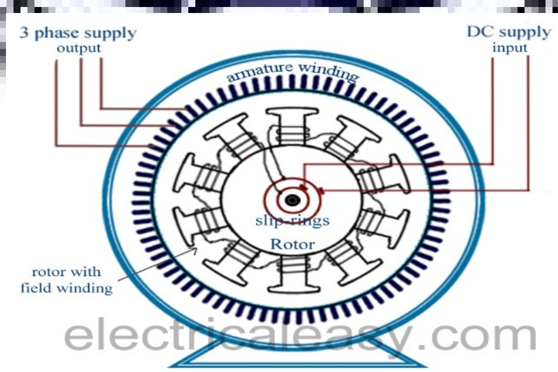
Above figure helps you understanding how an alternator or AC generator works. According to the Faraday's law of electromagnetic induction, whenever a conductor moves in a magnetic field EMF gets induced across the conductor. If the close path is provided to the conductor, induced emf causes current to flow in the circuit.

Now, see the above figure. Let the conductor coil ABCD is placed in a magnetic field. The direction of magnetic flux will be form N pole to S pole. The coil is connected to slip rings, and the load is connected through brushes resting on the slip rings.

Now, consider the case 1 from above figure. The coil is rotating clockwise, in this case the direction of induced current can be given by Fleming's right hand rule, and it will be along A-B-C-D.

As the coil is rotating clockwise, after half of the time period, the position of the coil will be as in second case of above figure. In this case, the direction of the induced current according to Fleming's right hand rule will be along D-C-B-A. It shows that, the direction of the current changes after half of the time period, that means we get an alternating current.

Construction Of AC Generator (Alternator):



Salient pole type alternator

Main parts of the alternator, obviously, consists of stator and rotor. But, the unlike other machines, in most of the alternators, field exciters are rotating and the armature coil is stationary.

Stator: Unlike in DC machine stator of an alternator is not meant to serve path for magnetic flux. Instead, the stator is used for holding armature winding. The stator core is made up of lamination of steel alloys or magnetic iron, to minimize the eddy current losses.

Why Armature Winding Is Stationary In An Alternator?

¬ At high voltages, it easier to insulate stationary armature winding, which may be as high as 30 kV or more.

¬ The high voltage output can be directly taken out from the stationary armature. Whereas, for a rotary armature, there will be large brush contact drop at higher voltages, also the sparking at the brush surface will occur.

¬ Field exciter winding is placed in rotor, and the low dc voltage can be transferred safely.

¬ The armature winding can be braced well, so as to prevent deformation caused by the high centrifugal force.

Rotor: There are two types of rotor used in an AC generator / alternator:

(i) Salient and (ii) Cylindrical type

1. Salient pole type: Salient pole type rotor is used in low and medium speed alternators. Construction of AC generator of salient pole type rotor is shown in the figure above. This type of rotor consists of large number of projected poles (called salient poles), bolted on a magnetic wheel. These poles are also laminated to minimize the eddy current losses. Alternators featuring this type of rotor are large in diameters and short in axial length.

2. Cylindrical type: Cylindrical type rotors are used in high speed alternators, especially in turbo alternators. This type of rotor consists of a smooth and solid steel cylinder havingg slots along its outer periphery. Field windings are placed in these slots.

The DC suppy is given to the rotor winding through the slip rings and and brushes arrangement.

Connecting an alternator in grid is called as synchronization of alternator

Linear electric generator

In the simplest form of linear electric generator, a sliding magnet moves back and forth through a solenoid - a spool of copper wire. An alternating current is induced in the loops of wire by

Faraday's law of induction each time the magnet slides through. This type of generator is used in the Faraday flashlight. Larger linear electricity generators are used in wave power schemes.

Variable speed constant frequency generators

Many renewable energy efforts attempt to harvest natural sources of mechanical energy (wind, tides, etc.) to produce electricity. Because these sources fluctuate in power applied, standard generators using permanent magnets and fixed windings would deliver unregulated voltage and frequency. The overhead of regulation (whether before the generator via gear reduction or after generation by electrical means) is high in proportion to the naturally-derived energy available.

New generator designs such as the asynchronous or induction singly-fed generator, the doubly fed generator, or the brushless wound-rotor doubly fed generator are seeing success in variable speed constant frequency applications, such as wind turbines or other renewable energy technologies. These systems thus offer cost, reliability and efficiency benefits in certain use cases.

Common use cases

Vehicular generators

Roadway vehicles

Motor vehicles require electrical energy to power their instrumentation, keep the engine itself operating, and recharge their batteries. Until about the 1960s motor vehicles tended to use DC generators with electromechanical regulators. Following the historical trend above and for many of the same reasons, these have now been replaced by alternators with built-in rectifier circuits.

Bicycles

Bicycles require energy to power running lights and other equipment. There are two common kinds of generator in use on bicycles: bottle dynamos which engage the bicycle's tire on an as-needed basis, and hub dynamos which are directly attached to the bicycle's drive train. In reality, neither of these is a dynamo, properly speaking - they are small permanent-magnet alternators.

Sailboats

Sailing boats may use a water- or wind-powered generator to trickle-charge the batteries. A small propeller, wind turbine or impeller is connected to a low-power generator to supply currents at typical wind or cruising speeds.

Genset

An engine-generator is the combination of an electrical generator and an engine(prime mover) mounted together to form a single piece of self-contained equipment. The engines used are usually piston engines, but gas turbines can also be used. And there are even hybrid diesel-gas units, called dual-fuel units. Many different versions of engine-generators are available - ranging from very small portable petrol powered sets to large turbine installations. The primary advantage of engine-generators is the ability to independently supply electricity, allowing the units to serve as backup power solutions.

Human powered electrical generators

A generator can also be driven by human muscle power (for instance, in field radio station equipment).

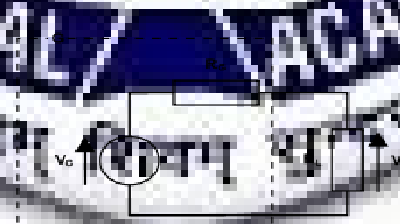
Protesters at Occupy Wall Streetusing bicycles connected to a motor and one-way diode to charge batteries for their electronics

Human powered direct current generators are commercially available, and have been the project of some DIY enthusiasts. Typically operated by means of pedal power, a converted bicycle trainer, or a foot pump, such generators can be practically used to charge batteries, and in some cases are designed with an integral inverter. An average "healthy human" can produce a steady 75 Watts (0.1 horsepower) for a full eight hour period, while a "first class athlete" can produce approximately 298 Watts (0.4 horsepower) for a similar period. At the end of which an undetermined period of rest and recovery will be required. At 298 Watts the average "healthy human" becomes exhausted within 10 minutes. It is important to note that the power figures referenced above are for direct human output and not the electrical power that can be generated from it. Portable radio receivers with a crank are made to reduce battery purchase requirements, see clockwork radio. During the mid 20th century, pedal powered radios were used throughout the Australian outback, to provide schooling (School of the Air), medical and other needs in remote stations and towns.

Mechanical measurement

Designed to measure shaft speed, a tachogenerator is a device which produces an output voltage proportional to that speed. Tachogenerators are frequently used to power tachometers to measure the speeds of electric motors, engines, and the equipment they power. speed. With precise construction and design, generators can be built to produce very precise voltages for certain ranges of shaft speeds.

Equivalent circuit



Equivalent circuit of generator and load.

G = generator

VG=generator open-circuit voltage

RG=generator internal resistance

VL=generator on-load voltage

RL=load resistance

An equivalent circuit of a generator and load is shown in the adjacent diagram. The generator is represented by an abstract generator consisting of an ideal voltage source and an internal resistance. The generator's and parameters can be determined by measuring the winding resistance (corrected to operating temperature), and measuring the open-circuit and loaded voltage for a defined current load.

This is the simplest model of a generator, further elements may need to be added for an accurate representation. In particular, inductance can be added to allow for the machine's windings and magnetic leakage flux, but a full representation can become much more complex than this.

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CENTRAL ACADEMY

सत्यम् शिवम् सुन्दरम्