Electric motors

The manufacture and use of machines designed to make our daily lives easier have made mankind depended on energy. Energy stored in fire and water was initially used to power machines, however these sources of energy had many limitations – the complexity of such machines was great and the distance from the energy sources had to be small because of energy loses. Electric current was easily transported over large distances with minimal loses. Transformation of electric energy into a mechanical and vice versa was achieved using electric motors.

Motor is a device that creates motion. Electric motor is a machine that converts electricity into a mechanical motion.

A device that converts mechanical motion into electric energy is called dynamo or alternator. Design wise are dynamos and alternators very similar to electric motors.

History

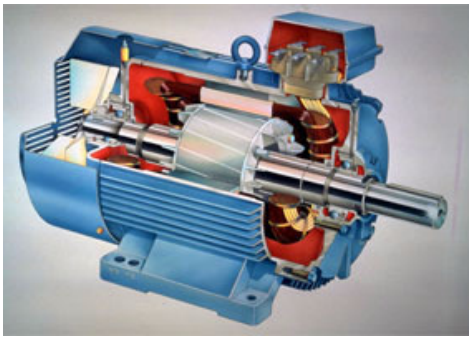
In 1882, Serbian inventor Nikola Tesla identified the rotating magnetic induction field principle used in alternators and pioneered the use of this rotating and inducting electromagnetic field force to generate torque in rotating machines.

Tesla would later obtain U.S. Patent for Electric Motor (December 1889). This classic alternating current electro-magnetic motor was an induction motor.

Michail Osipovich Dolivo-Dobrovolsky later invented a three-phase "cage-rotor" in 1890. This type of motor is now used for the vast majority of commercial applications.

Principle of operation

Electric motors utilize electromagnetic force to create motion. The basic principle of electromagnetism is mutual attractive force created by electrical current that flows through conductors. The motor works on the principle of Lorentz force, which states that any current carrying conductor placed within an external magnetic field experiences a torque or force known as Lorentz force.



Electric motor consists of two basic parts:

- **stator** – static, non-moving part
- **rotor** – moving part (rotating)

An electric motor converts electrical power to mechanical power in its rotor (rotating part). There are several ways to supply power to the rotor. An induction motor is sometimes called a rotating transformer because the stator (stationary part) is essentially the primary side of the transformer and the rotor (rotating part) is the secondary side.

In electric motor the rotating part is placed inside the stator and both parts have conductor windings around them. Direct current electric motor can contain a fixed set of electromagnets or magnets placed usually around rotor. Alternating current electric motors are constructed differently; they contain a special electric circuit in a form of a conductive cage.

Classification

DC motors

- using electromagnets
- series motor
- shunt motor (parallel)
- compound motor (serial-parallel)

AC motors

- Synchronous
- Induction
  - single-phase
  - three-phase

DCmotors

DC motor – an electric motor that runs on direct current electricity.

The brushed DC motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary permanent magnets, and rotating electrical magnets. Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor.

Series DC motor

Series motors have the field coils connected in series with the armature circuit. This type of motor, with constant potential applied, develops variable torque but its speed varies widely under changing load conditions. Series motors are commonly used to drive electric cranes, hoists and certain types of vehicles (electric trucks, trains,…).

Shunt DC motor

The stator and rotor windows are connected in parallel. The motor's revolutions are less dependent on the load. The current supplied to stator can be individually regulated. This motor is used where constant revolutions per minute are desired.

Compound DC motor

The compound DC motor is a compromise between shunt and series motors. It develops an increased starting torque over that of the shunt motor and has less variation in speed than series motor.

AC motors

AC motor – an electric motor that is driven by alternating current.

Synchronous motor

The rotor is surrounded by an electromagnet. The stator is creating a pulsating magnetic field. The rotor tries to be oriented with this pulsating field. The synchronous motor can also be used as an alternator.

Disadvantage: Synchronous motors are not self-starting motors. This property is due to the inertia of the rotor. To start a synchronous motor we need a separate motor (called pony motor), which is used to drive the rotor before it locks in into synchronization.

Induction motor

An induction motor or asynchronous motor is a type of alternating current motor where power is supplied to the rotor by means of electromagnetic induction. A polyphase current is supplied to the stator winding and produces a rotating magnetic field.

The design of induction motor's rotor differs from that of a synchronous motor.

The most common rotor is a squirrel-cage rotor. It is made up of bars of either solid copper (most common) or aluminium that span the length of the rotor, and those solid copper or aluminium strips can be shorted or connected by a ring. The rotor bars in squirrel-cage induction motors are not straight, but have some skew to reduce noise and harmonics.

A slip ring rotor (or form-wound rotor) replaces the bars of the cage rotor with windings that are connected to slip rings. When these slip rings are shorted, the rotor behaves similarly to a squirrel-cage rotor; they can also be connected to resistors to produce a high-resistance rotor circuit, which can be beneficial in starting.

Induction motors are now the preferred choice for industrial motors due to their rugged construction, absence of brushes (which are required in most DC motors) and — thanks to modern power electronics — the ability to control the speed of the motor.

Linear motor

A linear motor or linear induction motor is an alternating current (AC) electric motor that has had its stator "unrolled" so that instead of producing a torque (rotation) it produces a linear force along its length. The most common mode of operation is as a Lorentz-type actuator, in which the applied force is linearly proportional to the current and the magnetic field.

This type of motor is used in transportation to move trains gliding atop a magnetic field.

VOCABULARY

motion – pohyb
actuator – pohon
torque – krútiaci moment
cage-rotor – klietkový rotor
squirrel-cage rotor – rotor s kotvou nakrátko
inventor – vynálezca
pioneer – priekopník
obtain – získať, odbržať
load conditions – zaťaženie
form-wound rotor – rotor s vinutou kotvou

squirrel – veverička
shunt – bočník *tu:* paralený
vast – rozsiahly
the vast majority – drvivá väčšina
beneficial – prospešný, užitočný
windings – vinutia
pony motor – *tu*: motorček
crane – žeriav
hoist – kladkostroj, výťah, zdvihák
slip-ring rotor – rotor s vinutou kotvou
slip-ring – zberacie krúžky
strips – pásy
rotor bars – rotorové tyče
skew – šikmý
straight – rovný
certain types of vehicles – určité druhy vozidiel