DC Motor, how it works?

You can find DC motors in many portable home appliances, automobiles and types of industrial equipment. In this video we will logically understand the operation and construction of a commercial DC motor.

The Working

Let’s first start with the simplest DC motor possible. It looks like as shown in the Fig.1. The stator is a permanent magnet and provides a constant magnetic field. The armature, which is the rotating part, is a simple coil.

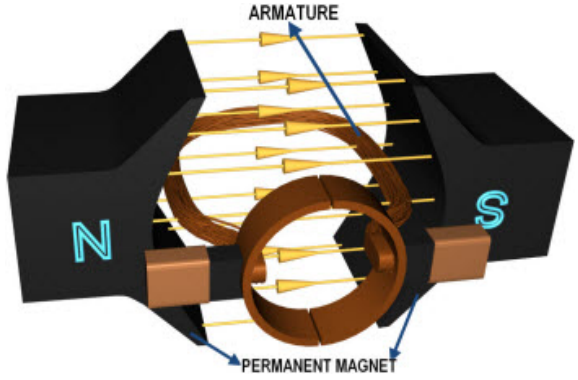

Fig.1 A simplified D.C motor, which runs with permanent magnet

The armature is connected to a DC power source through a pair of commutator rings. When the current flows through the coil an electromagnetic force is induced on it according to the *Lorentz law*, so the coil will start to rotate. The force induced due to the electromagnetic induction is shown using 'red arrows' in the Fig.2.

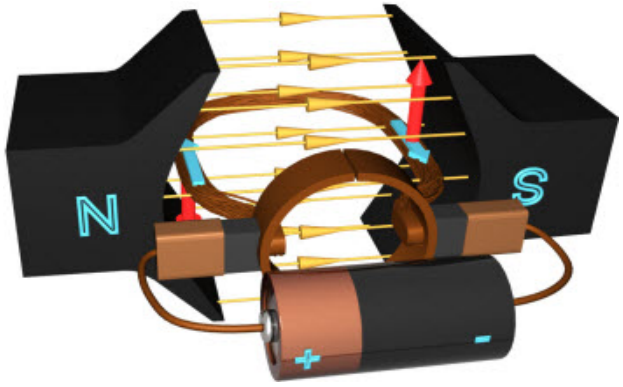

Fig.2 The electromagnetic force induced on the coils make the armature coil rotate

You will notice that as the coil rotates, the commutator rings connect with the power source of opposite polarity. As a result, on the left side of the coil the electricity will always flow ‘away ‘and on the right side , electricity will always flow ‘towards ‘. This ensures that the torque action is also in the same direction throughout the motion, so the coil will continue rotating.

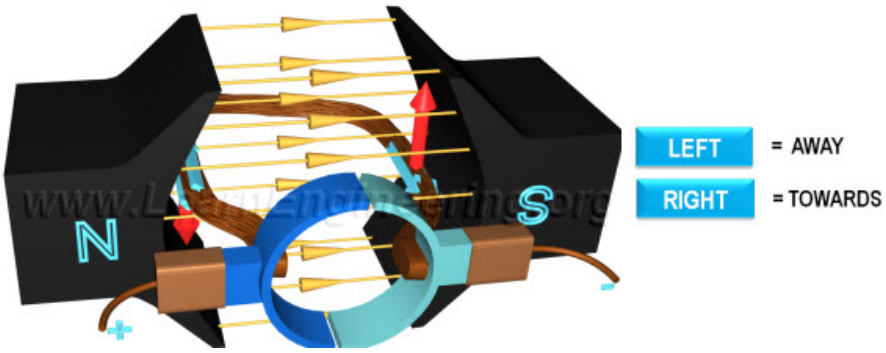

Fig.3 The commutator rings make sure a uni-directional current flows through the left and right part of the coil

Improving the Torque action

But if you observe the torque action on the coil closely, you will notice that, when the coil is nearly perpendicular to the magnetic flux, the torque action nears zero.

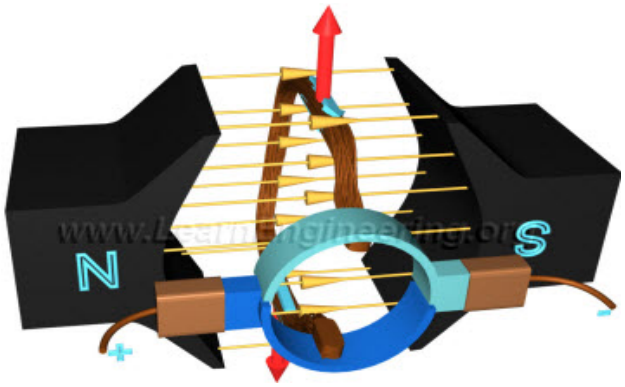

Fig.4 When the coil nears perpendicular to the magnetic flux, the torque produced nears zero

As a result there will be irregular motion of the rotor, if you run such a DC motor. Here is the trick to overcome this problem! Add one more loop to the rotor, with a separate commutator pair for it. In this arrangement when the first loop is in the vertical position, the second loop will be connected to the power source. So a motive force is always present in the system.

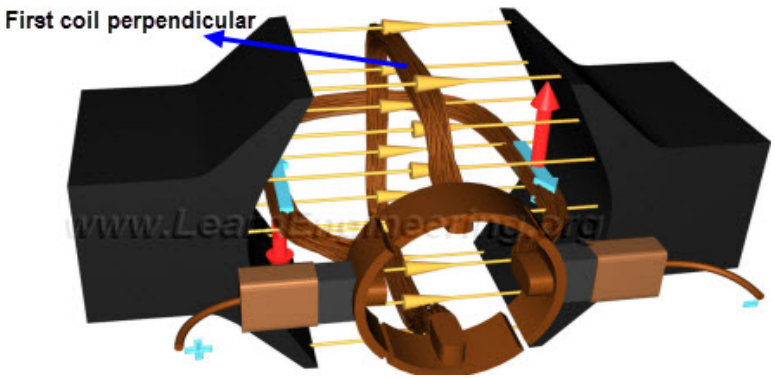

Fig.5 For the 2 coil rotor arrangement, when the first coil is perpendicular to the magnetic flux, second coil is connected to the power source

Moreover, the more such loops, the smoother will be the motor rotation. In a practical motor, the armature loops are fitted inside slots of highly permeable steel layers. This will enhance magnetic flux interaction. Spring loaded commutator brushes help to maintain contact with the power source.

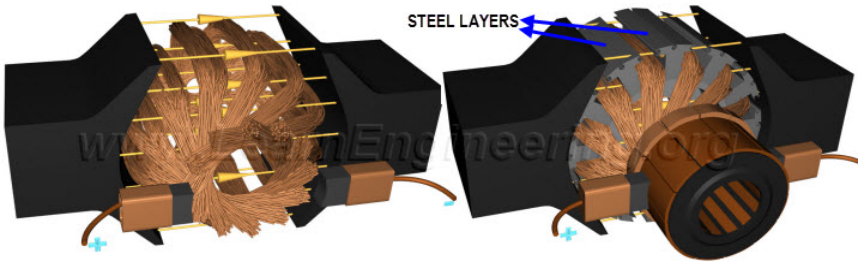

Fig.6 More the number of the coils, smoother will be motor rotation; to enhance magnetic flux interaction, coils are put between steel layer poles

Use of Electromagnet

A permanent magnet stator pole is used only for very small DC motors. Most often an electromagnet is used; the field coil of the electromagnet is powered from the same DC source.

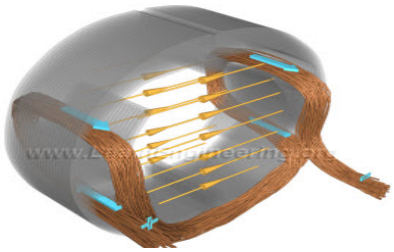

Fig.7 An electromagnet is used most of the time in D.C motor

Shunt & Series Motors

The field coils can be connected to the rotor windings in 2 different ways; parallel or series. This results into 2 different kinds of DC motor constructions; a shunt and a series motors.

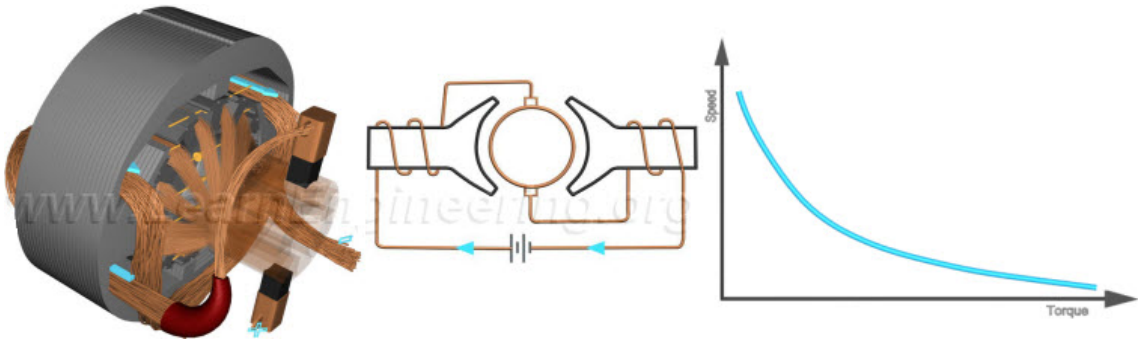

Fig.8 In a series motor rotor coil and stator coils are connected in series

The series wound motor has good starting torque, but its speed drops drastically with the load. This nature is shown in the Fig.8

The shunt motor has a low starting torque, but it is able to run almost at a constant speed, irrespective of the load acting on the motor. This is an attractive operation characteristic of a shunt wound motor, the nature of the speed-torque variation is shown in the Fig. 10.

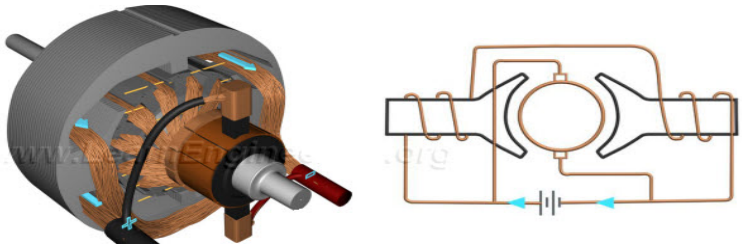

Fig.9 Shunt motor has a parallel connection between the field and stator winding

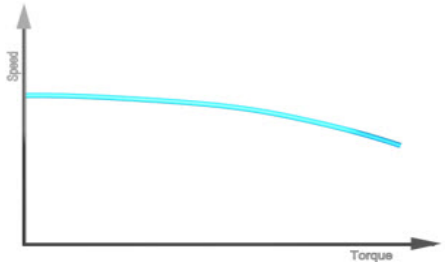

Fig.10 A shunt motor provides a constant Speed-Torque characteristics

The concept of Back E.M.F

Unlike the other electrical machines D.C motors exhibit a unique characteristic; the production of back EMF. A rotating loop in magnetic field will produce an EMF according to the principle of electromagnetic induction.

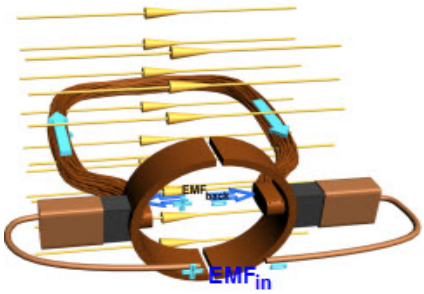

Fig.11 The back E.M.F induced greatly reduces current flow through the armature coil

The case of rotating armature loops is also the same. An internal EMF will be induced that opposes the applied input voltage. The back EMF reduces armature current by a large amount. Back EMF is proportional to the speed of the rotor. At the starting of the motor, back EMF is too low, thus the armature current becomes too high, leading to burnout of the rotor. Thus a proper starting mechanism that controls the applied input voltage is necessary in large D.C motors.