Experiment 4

Object: Demonstration of cut section of:

a) Dc machines (Commutator and brush arrangement),
b) Induction machines (Squirrel Cage Rotor),
c) Synchronous machines (Field winding-Slip ring arrangement)
d) Single phase induction machine(Ceiling fan)

BRIEF THEORY:

I. DC Machines:

A **DC Machine** is an **electro-mechanical energy conversion device**. There are two types of DC machines; one is **DC generator**, and another one is known as **DC motor**. A DC generator converts mechanical power (ωT) into DC electrical power (EI), whereas, a DC motor converts electrical power into mechanical power. 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.

Commutator and Brushes on DC Motor:

To keep the torque on a DC motor from reversing every time the coil moves through the plane perpendicular to the magnetic field, a split-ring device called a commutator is used to reverse the current at that point. The electrical contacts to the rotating ring are called "Brushes" since copper brush contacts were used in early motors. Modern motors normally use spring-loaded carbon contacts, but the historical name for the contacts has persisted.

The purpose of carbon brushes is to reduce wear on the commutator, compared with what metal brushes would do. In many cases, carbon brushes can be made long enough that they will not wear out while a device would otherwise be usable; when they do wear out, they can be readily replaced.

Applications:

The main applications of the three types of DC motors are given below.

1) Series Motors- The series DC motors are used where high starting torque is required, and variations in speed are possible. For example – the series motors are used in Traction system, Cranes, air compressors, Vaccum Cleaner, Sewing machine, etc.
2) Shunt Motors- The shunt motors are used where constant speed is required and starting conditions are not severe. The various applications of DC shunt motor are in Lathe Machines, Centrifugal Pumps, Fans, Blowers, Conveyors, Lifts, Weaving Machine, Spinning machines, etc.
3) Compound Motors- The compound motors are used where higher starting torque and fairly constant speed is required. The examples of usage of compound motors are in Presses, Shears, Conveyors, Elevators, Rolling Mills, Heavy Planners, etc.

The main applications of the various types of DC Generators are as follows:-

1) Separately Excited DC Generators
    - Separately excited DC Generators are used in laboratories for testing as they have a wide range of voltage output.
    - Used as a supply source of DC motors.
2) Shunt wound Generators
    - DC shunt wound generators are used for lighting purposes.
    - Used to charge the battery.

- Providing excitation to the alternators.

3) Series Wound Generators
   - DC series wound generators are used in DC locomotives for regenerative braking for providing field excitation current.
   - Used as a booster in distribution networks.

II. Induction Motor:

Induction Motors are the most commonly used motors in many applications. These are also called as Asynchronous Motors, because an induction motor always runs at a speed lower than synchronous speed. Synchronous speed means the speed of the rotating magnetic field in the stator.

There are basically 2 types of induction motor depending upon the type of input supply - (i) Single phase induction motor and (ii) Three phase induction motor. Or they can be divided according to type of rotor - (i) Squirrel cage motor and (ii) Slip ring motor or wound type.

Squirrel Cage Rotor:

A **squirrel-cage rotor** is the rotating part of the common squirrel-cage induction motor. It consists of a cylinder of steel laminations, with aluminum or copper conductors embedded in its surface. In operation, the non-rotating *stator* winding is connected to an alternating current power source; the alternating current in the stator produces a rotating magnetic field. The rotor winding has current induced in it by the stator field, and produces its own magnetic field. The interaction of the two magnetic fields from these two sources produces torque on the rotor.

By adjusting the shape of the bars in the rotor, the speed-torque characteristics of the motor can be changed, to minimize starting current or to maximize low-speed torque, for example.

Applications:

Squirrel-cage induction motors are very prevalent in industry, in sizes from below one kilowatt (fractional horsepower; less than 1 hp) up to tens of megawatts (10,000s of horsepower). They are simple, rugged, and self-starting, and maintain a reasonably constant speed from light load to full load, set by the frequency of the power supply and the number of poles of the stator winding. They are used in:

- Lathes and turning equipment
- Pumps
- Industrial Drives
- Fans and Blowers

III. Synchronous machine

Synchronous motor and induction motor are the most widely used types of AC motor. Construction of a synchronous motor is similar to an alternator (AC generator). A same synchronous machine can be used as a synchronous motor or as an alternator. Synchronous motors are available in a wide range, generally rated between 150kW to 15MW with speeds ranging from 150 to 1800 rpm.

Field Windings and Slip Ring Arrangement:

In a synchronous generator, a DC current is applied to the rotor winding producing a rotor magnetic field. The rotor is then turned by external means producing a rotating magnetic field, which induces a 3-phase voltage within the stator winding.

• Field windings are the windings producing the main magnetic field (rotor windings)

• Armature windings are the windings where the main voltage is induced (stator windings)

Two common approaches are used to supply a DC current to the field circuits on the rotating rotor:

1. Supply the DC power from an external DC source to the rotor by means of slip rings and brushes
2. Supply the DC power from a special DC power source mounted directly on the shaft of the machine.

Slip rings are metal rings completely encircling the shaft of a machine but insulated from it. Graphite-like carbon brushes connected to DC terminals ride on each slip ring supplying DC voltage to field windings.

Applications:

- Synchronous motors are used in generating stations and in substations connected to the busbars to improve the power factor.
- Synchronous motors are used to regulate the voltage at the end of transmission lines.
- In textile and paper industries synchronous motors are employed to attain wide range of speeds with variable frequency drive system.

IV. Single phase Induction Machine

Single phase motors are the most familiar of all electric motors because they are extensively used in home appliances, shops, offices etc. Single-phase induction motors are usually two-pole or four-pole, rated at 2 hp or less, while slower and larger motor can be manufactured for special purposes. They are widely used in domestic appliances and for a very large number of low power drives in industry. The single phase induction motor resembles, three-phase, squirrel-cage motor except that, single phase induction motor has no starting torque and some special arrangement have to be made to make it as self-starting.

Working of induction motor in Ceiling Fan

Ceiling fan: It's a propeller bladed fan, having two or more blades. It's driven by a single phase induction motor with operating voltage of 230V, 50Hz. It consists of the following parts:

(1) Motor: Motor is the main part of a ceiling fan which is a ***single phase permanent capacitor induction motor***. The capacitor is connected between two winding namely running and starting winding. The purpose of the capacitor is to provide a sufficient phase difference between the currents in two winding so as to for developing rotating field and make the fan self-starting. Torque can be produced by the two fluxes of current only if considerable phase difference exists between them. The motor windings are housed on stator only.

(2) Rotor: The rotor is squirrel cage type and it is rotating part of the ceiling fan. The blades of fan are connected on the motor cover.

Ceiling fans typically work on induction motors that convert electric energy into mechanical energy. The *capacitor of ceiling fans torques up electric motor that lets it run just after a start*. The current reaches motor and makes its path towards coil that is wrapped around metal base. While the current conducts through the wire, a magnetic field gets created that exerts force in a

clockwise motion that converts electric energy into mechanical energy. With this action the motor coil begins to rotate. When these coils are spinning the fan captures the motion while transferring to fan blades. Single phase induction motors (capacitor start, also known as split phase induction motor) are required in ceiling fans due to their easy handling and repair, simple design, cost and efficiency. It is the economical choice for office and house spaces as power output of loaded supplies are small.