## Module 1

## Electrical Machine Design and Magnetic Circuit Calculation

## ELECTRICAL MACHINE DESIGN

Ques I) Explain the principle of electrical machine designing. Also write the factors for general design consideration and limitations in design for electrical machine.

Ans: Principle of Electrical Machine Designing

There are several specific tasks to be performed by the electrical machines. The design of electrical machines/equipment for the specific applications is based upon the application of theoretical scientific concepts, technology and related inventions. The suitable design depends upon the proper adjustment of iron portion, copper, air gap, insulation, ventilation and cooling of machine. The selection of conducting, magnetic and insulating materials has important role in machine design. We have to explore the availability of the each type of material, its characteristics, which should be according to the specifications and the performance limitations and its cost.

When a machine is to be designed for a specific application then it is gerferred that the designed machine should fulfill the required specifications. But it is very difficult to design a machine which meets all the specifications and requirements. The machine should be cheaper, durable, and reliable and should be able to perform according to requirements, the manufacturing costs, operating and running costs of the machine are considered.

Factors for General Design Consideration for Electrical Machine

The basic components of all electromagnetic apparatus are the field and armature windings supported by dielectric or insulation, cooling system and mechanical parts. Therefore, the factors for consideration in the design are:

- Magnetic Circuit or the Flux Path: Magnetic circuit or the flux path should establish required amount of fluxusing minimum mmf. The core losses should be less.
- 2) Electric Circuit or Windings: Electric circuit or windings should ensure required emf is induced with no complexity in winding arrangement. The copper losses should be less.
- 3) Insulation: Insulation should ensure trouble free separation of machine parts operating at different potential and confine the current in the prescribed paths.

- Cooling system or ventilation: Cooling system or ventilation should ensure that the machine operates at the specified temperature.
- 5) EMF: An emf is induced in a conductor or a set of conductors subjected to a magnetic field in such a manner that either conductor moves and cuts the stationary lines of flux or it (stationary conductors) is cut by the varying lines of flux. In both the cases there will be a relative motion between the conductor and the magnetic field. This is the characteristics of the generator action.
- 6) Conductor: When a conductor or a set of conductors are placed in a magnetic field and an electric current is supplied through the conductor then conductor observes a mechanical force. This is the characteristic of the motor action.
- 7) Armature: The armature of an electrical machine carries the conductors in which the emf is induced. The field portion of the machine produces the magnetic field. The armature may be rotating with stationary field or the armature may be stationary with rotating field. Usually in large machines the armature is stationary (called stator) and the field is rotating (rotor).
- Machine parts: Should be robust.

Limitations in Design

The materials used for the machine and others such as cooling etc., imposes a limitation in design. The limitations stem from saturation of iron, current density in conductors, temperature, insulation, mechanical properties, efficiency, power factor etc.

- Saturation: Higher flux density reduces the volume of iron but drives the iron to operate beyond knee of the magnetization curve or in the region of saturation. Saturation of iron poses a limitation on account of increased core loss and excessive excitation required to establish a desired value of flux. It also introduces harmonics.
- Current Density: Higher current density reduces the volume of copper but increases the losses and temperature.
- Temperature: poses a limitation on account of possible damage to insulation and other materials.
- Insulation: poses a limitation on account of breakdown by excessive voltage gradient, mechanical forces or heat.
- Mechanical Strength: Mechanical strength of the materials poses a limitation particularly in case of large and high speed machines.

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**Stephen Chapman** 

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