AC MACHINES

These are machines that use AC current. An alternating circuit is an electric current which periodically reverses direction.

Ac machines are either generators that convert mechanical energy to AC electrical energy or motors that convert electrical energy to mechanical energy. There are of two types

(1) Synchronous (2) Asynchronous machines

9.1 Synchronous machines

These are otherwise known as alternator. They are used to convert mechanical energy to electrical energy.

A synchronous machine is an electrical machine whose rotating speed is proportional to the frequency of the alternating current supply and independent of the load.

9.2 Operating Principles of a Synchronous Generator

A rotor magnetic field is produced either by designing the rotor as a permanent magnet or by applying a DC (direct current) to a rotor winding to create electromagnet.

The rotor of the generator is turned by a prime mover producing a rotating field within the machine. Therefore the rotating magnetic field induces a 3 phase set of voltages between the stator winding of the generator. The field winding produces the main magnetic field in a machine while the armature winding applies to winding where the main voltage is induced.

For a synchronous machine, the field winding is the rotor, therefore the terms field winding can be used interchangeably. Because the rotor is subjected to changing magnetic field, it is usually constructed with thin lamination to reduce eddy current loss.

Winding of the electromagnet are wrapped around the poles itself instead of being embedded in notch in the surface of the rotor.

The synchronous generator has 3 important parameters:

1. Armature resistance (R_A): Every armature has its resistance R_A when load is put on the alternator the voltage loop caused by armature resistance per phase is R_A which is phase with R_A

2. Armature leakage resistance: This is due to the flow of load current through the armature. It creates the reaction flux, some part of the flux passes through the air around the conductor. It is known as the leakage flux, which makes the armature winding inductive.

3. Armature reaction: This is due to the connection of load to the alternator current flow through the armature winding which establishes its own flux in the air gap. There are 2 fluxes, one due to

the current through the field winding known as the main flux and the other due current through the armature known as the armature flux.

9.3 AC Machine Power

An AC generator takes in mechanical power and produces electrical power while AC motor does the reverse. In either case, not all power input to the machine appears in useful form. At the other end there is always loss associated with the power.

The percentage of power ratio of an AC machine is given by

R = $\frac{Power\ output}{Power\ input}$ × 100% ....Equation 1

The difference between power in (P_{in}) and the power out (P_{out}) is the power loss.

Power loss = P_{in} - P_{out}

the efficiency is given as

η = $\frac{\text{Pin} - \text{Pout}}{P_{in}}$ × 100% ....Equation 2

9.4 Voltage and Speed Regulation

Voltage regulation is the measure of the ability of the generator to keep a constant voltage at the terminal as load varies. This is expressed as equation 3

V_R = $\frac{V_{ni}-V_{fi}}{V_{ni}}$ × 100% ....Equation 3

Where, V_{ni} is the no load terminal voltage of the generator

V_{fi} is the full load terminal voltage of the generator

9.5 Regulation

Speed: This is the ability of the motor to keep a constant shaft speed as the load varies. This is expressed as equation 4

S_R = $\frac{n_{ni}-nfi}{n_{ni}}$ × 100% ....Equation 4

Where n_{ni} is the no load shaft speed of the motor while

n_{fi} is the full load shaft speed of the motor

Note: at no load losses are minimal

Example 1

The voltage of a generator is 2 volts at no load and 1.76volts at full load. Compute the percent voltage regulation.

Solution

$V_R = \frac{V_{ni}-V_{fi}}{V_{ni}} \times 100\%$

V_{ni} = 2 Volts

V_{fi} = 1.76 Volts

$V_R = \frac{2-1.76}{2} = 12\ \%$

Example 2

The speed of a motor is 200 rpm and 150rpm at no load and full load respectively. Compute the percent speed regulation

$S_R = \frac{n_{ni}-nfi}{n_{ni}} \times 100\ \%$

n_{ni} = 200 rpm

n_{fi} = 150rpm

$S_R = \frac{200-150}{200} \times 100\% = 25\ \%$