Generator/Motor Applications

Synchronous Machines : Synchronous machines can be categorized as salient-pole and cylindrical rotor based on their construction

Construction

- Main Use: Commonly function as AC generators (alternators).
- Function: Convert mechanical power from a prime mover into electrical power.
- Prime Movers: High-speed machines use steam turbines; low-speed machines use hydro-turbines, with options like diesel engines and wind turbines.
- Components: Consist of a rotor and a stator

Principle of operation – The rotating magnetic field

- Field Winding: DC current IfI f applied to rotor winding generates a magnetic field φ_f.
- Rotor Rotation: The rotor is externally driven at a constant speed nsn s , creating a rotating magnetic field.
- Voltage Induction: A 3-phase voltage is induced in the stator (armature windings).
- Output Frequency & Amplitude: Both depend on the rotor's speed of rotation.

$$f = n_s \frac{p}{120} \qquad E_A = K\varphi_f \omega$$

Power, Torque and Speed Relationships : $P(kW) = \frac{T(N.m)n(rpm)}{9549}$ $\quad n_s = \frac{120f}{p}$

Governor/Speed Control : Droop is defined as the drop in frequency of synchronous generator due to increase in load. Increase in power demand causes a decrease in rotor speed. Since $f = \frac{pn_s}{120}$, decrease in speed causes a decrease in frequency.

Speed Droop % = $\frac{n_{nl}-n_{fl}}{n_{fl}}100$

m_p = Governor Droop Response in MW/Hz

$$\frac{P_{fl} - P}{f_{fl} - f} = m_p$$

Change in output power due to change in frequency

$\Delta P = m_p(f_{nominal} - f_{actual})$