1- INDUCTION MACHINES

2-1 General Principle: -

The popularity of 3 phase induction motors on board ships is because of their simple, robust construction, and high reliability factor in the sea environment. A 3 phase induction motor can be used for different applications with various speed and load requirements. Electric motors can be found in almost every production process today. Getting the most out of your application is becoming more and more important in order to ensure cost-effective operations. The three-phase induction motors are the most widely used electric motors in industry. They run at essentially constant speed from no-load to full-load. However, the speed is frequency dependent and consequently these motors are not easily adapted to speed control. We usually prefer d.c. motors when large speed variations are required. Nevertheless, the 3-phase induction motors are simple, rugged, low-priced, easy to maintain and can be manufactured with characteristics to suit most industrial requirements. Like any electric motor, a 3-phase induction motor has a stator and a rotor. The stator carries a 3-phase winding (called stator winding) while the rotor carries a short-circuited winding (called rotor winding). Only the stator winding is fed from 3-phase supply. The rotor winding derives its voltage and power from the externally energized stator winding through electromagnetic induction and hence the name. The induction motor may be considered to be a transformer with a rotating secondary and it can, therefore, be described as a "transformer type" a.c. machine in which electrical energy is converted into mechanical energy. It has the following main advantages and also some disadvantages.

a) Advantages; -

1-it has very simple and extremely rugged, almost un breakable construction (especially squirrel cage type).

2-It´s cost is low and it is very reliable.

3-It has sufficiently high efficiency. in normal running conditions, no brushes are needed, hence frictional losses are reduced. it has a reasonably good power factor.

4-It´s starting arrangement is simple especially for squirrel cage type.

b) Disadvantages: -

1-It´s speed cannot be varied without sacrificing some of its efficiency

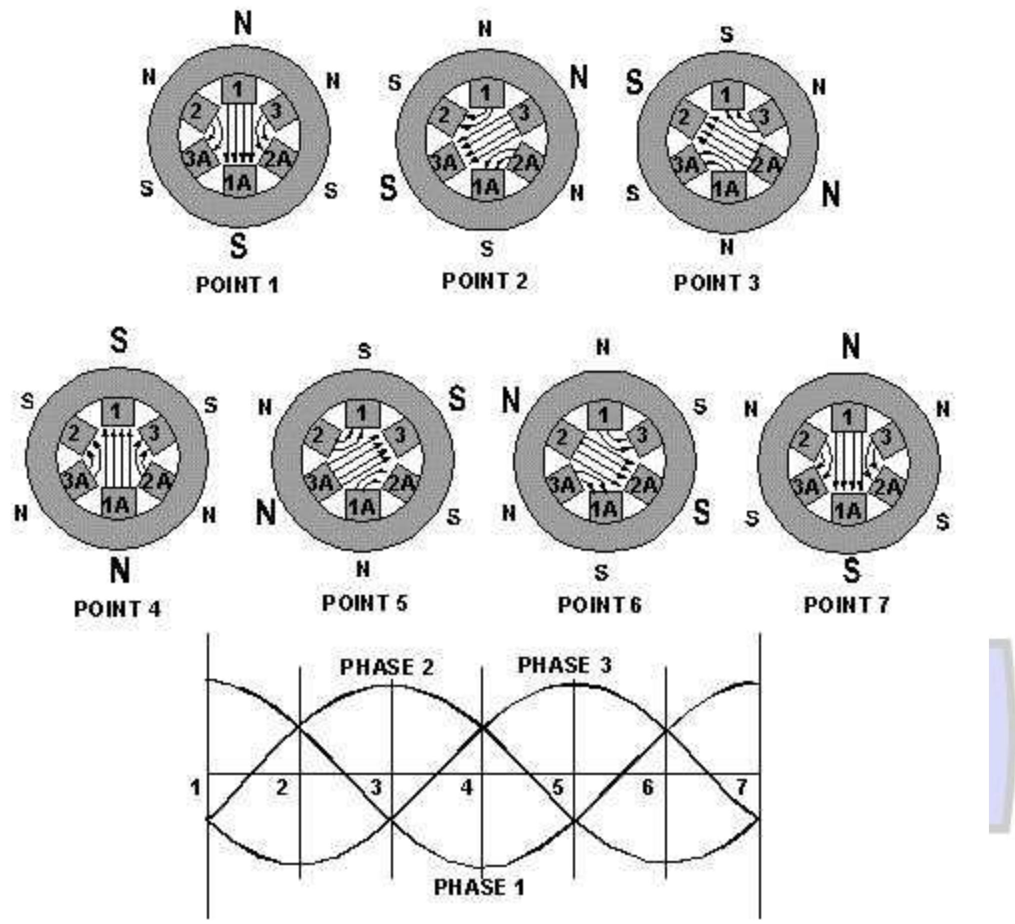
2-It´s speed decreases with increase in load.

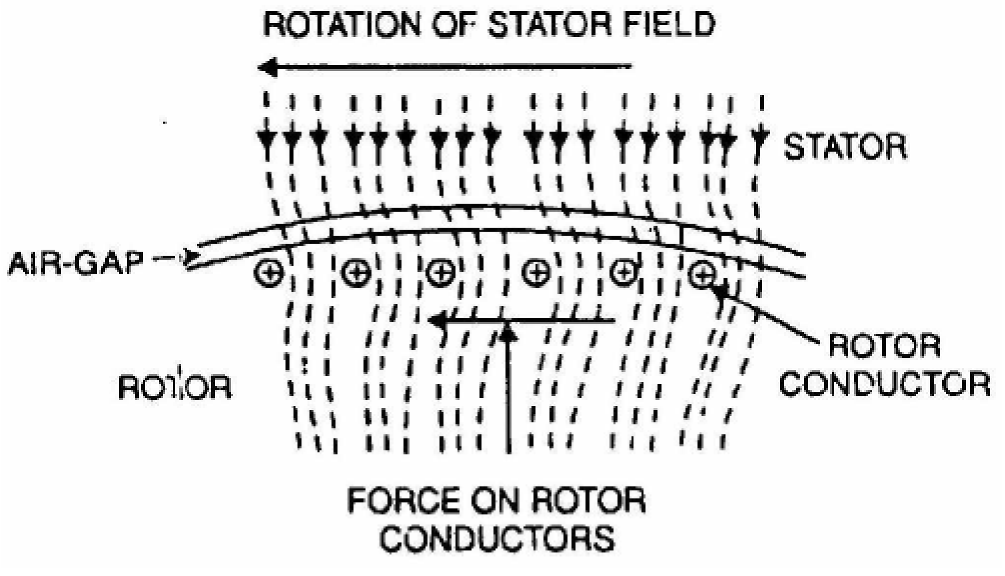
-from advantages and disadvantages we have they are simple ,reliable ,↓cost ,↑energy index ,rotor speed<syn. speed ,↓power factor.

2-2 Operating Principles:

1) Energize the stator with three-phase voltage.
2) Currents in the stator winding produce a rotating magnetic field. This field revolves in the air gap.
3) The stator magnetic field links the rotor conductors through the air gap and voltage will be induced in the rotor conductors.
4) Currents in the rotor conductors will produce their own magnetic field which opposes the stator magnetic field.
5) The torque developed due to interaction of the stator and rotor magnetic fields pushes the rotor into rotation.
6) The direction of the rotation of the rotor is the same as the direction of the rotation of the revolving magnetic field in the air gap.

In a 3-phase induction motor, the three-phase currents Ia, Ib and Ic, each of equal magnitude, but differing in phase by 120°. Each phase current produces a magnetic flux and there is physical 120 °shift between each flux. The total flux in the machine is the sum of the three fluxes. The summation of the three ac fluxes results in a rotating flux, which turns with constant speed and has constant amplitude. Such a magnetic flux produced by balanced three phase currents flowing in three-phase windings is called a rotating magnetic flux or rotating magnetic field (RMF). RMF rotates with a constant speed (Synchronous Speed). Existence of a RFM is an essential condition for the operation of an induction motor. If stator is energized by an ac current, RMF is generated due to the applied current to the stator winding. This flux produces magnetic field and the field revolves in the air gap between stator and rotor. So, the magnetic field induces a voltage in the short circuited bars of the rotor. This voltage drives current through the bars. The interaction of the rotating flux and the rotor current generates a force that drives the motor and a torque is developed consequently. The torque is proportional with the flux density and the rotor 6 bar current (F=BLI). The motor speed is less than the synchronous speed. The direction of the rotation of the rotor is the same as the direction of the rotation of the revolving magnetic field in the air gap. However, for these currents to be induced, the speed of the physical rotor and the speed of the rotating magnetic field in the stator must be different, or else the magnetic field will not be moving relative to the rotor conductors and no currents will be induced. If by some chance this happens, the rotor typically slows slightly until a current is re-induced and then the rotor continues as before. This difference between the speed of the rotor and speed of the rotating magnetic field in the stator is called slip. It is unitless and is the ratio between the relative speed of the magnetic field as seen by the rotor the (slip speed) to the speed of the rotating stator field. Due to this an induction motor is sometimes referred to as an asynchronous machine.





2-3 Operating Modes: -

We have three modes for operation in I. Machines

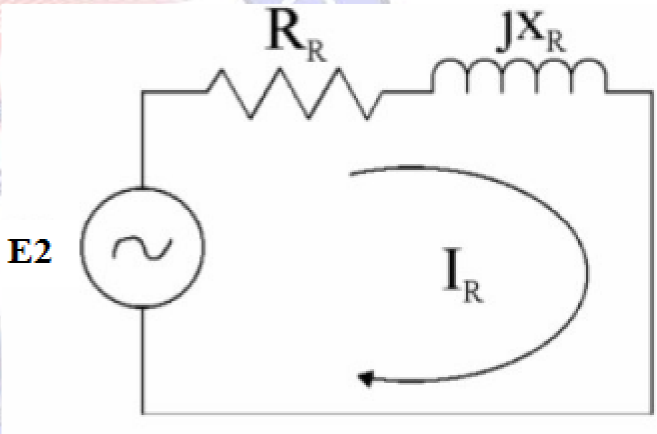
Motoring: n= 0 - n , s=1- 0

Generating: n: n_s - (+∞) ,s=0 - (-∞)

Braking: n: n - (+∞) ,s=1- (+∞)

mode	m	G	B
Driving	Self	P.M	P.M
Slip from to	0 +1	0 -∞	+1 +∞
speed	n<n1	n>n1	0<n<-∞
Rotating direction	→n →n_s	→n →n_s	→ n_s ←n

2-4 Rotating Rotor: -



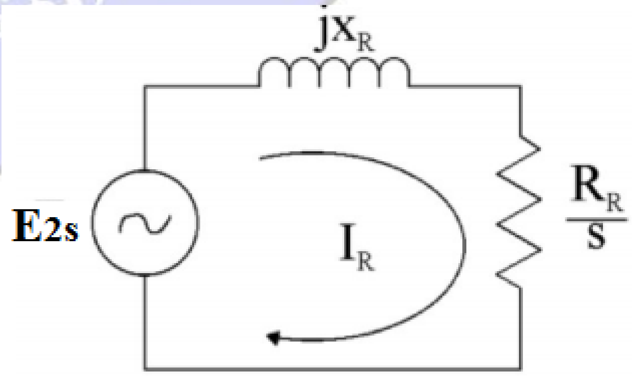
$$E2s = 4.44\, F2\, KW2\, T_2\, \emptyset M$$

$$= (4.44\, F1\, KW2\, T_2\, \emptyset M) * s = sE2$$

Where S=f_2/f_1

$$X2s = 2\pi f_2 L_2 = S(2\pi f_1 L_2) = SX_2$$

-R2S=R2 because it´s resistor



$$Z_2 s = R_2 s + jX_2 s\,, \quad Z_2 s = \sqrt{{R_2}^2 + {X_{2S}}^2}$$

$$I2S = \frac{E_2 s}{Z_2 s} = \frac{E_2 s}{R_2 + jX_{2S}} = \frac{SE2}{R_2 + \mathrm{S}jX_2}$$

$$= \frac{E2}{\frac{R_2}{\mathrm{S}} + \mathrm{j}X_2}$$

$$\varphi 2S = \tan^{-1}\frac{SX2}{R2} = \cos^{-1}\frac{R2}{Z2S}$$

$$I_{2S} = \left(\frac{E_2}{X_2}\right)\sin\varphi_{2S} \quad , \quad I_{2S} = I_2 \quad , \varphi_{2S} = \varphi_2$$