ELEMENTS OF ELECTRICAL ENGINEERING
Course Code : UE25EE141A/B

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ELEMENTS OF ELECTRICAL ENGINEERING

Working principle of three-phase induction motor, Concept of Slip and Numerical examples

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Concept of Rotating Magnetic Field in a Induction Motor

- 3Φ stator winding is excited by 3Φ supply, which will produce 3Φ rotating flux of constant magnitude in the stator.

- This flux is called as **Rotating Magnetic Field (RMF)**

The speed of the rotating magnetic field, called Synchronous speed (Ns) is given by

$$N_s = \frac{120f}{P}$$

f= frequency of the supply
P= number of poles

Principle of Operation of Three Phase Induction Motor

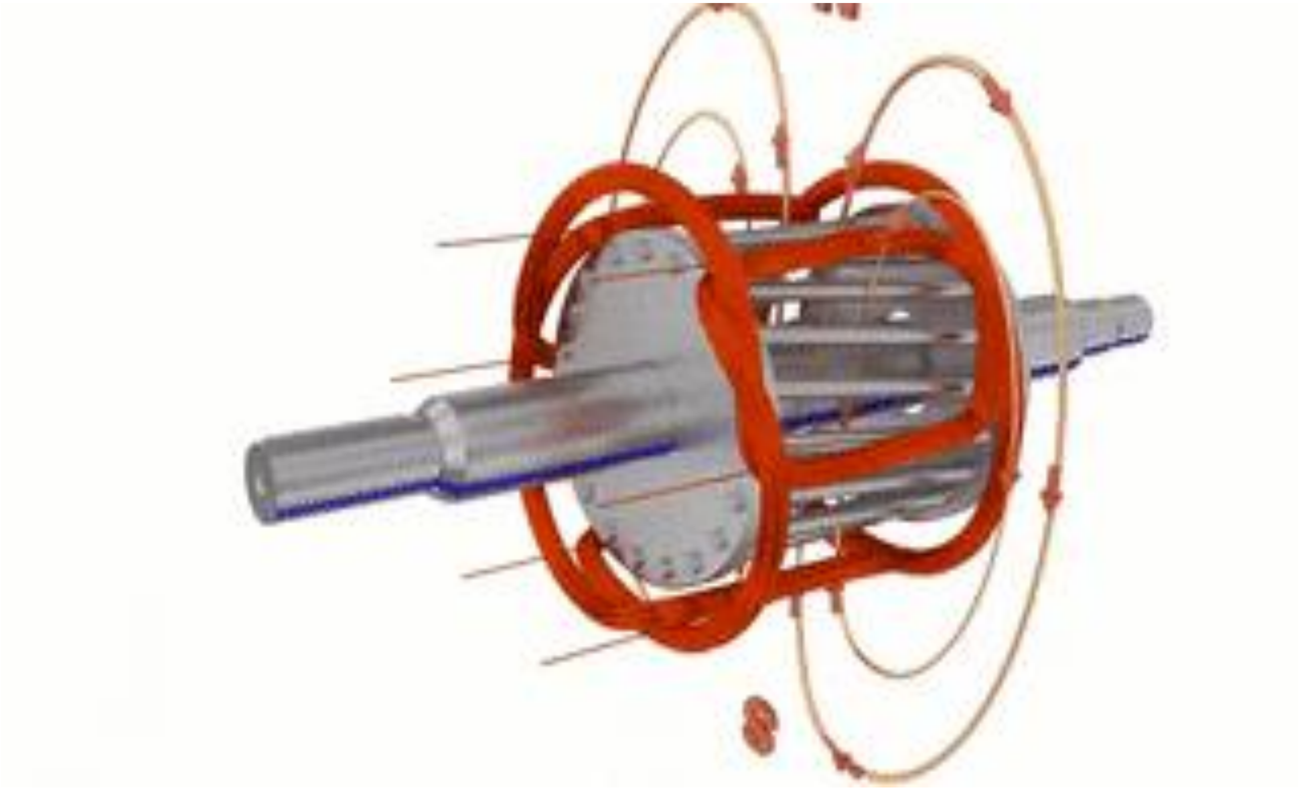
A RMF is set up in the stator, when 3Φ supply is given.

The stationary rotor conductors cut the revolving field and due to electromagnetic induction, an EMF is induced in rotor conductors.

As the rotor conductors are short circuited, current flows through them.

The current carrying rotor conductors in the presence of stator magnetic field experience torque which rotates the rotor.

Principle of Operation of Induction Motors



Slip of Induction Motors

- The speed of the Rotor (N) of the induction motor is always less than synchronous speed (Ns). N<Ns
- The difference between the synchronous speed (Ns) and the rotor speed (N) when expressed as a fraction of Synchronous speed is called Slip (S)

$$\text{Slip},\ S = \frac{(N_s - N)}{N_s}$$

- Usually it is expressed in percentage as

$$\%S = \frac{N_s - N}{N_s} \times 100$$

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Q1.A 3ϕ 4 pole induction motor is supplied from 3ϕ 50Hz AC supply. Find i) synchronous speed ii) rotor speed when slip is 4% iii) the rotor frequency when it runs at 600 RPM.

Soln :

Given $P = 4$; $f = 50$ Hz

i) $N_s = \frac{120f}{P} = 1500$ rpm

ii) $\% S = 4\%$

$\Rightarrow S = 0.04 = \frac{N_s - N}{N_s}$

$\Rightarrow N = 1440$ rpm

Numerical on 3ϕ Induction Motor (contd)

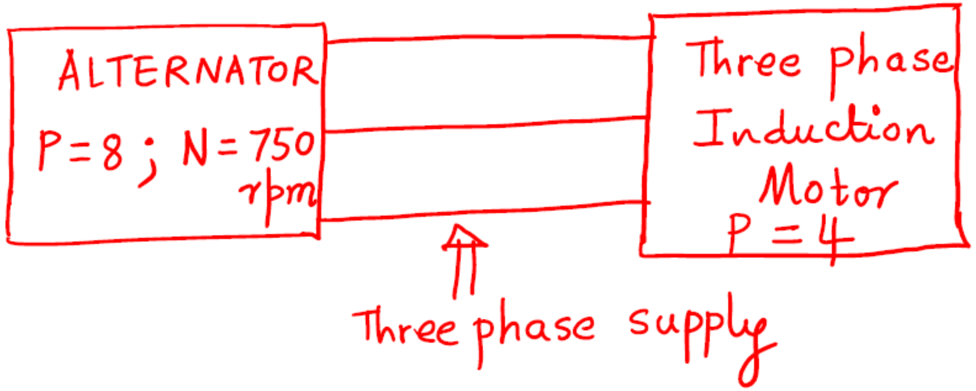
iii) $f_r = sf$

At $N = 600$ rpm, $s = \dfrac{N_s - N}{N_s} = 0.6$

$\Rightarrow f_r = 0.6 * 50 = 30$ Hz

Q2.An 8 pole alternator runs at 750 rpm. It supplies power to a 4 pole induction motor. The frequency of the rotor current is 1.5 Hz. What is the speed of the motor? What is the slip?

Soln :



Alternator : Frequency of AC Supply generated,

$$f = \frac{PN}{120} = 50 \text{ Hz}$$

Numerical on Three Phase Induction Motor (contd)

Frequency of Ac power generated by alternator is the supply frequency of Induction Motor

Induction Motor

$$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

Given $f_r = 1.5\text{ Hz} \Rightarrow sf = 1.5 \Rightarrow s = 0.03$

$$\therefore \quad s = 0.03 = \frac{N_s - N}{N_s} \Rightarrow N = \underline{1455 \text{ rpm}}$$

Numerical on Three Phase Induction Motor (contd)

Q3. A 3 phase, 6 pole, 50Hz induction motor has a slip of 1% at no load and 3 % at full load Find i) no load speed ii) full load speed iii) frequency of rotor current on full load.

Soln :

Given, $P = 6$; $f = 50$ Hz

$$N_S = \frac{120f}{P} = 1000 \text{ rpm}$$

i) No load slip = 1 %

$$\Rightarrow S_{NL} = \frac{N_s - N_{NL}}{N_s} = 0.01$$

Numerical on Three Phase Induction Motor (contd)

$\therefore$ No load speed, $N_{NL} = 990$ rpm

ii) Full load Slip = 3 %

$$\Rightarrow S_{FL} = 0.03 = \frac{N_s - N_{FL}}{N_s}$$

$\Rightarrow$ Full load speed, $N_{FL} = 970$ rpm

iii) f_r (under Full load) $= S_{FL} * f$

$= 1.5$ Hz

Q4.A Three Phase Induction Motor is running at 1740 rpm on a 60Hz supply. Calculate the number of poles, the slip and rotor frequency.

Soln :

Given $f = 60 Hz$; $N = 1740$ rpm

$$N_s = \frac{120f}{P} = \frac{7200}{P} \text{ rpm}$$

P can't be 2 because then $N_s = 3600$ rpm & that means % slip = 51.66 % which is not possible because % slip of an Induction motor will be less than 5% typically

Numerical on Three Phase Induction Motor (contd)

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$P = 6$ is not possible because in that case $N_s = 1200$ rpm will be less than N

Hence, Number of poles, $P = 4$ & $N_s = 1800$ rpm

$$\text{Slip, } s = \frac{N_s - N}{N_s} = 0.033$$

frequency of rotor currents $\Big\}$ $f_r = sf$

$= \underline{2 \text{ Hz}}$

Text Book & References

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Text Book:

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2. “Basic Electrical Engineering”, D. C. Kulshreshta, 2nd Edition, McGraw-Hill. 2019

3. “Special Electrical Machines” E G Janardanan, PHI Learning Pvt. Ltd., 2014

Reference Books:

1. “Engineering Circuit Analysis” William Hayt, Jack Kemmerly, Jamie Phillips and Steven Durbin, 10th Edition McGraw Hill, 2023

2. “Electrical and Electronic Technology” E. Hughes (Revised by J. Hiley, K. Brown & I.M Smith), 12th Edition, Pearson Education, 2016.

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THANK YOU

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