Tutorial 8

DC Machines and AC Machines

Example 1

A 208-V, 10hp, four pole, 60 Hz, Y-connected induction motor has a full-load slip of 5 percent. What is the synchronous speed of this motor?

Explanation

$$n_{sync} = \frac{120\, f_e}{P} = \frac{120(60)}{4} = 1800\ rpm$$

Example 2

- A 3-phase induction motor is wound for 4 poles and is supplied from 50 Hz system. Calculate
- (i) Synchronous speed
- (ii) Rotor speed when slip is 4%
- (iii) rotor frequency when motor runs at 600 rpm.

Explanation

Solution. (*i*) $N_s = 120 f/P = 120 \times 50/4 = 1500$ rpm

(*ii*) rotor speed, $N = N_s(1 - s) = 1500(1 - 0.04) = \mathbf{1440\ rpm}$

(*iii*) when rotor speed is 600 rpm, slip is

$$s = (Ns - N)/N_s = (1500 - 600)/1500 = 0.6$$

rotor current frequency, $f' = sf = 0.6 \times 50 = \mathbf{30\ Hz}$

Example 3

- A slip ring induction motor runs at 290 rpm at full load, when connected to 50 Hz supply. Determine the number of poles and slip?

Explanation

- N = 290 rpm
- Ns has somewhere near it ,say 300 rpm
- If Ns is assumed as 300 rpm then

  300 = 120 X 50/P

Hence P = 20

S = (300-290)/300

= 3.33%

Example 4

- A three phase, 50 Hz, 4 pole slip ring induction motor has a star connected rotor. The full load speed of the motor is 1460 rpm. Determine the synchronous speed and percentage slip.

Explanation

- (i) $N_s = 120f/p = 120 \times 50 / 4 = 1500$ rpm;

- (ii) slip = $(N_s - N) / N_s = (1500 - 1460)/ 1500 = 0.0266$
- Percentage slip = 2.66 %

Example 5

- A 4 pole, 3 phase induction motor operates from a supply whose frequency is 50 Hz, Calculate
- (i) the speed at which magnetic field of stator is running
- (ii) the speed of the rotor when slip is 0.04

Explanation

Solution. (*i*) Stator field revolves at synchronous speed, given by

$$N_s = 120f/P = 120 \times 50/4 = \mathbf{1500\ r.p.m.}$$

(*ii*) rotor (or motor) speed, $N = N_s(1-s) = 1500(1-0.04) = \mathbf{1440\ r.p.m.}$

Example 6

- The stator of 3 phase induction motor has 3 slots per pole per phase. If supply frequency is 50 Hz, then Calculate
- (i) number of stator pole produced and total number of slots on the stator
- (ii) speed of the rotating stator flux

Explanation

Solution. (*i*) $P = 2n = 2 \times 3 = \mathbf{6\ poles}$

Total No. of slots = 3 slots/pole/phase × 6 poles × 3 phases = **54**

(*ii*) $N_s = 120\,f/P = 120 \times 50/6 = \mathbf{1000\ r.p.m.}$

MCQ 1

- A 3-
  phase 440 V, 50 Hz induction motor has 4% sli
  p. The frequency of rotor e.m.f. will be
- (a) 200 Hz
- (b) 50 Hz
- (c) 2 Hz
- (d) 0.2 Hz

Answer

- Ans: c

MCQ 2

- 5 H.P., 50Hz, 3-phase, 440 V, induction motors are available for the following r.p.m. Which motor will be the costliest ?
- (a) 730 r.p.m.
- (b) 960 r.p.m.
- (c) 1440 r.p.m.
- (d) 2880 r.p.m.

Answer

- (a) 730 r.p.m.

Armature winding

There are 2 types of winding

Lap and Wave winding

Lap winding

- **A = P**

- The armature windings are divided into no. of sections equal to the no of poles

Wave winding

- **A = 2**

- It is used in low current output and high voltage.

- 2 brushes

Example

- A DC motor takes an armature current of 110 Amp. at 480 volts. The armature circuit resistance is 0.2 ohm. The machine has 6-poles and the armature is lap connected with 864 conductors. The flux per pole is 0.05 Wb. Calculate the speed of DC motor.

Explanation

Solution. $E_b = 480 - 110 \times 0.2 = 458$ V, $\Phi = 0.05$ W, $Z = 864$

Now, $$E_b = \frac{\Phi ZN}{60}\left(\frac{P}{A}\right) \text{ or } 458 = \frac{0.05 \times 864 \times N}{60} \times \left(\frac{6}{6}\right)$$

$\therefore$ $N = 636$ r.p.m.

Example

- A 250 V, 4 pole wave wound dc series motor has 782 conductors on its armature. It has armature and series field resistance of 0.75ohm. The motor takes a current of 40 Amp. Calculate the speed when flux per pole is 25mWb.

Explanation

Solution. $E_b = \Phi Z N (P/A)$

Now, $E_b = V - I_a R_a = 50 - 40 \times 0.75 = 220$ V

$\therefore$ $220 = 25 \times 10^{-3} \times 782 \times N \times 0.75 = 220$ V