UNIT III
THREE PHASE INDUCTION MOTOR
PART A

1. State the principle of 3 phase IM?

While starting, rotor conductors are stationary and they cut the revolving magnetic field and so an emf is induced in them by electromagnetic induction. This induced emf produces a current if the circuit is closed. This current opposes the cause by Lenz's law and hence the rotor starts revolving in the same direction as that of the magnetic field.

2. Why an induction motor is called a 'rotating transformer'?

The rotor receives electric power in exactly the same way as the secondary of a two-winding transformer receiving its power from the primary. That is why an induction motor can be called as a rotating transformer i.e. one in which primary winding is stationary but the secondary is tree to rotate.

3. Why an induction motor will never run at its synchronous speed?

If the rotor runs at synchronous speed, then there would be no relative speed between the two; hence no rotor EMF, no rotor current and so no rotor torque to maintain rotation. That is why the rotor runs at a speed, which is always less than syn. speed.

4. State the advantages of skewing?

- It reduces humming and hence quite running of motor is achieved.
- It reduces magnetic locking of the stator and rotor.

5. State the condition at which the starting torque developed in a slip-ring induction motor is maximum.

R2=X2

6. What are the effects of increasing rotor resistance on starting current and starting torque?

- The additional external resistance reduces the rotor current and hence the current drawn from the supply.
- It improves the starting torque developed by improving the power factor in high proportion to the decrease in rotor current.

7. What is slip of an induction motor?

The slip speed is defined as the ratio of relative speed to synchronous speed is expressed as % slip S=(Ns-N)/Ns*100

8. How the magnitude of rotor emf is related to the slip in an IM?

Rotor circuit emf per phase E2r=SE2

9. State the condition at which the torque developed in a 3 phase induction motor is maximum.

R2=SX2

10. What are the advantages of slip-ring IM over cage IM?

- Rotor circuit is accessible for external connection.
- By adding external resistance to the rotor circuit the starting current is reduced with the added advantage of improving starting torque.
- Additional speed control methods can be employed with the accessibility in the rotor circuit.

11. What are the losses occurring in an IM and on what factors do they depend?

Magnetic losses Wi, Electrical losses Wcu and Mechanical losses Wm

For IM operating in normal condition (with constant voltage and frequency) magnetic and mechanical losses remain constant whereas electrical losses vary in square proportion to the current.

12. What care should be taken at the time of construction to reduce eddy current losses in I M?

Make the resistance of the core body as large as possible. This is achieved by laminating the stator core, stacked and riveted at right angles to the path of eddy current. The laminations are insulated from each other by thin coat of varnish.

13. Why is there not appreciable magnetic losses in the rotor core of Induction motors?

Although the rotor core is also subjected to magnetic flux reversals and since the frequency of flux reversals in the rotor, fr = Sfs, is very small, the iron loss incurred in the rotor core is negligibly small.

14. What is meant by synchronous watts?

The torque developed in an induction motor is proportional to rotor input. By defining a new unit of torque (instead of the force at radius unit) we can say that the rotor torque equals rotor input. The new unit is synchronous watts. Synchronous wattage of an induction motor equals the power transferred across the air-gap to the rotor.

15. How does the shaft torque differ from the torque developed in 3-phase Induction motor?

The mechanical power developed Pd causes the rotor to rotate at a speed Nr due to the torque Td developed in the rotor. The remaining power, after the mechanical losses Wm are met with, available in the shaft as mechanical power output Po.

Po = Pd – Wm

The mechanical power output Po, which is less than Pd is available in the shaft running at a speed of Nr and with a shaft torque T. Therefore the shaft torque (T) is slightly less than the torque developed Td,

16. Name the tests to be conducted for predetermining the performance of 3-phase induction machine.

(a) No load test

(b) Blocked rotor test

17. What are the information's obtained from no-load test in a 3-phase I M?

(i) No –load input current per phase, Io

(ii) No load power factor and hence no load phase angle

(iii) Iron and mechanical losses together

(iv) Elements of equivalent circuit shunt branch

18. What are the information's obtained from blocked rotor test in a 3-phase I M?

(i)Blocked rotor input current per phase at normal voltage

(ii) Blocked rotor power factor and hence phase angle

(iii) Total resistance and leakage reactance per phase of the motor as referred to the stator.

19. What is circle diagram of an IM?

When an I M operates on constant voltage and constant frequency source, the loci of stator current phasor is found to fall on a circle. This circle diagram is used to predict the performance of the machine at different loading conditions as well as mode of operation.

20. What are the advantages and disadvantages of circle diagram method of predetermining the performance of 3 –phase IM?

The prediction can be carried out when any of the following information is available The input line current., the input power factor, The active power input, The reactive power input, The apparent power input, The output power , The slip of operation, The torque developed, The equivalent rotor current per phase, Maximum output power, Maximum torque developed. The only disadvantage is, being a geometrical solution; errors made during measurements will affect the accuracy of the result.

21. What are the advantages and disadvantages of direct load test for 3 –phase I M?

Advantages

- Direct measurement of input and output parameters yield accurate results
- Aside from the usual performance other performances like mechanical vibration, noise etc can be studied.
- By operating the motor at full load for a continuous period, the final steady temperature can be measured.

Disadvantages

- Testing involves large amount of power and the input energy and the entire energy delivered is wasted.

22. What is an induction generator?

An induction generator does not differ in its construction from an induction motor. Whether the induction, machine acts as generator or motor depends solely upon its slip. Below synchronous speed it can operate only as motor, above synchronous speed it operates as generator and is now called as induction generator.

23. Describe a method to make an induction motor a two-speed motor.

The change in number of poles is achieved by having two entirely independent stator windings in the same slots. Each winding gives a different number of poles and hence different synchronous speed.

24. What do you mean by slip speed?

The difference between the synchronous speed and the rotor speed N is called as slip speed. The rotor speed will be always less than synchronous speed.

25. Explain why an induction motor, at no-load, operates at very low power factor.

The current drawn by an induction motor running at no load is largely a magnetizing current. So, no-load current lags behind the applied voltage by a large angle. Therefore the power factor of a lightly loaded induction motor is very low.

26. What is cogging of induction motor?

When the number of teeth in stator and rotor are equal, the stator and rotor teeth have a tendency to align themselves exactly to minimum reluctance position. In such case the rotor may refuse to accelerate. This phenomenon is called "magnetic locking, or cogging.

27. What are the advantages of double squirrel cage induction motor?

- Improves the starting torque
- Low I2R loss under running conditions and hence high efficiency.

28. How the direction of rotation of a three phase induction motor can be reversed?

The direction of rotation of three phase induction motor can be changed by interchanging any two terminal of input supply (R&Y, R&B, etc.,). The direction of the synchronously rotating field reverses and hence the direction of rotor reverses.

29. Describe a method to make an induction motor a two-speed motor.

The change in number of poles is achieved by having two entirely independent stator windings in the same slots. Each winding gives a different number of poles and hence different synchronous speed.

30. What do you mean by slip speed?

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PART B

1. Explain the construction and working of three phase induction motor.

2. Explain the power flow diagram and torque slip characteristics of induction motor.

3. Derive the torque equation of a three phase induction motor.

4. Develop an equivalent circuit for three phase induction motor. State the difference between exact and approximate equivalent circuit.

5. The power input to the rotor of a 3 phase, 50 HZ, 6 pole induction motor is 80 KW. The rotor emf makes 100 complete alternations per minute. Find (i)Slip (ii)Motor Speed (iii)Rotor copper loss per phase (iv)Rotor resistance per phase if rotor current is 65A.

6. Derive the equation for torque developed by an induction motor .Draw a typical torque – slip curve and deduce the condition for maximum torque.

7. A 3300V,10 pole ,50HZ three phase star connected induction motor has slip ring rotor resistance per phase=0.015Ω and standstill reactance per phase =0.25Ω .If the motor runs at 2.5 percent slip on full load ,find (i)Speed of the motor (ii) Slip at which the torque will be maximum. (iii)The ratio of maximum torque to full load torque. A 3 phase, 4 pole, 50 HZ induction motor is running at 1440 rpm. Determine the synchronous speed and slip.

8. Describe the no load and blocked rotor tests in a three phase induction motor.

9. A 100kW, 330V, 50Hz, 3 phase, star connected induction motor has a synchronous speed of 500 rpm. The full load slip is 1.8% and full load power factor 0.85. Stator copper loss is 2440W, iron loss is 3500W, and rotational losses is 1200W. Calculate (i) rotor copper loss, (ii) the line current and (iii) the full load efficiency.

10. A 6 pole, 50Hz, 3 phase, induction motor running on full load develops a useful torque of 160Nm. When the rotor emf makes 120 complete cycle per minute. Calculate the shaft power input. If the mechanical torque lost in friction and that for core loss is 10 Nm, compute (i) the copper loss in the rotor windings.(ii)The input of motor. The efficiency. The total stator loss is given to be 800W.

11. Explain the torque slip characteristics of 3 phase induction motor.

12. Explain the test required to be performed to obtain the data for the circle diagram.
13. Describe the principle and operation of synchronous induction motor
14. Explain the construction of circle diagram of 3 phase induction motor.