UNIT I

INTRODUCTION

PART-A (TWO MARKS)

1. What is peripheral speed? Univ

   The peripheral speed is a translational speed that may exist at the surface of the rotor while it is rotating. A translational speed equivalent to the angular speed at the surface of the rotor.

   Peripheral speed $V_a = \pi Dn$ m/sec.

2. What is leakage flux? Univ

   The leakage flux is the flux passing through unwanted path. The leakage flux will not help either for transfer or conversion of energy.

3. What is relation between MMF, flux, reluctance?Univ

   Flux = $\frac{mmf}{reluctance} = \frac{AT}{S}$

4. What is design?

   Design may be defined as a creative physical realization of theoretical concepts.

5. How the design problems of an electrical machine can be classified?Univ
   - ✓ Electromagnetic design
   - ✓ Mechanical design
   - ✓ Thermal design
   - ✓ Dielectric design

6. What are the limitations in designing electrical machines?Univ
   - ✓ Saturation
   - ✓ Temperature rise
   - ✓ Insulation
   - ✓ Efficiency
   - ✓ Mechanical parts
   - ✓ Commutation
   - ✓ Consumer specifications
   - ✓ Standard specifications

7. Define total magnetic loading.Univ

   The total magnetic loading is defined as the total flux around the armature periphery.

   Total magnetic loading = $p\phi$

8. Define total electric loading.Univ

The total number of ampere conductors around the armature periphery.

Total electric loading = I_zZ

9. Define specific magnetic loading.

The average flux density over the air gap of a machine.

$$\text{Specific magnetic loading} = \frac{total\ flux\ around\ the\ airgap}{area\ of\ flux\ path\ at\ the\ airgap} = \frac{p\phi}{\pi DL}$$

10. Define specific electric loading.Univ

The number of armature ampere conductors per metre of armature periphery at the air gap.

$$\text{Specific electric loading} = \frac{total\ armature\ ampere\ conductors}{armture\ periphery\ at\ air\ gap} = \frac{I_zZ}{\pi D}$$

11. What are the factors that decide the choice of specific magnetic loading?Univ

- ✓ Maximum flux density in iron parts of machine.
- ✓ Magnetizing current
- ✓ Core losses
- ✓

12. What are the factors that decide the choice of specific magnetic loading?Univ

- ✓ Permissible temperature rise
- ✓ Voltage rating of machine
- ✓ Size of machine
- ✓ Current density

13. What are the major considerations to evolve a good design of electrical machine?

- ✓ Specific magnetic loading
- ✓ Specific electric loading
- ✓ Temperature rise
- ✓ Efficiency
- ✓ Length of air gap
- ✓ Power factor

14. What is magnetic circuit?

The path of the magnetic flux is called magnetic circuit. The mmf of the circuit creates flux in the path against the reluctance of the path.

$$\text{Flux} = \frac{mmf}{reluctance}$$

15. Write a short note on standard specifications.Univ

The standard specifications are the specifications issued by the standards organisation of a country. The standard specifications serve as guideline for the manufactures to produxce quality products at economical prices.

Ex : The standard specifications for electrical machines are ratings, types of enclosure, dimensions of conductors, name plate details, performance indices, permissible temperature rise etc.,

16. What are the constituents of magnetic circuit in rotating machines?Univ

The various elements in the flux path of salient pole machines are poles, pole shoes, air-gap, armature core and yoke. The various elements in the flux path of non salient pole machines are stator core, stator teeth, air-gap, rotor teeth and rotor core.

17. Give the simpson's rule for calculation of mmf for tooth.Univ

Mmf for teeth = $at_{mean} \times l_t = at_{mean} \times d_s$

$at_{mean} = \frac{at_1 + 4at_2 + at_3}{6}$

l_t = length of tooth

at_1= at for the root of tooth

at_2 = at for the centre of the tooth

at_3 = at for the tip of the tooth

18. Write the rule for calculation mmf for tooth by $B_{t\ 1/3}$ method.

Mmf for tooth = $at_{1/3} \times l_t$

$At_{1/3}$ = at for flux density at one third height from the narrow end

L_t = length of tooth

19. What are the similarities in electric and magnetic circuits?

Sl.no	Electric circuit	Magnetic circuit
1.	The mmf circulates current in a closed path	The mmf creates flux in a closed path
2.	Flow of current is opposed by resistance of the circuit	The creation of flux is opposed by reluctance
3.	The path of current is called electric circuit.	Path of flux is called magnetic circuit
4.	Resistance R= ρl/A	Reluctance S= l/μA
5.	Current = emf/resistance	Flux = mmf/reluctance
6.	Current density δ=current/area	Flux density B= flux/area

20. Distinguish between electric and magnetic circuit.

Sl.no	Electric circuit	Magnetic circuit
1.	Current actually flows in the electric circuit.	Flux does not flow, but it only assumed to flow.
2.	When current flows, the energy is spent continuously.	The energy is needed only to create flux but no need to maintain it.

3.	Resistance is independent of the current strength.	Reluctance depends upon total flux of flux density in the material.

21. Define reluctance and permeance.

Reluctance = $\frac{length}{area} \; x \frac{1}{permeabilty} = \frac{l}{\mu A}$; Permeance = $\frac{1}{reluctance}$

22. What is magnetization curve?Univ

The curve shows the relation between the magnetic field intensity (H) and the flux density (B) of a magnetic material. It is used to estimate the mmf required for the flux path in the magnetic material and it is supplied by the manufacturer of stampings or laminations

23. What is meant by magnetic circuit calculations?Univ

The calculations of reluctance, flux density and mmf for various sections of magnetic circuit are commonly referred as magnetic circuit calculations.

24. How the mmf of a magnetic circuit is determined?

The magnetic circuit split into convenient parts (Sections) which may be connected in series or parallel. Then the reluctance, flux density and mmf for every section of the magnetic circuit is estimated. The summation of mmf of all sections in series gives the total mmf for the magnetic circuit.

25. Define gap contraction factor for the slots.Univ

The gap contraction factor for slots K_{gs} is defined as the ratio of reluctance of air gap in machine with slotted armature to the reluctance of air gap in machines with smooth armature.

26. Define gap contraction factor for the ducts.

The gap contraction factor for the ducts K_{gd} is defined as the ratio of reluctance of air gap in machines with ducts to reluctance of air gap in machine without ducts.

27. Define total gap contraction factor, K_g.Univ

The total gap contraction factor K_g, is defined as the ratio of reluctance of air gap of machines with slotted armature & ducts to the reluctance of air gap in machines with smooth armature and without ducts. The total gap contraction factor is equal to the product of gap contraction factors for slots and ducts.

28. What is carter's coefficient?

The carter's coefficient is a parameter that can be used to estimate the contracted or effective slot pitch in case of armature with open or semi enclosed slots. It is the function of the ratio w_0/l_g where w_0 is slot opening and l_g is air gap length.

29. Write the expression for the gap contraction factor for slots and ducts

Gap contraction factor for slots, $K_{gs} = y_s / (y_s - K_{cs}W_s)$

Gap contraction factor for ducts , $K_{gd} = L / (L - K_{cd}n_d w_d)$

30. Write down the formula for computing the mmf for the air gap length.

Mmf for the air gap = $800000BK_{gl}g$ in AT

31. Write the expressions for reluctance of air gap in machines with smooth armature and slotted armature.

Reluctance of air gap in machines with smooth armature and without ducts

$= l_g / \mu_0 L y_s$

Reluctance of air gap in machines with open armature slots and ducts

$= l_g / \mu_0 L' y_s'$

32. Define field form factor.Univ

The filed form factor K_f is defined as the ratio of average gap density over the pole pitch to maximum flux density in the air gap.

$K_f = B_{av} / B_g$ $K_f \approx \psi$ = pole arc/pole pitch

33. List the methods used for estimating the mmf for the teeth(tapered teeth)Univ

- ✓ Graphical method
- ✓ Three ordinate method (Simpson's rule)
- ✓ $B_{t1/3}$ method

34. What is real flux density and apparent flux density?Univ

The real flux density is due to actual flux through a tooth. The apparent flux density is due to total flux that has to be passed through the tooth. Since some of the flux passes through slot, the real flux density is always less than the apparent flux density

35. Define real flux density.

The real flux density is defined as the ratio of actual flux in the teeth to the area of the teeth

36. Define apparent flux density

The apparent flux density is defined as the ratio of the total flux in the slot pitch to the area of the teeth.

37. State the relation between real and apparent flux density.Univ

$B_{real} = B_{app} - \mu_0 \mathbf{at}_{real}(K_s - 1)$

38. Define leakage coefficient

The leakage coefficient is defined as the ratio of total flux to the useful flux.

39. What is fringing flux?Univ

The bulging of magnetic path at the air gap is called fringing. The fluxes in the bulged portion are called fringing flux.

40. List some leakage fluxes available in the rotating machine.

- ✓ Slot leakage flux
- ✓ Zig-zag leakage flux
- ✓ Harmonic or differential leakage flux
- ✓ Peripheral leakage flux
- ✓ Tooth to leakage flux
- ✓ Skew leakage flux
- ✓

41. Define specific permeance of a slot.

Specific permeance of a slot is defined as the paermeance per unit length of slot or depth of field

.

42. What is unbalanced magnetic pull?Univ

The unbalanced magnetic pull is the radial force acting on the rotor due to non uniform air gap around the armature periphery.

43. What do you understand by slot pitch?

The slot pitch is defined as the distance between centres of two adjacent slots measured in linear scale.

44. Define slot space factor or slot insulation factor.Univ

The slot space factor is defined as the ratio of conductor area to slot area.

45. List the different types of slots that are used in rotating machines.

- ✓ Parallel sided slots with flat bottom
- ✓ Tapered slots with flat bottom
- ✓ Parallel sided slots with circular bottom
- ✓ Tapered sided slots with circular bottom
- ✓ Circular slot

PART-B (13 MARKS)

1. What are the limitations in the design of electrical apparatus? Explain in detail.(P.no: 1.2 – 1.4)
2. Explain in detail about total loadings and specific loadings of a rotating machine. (P.no: 6.5 – 6.9) (Or)
   Explain the factors influence that choice of specific magnetic and electric loadings.
3. Explain the concept of magnetic circuits. (P.no: 3.1 – 3.5)
4. Derive the expression for calculation of mmf required in the airgap. (P.no: 3.6 – 3.9)
5. Derive the expression for calculation of mmf in induction motor. (P.no: 3.9 – 3.10)
6. Derive the expression for calculation of mmf required in the synchronous machines. (P.no: 3.11 – 3.12)
7. What are the methods to estimate mmf required in the teeth? Explain in detail.(P.no:3.15 – 3.17)
8. Derive the relation between real and apparent flux densities of rotating machines. (P.no: 3.17 – 3.18)
9. Explain leakage reactance calculation for transformers. (P.no: 5.85 – 5.88)
10. Explain leakage reactance calculation for induction motors. (P.no: 3.56 – 3.58)
11. Explain leakage reactance calculation for synchronous machines. (P.no: 3.59 – 3.62)

Problems:

- Based on finding specific magnetic and electric loadings.(Example 6.1)
- Based on mmf calculations in airgap. (Example 3.1 – 3.4)
- Based on mmf calculations in teeth. (Example 3.5,3.6,3.10)
- Based on real and apparent flux densities calculation. (Example 3.7 – 3.9)

BOOK NAME:

A.K. Sawhney, 'A Course in Electrical Machine Design', Dhanpat Rai and Sons, New Delhi, 2003.

UNIT II

DC MACHINES

PART-A (TWO MARKS)

1. Main parts of d.c machine.Univ
   - Yoke or Frame
   - Field poles
   - Armature
   - Armature winding
   - Commutator
   - Brushes & bearings
   - Interpoles

2. State the relation between the number of commutator segments and numbers of armature coils in d.c generator.Univ

   The number of commutator segments is equal to the number of coils.

   $C = (1/2)\ U\ S$

   U – coil sides per slot

   S – number of slots

3. Different losses in d.c machines.Univ
   a. Rotational losses
      - ✓ Frictional loss and windage loss
      - ✓ Iron losses
   b. Copper loss
   c. Additional losses

4. Explain about flash over.Univ

   Flash over is a very important factor when deciding about the number of poles to be used. The number of brush arms is equal to the number of poles. For the same diameter of the commutator, the distance between the adjacent brush arms decreases as the number of poles is increased. This causes flash over between the adjacent brush arms.

5. How we can avoid the flash over between the adjacent brush arms in d.c machines?Univ

   To avoid possibility of flash over, the diameter of the commutator will have to be increased as the number of poles increases.

6. What are the design modifications done in d.c machines to reduce the effects of armature reaction?Univ

i. Increasing the Length of air gap at pole tips
ii. Increasing the reluctance at pole tips
iii. Providing compensating winding and interpoles

7. What is the role or use of interpoles?Univ

The interpole are used in d.c machines to neutralize the cross magnetizing armature mmf at the interpolar axis and to neutralize the reactance voltage in the coil undergoing commutation.

8. Define output equation.Univ

The output equation which relates the power output to the main dimensions (D and L), specific electric loadings (electric and magnetic) and speed of a machine.

$$P_a = C_o D^2 L n$$

9. What is the relation between the power developed in armature and the power output in the dc machine?

Output for generators = $P_a = P/\eta$

Output for motors = $P_a = P$

10. Write the expression for the output equation of d.c machine.

Power developed the armature $P_a = C_0 D^2 L n$

$$C_0 = \pi^2 B_{av} ac \times 10^{-3}$$

11. What is the range of specific magnetic loading in a dc machine?

The usual range of specific magnetic loading in dc machine is 0.4 to 0.8 wb/m^2

12. Mention the main dimensions of rotating machines.Uni

- Armature diameter – D
- Core length – L

13. Mention the factors which governing the length of armature core in d.c machine.

i. Dimensions of pole
ii. Moment of inertia
iii. Peripheral speed
iv. Voltage between adjacent commutator segments.

14. What is simplex and multiplex winding?UNIV

In simplex lap winding the number of parallel paths is equal to number of poles and in simplex wave winding the number of parallel paths is two. In multiplex windings the number of parallel paths will be multiples of simplex winding.

In duplex winding the number of parallel paths will be double that of simplex winding and in triplex winding the number of parallel of paths is thrice that of simplex winding and so on.

15. What are the factors to be considered for the choice of specific magnetic loading?
    - ✓ Flux density in the teeth
    - ✓ Frequency of flux reversals
    - ✓ Size of the machine

16. What is the range of specific electric loading in dc machine?

The usual range of specific electric loading in dc machine is 15000 to 50000 ampere conductor/metre

17. What is square pole and square pole face?

In square pole, the width of the pole body is made equal to the length of the armature. In square pole face, the pole arc is made equal to the length of the armature.

18. What is the purpose of constructing the pole body by laminated sheets?

The laminated pole offers the homogeneous construction, (Because while casting internal blow holes may develop and while forging internal cracks may develop) Also the laminated poles offers the flexibility of increasing the length by keeping the diameter fixed, in order to increase the power output (or capacity) of the machine.

19. What are the factors to be considered for the selection of number of poles in dc machine?Univ
    - ✓ Frequency
    - ✓ Weight of iron parts
    - ✓ Weight of copper parts
    - ✓ Length of commutator
    - ✓ Labour charges
    - ✓ Flash over and distorsion of filed form.

20. List the advantages of large number of poles

. The large number of poles results in reduction of the following
    - ✓ Weight of armature core and yoke
    - ✓ Cost of armature and field conductors
    - ✓ Overall length and diameter
    - ✓ Length of Commutator
    - ✓ Distortion of field form under load condition

21. List the disadvantages of large number of poles.Univ

The large number of poles results in increase of the following
    - ✓ Frequency of flux reversals

- ✓ Labour charges
- ✓ Possibility of lash over between brush arms.

22. Why square pole is preferred?Univ

If the cross section of the pole body is square then the length of the mean turn of field winding is minimum. Hence to reduce the copper requirement a square cross section is preferred for the poles of the dc machines.

23. Mention guiding factors for the selection of number of poles

a. The frequency of flux reversals should lie between 25 to 50 Hz.
b. The value of current per parallel path is limited to 200 A. thus the current per brush arm should not be more than 400A.
c. The armature mmf should not be too large. The mmf per pole should be in the range 5000 to 12500 AT.
d. Choose the largest value of poles which satisfies the above three conditions.

24. What is meant by equalizer connections?Univ

In lap winding, due to the difference in the induced emf in various parallel paths, there may be circulating currents in brushes and winding. The connections that are made to equalize the difference in induced emf and to avoid circulating currents through brushes are called equalizer connections

25. What are the advantages of large length of air gap in dc machine?

In dc machines a larger value of air gap length results in lesser noise, better cooling, reduced pole face losses, reduced circulating currents, less distortion of field form and lesser armature reaction.

26. Mention the factors governing the choice of number of armature slots in a dc machine.

The factors governing the choice of number of armature slots are,

- ✓ Slot pitch
- ✓ Slot loading
- ✓ Flux pulsations
- ✓ Commutation
- ✓ Suitability for winding

27. What are the factors to be considered for estimating the length of air gap in dc machine?

The factors to be considered for estimating the length of air gap are armature reaction, cooling, iron losses, distortion of filed form and noise.

28. What is the purpose of slot insulation?

The conductors are placed on the slots in the armature. When the armature rotates the insulation the insulation of the conductors may damage due to vibrations. This may lead to a short circuit with armature core if the slots are not insulated.

29. What are the factors to be considered for deciding the slot dimensions?
    a. Flux density in the tooth
    b. Flux pulsations
    c. Eddy current loss in conductors
    d. Reactance voltage
    e. Fabrication difficulties

30. What factor decides the minimum number of armature coils?

The maximum voltage between adjacent commutator segments decides the minimum number of coils.

31. Mention the two types of winding used in the dc machines.
    a. Lap winding
    b. Wave winding

32. What is the length of mean turn of filed coil?

Length of mean turn $L_{mt} = 2(L_p + b_p + 2d_r)$

33. Mention the factors to be considered for the design of shunt field coil?
    - ✓ MMF per pole and flux density
    - ✓ Loss dissipated from the surface of field coil
    - ✓ Resistance of the field coil
    - ✓ Current density in the field conductors

34. Define copper space factor of the coil.Univ

The copper space factor of a coil is defined as the ratio of conductor area and the area of the cross section of the coil.

Copper space factor = Conductor area/Area of cross section of the coil

Conductor area = Number of turns x area of cross section of conductor

35. How the ampere turns of the series field coil is estimated?

In compound machines the ampere turns to be developed by the series field coil is estimated as 15 to 25% of full load armature mmf.

In series machines the ampere turns to be developed by the series field is estimated as 1.15 to 1.25 times the full load armature mmf.

36. What is meant by commutation?

The process of current reversal in a coil is called commutation.

37. Discuss the parameters governing the length of commutator.

The length of the commutator depends upon the number of brushes and cleanliness between the brushes. The surface area required to dissipate the heat generated by the

commutator losses is provided by keeping sufficient length of the commutator,

38. What are the factors that influence the choice of commutator diameter?
    - ✓ The peripheral speed
    - ✓ The peripheral voltage gradient should be limited to 3 V/mm
    - ✓ Number of coils in the armature.

39. What is the purpose of mica strip between two adjacent commutator segments?

Mica is placed in between two commutator segments in order to insulate the segments from each other.

40. What are the factors to be considered for the design of commutator?
    - ✓ Peripheral speed
    - ✓ Voltage between adjacent segments
    - ✓ Number of coils in the armature
    - ✓ The number of brushes
    - ✓ Commutator losses.

41. What type of copper is used for commutator segments?

The commutator segments are made of hard drawn copper or silver copper (0.05% silver)

42. What is the need for brushes in dc machine?

The brushes are used in dc machines to collect or draw current from the rotating armature.

43. What are the materials used for brushes in dc machines?
    a. Natural graphite
    b. Electro graphite
    c. Hard carbon
    d. Metal graphite

44. What are the effects of armature reaction?

The various effect of armature reaction are reduction in induced emf, increase in iron loss, delayed commutation, sparking and ring firing.

PART-B(13 MARKS)

1. Derive the output equation of a d.c machine.(P.no: 6.2 – 6.3)
2. State and explain the factors which govern the choice of specific magnetic and electric loadings of a d.c machine. (P.no:9.14 – 9.17)
3. Explain the factors affecting the size of rotating machine.(P.no: 6.4)
4. What are the factors that influence the separation of D & L of a d.c machine? Explain in detail. (P.no: 6.15 – 6.17)
5. Explain the various factors that are affected by the selection of number of poles in a d.c machines. (P.no:9.18 – 9.24)
6. Clearly explain the design procedure to be followed for a shunt field winding of a d.c machine. (P.no: 9.63 – 9.65)
7. Explain the factors to be considered for the length of airgap for a d.c machine.(P.no: 9.27 – 9.28)
8. Explain briefly on armature design of d.c machine.(P.no: 9.40 – 9.49)
9. List the guiding factors for choice of number of armature slots. (P.no:9.44)
10. Enumerate the factors which govern the selection of slot dimensions. (P.no:9.48)
11. Discuss the procedure for design of commutator and brushes.(P.no: 9.88 – 9.89)
12. Write a note on design of series field.(P.no:9.65)

BOOK NAME:

A.K. Sawhney, 'A Course in Electrical Machine Design', Dhanpat Rai and Sons, New Delhi, 2003.

UNIT III

TRANSFORMERS

PART-A (TWO MARKS)

1. Why transformer core is laminated?Univ

   The stampings of laminated construction are used to reduce eddy current losses. The stampings are insulated by thin coating of varnish, hence when the stampings are stacked to form a core so that resistance for eddy current is high. (this is due to very small cross section area of laminations)

2. Draw the cruciform section of the transformer core and give the optimum dimensions in terms of circumscribing circle diameter d.(Univ)

   The optimum dimensions of a and b interms of d

   a = 0.85d

   b = 0.53 d

3. What are the factors on which no load current of a transformer depend?Univ

   MMF per metre of the flux densities in yoke and core.

4. Write an empirical relation which is normally used for the estimation of window space factor in design of transformer.Univ

   $K_w = \frac{10}{30+KV}$ for rating 50 to 200 KVA

   $K_w = \frac{12}{30+KV}$ for rating 1000 KVA

   $K_w = \frac{8}{30+KV}$ for rating 20 KVA

   KV –voltage of h.v winding in kilo-volt

5. Top and bottom surfaces of the transformer tank are not considered for the design of cooling tubes for transformer. Why?Univ

   The dimensions of the tank are decided by the dimensions of the transformer frames and clearance required on all sides. The clearance on the sides depends on voltage and power rating of the winding. The clearance at the top depends on the oil height above the assembled transformer and the space for mounting the terminals and tap changing gear. The clearance at the bottom depends on the space required for mounting the transformer frame inside the tank.

6. What are the usual values of maximum flux densities in the core of power and distribution transformer?Univ

   Distribution transformer – 1.1 to 1.35 wb/m^2

   Power transformer - 1.25 to 1.45 wb/m^2

7. What is meant by air blast cooling?Univ

The radiators are forced cooled by small fans mounted on it. Compare with natural cooling, air blast cooling of a tank increases the neat dissipation 50% to 60%.

8. What are the factors to be considered while designing the insulation of power transformer?Univ

a. Electrical consideration
   - ✓ Eddy current loss
   - ✓ Leakage reactance
b. Mechanical considerations
c. Thermal considerations which governing

9. How the design of distribution transformer differs from that of a power transformer?Univ

- The distribution transformers are designed to have low iron loss and high copper loss, whereas in power transformers the copper loss will be less than iron loss.
- The distribution transformers are designed to have the maximum efficiency at a load much lesser than full load, where as the power transformers are designed to have maximum efficiency at or near full load.
- In distribution transformer the leakage reactance is kept low to have better regulation, where as in power transformers the leakage reactance is kept high to limit the short circuit current.

10. What are the various types of Transformers?Univ

Based on construction

a. Core Type
b. Shell Type

Based on the applications

a. Distribution transformer
b. Power transformer
c. Special transformers
d. Instrument transformer
e. Electronics Transformers

11. What is the range of efficiency of transformers?

The efficiency of the transformer will be in the range of 94% to 99%. Among the available electrical machines the transformer has the highest efficiency

12. What is transformer bank?

A transformer bank consists of three independent single phase transformers with their primary and secondary windings connected either in star or delta.

13. What is the purpose of constructing the pole body by laminated sheets?

The laminated pole offers the homogeneous construction, (Because while casting internal blow holes may develop and while forging internal cracks may develop) Also the laminated poles offers the flexibility of increasing the length by keeping the diameter fixed, in order to increase the power output (or capacity) of the machine.

14. What are the salient features of distribution transformer?
    - ✓ The distribution transformer will have low iron loss and higher value of copper loss
    - ✓ The capacity of transformers will be up to 500 KVA
    - ✓ The transformers will have plain walled tanks or provided with cooling tubes or radiators.
    - ✓ The leakage reactance and regulation will be low.

15. What is yoke section of distribution transformers?

    The sections of the core which connect the limbs are called yoke. The yoke is used to provide a closed path for the flux.

16. What are distribution transformers?Univ

    The transformers used at the load centres to step down the distribution voltage to a standard service voltage required for consumers are called distribution transformers.

17. What are power transformers?

    The transformers used in substations and generating stations for step up the voltage are called power transformers.

18. State the use of power transformers
    - ✓ In generating stations the power transformers are used to step up the voltage to a higher level required for the primary transmission.
    - ✓ In substations the power transformers are used to step down the voltage level required for the secondary transmission.

19. Distinguish between core and shell type transformer.Univ

    In core type transformer the coil surrounds the core, while in shell type transformer the core surrounds the coil

20. What are the advantages of shell type transformer over core type transformers?

    In shell type transformers the coils are well supported on the all sides and so they can withstand higher mechanical stresses developed during short circuit conditions. Also the leakage reactance will be less in shell type transformers.

21. In transformers, why the low voltage winding placed near the core?

    The winding & Core are both made of metals and so an insulation have to be placed in between them, the thickness of insulation depends on the voltage rating of the

winding. In order to reduce the insulation requirement the low voltage winding place near the core.

22. What is window space factor?Univ

The window space factor is defined as the ratio of copper area in window to total area of window.

23. Write down the output equation for the1phase and 3 phase transformer.

Output KVA of single phase transformer $Q = 2.22fB_mA_iK_wA_w\delta \times 10^{-3}$

Output KVA of three phase transformer, $Q = 3.33fB_mA_iK_wA_w\delta \times 10^{-3}$

24. Define copper space factor.Univ

The copper space factor is the ratio of conductor area and window area in case of transformers.

25. How will you select the emf per turn of a transformer?

The equation of emf per turn in terms of KVA rating, flux frequency and ampere turn is given by,

Emf per turn, $E_t = K\sqrt{Q}$

Where $K = \sqrt{4.44f(\phi_m/AT)} \times 10^3$

26. Why circular coils are preferred in transformers?Univ

The excessive leakage fluxes produced during short circuit and over loads, develop severe mechanical stresses on the coil. On circular coils these forces are radial and there is no tendency to change its shape. But on rectangular coils the force are perpendicular to the conductors and tends to deform the coil in circular form.

27. What are the advantages of stepped cores?

For same area of cross section the stepped cores will have lesser diameter of the circumscribing circle than square cores. This results in length of mean turn of the winding with consequent reduction in both cost of copper and copper loss.

28. What are the disadvantages of stepped cores?

With large number of steps a large number of different sizes of laminations have to be used. This results in higher labour charges for sheering and assembling different types of laminations.

29. What do you meant by stacking factor (iron space factor)?Univ

In transformers, the core is made of laminations and the laminations are insulated from each other by a thin coating of varnish. Hence when the laminations are stacked to the form the core, the actual iron area will be less than the core area. The ratio of iron area and total core area is called stacking factor. The value is usually 0.9.

30. Why stepped cores are used?

When stepped cores are used the diameter of the circumscribing circle is minimum for a given area of the core. This helps in reducing the length of mean turn of the winding with consequent reduction in both cost of copper and copper loss.

31. What are the factors to be considered for choosing the type winding for a core type transformer?
    a. Current density
    b. Short circuit current
    c. Temperature rise
    d. Surge voltage
    e. Impedance
    f. Transport facilities

32. What is tertiary winding?Univ

Some three phase transformers may have a third winding called tertiary winding apart from primary and secondary. It is also called auxiliary winding or stabilizing winding.

33. How the tertiary winding is connected?Univ

The tertiary winding is normally connected in delta. When the tertiary is connected in delta, the unbalance in phase voltage during unsymmetrical faults in primary and secondary is compensated by the circulating currents flowing in the closed delta.

34. What is the purpose of tertiary winding?
    - ✓ To supply additional loads at a different voltage
    - ✓ To give supply to phase compensating devices such as capacitors which work at different voltage
    - ✓ To limit the short circuit current
    - ✓ To indicate voltage in high voltage testing transformer.

35. List some methods of cooling of transformers.Univ

Air natural, Air blast, Oil Natural, Oil natural air forced, Oil natural water forced, Oil forced, Oil forced air natural, Oil forced air natural, Oil forced water forced.

36. What are the factors to be considered for choosing the method of cooling?

The choice of cooling method depends on KVA rating of transformer, size, application and the site conditions where it will be installed.

37. How the heat dissipates in a transformer?

The heat dissipation of a transformer occurs by convection, conduction and radiation.

38. Why transformer oil is used as a cooling medium?

When transformer oil is used as a coolant the heat dissipation by convection is 10 times more than the convection due to air. Hence transformer oil is used as a cooling medium.

39. Why cooling tubes are provided? How the heat dissipation is improved by providing the cooling tubes?Univ

Cooling tubes are provided to increase the heat dissipating area of the tank. The cooling tubes will improve the circulation of oil. The circulation of oil is due to effective pressure heads produced by columns of oil in tubes. The improvement in cooling is accounted by taking the specific heat dissipation due to convection as 35% more than that without tubes.

40. What is a breather?

The breather is a device fitted in the transformer for breathing. In small oil cooled transformers some air gap is provided between the oil level and tank top surface. When the oil is cooled, it shrinks and air is drawn from the atmosphere through breather. This action of transformer is called breathing.

41. Why silica gel is used in breather?

The silica gel is used to absorb the moisture when the air is drawn from the atmosphere in to the transformer.

42. What is conservator?

A conservator is a small cylindrical drum fitted just above the transformer main tank. It is used to allow the expansion and contraction of oil without contact with surrounding atmosphere. When conservator is fitted in a transformer, the tank is fully filled with oil and the conservator is half filled with oil.

43. How the leakage reactance of the transformer is reduced?

In transformers the leakage reactance is reduced by interleaving the high voltage and low voltage winding.

44. Different losses in transformer.Univ

i. Iron loss
ii. Copper loss

PART-B (13 MARKS)

1. Derive the output equation of single phase and three phase transformer.(P.no: 5.49 – 5.50)

2. Design a transformer with minimum cost with necessary equations. (P.no: 5.52 – 5.53)
3. Derive the condition for getting maximum efficiency in a transformer. (P.no: 5.53)
4. Explain briefly on design of core. (P.no: 5.54 – 5.57)
5. How to design the windings of transformers. (P.no: 5.59 – 5.61)
6. Write a note on window dimensions. (P.no: 5.71)
7. Obtain the condition for width of window for optimum output. (P.no: 5.72)
8. Write a note on yoke and overall dimensions of transformer. (P.no: 5.72 – 5.74)
9. List the various steps involved to determination of main dimensions for core, window and yoke. (P.no: 5.74)
10. Explain the design steps for Low voltage (LV) windings. (P.no: 5.75)
11. Explain the design steps for High voltage (HV) windings. (P.no: 5.76)
12. Derive an expression for the number of cooling tubes needed for a transformer tank. (P.no: 5.105 – 5.106)
13. Discuss in detail about cooling methods adopted in transformers. (Xerox)

BOOK NAME:

A.K. Sawhney, 'A Course in Electrical Machine Design', Dhanpat Rai and Sons, New Delhi, 2003.

UNIT IV

THREE PHASE INDUCTION MOTORS

PART-A(TWO MARKS)

1. What are the losses in induction motor?Univ
   i. Stator copper loss
   ii. Rotor copper loss
   iii. Iron loss
   iv. Friction and windage loss

2. List the main parts of slip ring induction motor.Univ
   i. Stator
   ii. Rotor – slip rings, external resistance arrangement
   iii.

3. What is the function of end rings in the rotor of a cage induction motor?Univ
   Copper or aluminium bars are placed in each slot. All bars are joined at each end by metal rings called end rings which forms permanent short circuited winding.

4. What are the different types of induction motor and how differ from each other?Univ
   The two different types of induction motor are squirrel cage and slip ring induction motor. The stator is identical for both but they differ in construction of rotor.

5. Why wound rotor construction is adopted?
   The wound rotor has the facility of increasing the rotor resistance through slip rings. High value of rotor resistance is need during starting to get a high value of starting torque.

6. What is rotating transformer?
   The principle of operation of induction motor is similar to that a transformer. The stator winding is equivalent to primary of the transformer and the rotor winding is equivalent to short circuited secondary of a transformer. In transformer the secondary is fixed but in induction motor it is allowed to rotate. Hence the induction motor also called rotating transformer.

7. How the slip ring motor is started?
   The slip ring motor is started by using rotor resistance starter. The starter consists of star connected to slip rings. While starting the full resistance is included in the rotor circuit to get high starting torque. Once the rotor starts rotating the resistance is gradually reduced in steps. At running condition the slip rings are shorted and so it is equivalent to squirrel cage rotor.

8. What are the materials used to manufacture the brushes for slip rings of an induction motor?

The slip rings are made of brass and phosphor bronze. The brushes are made of metal graphite which is an alloy of copper and carbon.

9. What are the advantages of slip ring motor over squirrel cage motor?Univ
   - ✓ The starting torque can be varied by adding resistance to rotor.
   - ✓ The speed of the machine can be varied by injecting an emf through slip rings to the rotor.

10. Write the expression for the output equation and out coefficient of induction motor.Univ

    . $Q = C_0 D^2 L n_s$ in KVA

    $C_0 = 11 K_{ws} B_{av} \mathbf{ac} \times 10^{-3}$ in KVA/m^3-rps.

11. What are the factors to be considered for choosing the specific magnetic loading?Univ

    The choice of specific magnetic loading depends on power factor, iron loss and over load capacity.

12. What are the factors to be considered for the choice of specific electric loading?Univ

    The choice of specific loading depends on copper loss, temperature rise, voltage rating and over load capacity.

13. What are the main dimensions of an induction motor?

    The main dimensions of induction motor are stator core internal diameter and stator core length.

14. How the induction motor can be designed for best power factor?Univ

    For best power factor the pole pitch, τ is chosen such that, $\tau = \sqrt{0.18}L$

15. What are the different types of stator winding in induction motor?

    The different types of stator windings are mush winding, lap winding and wave winding.

16. Where mush windings are used?

    The mush windings are used in small induction motors of ratings below 5 HP.

17. What types of slots are preferred for the induction motor?Univ

    Semi enclosed slots are preferred for induction motor. It results in less air gap contraction factor giving a small value of magnetizing currents, low tooth pulsation loss and much quieter operation(less noise)

18. What is slot space factor?

    The slot space factor is the ratio of conductor (or copper) is per slot and slot area. It

gives an indication of the space occupied by the conductors and the space available for insulation. The slot space factor for induction motor varies from 0.25 to 0.4.

19. What is the minimum value of slot pitch in induction motor?

The minimum value of slot pitch in three phase induction motor is 15mm.

20. What are the factors to be considered for selecting number of slots in induction machine stator?Univ

The factors to be considered for selecting the number of slots are tooth pulsation loss, leakage reactance, magnetizing current, iron loss and cost. Also the number of slots should be multiple of slots per pole per phase for integral slot winding.

21. Which part of induction motor has the maximum flux density? What is the maximum flux density in that part?

The teeth of the stator and rotor core will have maximum flux density. The maximum value of flux density in the teeth is 1.7 wb/m^2

22. What are the factors to be considered for estimating the length of air gap?Univ

- ✓ Power factor
- ✓ Unbalanced magnetic pull
- ✓ Overload capacity
- ✓ Pulsation loss
- ✓ Cooling
- ✓ Noise.

23. What are the advantages and disadvantages of large air gap length in induction motor?Univ

Advantage: A large air gap length results in higher overload capacity, better cooling, reduction in noise and reduction in unbalanced magnetic pull.

Disadvantages: The disadvantage of large air gap length is that it results in high value of magnetizing current.

24. What happens if the air gap length is doubled?

If the air gap of an induction motor is doubled then the mmf and magnetizing current approximately doubles. Also increase in air gap length increases the overload capacity, offers better cooling, reduces noise and reduces unbalanced magnetic pull.

25. List out the methods to improve the power factor of the induction motor.Univ

The power factor of the induction motor can be improved by reducing the magnetizing current and leakage reactance. The magnetizing current can be reduced by reducing the length of air gap. The leakage reactance can be reduced by the depth of stator & rotor slots, by providing short chorded winding and reducing the overhang in stator winding.

26. Why the air gap of an induction motor is made as small as possible?Univ

The mmf and the magnetizing current are primarily decided by length of air gap. If air gap is small then mmf and magnetizing current will be low, which in turn increase the value of power factor. Hence by keeping small air gap, high power factor is achieved.

27. What are the different types of windings used for the rotor of induction motor?

The different types of windings employed in induction motor rotor are mush winding and double layer winding.

28. Write the formula for air gap in case of three phase induction motor in terms of length and diameter.

The length of air gap, $l_g = 0.2 + 2\sqrt{DL}$ in mm

Where D, L are expressed in metre.

29. Discuss the relative merits and demerits of open and closed slots for induction motor.

The closed slots will not increase reluctance of air gap and has lesser noise but it has difficulty in casting the rotor bars.

The open slots increase the reluctance of air gap and has high noise but it offers flexibility in casting rotor bars.

30. List the undesirable effects produced by certain combination of rotor and stator slots.

- ✓ The motor may refuse to start (cogging)
- ✓ The motor may run at sub synchronous speed (Crawling)
- ✓ Severe vibrations may develop and the noise will be excessive.

31. What is crawling and cogging?Univ

Crawling is a phenomena in which the induction motor runs at a speed lesser than the sub synchronous speed.

Cogging is a phenomena in which the induction motor refuse to start.

32. What are the methods adopted to reduce harmonic torques?

The methods used for reduction or elimination of harmonic torques are chording, integral slot winding, skewing and increasing the length of air gap.

33. What is skewing?

Skewing is twisting either the stator or rotor core. The motor noise, vibrations, cogging and synchronous cusps can be reduced or even entirely eliminated by skewing.

PART- B (13 MARKS)

1. Derive the output equation of a a.c machine (three phase induction motor).(P.no: 6.4)
2. Compare squirrel cage and slip ring induction motors. (P.no: 10.7)
3. State and explain the factors which govern the choice of specific magnetic (average flux density) and electric loadings (ampere conductor per metre) in the design of three phase induction motor. (P.no: 10.8)
4. Write a note on main dimensions in induction motors. (P.no: 10.9)
5. Explain briefly on design of stator. (P.no: 10.10 – 10.13)
6. Explain the design of stator slot for an induction motor. (P.no: 10.11)
7. Discuss the effects of Length of air gap on the performance of three phase induction motor (P.no: 10.19 – 10.21)
8. Explain briefly on design of squirrel cage rotor.(P.no: 10.21 – 10.27)
9. State the rules that has to be followed for selection of rotor slots for an induction motor.(P.no: 10.25)
10. Give the detailed procedure for design of rotor bars and end rings of a squirrel cage induction motor. (OR)
    Explain design of rotor bars and slots. (P.no: 10.28 – 10.31)
11. Explain briefly on design of wound rotor or slip ring rotor.(P.no: 10.34 – 10.36)
12. Write short notes on dispersion coefficient. (P.no: 10.57 – 10.60)
13. Derive the relation between D and L for best power factor.(P.no: 10.61)

BOOK NAME:

A.K. Sawhney, 'A Course in Electrical Machine Design', Dhanpat Rai and Sons, New Delhi, 2003.

UNIT V

SYNCHRONOUS MACHINES

PART-A (2 MARKS)

1. What are the different methods available for the elimination of harmonics in synchronous machine?Univ
    i. Distribution
    ii. Chording
    iii. Skewing
    iv. Fractional slot winding
    v. Large length of airgap

2. What are the factors to be considered for the selection of number of armature slots in synchronous machine?Univ
    i. Balanced winding
    ii. Cost
    iii. Leakage reactance
    iv. Tooth losses
    v. Hot spot temperature in winding
    vi. Tooth flux density

3. Name the two types of synchronous machines.Univ
    a. Salient pole machines
    b. Non salient pole or smooth cylindrical machines

4. What is run away speed?Univ

    The runaway speed is defined as the speed which the prime mover would have, if it is suddenly unloaded, when it is working at its rated load.

5. State any two methods of cooling the turbo alternators.Univ
    - Air cooled turbo alternators
    - One sided axial ventilation
    - Two sided axial ventilation
    - Hydrogen cooling direct cooling
    - Multiple inject system.

6. Distinguish between cylindrical pole and salient pole construction.Univ

    In cylindrical pole construction the rotor is made of solid cylinder and slots are cut on the outer periphery of the cylinder to accommodate field conductors In salient pole construction, the circular or rectangular poles are mounted on the outer surface of the cylinder. The field coils are fixed on the pole.

The cylindrical pole construction is suitable for high speed operation, whereas the salient pole construction is suitable for slow speed operations

7. Salient pole machines are not suitable for high speed operations, why?Univ

The salient pole rotors cannot withstand the mechanical stresses developed at high speed. The projecting poles may be damaged due to mechanical stresses.

8. What is critical speed of alternator?Univ

When the rotor of the alternator has an eccentricity, it may have a deflection while rotating. This deflection will be maximum at a speed called critical speed. When a rotor with eccentricity passes through critical speed, severe vibrations are developed.

9. List the factors to be considered for separation of D and L for salient pole machines.
    a. Peripheral speed
    b. Number of poles
    c. Short circuit ratio

10. Mention the uses of damper windings in a synchronous machines.Univ
    - ✓ Damper windings are used to reduce the oscillations developed in the rotor of alternator when it is suddenly loaded.
    - ✓ It is used to start the synchronous motor as induction motor.

11. Define pitch factor.Univ

The pitch factor is defined as the ratio of vector sum of emf induced in a coil to arithmetic sum of emf induced in the coil

12. Define distribution factor.Univ

The distribution factor is defined as the ratio of vector sum to arithmetic sum of emf induced in the conductor of one phase spread.

13. Why alternators are rated in KVA?

The KVA rating of ac machine depends on the power factor of the load. The power factor in turn depends on the operating conditions. The operating conditions differ from place to place. Therefore the KVA rating is specified for all ac machines.

14. What are the factors to be considered for the choice of specific magnetic loading?
    a. Iron loss
    b. Voltage rating
    c. Transient short circuit current
    d. Parallel operation

15. What are the factors to be considered for the choice of specific electric loading?

a. Copper loss
b. Temperature rise
c. Voltage rating
d. Synchronous reactance
e. Stray load losses

16. Define short circuit ratio (SCR).Univ

The short circuit ratio is defined as the ratio of field current required to produce rated voltage on open circuit to field current required to circulate the rated current on short circuit. It is also given as the reciprocal of synchronous reactance.

17. How the value of SCR affects the design of alternator?Univ

For high stability and low regulation, the value of SCR should be high, which requires large air gap, when the length of air gap is large, the mmf requirement will be high so the field system will be large. Hence the machine will be costlier.

18. Write the expression for length of airgap in salient pole synchronous machine.

$l_g = AT_{f0}/(B_g K_g \times 10^6)$ or $l_g = AT_a \times SCR \times K_f / B_{av} \times K_g \times 10^6$

19. List the influence of the air gap length on the performance of the synchronous machine.

a. Armature reaction
b. Noise
c. Unbalanced magnetic pull
d. Regulation
e. Tooth pulsation loss
f. Sensitivity to load variation

20. What is the limiting factor for the diameter of synchronous machine?Univ

The limiting factor of synchronous machine is the peripheral speed. The limiting value of peripheral speed is 175 m/s for cylindrical and 80 m/s for salient pole machines

21. Write the expression for air gap length in cylindrical rotor machines.

Length of air gap, $l_g = (0.5 SCR\ ac\ \tau\ K_f \times 10^{-6})/(K_g\ B_{av})$

22. What are the factors to be considered for selecting the number of poles in an alternator?

The number of poles depends on the speed of the prime mover and frequency of generated emf.

23. Write the output equation of a synchronous machine.Univ

$Q = C_0 D^2 L n_s$ in KVA

$$C_0 = 11K_{ws}B_{av}\mathbf{ac} \times 10^{-3} \text{ in KVA/m}^3\text{-rps.}$$

24. Discuss how the ventilation and cooling of large high speed alternator is carried out.

For high speed alternator two cooling methods are available and they are conventional cooling and direct cooling.

In conventional cooling methods, radial and axial ventilating ducts are provided in the core. Cooling is performed by forced circulation of air or hydrogen at a pressure higher than atmosphere.

In direct cooling methods, cooling ducts are provided in the stator and rotor slots or conductor itself will be in the form of tubes. Coolants like water or oil or hydrogen are circulated in the ducts to remove the heat directly from the conductors.

25. Mention the factors that govern the design of field system of the alternator.

1. Number of poles and voltage across each field winding
2. Amp-turn per pole
3. Copper loss in the field coil
4. Dissipating surface of field coil
5. Specific loss dissipation and allowable temperature rise.

26. What type of prime movers is used in hydro electric stations depending on the head?

The type of water turbine used in hydroelectric station depends on water head. Pelton wheel is used for water heads of 400 m and above. Francis turbine is used for water heads upto 380 m. Kaplan turbine is used for water heads upto 50m.

27. List the types of synchronous machines operating on general power supply.

i. Hydro generators
ii. Turbo generators
iii. Engine driven generators
iv. Motors
v. Compensators

28. Give the approximate values of runaway speed of the turbines with full gate opening.

Pelton wheel – 1.8 times the rated speed.
Francis turbine – 2 to 2.2 times the rated speed.
Kaplan turbine – 2.5 to 2.8 times the rated speed.

PART-B (13 MARKS)

1. Derive the output equation of a synchronous machine.(P.no: 6.4)
2. How is D and L separated for synchronous machine. (P.no: 6.17 – 6.18)

3. Explain the factors influence that choice of specific magnetic and electric loadings for a synchronous machine. (P.no: 11.14 – 11.15)
4. Write a note on main dimensions for synchronous machine. (P.no: 11.15)
5. Explain the SCR and its effect on machine performance. (P.no: 11.18 – 11.19)
6. Explain briefly on armature design. (P.no: 11.21 – 11.22)
7. Give the comparison between single and double layer winding. (P.no: 11.21)
8. Explain the factors that influenced for choice of number of armature slots. (P.no: 11.21)
9. Explain briefly on design of rotor for synchronous machine. (P.no: 11.38 – 11.39)
10. With neat sketch indicate the location of damper windings in a synchronous machines and mention its uses. (P.no: 11.41 – 11.42)
11. Clearly explain the procedure for design of field winding in synchronous machines. (P.no: 11.48 – 11.49)
12. Discuss the cooling methods of turbo alternators. (P.no: 4.39 – 4.46)

BOOK NAME:

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