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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

SUBJECT CODE & NAME : EE 1403 – DESIGN OF ELECTRICAL APPARATUS

YEAR / SEM : IV / VII

UNIT – I

MAGNETIC CIRCUITS AND COOLING OF ELECTICAL MACHINES

PART – A

1. Define gap contraction factor for slots.(2)
2. Define total gap contraction factor. (2)
3. What is Carter's Co-efficient? What is its usefulness in the design of dc machine? (2)
4. What is the effect of salient poles on the air gap mmf? (2)
5. Define Field form factor. (2)
6. List the methods used for estimating the mmf for tapered teeth. (2)
7. What is real and apparent flux density? (2)
8. In which way the air gap length influence the design of machines? (2)
9. What is magnetic leakage and leakage co-efficient? (2)
10. What is fringing flux? (2)
11. What are the differences between leakage flux and fringing flux? (2)
12. What is tooth top leakage flux? (2)
13. What is Zig – Zag leakage flux? (2)
14. What is skew leakage flux? (2)
15. How will you minimize the leakage flux? (2)
16. Define slot space factor. (2)
17. Mention the undesirable effects of un balanced magnetic pull. (2)

PART – B

1. a) Discuss in detail about the cooling methods adopted in transformers (10).
   b) Discuss about the cooling methods used in Turbo alternators (6)
2. a) Discuss about the various types of thermal ratings of the electrical machines (10)
   b) Discuss about the various Insulating materials and their grades.(6)
3. a) Explain in detail about the MMF calculation for Teeth.(10)
b) Discuss in detail about the real and apparent flux densities.(6)
4. a) Write about specific magnetic loading and specific electric loading.(8)
b) Explain about the cooling of Turbo alternators.(8)
5. a) What are the direct and indirect cooling methods used in electrical machines (8)
b) Derive an equation for the slot leakage reactance (8)
6. a) Discuss in detail about the unbalance magnetic pull.(8)
b) Explain about the air gap reluctances in different types of armature slots(8)

UNIT – II

D.C. MACHINES

PART – A

1. Mention the factors governing the length of armature core in dc machines. (2)
2. State the factors which limit the armature diameter of a dc machine. (2)
3. Write the equation for maximum value of the main dimension of a dc machine. (2)
4. List out the design consideration for dc motors operating on solid state circuits. (2)
5. Define the terms “active copper” and “inactive copper” in design of dc machine. (2)
6. What are the factors that influence the choice of specific electric loading? (2)
7. List the advantages and disadvantages of large number of poles. (2)
8. Why square pole is preferred? (2)
9. Mention guiding factors for the selection of number of poles. (2)
10. Mention the factor that governs the choice of number of armature slots in a dc machine. (2)
11. List the characteristics of a lap winding. (2)
12. What is simplex and multiplex winding? (2)
13. What are dummy coils? (2)
14. What is meant by equalizer connections? (2)
15. What are the factors that influence the choice of commutator diameter? (2)
16. How to design the number of brushes for a dc machines. (2)

PART – B

1. a) A 4 pole, 25 HP, 500 V, 600 rpm series motor has an efficiency of 82%. The pole faces are square and the ratio of pole arc to pole pitch is 0.67. Take B_{av} = 0.58 Wb/m^2 and ac = 17000 amp.cond/m. Obtain the main dimensions of the core particular of a suitable armature winding.(12)
   b) Enumerate the procedure for shunt field design (4)

2. a) A 4 pole, 400 V, 960 rpm, shunt motor has an armature of 0.3 m in diameter and 0.2 m in length. The commutator diameter is 0.22 m. Give full details of a suitable winding including the number of slots, number of commutator segments and number of conductors in each slot Wb / m^2 in the air gap. (12)
b) Find the main dimension and number of poles of a 37 kW, 230V, 1400 rpm, shunt motor so that a square pole face is obtained. The average gap density is 0.5 wb/m^2 and the ampere conductors / meter are 22000. The ratio of pole arc to pole pitch is 0.7 and the full load efficiency is 90%(4)

3. i) A 4 pole, 400V, 960 rpm shunt motor has an armature of 0.3 m. in diameter and 0.2 m. in length. The commutator diameter is 0.22m. Give the full details of a suitable winding including the number of slots, number of commutator segments and number of conductor in each slot for an average flux density of approximately 0.55wb/m^2 in the air gap.(10)
ii) Discuss in details about the design of field coil of a dc motor. (6)

4. i) A 4 pole, 500V, 600rpm, series motor has an efficiency of 82%. The pole face is square and the ratio of pole arc to pole pitch is 0.67. Take $\mathbf{B_{av}}$ is 0.55 wb/ m^2 and **ac** = 17000 amp conductor/m. obtain the main diameters of the core and particulars of a suitable armature winding. (10)
   ii) Enumerate the design of lap winding for a dc machine. (6)

5. i) Determine the total commutator losses for a 1000kw, 500V, 800rpm, 10poles generator. Given that commutator diameter is 1.0m, current density at brush contact =75x10^{-3} A/mm^2 brush pressure = 14.7kv/ m^2, co efficiency of friction = 0.28, brush contact drop= 2.2V (10).
   ii) Enumerate the design of wave windings for a dc machine (6)

6. i) Design a suitable commutator for a 350kw, 600rpm, 440V, 6poles DC generator having an armature diameter of 0.75m. The number of cores is 288. Assume suitable values where it's necessary? (10)
   ii) Compare lap winding and wave winding of dc machine.(6)

7. i) List out the procedure involved in design of shunt field winding and series field winding? (10)

ii) Find the main dimension and number of poles of a 37 kW, 230V, 1400 rpm, shunt motor so that a square pole face is obtained. The average gap density is 0.5 wb/m^2 and the ampere conductors / meter are 22000. The ratio of pole arc to pole pitch is 0.7 and the full load efficiency is 90 %(6)

8. i) Determine the total commutator losses of a dc machine from the given data, P = 500 kW, 400V, 600 rpm, 4 pole, diameter of commutator = 0.9 m, current density of brush contact = 68 x 10^{-3} A/mm^2, brush pressure = 13.8 kN / m^2, co-efficient of friction = 0.28, brush contact drop = 1.9 V.
ii) Discuss about the choice of specific magnetic loading and specific electric loading. (6)

9. i) Find the main dimension and number of poles of a 100 kW, 230V, 1000 rpm shunt motor so that a square pole face is obtained. The average gap density is 0.85 Wb / m2 and ampere conductors per meter are 22000. The ratio of pole arc to pole pitch = 0.67. The full load efficiency is 91%.
ii) Discuss in detail about the design of commutator and brushes. (6)

10. List out the procedure for shunt field winding and series field winding. (16)

11. Determine the shunt field winding of a 6-pole, 440V, dc generator allowing a drop of 15 % in the regulator. The following design date are available, mmf per pole = 7200 AT; mean length of turn = 1.2 m; winding depth = 3.5 cm; watts per sq.cm. of cooling surface = 650. Calculate the inner, outer and end surfaces of the cylindrical field coil for cooling. Take diameter of the insulated wire to be 0.4 mm greater than the bare wire. Assume 2 micro – ohm / cm as the resistivity of copper at the working temperature. (16)

12. Determine the diameter and length of armature core for a 55kW, 110V, 1000 rpm, 4 pole shunt generator, assuming specific electric and magnetic loadings of 26000 amp.cond. / m and 0.5 Wb / m^2 respectively. The pole arc should be about 70% of pole pitch and length of core about 1.1 times the pole arc. Allow 10 ampere for the field current and assume a voltage drop of 4 volts for the armature circuit. Specify the winding to be used and also determine suitable values for the number of armature conductors and slots. (16)

UNIT – III

TRANSFORMERS

PART – A

1. What are the salient features of a distribution transformer? (2)
2. How the design of distribution transformer differs from that of a power transformer. (2)
3. In transformers, why the low voltage winding is placed near the core? (2)
4. Why circular coils are preferred in transformers? (2)
5. What are the advantages and disadvantages of stepped cores? (2)
6. The area of yoke in a transformer is taken 15 to 20 % larger than that of core. Why? Why not increase the size of core also? (2)
7. What do you mean by stacking factor? What is its usual value? (2)
8. What is tertiary winding? (2)
9. List the different methods of cooling of transformers. (2)
10. How the heat dissipation is improved by the provision of cooling tubes? (2)
11. In mines applications transformer with oil cooling should not be used why? (2)

PART – B

1. i) Estimate the main dimensions including winding conductor area of a 3 phase delta-star core type transformer rated at 300KVA, 6600/400 V, 50 Hz. A suitable core with 3 steps having a circumscribing circle of 0.25m diameter and leg spacing of 0.4 m is available. EMF / turn = 8.5 V, $\delta = 2.5$ A /mm^2, k_w= 0.28 and $S_f = 0.9$ (stacking factor) (10)
   ii) Derive the output equation of a single phase transformer (6)

2. i) Determine the main dimensions of the core, the number of turns, the cross sectional area of conductors in primary and secondary windings of a 100 kVA, 2200 / 480 V, 1-phase, core type transformer, to operate at a frequency of 50 Hz, by assuming the following data. Approximate volt per turn = 7.5 volt. Maximum flux density = 1.2 Wb / m^2. ratio of effective cross – sectional area of core to square of diameter of circumscribing circle is 0.6. Ratio of height to width of window is 2. Window space factor = 0.28. Current density = 2.5 A/mm^2.(10)
   ii) Estimate the no-load current of a three phase transformer.(6)

3. i) A 250 kVA, 6600 / 400 V, 3-phase core type transformer has a total loss of 4800 watts on full load. The transformer tank is 1.25 m in height and 1 m x 0.5 m in plan. Design a suitable scheme for cooling tubes if the average temperature rise is to be limited to 35℃. The diameter of the tube is 50 mm and are spaced 75 mm from each other. The average height of the tube is 1.05 m.(10)
   ii) Describe about the effect of frequency on Iron losses.(6)

4. i) The tank of a 500 kVA, 1-phase, 50 Hz, 6600 / 400V transformer is 110cm x 65 cm x 155 cm. If the full load loss is 6.2 kW, find the suitable arrangements for the cooling tubes to limit the temperature rise to 35℃. Take the diameter of the cooling tubes as 5 cm and average length of the tubes as 110 cm.(10)
   ii) Describe about the various cooling methods of a transformer.(6)

5. i) Derive the output equation of a 3-phase transformer. (8)
   ii) Discuss about cooling of transformer using cooling tubes. (8)

6. i) Determine the core and yoke dimensions for a 250 kVA, 50Hz, single phase, core type transformer, Emf per turn = 12 V, the window space factor = 0.33, current density = 3A / mm2 and B_{max} = 1.1 T. The distance between the centers of the square section core is twice the width of the core.(6)

   ii) Calculate the dimensions of the core, the number of turns and cross sectional area of conductors in the primary and secondary windings of a 250 kVA, 6600 / 400 V, 50 Hz, single phase shell type transformer. Ratio of magnetic to electric loadings = 560 x 10^{-8}, B_m = 1.1 T. δ = 2.5 A / mm2, K_w = 0.32, Depth of stacked core / width of central limb = 2.6; height of window / width of window = 2.0.(10)

7. i) A 375 kVA, single phase core type transformer operating on 6.6 kV / 415V is to be designed with approximately 7.5V per turn and a flux density of 1.1 T. Design a suitable core section and yoke section using two sizes of stampings. The width of smaller stampings may be approximately 0.62 times the larger stampings. State the assumptions made.(6)
   ii) The tank of a 500 kVA, 50Hz, 1-phase, core type transformer is 1.05 x 0.62 x 1.6 m high. The mean temperature rise is limited to 35℃. The loss dissipating surface of tank is 5.34 m^2. Total loss is 5325 W. Find the area of tubes and number of tubes needed. (10)

8. The tank of 1250 kVA, natural oil cooled transformer has the dimensions length, width and height as 0.65 x 1.55 x 1.85 m respectively. The full load loss = 13.1 kW, loss dissipation due to radiations = 6 W / m^2-°C, loss dissipation due to convection = 6.5 W / m^2°C, improvement in convection due to provision of tubes = 40%, temperature rise = 40°C, length of each tube = 1m, diameter of tube = 50mm. Find the number of tubes for this transformer. Neglect the top and bottom surface of the tank as regards the cooling. (16)

UNIT – IV

THREE PHASE INDUCTION MOTORS

PART – A

1. What is the advantage of having wound rotor construction? (2)
2. What is rotating transformer? (2)
3. What are the special features of the cage rotor of induction machines? (2)
4. What are the advantages of cage induction motor over slip ring induction motor? (2)
5. What is integral slot winding and fractional slot winding? (2)
6. What types of slots are preferred in induction motor? (2)
7. What are the criteria used for the choice for number of slots of an induction machine? (2)
8. What are the factors to be considered for estimating the length of air gap in induction motor? (2)
9. List out the methods to improve the power factor of an induction motor? (2)
10. Why the air gap of a induction motor is made as small as possible? (2)
11. List the undesirable effects produced by certain combination of rotor and stator slots. (2)
12. What are the advantages and disadvantages of large air gap length in induction motor? (2)
13. Define dispersion coefficient. (2)

PART – B

1. Estimate the main dimension, air gap length, stator slots, slots / phase and cross sectional area of stator and rotor conductors and end ring for three phase, 15HP, 400V, 6 pole, 50Hz, 975 rpm induction motor. The motor is suitable for star – delta starting. B_{av} = 0.45 wb/m^2. ac = 20000 AC/m. L / τ = 0.85. η = 0.9 , P.F = 0.85. (16)

2. A 15 kW, three phase, 6 pole, 50 Hz, squirrel cage induction motor has the following data, stator bore dia = 0.32m, axial length of stator core = 0.125 m, number of stator slots = 54, number of conductor / stator slot = 24, current in each stator conductor = 17.5 A, full load P.F = 0.85 lag. Design a suitable cage rotor giving number of rotor slots section of each bar and section of each ring. The full speed is to be 950 rpm, use copper for rotor bar and end ring conductor. Resistivity of copper is 0.02 Ωm. (16)

3. A 90 kW, 500V, 50 Hz, three phase, 8 pole induction motor has a star connected stator winding accommodated is 63 slots with a 6 conductors / slot. If slip ring voltage, an open circuit is to be about 400V at no load find suitable rotor winding. Calculate number of rotor slots, number conductors / slot, coil span, number of slots. pole slip ring voltage an open circuit , approximately full load current / phase is rotor. Assume η = 0.9 , P.F = 0.8. (16)

UNIT – V

SYNCHRONOUS MACHINES

PART – A

1. What is runaway speed? (2)
2. State three important features of turbo-alternator rotors. (2)
3. Distinguish between cylindrical pole and salient pole construction. (2)
4. What is critical speed of alternator? (2)
5. Why the field is wound on rotor in a 3 phase synchronous machine? (2)
6. Define the pitch factor and distribution factor. (2)
7. Mention the advantages of fractional slot winding. (2)
8. What is short circuit ratio? How it affects the synchronous machine design. (2)
9. What are the advantages of large air gap in synchronous machines? (2)
10. List the factors to be considered for the choice of number of slots in synchronous machine. (2)
11. Discuss how the ventilation and cooling of a large high speed alternator is carried out. (2)
12. Mention the factors that govern the design of field system of alternator. (2)

PART – B

1. Determine the main dimension for 1000 kVA, 50 Hz, three phase, 375 rpm alternator. The average air gap flux density = 0.55 wb/m^2 and ampere conductors / m = 28000. Use rectangular pole. Assume a suitable value for L / τ in order that bolted on pole construction is used for which machine permissible peripheral speed is 50 m/s. The runway speed is 1:8 times synchronous speed. (16)

2. Find main dimension of 100 MVA, 11 kV, 50 Hz, 150 rpm, three phase water wheel generator. The average gap density = 0.65 wb/m^2 and ampere conductors / m are 40000. The peripheral speed should not exceed 65 m/s at normal running speed in order to limit runaway peripheral speed. (16)

3. Determine suitable number of slots conductors / slot for stator winding of three phase, 3300V, 50 Hz, 300 rpm alternator, the diameter is 2.3m and axial length of core = 0.35 m. Maximum flux density in air gap should be approximately 0.9 wb / m^2. Assume sinusoidal flux distribution use single layer winding and star connection foe stator. (16)

4. Determine for 500kVA, 6600V, 20Hz, 500 rpm and connected three phase salient pole machine estimate dia, core length for square pole face number of stator slots and number of stator conductors for double layer winding. Assume specific magnetic loading = 0.68 tesla, ac = 30000 AC/m and KWs = 0.955. (16)

5. A 1000 kVA, 3300V, 50Hz, 300 rpm, three phase alternator has 180 slots with 5 conductors / slot single layer winding with full pitch coil is used. The winding is star connected with one circuit / phase. Determine specific electric loading and magnetic loading, IF stator core is 0.2 m and core length = 0.4 m. Using same loading determine the data for 1250 kVA, 3300V, 50 Hz, 250 rpm, three phase star connected alternator having 2 circuits / phase. (16)