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NEW SCHEME

Sixth Semester B.E. Degree Examination, Dec.06 / Jan.07
Electrical & Electronics Engineering
Electrical Machine Design

Time: 3 hrs.] [Max. Marks:100

Note: *1. Answer any FIVE full questions.*
2. Electrical machine design data hand book is permitted.

1 a. Explain clearly the factors which impose limitations in the design of electrical machines. **(05 Marks)**

b. Classify the electrical insulating materials as per IS No. 1271 – 1958 with examples and show how, the life of electrical insulation gets shortened by increase in temperature beyond its limit. **(05 Marks)**

c. Determine the main dimensions, number of poles and the length of air gap of a 600 kW, 500 V, 900 rpm dc generator. The average gap density is 0.6 wb/m^2 and 'ac' per meter is 35000. The ratio of pole arc to pole pitch is 0.75 and the efficiency is 91%. Assume square pole face. Use the following design constraints for check: peripheral speed ≤ 40 m/s, frequency of flux reversals ≤ 50 Hz, current per brush arm ≤ 400 A and armature mmf per pole ≤7600 A. The mmf required for air gap is 50% of armature mmf and gap contraction factor is 1.15. **(10 Marks)**

2 a. A 10 Kw, 500 V, 8 pole, dc shunt generator requires an mmf of 5000 A per pole for its field excitation. The pole body is rectangular with cross section 120 × 120 mm^2. The winding is 120 mm in height and 25 mm in depth. The round copper wire used for field winding has an insulation covering of 1 mm thickness. Take resistivity of copper as 0.02 Ω/m and mm^2. Allow a voltage drop of 50 V in the field regulator. Determine :

i) The cross-sectional area of field conductor,
ii) The number of turns,
iii) The loss dissipation in the field coil in W/m^2 considering outside, top and bottom surfaces only. **(08 Marks)**

b. A 500 kW, 460 V, 8 pole, 375 rpm dc compound generator has an armature diameter of 1.1 m and a core length of 0.33 m. The 'ac' per meter is 34000. The internal voltage drop is 4% of terminal voltage. The field current is 1% of output current. The ratio of pole arc to pole pitch is 0.7. The voltage between adjacent commutator segments at no load should not exceed 15 V and the slot loading should not exceed 1500 A. The diameter of commutator is 0.65 of armature diameter and the minimum allowable pitch of commutator segment is 4 mm. Suggest suitable type of armature winding. Find the number of slots, number of coils, number of commutator segments, number of conductors per slot and the number of turns per coil in the winding. **(12 Marks)**

3 a. Derive the output equation of 3 phase core type transformer and hence deduce the expression of output – emf per turn. **(10 Marks)**

3 b. Calculate the approximate overall dimensions of 200 KVA, 6600 / 440 V, 50 Hz, 3 phase core type transformer. The following data may be assumed:
emf per turn =10 V, maximum flux density=1.3 Wb/m^2, current density=2.5 A/mm^2, window space factor = 0.3, overall height = overall width, stacking factor = 0.9.
Use 3 stepped core. Width of largest stamping = 0.9 d and net iron area = $0.6d^2$ where d is the diameter of circumscribing circle. **(10 Marks)**

4 a. Derive an expression for the number of cooling tubes required to limit the temperature rise in a 3 phase transformer. Design its tank dimensions and show them pictorially. **(10 Marks)**

b. A 15000 kVA, 33/6.6 kV, 3 phase star/delta, core type transformer has the following data:
Net iron area of each limb = 0.15 m^2, net area of yoke = 0.18 m^2, mean length of flux path in each limb = 2.3 m, mean length of flux path in each yoke = 1.6 m, number of turns in hv winding = 450, density of iron = 7.8 × 103 kg/m^3. Calculate the no load current. Use the following table. **(10 Marks)**

$B_m Wb/m^2$	0.9	1.0	1.2	1.3	1.4
Mmf A/m	130	210	420	660	1300
Iron loss W/kg	0.8	1.3	1.9	2.4	2.9

5 a. Derive the output equation of 3 phase induction motor and explain the factors which influence the choice of specific magnetic and specific electric loading. **(10 Marks)**

b. A 90 kW, 500 V, 50 Hz, 3 phase, 8 pole induction motor has star connected stator winding accommodated in 63 slots with 6 conductors per slot. If the slip ring voltage on open circuit is to be about 400 V, find
i) Number of slots.
ii) Number of conductors per slot.
iii) Coil span.
iv) Slip ring voltage on open circuit.
v) Approximate full load current per phase in rotor. Assume efficiency = 0.9; power factor = 0.86. **(10 Marks)**

6 a. Explain the factors which influence the length of air gap of 3 phase induction motor and write few empherical formulae for the length of air gap. **(10 Marks)**

b. A 15 kW, 400 V, 3 phase, 50 Hz, 6 pole induction motor has stator bore diameter of 0.3 m and core length of 0.12 m. The number of slots is 72 with 20 conductors per slot. The stator is delta connected. Calculate the value of magnetizing current per phase if the length of air gap is 0.55 m. The gap contraction factor is 1.2. Assume that mmf required for iron parts to be 35% of the air gap mmf. Coil spin = 11 slots. **(10 Marks)**

7 a. Define the short circuit ratio of synchronous machine and explain the effect of SCR on machine performance. **(04 Marks)**

b. Explain the factors to be considered in the selection of number of armature slots of synchronous machine. **(04 Marks)**

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7 c. A 2500 kVA, 2400 V, 225 rpm, 3 phase, 60 Hz, star connected salient pole alternator has the following design data :
Stator bore = 2.5 m; core length = 0.44 m; slot pole per phase = 3.5 ; conductors per slot = 4; circuits per phase = 2; leakage factor = 1.2; winding factor = 0.95. The flux density in pole core is 1.5 Wb/m^2, the winding depth is 30 mm, the ratio of full load field mmf to armature mmf is 2, field winding space factor is 0.84 and the field winding dissipates 1800 W/m^2 of inner and outer surface without the temperature rise exceeding the permissible limit. Leave 30 mm for insulation, flanges and height of pole shoe along the height of pole. Find

i) The flux per pole.
ii) Length and width of pole.
iii) Winding height and
iv) Pole height. **(12 Marks)**

8 Answer any four of the following :

a. Design the rotor of non salient synchronous machine.
b. Design the rotor of single phase induction motor.
c. Design the end ring of 3 phase squirrel cage induction motor.
d. Design the slot dimensions of dc machine and show the slot insulation details.
e. Explain what is leakage reactance and state the assumptions made in the calculations of leakage reactance of core type transformer. **(20 Marks)**