B.E. (Electrical Engineering (Electronics & Power)) Fifth Semester (C.B.S.)

Electrical Machine Design

P. Pages : 3 **NRT/KS/19/3420**

Time : Three Hours *0129* Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
3. Solve Question 3 OR Questions No. 4.
4. Solve Question 5 OR Questions No. 6.
5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Due credit will be given to neatness and adequate dimensions.
9. Assume suitable data whenever necessary.
10. Use of non programmable calculator is permitted.

1. a) Define Heating and mechanical overload ratio. Derive relation between them. **6**

b) Calculate maximum overload that can be carried by 20 kW output motor if temperature rise hot to exceed 45ºC after 1 Hour on overload. Temperature rise on full load after 1 hour is 30ºC and after two hours is 40ºC. Assume losses to be proportional to the square of the load. **7**

OR

2. a) State classification of insulating material on the basis of temperature rise. **6**

b) Heat run test on dc motor give the following results **7**

Time (minutes)	0	15	30	45	60	75
Temp. (ºC)	50	56.6	61.8	65.8	69	71.2

Calculate final steady temperature rise and heating time constant of the machine if ambient temperature is 30ºC.

3. a) Derive an expression for width of window for maximum output per unit height of window of 1ϕ transformer. **6**

b) Calculate approximate overall dimensions number of turns and conductor cross section for a 200 kVA, 6600 V/440V, 50 Hz, 3ϕ, Δ / Y core type transformer. **7**

The following data may be assumed:
Volt/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, SF = 0.9. Use 3 stepped core.

OR

4. a) Derive condition for minimum cost of transformer. **6**

b) Calculate the main dimensions of a 125 kVA, 6.6 kV/400V, 50 Hz, single phase, shell type transformer taking volt/Turn = 10V, flux density = 1.1 Wb/m ^{2}, current density = 2 A/mm^2, Window space factor = 0.33 stacking factor = 0.9, $H_w/W_w = 3$, depth/width $\frac{b}{2a} = 2.5$. Also calculate number of turns and size of conductors **7**

5. a) What are properties of transformer oil. **6**

b) Calculate the leakage reactance of transformer referred to HV side, per unit regulation at full load and 0.8 pf lagging. Resistance per phase referred to HV side is 0.8 Ω for 750 kVA, 6600V/400V, 50 Hz, 3 ϕ, Δ / Y type transformer **8**

Width of LV winding = 30 mm
Width of HV winding = 25 mm
Radial width of duct = 15 mm
Length of mean turn = 1.5 m
Height of winding = 0.4 m
High voltage winding turns = 217

OR

6. a) Explain different methods of cooling of transformer. **6**

a) 6600V, 60 Hz, single phase transformer has a core of sheet steel. The net iron area is 22.6×10^{-3} m^2 mean length is 2.23 m and there are four lap joints. Each lap joint takes mmf equal to $\frac{1}{4}$ times mmf/meter of core. If Bm = 1.1 Wb / m^2 **8**

Determine
a) Number of turns on HV side
b) No load current.

Assume amplitude factor 1.52, mmf/meter = 232 A/m, specific loss = 1.76 W/kg specific gravity = 7.5x10^3 kg/m^3.

7. a) State factor affecting specific magnetic loading and specific electric loading. **6**

b) Estimate the main dimensions, net iron length, stator turns/ph, cross sectional area of stator conductor for 3 ϕ, 100 kW, 3300V, 12 pole, 50 Hz, star connected Induction motor. **7**

B_{av} = 0.4 Wb/m^2, ac = 25000 A/m. Efficiency = 0.9 Power factor = 0.9, K_{ws} = 0.955, δ = 3.5 A/mm^2. Choose main dimensions to give best power factor.

OR

8. a) State factors affecting type of stator slots. **6**

b) 3 ϕ, 5 HP, 400V, 50 Hz, 4 pole, slip ring delta connected Induction motor has following data: **7**

efficiency = 0.88, power factor = 0.87, δ = 3.5 A/mm^2, Diameter at air gap = 395 mm, Net iron length = 316 mm. Flux Per pole = 59 mWb. B_{cs} = 1.3 Wb/m ^{2} calculate number of stator slots & outside diameter of stator laminations flux density in stator teeth should not exceed 1.7 Wb/m^2.

9. a) State factors affecting selection of length of air gap in case of Induction motor. **6**

b) 250 HP, 3ϕ, 400V, 4 pole, 50 Hz squirrel cage induction motor has following data stator bore diameter = 0.4 m, Axial length of core = 0.375 m No. of stator slots = 60, Stator turns/phase = 32, current in each stator conductor = 200 A Design a suitable cage rotor giving number of rotor slots, rotor bar & end ring current and rotor speed Resistivity of copper = $0.02\,\Omega$ mm^2/m $\delta_b = 6$ A/mm^2 & $\delta_e = 6.5$ A/mm^2. **8**

OR

10. a) State factors affecting selection of rotor slots. **6**

b) 15 kW, 400V, 3 phase, 50 Hz, 6 pole Delta connected induction motor has a diameter of 0.3 m and length of stator core = 0.12 m. **8**
The number of stator slots = 72 conductors/slot = 20. Calculate value of magneting current/phase if length of air gap is 0.55 mm. The gap contraction factor is 1.2. Assume mmf required for iron parts to be 35% of air gap mmf and coil span = 11 slots.

11. a) Explain effect of SCR on performance of synchronous machine. **6**

b) Find the main dimension, number of stator conductors/slot, cross section of conductor, air gap length for 250 kVA, 12 pole, 50 Hz, 3ϕ, 1.1 kV, star connected salient pole synchronous generator. The generator is to be vertical water wheel type. The specific magnetic loading is 0.6 Wb/m ^{2} and specific electric loading is 28500 A/m use circular poles with ratio of core length to pole pitch = 0.65. Ratio of length of air gap to pole pitch = 0.012. Specify the type of pole construction used if the run away speed is about 1.8 times normal speed. **7**

OR

12. a) State advantages of Hydrogen cooling. **6**

b) The losses of a 50 MVA, turbo alternator on full load is 1500 kW. Calculate the volume of air required per second if temperature rise in machine is to be limited to 30ºC Inlet temperature of air = 25ºC Barometric height = 760 mm of Hg Also calculate fan power if pressure = 2 kN/m^2 & fan efficiency = 0.9 **7**

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