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

Electrical Machine Design

P. Pages : 3 **NIR/KW/18/3420**

Time : Three Hours *1769* 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. Illustrate your answers whenever necessary with the help of neat sketches.
11. Use of non programmable calculator is permitted.

1. a) Derive the expression of temperature rise of machine when it is heated. **6**

b) Transformer gave a temperature rise of 20ºC after 1 hour & 32ºC after 2 hours on continuous full load. What final steady temperature rise on this load? Also find heating time constant. **7**

OR

2. a) Classify insulating materials based upon the working temperature. **6**

b) The heat run on a D.C. Motor gave the following result **:-** **7**

Tim (Min)	Temperature (ºC)
0	50
15	56.6
30	61.8
45	60
75	71.5

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

3. a) Derive the equation for width of window for optimum output. **6**

b) Determine the dimension of core, no of turns & cross-Sectional area of the conductor in primary & secondary winding of 100kVA, 2200/480V single phase core type transformer operated at 50Hz frequency. Assuming following data voltage per turn 7.5V, maximum flux density 1.5Wb / m^2, ratio of effective cross sectional area to the square of diameter of circumscribing circle is 0.6, ratio of height of window to width of window is 2, window space factor 0.28 and current density is 2.5A/mm^2. **7**

OR

4. a) What is need of stepped core cross-section? **5**

b) Determine the dimension of core, yoke for 200kVA, 50Hz, 1ϕ core type transformer a cruciform core used with distance between adjacent limb is equal to 1.6 times the width of core lamination. Assume voltage per turn is 14 volt. Maximum flux density (Bm) is 1.1. Wb/m^2. Window space factor 0.32, current density is $3A / mm^2$. Staking factor 0.9 & net iron area is $0.56d^2$ in cruciform core where d is diameter of circumscribing circle. Also width of largest stamping is 0.85d. **8**

5. a) Derive the expression for leakage reactance of core type transformer per phase referred to High voltage side having cylindrical concentric winding of equal axial length. **7**

b) A 100kVA, 2000/400V, 50Hz, 1ϕ shell type transformer has sandwich coils. There are two full high voltage coils, one full low voltage coil and two half low voltage coils. Calculate the values of leakage reactance referred to high voltage side. Also calculate per unit leakage reactance. The data given is : - **7**
Depth of high voltage coil = 40mm.
Depth of low voltage coil = 36mm
Depth of duct between high voltage & low voltage coil = 16mm
Hight of winding = 0.12m
Length of mean turn = 1.5m
Number of turn in high voltage winding = 200.

OR

6. a) Explain different methods of cooling of transformer. **7**

b) A 6600V, 50Hz single phase transformer has net core cross-sectional area of $22.6 \times 10^{-3} m^2$. the mean length of flux path is 2.23m, flux density is 1.1 Wb/m^2. **7**
Determine number of turns on 6600V winding side & no-load current of the transformer:
Assume: -
MMF per meter = 232A/m
Specific loss = 1.76 W/kg
Specific gravity of iron $= 7.5 \times 10^3 kg / m^3$.

7. a) Derive the output equation of an Induction motor. **5**

b) Determine the main dimension, number of radial ventilating ducts, number of stator slots & the number of tarns per phase of a 3.7kW, 400V, 3ϕ, 4 pole, 50Hz, squirrel cage induction motor to be started by star-delta starter. **8**
Assume :-
Average flux density in the gap $= 0.45 Wb / m^2$
Ampere conductor per meter = 23000A/m.
Efficiency= 0.85.
Power factor = 0.84, kW = 0.955.
Stacking factor = 0.9
Machine started at 3.7kW, 4 pole are sold at a competitive price & therefore choose the dimensions to give a cheap design
i.e. $\frac{L}{\tau} = 1.5$.

OR

8. a) Discuss briefly about the various stator slots used in Induction motor. **6**

b) A 15kW, 4 pole, 50Hz, 3ϕ Induction motor is built with a stator bore 0.25m and a core length of 0.16m. The specific electric loading is 25000A/m. Using the data of this machine, determine the core dimensions, number of stator slots & number of stator conductors for a 11kW, 460V, 6 pole, 50Hz motor. Assume a full load efficiency of 84% & power factor of 0.82 for each machine. The winding factor is 0.955. **7**

9. a) Explain the choice of Average flux density. **5**

b) A 15kW, 3ϕ, 6 pole, 50Hz squirrel cage induction motor has the following data :- **9**
Stator bore diameter = 0.32m
Axial length of stator core = 0.125m
Number of stator slot = 54
Number of conductor per stator slot = 24
Current in each stator conductor = 17.5A
Full load power factor = 0.85 lagging.
Design a suitable cage motor giving number of rotor slots, section of each bar & section of each ring. The full load speed is to be about 950rpm approximately. Use copper for the rotor bars & end rings. Resistivity of copper is $0.02\Omega / m$.

OR

10. a) Explain the factor taken into consideration while calculating/estimating the air gap length. **7**

b) 250HP, 3ϕ, 50Hz, 400V, 4 pole squirrel cage induction motor has following data :- **7**
Stator bore diameter = 40cm
Axial length of stator = 37.5cm
No. of stator slot = 60
Stator turns/phase = 32
Current in each stator conductor = 200A
Current density in bar = $6A/mm^2$.
Current density in end ring = $6.5A / mm^2$
Design a suitable cage motor, number of rotor slots, section of each bars & ring and rotor speed. Use copper for rotor bars & end rings $\rho = 0.021 \times 10^{-6} \Omega m$.

11. a) What is the effect of SCR on synchronous machine? **6**

b) Determine a suitable number of slots & conductor per slot for stator winding of 3 phase, 3300V, 50Hz, 300rpm alternator. Diameter is 2.3m and axial length of core is 0.35m. The maximum flux distribution, used single layer winding & star connection of stator. **7**

OR

12. Write a short note on:

a) Distribution factor & pitch factor. **4**

b) Cogging & crawling of Induction motor. **4**

c) Methods of eliminating harmonics in Induction motor. **5**

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