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

Electrical Machine Design

P. Pages : 4 **NKT/KS/17/7335**

Time : Three Hours * 0 0 1 3 * 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 the machine when it is heated. **6**

b) A machine running on steady full load gave the following temperature rise at the end of the specified intervals. **7**

Time (hrs)	Temp. rise (ºC)
0.25 →	9.5
0.5 →	17.0
1.0 →	29.2
1.50 →	38.00
2.00 →	44.2
2.50 →	48.7
3.00 →	52.00

Find graphically the final temp rise and heating time constant of a machine.

OR

2. a) Explain the following duties for electrical machines. **6**

i) continuous duty

ii) short time duty

iii) Intermittent duty

b) The rate of temp rise as measured from a temp. rise time curve of a D.C. motor is 0.0803ºC per minute and 0.0605ºC per minute when temp. rise is 20.5ºC and 28.5ºC respectively. Calculate : **7**

1) Final Steady temp. rise.

2) Heating Time Constant

3. a) Derive an expression for output equation of $3-\phi$ transformer. **5**

b) Determine main dimensions of core the no. of turns and cross section area of conductor for 5 KVA, 11000/400V, $1-\phi$, 50Hz core type transformer net conductor area in window is 0.6 times net cross - section area of iron in core. Assume a square cross - section for core of flux density $1 wb/m^2$, current density is $1.4 A/mm^2$ & window space factor is 0.2 height of window is 3 times it's width. **9**

OR

4. a) What is ideal cross section of core? Why? Derive the ratio of net core area of circumscribing circle for two stepped core. **6**

b) Determine the main dimensions of the core no. of turns & cross sectional area of conductors in primary & secondary windings of 100 KVA, 2200/480V, $1-\phi$, core type transformer to operate at 50Hz. **8**

The following data may be assumed.

EMF per turn = 7.5 V

Max^m Flux density = $1.2 wb/m^2$

Current density = $2.5 A/mm^2$

Window space factor = 0.28

Ratio of effective cross sectional area of core to the square of diameter of circumscribing circle is 0.6, Ratio of $\frac{HW}{WW} = 2$ stacking factor = 0.9.

5. a) 300 KVA, 50Hz, 11 KV/440 V, 3 phase Δ/γ core type transformer has following data. **9**

Length of coil = 0.5 m

<u>LV winding</u>

Outside diameter = 0.25 m

Inside diameter = 0.2 m

Area of cross - section = $180 mm^2$

No. of turns = 30

<u>HV Winding</u>

Outside diameter = 0.4 m

Inside diameter = 0.32 m

Area of cross - section = $10 mm^2$

No. of turns = 1320

Calculate Pu regulation at half load and 0.8 p.f. lag.

b) Discuss OFFLOAD tap changer. **4**

OR

6. a) Describe in brief, with the help of diagrams, the different methods of cooling of transformer. **6**

b) A 1000 KVA, 11 KV/415 V, 50 Hz, 3ϕ, delta / star connected, core type, oil immersed 'ON' cooled transformer, has the following data : **7**

Distance between centres of adjacent limbs = 0.47 m.
Outer diameter of - H. V. winding = 0.44 m
Height of frame = 1.24 m
Core loss = 3.7 KW, & Cu loss = 10.5 KW
Design a suitable tank for the transformer, the average temp rise of oil should not exceed 35ºC. The specific heat dissipation from the tank walls is $6 w/m^2 - °C$ and $6.5 w/m^2 - °C$ due to radiation and convection respectively. Assume that the convection is improved by 35% due to tubes.

7. Determine main dimensions, stator slot dimension and outer diameter of stator for 100 KW, 3300 V, 50 Hz 12 pole, Y - connected slip ring Induction motor. Assume following data : **13**

Average flux density at air = $0.4 wb/m^2$
conductors / metre = $25{,}000 A/m$
efficiency = 0.9, Power factor = 0.9
Stator winding factor = 0.96
Current density = $3.5 A/mm^2$
Choose main dimensions to give best power factor. Flux density in stator core is $1.3 wb/m^2$. Flux density in stator teeth should not exceed $1.7 wb/m^2$.

OR

8. a) Derive the output equation of 3ϕ Induction motor. **6**

b) A $3-\phi$ slip ring star - connected induction motor of 120 KW operated on 2200 V, 50 Hz, data given, **7**

$Bav = 0.48 wb/m^2$, $ac = 26000\ A/m$
efficiency 92%, P.F. = 0.88
Ratio of core length to pole pitch = 1.25
kws = 0.955, synchronous speed = 750 rpm current density = $3.5\ A/mm^2$,
mean length of stator turn = 0.75 m.
Specific resistance = $0.021\ \Omega/m\ \&\ mm^2$.
Calculate

1) Stator bore diameter
2) Length of stator core
3) No. of turns / ph.
4) Full load current & cross sectional area of conductor.
5) Total I^2R loss of stator.

9. a) How does the choice of length of air gap affects the design of Induction motor. **5**

b) A 11 KW, 3ϕ, 6 pole, 50 Hz, 220 V, star connected induction motor has 54 stator slots, each containing 9 conductors. Calculate the values of bar and end ring currents. The number of rotor bars is 64. The machine has an efficiency of 0.86 and a power factor of 0.85. The rotor mmf may be assumed as 85% of stator mmf. **8**

Also find the bar and the end ring sections if the current density is $5 A/mm^2$.

OR

10. a) Explain in detail the effect of harmonics on the Induction Motor. **5**

b) A 15 kw, 400 V, 3 Phase, 50 Hz, 6 pole induction motor has a diameter of 0.3 m and the length of core 0.12 m. The number of stator slots is 72 with 20 conductors per slot. The stator is delta connected. Calculate the value of magnetising current per phase if the length of air gap is 0.55 m. The gap contraction factor is 1.2. Assume the mmf required for the iron parts to 35% of the air gap mmf. **8**
Coil span = 11 slots.

11. a) Determine the main dimensions of a 75000 KVA, 13.8 KV, 50 Hz, 62.5 r.p.m. 3ϕ, star connected alternator. Also find the number of stator slots, conductor per slot, conductor area and workout the winding details. The peripheral speed should be about 40 m/s. Assume, average gap density $= 0.65\,\text{wb/m}^2$. ampere conductors per meter = 40,000 and current density $= 4\,\text{A/mm}^2$. **9**

b) What is the short circuit ratio of synchronous machine? Discuss its effect on machine (alternator) performance. **5**

OR

12. a) Obtain the main dimensions of the rotor of a 50 MVA, 2 pole, 50 Hz, synchronous generator. The peripheral speed is limited to approximately 160 m/sec. Take the electric loading of 65000 A/m and the mean gap density of $0.575\,\text{wb/m}^2$. Assume gap length of 25 mm. **8**

b) A 50 MVA, turbo alternator has a total loss of 1550 kw. Calculate the volume of air required per second and also the fan power if the temp. rise in the machine is to be limited to 30ºC. The data given is, inlet temp of air = 25º C. Barometric height = 760 mm of mercury, Pressure = $2\,\text{KN/m}^2$. fan efficiency = 0.4. **6**

****