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

# Electrical Machine Design

P. Pages : 4 **TKN/KS/16/7423**

Time : Three Hours Max. Marks : 80

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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) Explain various ratings of modern electric machines. Sketch the typical load, electric losses and temperature rise V/S time curves for these ratings to illustrate the answers. **6**

b) A machine running on steady full load showed the following temp. rises at the end of the specified time intervals. **7**

| Time (hours) | 0.25 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 |
|---|---|---|---|---|---|---|---|
| Temp. rise (ºC) | 9.5 | 17.0 | 29.2 | 38.0 | 44.2 | 48.7 | 52 |

Find graphically the final temp. rise and the heating time constant.

**OR**

**2.** a) Describe Heat – Run Test method to determine the heating time constant and final steady temp. rise of the rotating machine. **7**

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 **6**
i) Final steady temp rise.
ii) Heating time constant.

**3.** a) State and prove the design criteria that results into the minimum weight of the transformer. **6**

b) Estimate the main dimensions of core, No. of turns and cross sectional area of conductors of primary and secondary winding of a 300 KVA, 11KV/440V, $3-\phi$, $\Delta/Y$ connected core type, 50Hz, distribution transformer. The following data is given, **8**
- Ratio of voltage per turn to square root of KVA rating is 0.45.
- Window space factor is 0.3, stacking factor is 0.9
- Maximum flux density = $1.2 wb/m^2$, current density = $2.5 A/mm^2$.
- Ratio of height to width of window = 3
- Ratio of net area of core to square of diameter of circumscribing circle = 0.6

**OR**

4. a) Calculate the core and window area of a 400 KVA, 50Hz, $1-\phi$, core type power transformer. Following data may be assumed. **7**

$$\frac{\text{Ratio of weight of iron}}{\text{Weight of copper}} = \frac{Gi}{Gc} = 4$$

$$\frac{\text{Ratio of length of mean turn of copper}}{\text{Length of mean flux path}} = \frac{L_{mt}}{Li} = 0.5$$

Maximum flux density $Bm = 1.5\,wb/m^2$

Current density = $2.24\,A/mm^2$

density of copper = $gc = 8.9 \times 10^3 kg/m^3$ and

density of Iron = $gi = 7.8 \times 10^3 kg/m^3$

Copper space factor = window space factor = $kw = 0.12$

b) Calculate the main dimensions of a 125 KVA 6.6/0.4KV, 50Hz, $1-\phi$, shell type transformer taking, voltage per turn = 10V, flux density in core = 1.1wb/m$^2$, current density $\delta = 2A/mm^2$, window space factor = 0.33, stocking factor = 0.9 Ratio, **7**

$$\frac{HW}{Ww} = 3 \text{ and } \frac{Dy}{2a} = \frac{b}{2a} = 2.5$$

Also calculate the size of conductors.

5. a) Estimate the per unit regulation at full load and 0.8 p.f. lagging for a 300KVA, 6600/400V, $3-\phi$, $\Delta - Y$ core type xmer. The data given is **10**

| H.V. Windings | LV. windings |
|---|---|
| Outer diameter = 0.36m | Outer diameter = 0.26m |
| Inside diameter = 0.29m | Inside diameter = 0.22m |
| Area of conductor = 5.4mm$^2$ | Area of conductor = 170mm$^2$ |

length of coils = 0.5m, Voltage per turn = 8V

Resistivity = $\rho = 0.021 \times 10^{-6} \Omega^{-m}$.

b) Discuss properties of transformer oil. **4**

**OR**

6. a) A $1-\phi$, 400V, 50Hz, transformer is built from stamping having relative permeability of 1000. The length of flux path in iron is 2.5 m, the area of gross cross section of the core is $2.5 \times 10^{-3} m^2$ and primary winding has 800 turns. **7**
Estimate the maximum flux and no load current of the transformer. The Iron loss at the working flux density is 2.6 W/kg. Iron weight $7.8 \times 10^3 kg/m^3$ stocking factor is 0.9.

b) A 250KVA, 6600/400V, $3-\phi$, core type transformer has a total losses of 4800W at full load. The transformer tank is 1.25 m in height and $1m \times 0.5m$ in plan. Design a suitable scheme for tubes if the average temp. rise is to be limited by 35ºC. The diameter of tubes is 50mm and are spaced 75mm from each other. The average height of tubes is 1.05m. Specific heat dissipation due to radiation and convection is respectively 6 and 6.5 $W/m^2-{}^oC$. Neglect area of top cover. Assume that convection is improved by 35% due to provision of tubes. **7**

**7.** a) What is effect of number of slots on following : **6**

i) Leakage reactance.

ii) Magnetising current

iii) Tooth pulsation loss and noise.

b) Determine the approximate length and diameter of stator core, the no. of stator slots, no. of conductor for 15 HP, 400V, $3-\phi$, 4 – pole, 1425 rpm Induction motor for good overall design. **7**

Assume specific magnetic loading $B_{av} = 0.45\, wb/m^2$, specific electric loading (ac) = 23000 amp. conductor. Efficiency = 85% power factor = 0.88, the Stator winding is delta connected.

**OR**

**8.** a) Discuss specific electric loading and specific magnetic loading. **4**

b) A $3-\phi$ slip ring Y – connected induction motor of 120 KW operated on 2200V, 50Hz, **9**

Data given : Avg. flux density = $0.48\, wb/m^2$, Amp. conductors/meters = 26000 efficiency = 92%, power factor = 0.88. Ratio of core length to pole pitch = 1.25, kws = 0.955, synchronous speed = 750rpm, current density = $3.5\, A/mm^2$. Mean length of stator turn = 0.75m, specific resistance = $0.021\Omega/m\ \&\ mm^2$.

Calculate :

1) Stator bore diameter (D)

2) Length of stator core (L)

3) No. of turns/ph (Tph)

4) Full load current & cross section area of conductor.

5) Total $I^2R$ losses of stator.

**9.** a) Explain in brief phenomenon of cogging and crawling in induction motor. **5**

b) Write short notes on skewing of slots of induction motor. **4**

c) For MMF calculations of an Induction motor, why the flux density at 60º from interpolar axis is considered? **4**

**OR**

**10.** 250 HP, $3-\phi$, 50Hz, 400V, 4 – pole squirrel cage Induction motor has following data : **13**

Stator bore diameter = 40 cm
Axial length of stator = 37.5 cm
No. of stator slots = 60
Stator turns / phase = 32
Current in each stator conductor = 200A
Current density in bar = $6\,A/mm^2$
Current density in end ring = $6.5\,A/mm^2$
Design a suitable cage rotor giving number of rotor slots, section of each bar and end ring and rotor speed. Use copper bars for rotor bars and end rings. $\rho = 0.021 \times 10^{-6} \Omega^{-m}$.

**11.** a) Determine the main dimensions for a 1MVA, 50Hz, $3-\phi$, 375rpm alternator, $B_{av} = 0.55 wb/m^2$, $ac = 28{,}000\,A/m$, Use rectangular poles. Maximum permissible peripheral speed is 50m/sec. The runaway speed is 1.8 times the synchronous speed. **7**

b) A 50 MVA turbo alternator has a total loss of 1500KW. Calculate the value of air required per second and also the fan power if temp. rise in the machine is to be limited to 30ºC. The other data given is **6**

Inlet temp. of air = 25ºC
Barometric height = 760mm of mercury.
Pressure = $2\,KN/m^2$
Fan efficiency = 0.4

**OR**

**12.** Write short notes on :

i) Hydrogen cooling of alternator. **4**

ii) Run – away speed of alternator. **4**

iii) Short circuit ratio of alternator and it's effects on performance of alternator. **5**

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