

This question paper contains 4 printed pages.

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Your Roll No.

B.Tech. (E) / IV

J

Paper EEE-401— DESIGN OF POWER APPARATUS

Time : 3 hours

Maximum Marks : 70

*(Write your Roll No. on the top immediately
on receipt of this question paper.)*

Attempt any five questions.

Assume missing data, if any.

1. (a) What is basic difference between dynamo-grade and high resistance steel? Where is each type used? Explain. 5
- (b) Explain why higher specific electric loading can be used in machines using copper conductors compared to those using aluminium conductors. 5
- (c) Prove that I^2R loss per unit mass of conductor material is equal to $\delta^2\rho/g$, where δ =current density, ρ =resistivity and g is volume density. 4
2. (a) Derive an expression for temperature rise as a function of time for an electrical machine. Define all the symbols with their S.I. unit and state the assumptions made. 6

P. T. O.

- (b) A 15 MVA transformer has an iron loss of 75 kW and copper loss of 100 kW at full load. The tank dimensions are $3.5 \times 3 \times 1.5$ meters. The transformer oil is cooled by 2.4 liters of water per second through a cooling coil. Estimate the average temperature rise of the tank, if difference of temperature of water at inlet and the outlet is 16°C . The specific loss dissipation from the tank walls is $12 \text{ W/m}^2\text{-}^{\circ}\text{C}$. 8
3. (a) A 3 phase core type power transformer has following design specification : 1000 kVA, 50 Hz, 6600/433 volts delta-star connected. Estimate:
- (i) Net iron area of the core with two step core
 - (ii) Dia of the circumscribing circle.
 - (iii) No. of HV and LV turns. 8
- (b) Prove that for minimum copper loss in transformer windings, the current densities in primary and secondary must be equal. 6
4. (a) A 15 HP, 400 V, 1430 rpm, 3ϕ Induction motor with an efficiency of 80% and p.f. 0.81 has inner dia of stator 30 cm and length 12 cm. Estimate the diameter and length for a 50 HP, 406 V 4-pole, 50 Hz induction motor to be designed for 84% efficiency and 85% p.f., assuming same specific loadings as the previous motor. 7

- (b) What do you understand by phenomenon of cogging and crawling in the induction motor? What steps will you suggest at the design stage to avoid the occurrence of these phenomena? 7
5. (a) A 500 kVA, 3.3 kV, 50 Hz, 600 rpm, 3 phase salient pole alternator has 180 turns per phase. Estimate the length of air gap if the average flux density is 0.54 Wb/m^2 . The ratio of pole arc to pole pitch is 0.66, the short circuit ratio is 1.2 and gap extension co-efficient is 0.15. The mmf required for the gap is 80% of no load mmf and winding factor is 0.955. 7
- (b) Explain the procedure for tentative design of the field winding of 3-phase hydro generator and show that the height of the field winding is:

$$h_f = \frac{AT_f \times 10^{-4}}{\sqrt{q_f s_f d_f}} \quad . \quad 7$$

where AT_f = field mmf per pole at full load

q_f = permissible loss per m^2 of cooling surface

s_f = copper space factor

d_f = depth of winding. 7

6. (a) Prove from the first principles that for rotating

machine output in volt ampere is $C_o D^2 L_n$. Show fully how and why the output co-efficient C_o changes with size and type of machine, and show that in all designs, it approaches a fixed maximum value. 7

- (b) A 350 kW, 500 V, 600 rpm, 6 pole dc generator is built with armature diameter of 0.87 m and a core length of 0.32 m. The lap wound armature has 660 conductors. Calculate the specific electric and magnetic loading. 7

7. Write short notes on any *three* of the following:

- (a) Hydrogen cooling of electric machines
- (b) Choice of specific magnetic loading
- (c) Short circuit ratio
- (d) Choice of air gap in induction motor design. 5,5,4