This question paper contains 4 printed pages.

3299 *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 3·5×3×1·5 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 W/m^2–°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:

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