This question paper contains 4 printed pages.

8489 *Your Roll No.* .....

B.Tech. (E) / IV **A**

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*) Explain why higher specific electric loading can be used in machines using copper conductors compared to those using aluminium conductors. 5

   (*b*) Prove that for the same I^2R loss and same length of conductor the weight of aluminium used in an electrical machine is approximately 50% of that of copper conductor. Given density of copper is 8900 kg/m^3 and density of aluminium 2700 kg/m^3. 5

   (*c*) What are the desired properties of insulating materials used in electric machines? 4

2. (*a*) During a heat run test of a 100 kVA transformer the temperature rise after one hour and two hours is found to be 24°C and 34°C respectively. Calculate the heating time constant and final steady state temperature rise. If the cooling is

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improved by using an external fan so that the rate of heat dissipation is increased by 18%, find the new kVA rating for the same final temperature rise. Assume that maximum efficiency occurs at 80% of full load and unity p.f. 7

(*b*) Explain the terms continuous duty, short time duty and intermittent periodic duty as applied to electric machines. Sketch the typical load, electric losses and temperature rise *versus* time curves for these ratings to illustrate the answer. 7

3. (*a*) Determine the dimensions of the core and yoke for a 100 kVA, 50 Hz single phase core type transformer. A square core is used with distance between the adjacent limbs equal to 1·6 times the width of the laminations. Assume voltage per turn of 14 volts, maximum flux density 1·1 Wb/m^2, window space factor 0·32, current density 3 A/mm^2. Take stacking factor equal to 0·9. Flux density in the yoke to be 80% of flux density in the core. 7

(*b*) Obtain the expression for leakage reactance of a 1φ core type distribution transformer. 7

4. (*a* The following design data are provided for a 3 phase, 4 pole, 400 V, 50 Hz, 10 kW, delta connected induction motor:

Diameter of stator bore	=15 cm
Length of stator core	=9 cm
Average flux density	=0·45 Tesla

Efficiency =84%
Power factor =0·86
Current density =5 A/mm^2
Stator slots =36
Rotor slots =30
Length of rotor bar =15 cm.
Mean dia. of end ring =12 cm.

Calculate:

(*i*) no load maximum flux

(*ii*) length of air gap

(*iii*) number of stator turns per phase

(*iv*) rotor bar current and area

(*v*) end ring current and area

(*vi*) Losses in bars and end rings. 8

(*b*) Discuss the factors that determine the choice of airgap in induction motor. 6

5. (*a*) Give important considerations for the choice of types of slots for stator winding of synchronous machine. 5

(*b*) Give reasons why turbo-alternator has smaller diameter and larger length whereas a waterwheel generator has larger diameter and smaller length. 5

(*c*) Prove with usual notations that the kVA rating of synchronous generator is given by

$$1{\cdot}11 K_w B_{av} ac \, L \frac{V_a^2}{n_s} \times 10^{-3}.$$ 4

5. (*a*) Explain the procedure for tentative design of the field winding of 3-phase hydrogenerator and derive the expression for the height of field winding. 7

(*b*) A 15 HP, 400 V, 1430 rpm, 3 phase induction motor with an efficiency of 80% and p.f. of 81% has inner dia of stator 30 cm and length 12 cm. Estimate the length and diameter of 50 HP, 406 V, 4 pole, 50 Hz, 3ϕ induction motor to be designed for 84% efficiency and 85% p.f. Assume same specific loading as in previous motor. 7

7 (*a*) Derive the expression for o/p equation of dc machine in terms of its volume. Also discuss the effect of specific loading and speed on size of the machine. 8

(*b*) Show that gross core area of 3-stepped transformer core is approximately 85% of the area of circumscribing circle. 6

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

(*a*) Harmonic induction torque and harmonic synchronous torque in an induction motor.

(*b*) Effect of SCR on the performance of synchronous machine.

(*c*) Methods of reducing armature reaction in dc machines.

(*d*) Estimation of motor rating for variable drives.

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