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10EE63

Sixth Semester B.E. Degree Examination, Dec.2017/Jan.2018

Electrical Machine Design

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. ***Missing data if any assume suitably.***

PART – A

1 a. Explain the factors those limit the design of electrical machines. **(08 Marks)**

b. Classify the insulating materials used in electrical machines based on thermal considerations. **(07 Marks)**

c. Derive the output equation of a DC machine with usual notations. **(05 Marks)**

2 a. List the advantages and disadvantages of higher number of poles in DC machines. Hence write the guiding factors for the choice of number of poles. **(08 Marks)**

b. Discuss the factors to be considered while fixing the dimensions of armature slots in a DC machine. **(05 Marks)**

c. A 350 KW, 500 V, 450 rpm, 6 pole DC generator is built with an armature diameter of 0.87 m and core length of 0.32 m. The lap wound armature has 660 conductors. Calculate the specific electric and magnetic loadings. **(07 Marks)**

3 a. Develop the output equation for a three phase core type transformer. **(05 Marks)**

b. Calculate the KVA output of a single phase transformer from the following data:

$$\frac{\text{core height}}{\text{distance between core centres}} = 2.8$$

$$\frac{\text{diameter of circumscribing circle}}{\text{distance between core centres}} = 0.56$$

$$\frac{\text{net iron area}}{\text{area of circumscribing circle}} = 0.7$$

Current density = 2.3 A/mm^2, window space factor = 0.27, frequency = 50 Hz, flux density in the core = 1.2 Wb/m^2, distance between core centres = 0.4 m. **(07 Marks)**

c. A single phase, 400 V, 50 Hz transformer is built with stampings having a relative permeability of 1000. The length of flux path is 2.5 m, the area of cross section of the core is 2.5×10^{-3} m^2 and the primary winding has 800 turns. Estimate the maximum value of flux and no load current of transformer. The iron loss at the working flux density is 2.6 W/kg, iron weights 7.8×10^3 kg/m^3. Stacking factor is 0.9. **(08 Marks)**

4 a. Estimate the main dimensions, turns per phase of primary and secondary winding, primary and secondary conductor cross section of a 3 phase, Δ-Y core type transformer rated at 300 KVA, 6600/400 V 50 Hz. 3-stepped core have circumscribing circle diameter of 0.25 m and a leg spacing of 0.4 m. Given emp/turn = 8.5 V; δ = 2.5 A/mm^2; window space factor = 0.28; iron stacking factor = 0.9.

$$\text{Ratio} = \frac{\text{Gross core area}}{\text{Area of circumscribing circle}} = 0.84 \quad \text{for a 3 stepped core.}$$ **(10 Marks)**

b. The full load efficiency of a 300 KVA transformer is 98.2% at unity power factor. Design the number of cooling tubes necessary, if the temperature rise is 35°C. The tank area may be assumed as 4.92 m^2. Assume tube diameter as 5 cm and average length as 105 cm. Heat dissipation may be assumed as 12.5 $W/m^2/C°$. **(10 Marks)**

PART – B

5 a. Explain the factors affecting the choice of specific loadings in induction motors. **(08 Marks)**

b. Estimate the stator core dimensions, number of stator slots and number of stator conductors per slot for a 100 KW, 3300 V, 50 Hz, 12 pole star connected slip ring induction motor assume:
Average gap density = 0.4 Wb/m^2
Ampere conductors per meter = 25000 A/m
Efficiency = 0.9
Power factor = 0.9
Winding factor = 0.96
Choose main dimensions to give best power factor. The slot loading should not exceed 500 A. **(12 Marks)**

6 a. Explain Crawling and Cogging of induction motor. **(10 Marks)**

b. A 90 KW, 500 V, 50 Hz, 3 phase, 8 pole induction motor has a star connected stator winding accommodated in 63 slots with 6 conductors per slot. If the slip ring voltage on open circuit is to be about 400 V. Design a suitable rotor winding with the following details:
i) Number of rotor slots if $q_r = 3$ (slots/pole/phase)
ii) Number of conductors/rotor slot
iii) Coil span
iv) Slip ring voltage on open circuit if rotor is Y connected
v) Approximate full load current per phase in rotor
Assume efficiency = 0.9 and power factor = 0.86. **(10 Marks)**

7 a. From first principles derive the output equation of a synchronous machine. **(05 Marks)**

b. Describe the various factors to be considered while selecting the number of slots in the armature of a 3-phase synchronous machine. **(07 Marks)**

c. Find the main dimensions of 100 MVA, 11 KV, 50 Hz, 1500 rpm, 3 phase water wheel generator. The average gap density is 0.65 Wb/m^2 and ampere conductors/m are 40000. The peripheral speed should not exceed 65 m/sec, at normal running speed, in order to limit the runaway speed. Suggest type of pole construction used. Given $\frac{L}{\psi} = 0.65$ for circular pole and $\frac{L}{\psi} = 4$ for rectangular pole. **(08 Marks)**

8 a. For a 250 KVA, 1100 V, 12 pole, 500 rpm, 3 phase alternator. Determine air gap diameter, core length, number of stator conductors, number of stator slots and cross section of stator conductors. Assume average gap density as 0.6 Wb/m^2 and specific electric loading as 30000 A/m $\frac{L}{\psi} = 1.5$, stator winding factor = 0.955 and stator slots/pole/phase = 3, current density $\delta_s = 3.5$ A/mm^2. **(10 Marks)**

b. Define short circuit ratio and explain the factors affecting SCR in a synchronous generator. **(10 Marks)**

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