USN | | | | | | | | | | 10EE63

Sixth Semester B.E. Degree Examination, June/July 2016
Electrical Machine Design

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer FIVE full questions, selecting at least TWO questions from each part.*
2. *Design data manual may be used, if necessary.*

PART – A

1 a. Define 'Specific Magnetic loading' and 'Specific electric loading'. What are advantages and disadvantages of using higher specific loadings? **(10 Marks)**

b. What are desirable properties of insulating materials? Explain classification of insulating materials based on maximum temperature rise mentioning at least 2 examples in each. **(10 Marks)**

2 a. With usual notations, derive output equation for a d.c. machine. **(06 Marks)**

b. A 5 KW, 250 V, 4 pole, 1500 rpm shunt generator is designed to have a square pole face. The specific loadings are – average flux density in the gap = 0.42 Wb/m^2; Ampere conductors per meter length of armature periphery = 15000 Amp.cond/m; Full load efficiency = 87%; Ratio of pole arc to pole pitch = 0.66. Calculate the main dimensions of the machine. **(06 Marks)**

c. During the design of a 1000 KW, 500 V, 10 pole, 300 rpm compound generator, the following data have been obtained. External diameter of armature = 1.4 m. Gross core length = 0.35 m. Flux per pole = 0.105 Wb. Based on above design data, calculate the following details referring to design of field system:
i) Axial length of the pole ii) Width of the pole iii) Height of the pole
iv) Pole arc.
Permissible loss per cooling surface may be assumed as 700 watts/m^2; Assume leakage coefficient for the pole $K_l = 1.2$; Flux density in the pole = 1.6 Tesla; Iron factor $K_i = 0.95$; Voltage drop as 2% of terminal voltage; $AT_f = 1.2\ AT_a$; Copper space factor = 0.6 and depth of field winding as 0.05 mt. Thickness of pole shoe = 4 cm. Ratio of pole arc to pole pitch = 0.68. Axial length of pole 1 cm less than gross length of armature. Winding is lap connected. **(08 Marks)**

3 a. Derive the output equation for a 3 phase transformer. **(10 Marks)**

b. Calculate dimensions of the core, number of turns and area of cross section of the conductors for the primary and secondary windings of a 125 KVA, 6600 V/460 V, 50 Hz single phase core type distribution transformer. The data are B_m in core = 1.2 Wb/m^2 and current density $\delta = 250\ \text{A/cm}^2$. Assume cruciform (or stepped core) for the assembled core allowing 8% for the insultation between laminations. Take yoke cross section 15% higher than the core. Net cross section of copper = 0.225 times net cross section of iron in the core and window space factor $K_W = 0.3$. Assume ratio of height of window to width of window = 2. Draw a neat sketch of core indicating the dimensions. **(10 Marks)**

4 a. Derive the equation for calculation of no load current of single phase transformer. **(08 Marks)**

b. A single phase 400 V, 50 Hz, transformer is built from core stampings having a relative permeability of 1000. The length of the flux path is 2.5 m. The gross area of cross section of the core is $2.5 \times 10^{-3}\,m^2$ and the primary winding has 800 turns. Calculate the maximum flux and the no load current of transformer. The iron loss at the maximum flux density is 2.6 W/kg. Iron weighs 7.8×10^3 kg/m^3 and stacking factor is 0.9. **(07 Marks)**

c. A 300 KVA, 6600 V/ 400 V, 50 Hz delta-star, 3 phase, core type transformer has the following data:
Width of HV winding = 25 mm; Width of LV winding = 16 mm; Height of coils 0.5 m; Length of mean turn = 0.9 m; hv winding turns = 830. Width of duct between hv and lv winding = 15 mm.
Calculate the leakage reactance of the transformer referred to the hv side. **(05 Marks)**

PART – B

5 a. With usual notations, derive output equation for a 3 phase induction motor. **(10 Marks)**

b. Calculate the following design information for a 30 kW, 440 V, 3 phase, 6 pole, 50 Hz, delta connected squirrel cage induction motor. (i) Main dimensions (ii) Number of stator slots. (iii) Number of turns/phase in stator winding (iv) Number of conductors per slot.
The available data are:
Specific magnetic loading = 0.48 Tesla; Specific Electric loading = 26000 Amp Conductors/m; Full load efficiency = 88%; Full load power factor = 0.86; Winding factor K_{WS} = 0.955; No. of slots / pole / phase = 3. **(10 Marks)**

6 a. What are factors to be considered for estimating the length of air gap for induction motors? Explain these factors. **(10 Marks)**

b. A 15 kW, 3 phase, 6 pole, 50 Hz, squirrel cage induction motor has the following data:
Stator bore diameter = 0.32 m; Axial length of stator core = 0.125 m; Number of stator slots = 54; Number of conductors per stator slot = 24; Current in each conductor = 17.5 A; Full load power factor = 0.85 lag. Design for a suitable cage rotor, number of rotor slots, Section of each bar and section of each end ring. The full load speed is about 950 rpm approximately. Use copper for rotor bars and the end rings. Resistivity of copper is 0.02 Ω mm^2/m. Assume current density in rotor bars and end rings 7 A/mm^2. **(10 Marks)**

7 a. Explain the factors that influence the selection of "Specific magnetic loading" and "Specific electric loading" for synchronous machines. **(10 Marks)**

b. Calculate the main dimensions of a 1000 KVA, 50 Hz, 3 phase, 375 rpm alternator. The average air gap flux density is 0.55 Wb/m^2; Ampere conductors/meter are 28,000. Assume ratio of core length to pole pitch = 2 and winding factor = 0.955. Permitted maximum peripheral speed is 50 m/s. **(10 Marks)**

8 a. Define "Short Circuit Ratio" (SCR) for a synchronous generator. Explain effects of SCR on synchronous machine performance. **(10 Marks)**

b. A 500 KVA, 3.3 KV, 50 Hz, 600 rpm, 3 phase salient pole alternator has 180 turns / phase. Calculate the length of the air gap, if the average flux density is 0.54 Wb/m^2; ratio of pole arc to pole pitch 0.66; SCR is 1.2 ; the gap contraction factor is 1.15 and winding factor is 0.955. The mmf required for air gap is 80% of no load field mmf. **(10 Marks)**

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