2002 SCHEME EE62

Sixth Semester B.E. Degree Examination, June-July 2009
Electrical Machine Design

3 hrs. Max. Marks:100

Note: 1. *Answer any FIVE full questions.*
2. *Missing data may be assumed suitably.*
3. *Use of design data hand book is permitted.*

a. Explain clearly the factors, which impose limitations in the design of electrical machines. (06 Marks)

b. Classify the insulating materials used in electrical machines based on thermal considerations. Give examples under each classification. (08 Marks)

c. Explain briefly the factors that help in selecting the specific loadings for a dc machine design. (06 Marks)

a. Explain the various factors that affect the choice of number of poles of a dc machine. (10 Marks)

b. Determine the main dimensions, number of poles and the length of air-gap of a 600 kW, 500 V, 900 rpm dc generator. The average gap density is 0.6 wb/m^2 and ac per metre is 35000. The ratio of pole arc to pole pitch is 0.75 and the efficiency is 91%. Assume square pole face. Use the following design constraints for check: peripheral speed $\leq$ 40 m/s, frequency of flux reversals $\leq$ 50 Hz, current per brush arm $\leq$ 400 A and armature mmf per pole $\leq$ 7600 A. The mmf required for air-gap is 50% of armature mmf and gap contraction factor is 1.15. (10 Marks)

a. A 250 kW, 500 V, 600 rpm DC generator is built with an armature diameter of 0.75 m and a core length of 0.3 m. The lap-connected armature has 720 conductors. Using the data obtained from this machine, determine the armature diameter, core length, number of armature slots, armature conductors and commutator segments for a 350 kW, 440 V, 720 rpm, 6-pole dc generator. Assume a square pole face with ratio of pole arc to pole pitch = 0.66, F.L. efficiency = 0.91 and the internal voltage drop is 4% of rated voltage. Diameter of commutator is 0.7 times that of armature diameter, the pitch of commutator segments $\leq$ 4 mm, voltage between adjacent segments $\geq$ 15V at no-load. (10 Marks)

b. A 50 HP, 4-pole, 480 V, 600 rpm shunt motor has a wave wound armature with 770 conductors. The leakage factor for the poles is 1.2. The poles are to be of circular in cross-section, the field coils are 70 mm thick and produce an mmf of 10000 A per pole. The flux density in the poles is 1.5 wb/m^2. Calculate i) diameter of pole ii) diameter of field wire iii) length of field coil iv) turns per pole and v) field current. Keep 20% of voltage applied to shunt field coil in reserve for speed control. Assume that the thickness of insulation over wires is 0.125 mm, permissible loss is 1600 w/m^2 of external cylindrical surface. Resistivity of copper is 0.02 Ω/m and mm^2. (10 Marks)

a. Derive the output equation of three-phase core type transformer and hence deduce the expression of output-emf per turn. (10 Marks)

b. The window in the core of a 2200/440 V, 50 KVA, 50 Hz, single-phase core type transformer has a gross available area of 340 cm^2. Window space factor K_w = 0.35. Given the max core density of 1.0 Tesla, current density = 2.1 A/mm^2. Estimate i) the sectional area of iron in the limb ii) the diameter of circumscribing circle round the square core section iii) dimensions of the window, if the distance between the centers of the square core is twice the width of the core iv) Number of primary and secondary turns v) conductor cross-section for primary and secondary windings. (10 Marks)

5 a. A 15000 KVA, 33/6.6 KV, 3-ph star/delta, core type transformer has the following data: Net iron area of each limb = 0.15 m^2; Net area of Ydec = 0.18 m^2; Mean length of flux path in each limb = 2.3 m; Mean length of flux path in each yoke = 1.6 m; Number of turns in HV wdg = 450; Density of iron = 7.8×10^3 kg/m^3. Calculate no-load current. Make use of the following table: **(10 Marks)**

B_{max} Tesla	0.9	1.0	1.2	1.3	1.4
MMF A/m	130	210	420	660	1300
Iron loss W/kg	0.8	1.3	1.9	2.4	2.9

b. A 250 KVA, 6600/400 V, 3ph, core type transformer has a total loss of 4800 W at full load. The transformer tank is 1.25 m in height and 1 m × 0.5 m in plan. Design a suitable scheme for tubes if the average temperature rise is to be limited to 35°C. The diameter of tubes is 50 mm and are spaced 75 mm apart. The average height of tubes is 1.05 m. Specific heat dissipation due to radiation and convection is respectively 6 and 6.5 $W/m^2/°C$. Assume that convection is improved by 35% due to provision of tubes. **(10 Marks)**

6 a. Derive the output equation of a three-phase induction motor and explain the factors, which influence the choice of specific magnetic and electric loadings. **(10 Marks)**

b. A 15 KW, 440 V, 4-pole, 50 Hz, 3-phase induction motor is built with a stator bore 0.25 m and a core length of 0.16. The specific electric loading is 23000 amp conductors/metre. Using the data of this machine, determine the core dimensions, number of stator slots and number of stator conductors for a 11 KW, 460 V, 6-pole, 50 Hz, induction motor. Assume a full load efficiency of 84% and P.F. of 0.82 for each machine. Winding factor is 0.955. **(10 Marks)**

7 a. Derive an expression for the equivalent resistance of rotor of a squirrel cage induction motor referred to stator/ph. **(10 Marks)**

b. During the design of stator punching of ¼ HP, 110 V, 4-pole, 1725 rpm, 60 Hz, split phase induction motor, following information have been obtained:
Gross length of stator core, L = 5 cm
Inner diameter of stator punching, D_i = 9 cm
Outer diameter of stator punching, D_o = 15 cm
Width of the rectangular teeth, bt_1 = 0.35 cm
Height of stator teeth, Ht_1 = 1.71 cm
Using the above information, design a suitable main winding for the stator giving its following details : i) Number of stator slots ii) Winding factor iii) Flux per pole iv) Number of turns v) Turns in various coils and vi) Conductor size. **(10 Marks)**

8 a. What is SCR of a synchronous machine? Establish its relationship with the direct axis synchronous reactance of the machine. Discuss the influence of variation in SCR on the performance of synchronous machine. **(08 Marks)**

b. A 1250 KVA, 3-ph, 50 Hz, 3300 V, star connected, 300 rpm alternator of salient pole type has the following design data:
Stator bore = 1.9 m; Stator core length = 0.335 m; Pole arc / pole pitch = 0.66; Turns per phase = 150; Single layer concentric winding with 5 conductors/slot, SCR = 1.2. Assume that the distribution of gap flux is rectangular under the pole arc with zero values in the interpolar region. Calculate i) Specific magnetic loading ii) Armature mmf per pole iii) Gap density over pole arc iv) Air-gap length. MMF required for air gap is 0.88 times that of no-load field mmf and the gap contraction factor is 1.15. **(12 Marks)**

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