USN

10EE63

Sixth Semester B.E. Degree Examination, June/July 2014

Electrical Machine Design

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer FIVE full questions, selecting at least TWO questions from each part.*
2. *Use of design data handbook is permitted.*

PART – A

1 a. List the desirable properties of insulating materials. Give the classification of insulating materials based on thermal considerations with examples of materials used in each class. **(10 Marks)**

b. A design is required for a 50 KW, 4 pole, 600 rpm D.C. shunt generator, the full load terminal voltage being 220 V. If the maximum gap density is 0.83 wb/mt^2 and the armature ampere conductors per metre are 30,000, calculate suitable dimensions of armature core. Assume that the full load armature voltage drop is 3 percent of the rated terminal voltage and that the field current is 1 percent of rated full load current. Ratio of pole arc to pole pitch is 0.67. **(10 Marks)**

2 a. Discuss the factors that should be given due considerations while selecting number of poles for DC machine. **(06 Marks)**

b. Define specific loadings and mention the advantages of choice of higher values of specific loadings in the design of any machine. **(04 Marks)**

c. During the design of armature of a 1000 KW, 500 V, 10 pole, 300 rpm DC compound generator, following information has been obtained:

External diameter of armature, 1.4 m
Gross core length, 0.35 m
Flux per pole 0.105 wb.

Based on the above design information, find out the following details regarding the design of field system:

i) Axial length of the pole ii) Width of the pole iii) Height of the pole

Permissible loss per square meter of the cooling surface may be assumed as 700 W/mt^2. Assume leakage factor of the pole k_f = 1.2, flux density in the pole B_p = 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 S_f = 0.6 and depth of the winding as 0.05 mt and thickness of pole shoe = 4 cm. **(10 Marks)**

3 a. Derive the output equation of a 3-ϕ core type transformer. **(06 Marks)**

b. Derive an expression for the no load current of a 3 phase transformer. **(04 Marks)**

c. Calculate: i) net cross section of core, ii) gross area of the core, iii) core dimensions, iv) window area, v) dimensions of the window, for a 200 KVA, 6600/250 V, 50 Hz, single phase, shell type, oil immersed, self cooled, distribution transformer based on the following design parameters:

Window space factor, K_w = 0.28 Maximum flux density in core, B_m = 1.1 Tesla
Average current density, δ = 2.2 A/mm^2 Stacking factor = 0.9
Window proportion = 2.5 : 1 Rectangular core proportion = 1.8 : 1

Net cross section of copper in the window is 0.2 time the net cross section of iron in the core. **(10 Marks)**

4 a. Obtain an expression for the leakage reactance of a transformer with primary and secondary coils of equal length. **(08 Marks)**

b. A 300 KVA, 11000/440 V, 50 Hz, 3 phase, delta/star, core type oil immersed, self cooled transformer gave the following results during the design calculations of magnetic frame and windings.

Centre to centre distance between the cores = 36 cm
Height of the window = 44 cm
Height of the yoke = 17 cm
Total weight of the magnetic frame = 700 kg
Average specific iron loss = 2.1 W/kg
Outer dia of HV winding = 35 cm
Resistance of LV winding per phase = 0.0047 Ω
Resistance of HV winding per phase = 9.74 Ω

Based on the above design data, calculate the following:

i) The dimensions of the tank with clearance; $\Delta L = 8$ cm; $\Delta W = 10$ cm; $\Delta H = 45$ cm.
ii) The temperature rise of the transformer with plain tank.
iii) Number of cooling tubes, if the temperature rise not to exceed 35°C. Assuming diameter of cooling tube as 5 cm and length of cooling tube = 95 cm. **(12 Marks)**

PART – B

5 a. Discuss the various factors considered when estimating length of air gap of a 3-phase induction motor. Give the expressions used in calculations of length of air gap. **(10 Marks)**

b. Calculate the following design information for a 30 KW, 440 V, 3-phase, 6 pole, 50 Hz delta connected, sq. cage induction motor.

i) Main dimensions of stator frame
ii) No. of turns per phase in state winding
iii) No. of stator slots
iv) No. of conductors per slot.

The various data required for the design calculations are:

Specific magnetic loading, $B_{av} = 0.48$ Tesla
Specific electric loading, $q = 26000$ AC/mt
Full load efficiency, $y = 0.88$
Full load p.f. $\cos\phi = 0.86$
Winding factor, $K_w = 0.955$
Slots per pole per phase = 3 **(10 Marks)**

6 a. What is meant by the terms 'crawling' and 'cogging' in case of 3 phase induction motors? What steps would you take in the design procedure, so as to minimize these tendencies? **(08 Marks)**

b. During the design of a 3-phase, 5 KW, 400 V, 50 Hz, 4 pole squirrel cage induction motor designed for star-delta starting, following data have been obtained.
Rotor diameter = 0.14 m, Core length = 0.11 m, Turns per phase on stator = 360, Air gap length = 0.45 mm, Coater's gap contraction coefficient = 1.25.
Assuming that the ampere turns required for the iron parts are about 32% of that needed for the gap, calculate the magnetizing current drawn by the motor and comment, upon its value. Assume, winding factor, $K_w = 0.955$, efficiency = 85% and p.f. = 0.85. **(12 Marks)**

7 a. Explain the term 'short-circuit ratio' as applied in synchronous machines. How does the value of short circuit ratio affects the design of alternators? **(06 Marks)**

b. Derive the output equation of a synchronous machine. **(08 Marks)**

c. Calculate the stator core dimensions for a 10 MVA, 11 KV, 50 Hz, 3 phase, 2 pole turbo alternator, based on the following information:
Specific magnetic loading $B_{av} = 0.63$ Tesla
Specific electric loading q = 48,000 amp.cond./mt
Limiting peripheral speed, $\nu = 120$ m/sec
Length of air gap = $\ell_g = 2.0$ cm
Stator wdg. Factor, $K_w = 0.955$ **(06 Marks)**

8 a. It is advisable to have field system rotating and armature stationary for large synchronous machines. Justify the above statement. **(06 Marks)**

b. Enumerate the advantages and disadvantages of providing a large airgap in synchronous machines. **(06 Marks)**

c. A 500 KVA, 33 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/mt^2. The ratio of pole arc to pole pitch, 0.65. the short circuit ratio, 1.2, the gap contraction factor 1.15, and the winding factor, 0.955. The mmf required for gap is 80% of no load field mmf and the winding factor 0.955. **(08 Marks)**

* * * * *