B.E. Electrical (Electronics & Power) Engineering (Model Curriculum) Semester-V

TE101A - Electrical Machine Design

P. Pages : 2 **GUG/W/23/13861**

Time : Three Hours * 7 4 4 8 * Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Illustrate your answers wherever necessary with the help of neat sketches.
5. Use of slide rule, Logarithmic tables, Steam tables, Mollier's chart, Drawing instruments, Thermodynamic tables for moist air, Psychrometric charts and Refrigeration charts is permitted.
6. Use of non-programmable calculator is permitted.
7. Solve question as per internal choice.

1. a) What are the fundamental requirement of insulating materials? Classify the insulating materials according to temperature withstanding capacity. **8**

b) A 400 kVA, 11kV/400V, $3-\varphi$ transformer working in an ambient temperature on switching the FL, its of temperature is recorded as follows. **8**
59ºC after 1.5 Hrs.
71ºC after 3 Hrs.
It's full load copper loss is twice the iron loss. Calculate its heating time constant, Final temperature rise, one hour rating and half hour rating.

OR

2. a) Define overload ratio & mechanical overload ratio. Derive the relation between them. **8**

b) Measurement made from a temperature rise time curve of a transformer, in which the loss dissipated is constant. The rate of change of temperature rise is 0.375ºC per minute and 0.022ºC per minute when the temperature rise is 29ºC and 46.7ºC respectively. Find the final steady temperature rise & the heating time constant of the transformer. **8**

3. a) Derive the output equation of $3-\varphi$ transformer. **8**

b) What is the need of stepped core in transformer? Derive the equation for two stepped core. **8**

OR

4. a) Calculate the dimension of the core, the number of turns & the cross section of the conductor for a 100 kVA, 2300/400V, 50Hz, $1-\varphi$ Shell type transformer. Assuming $B_m = 1.1 wb/m^2$, currently density is $2.3 A/mm^2$, kw = 0.3, ratio of depth of stacked core to width of the control limb is 2.8, ratio of $(H_W/W_W) = 2.5$ stacking factor. Assume ratio of flux to secondary mmf at full load is 480×10^{-8}. **8**

b) Calculate the core and window area of a 400 kVA, 50Hz, $1-\varphi$ core type transformer. The weight of the copper = 4 kg, ratio of length of mean turn of a copper to length of mean flux path = 0.5, maximum flux density = $1.5 Wb/m^2$. Current density = $2.2 A/mm^2$. Density of copper is $8.9 \times 10 kg/m^3$. Density of iron is $7.8 \times 10 kg/m^3$. Copper space factor is 0.12. **8**

5. a) State the assumptions made in the calculations of leakage reactance of core type transformer. **6**

b) A 300 kVA, 6.6kV/0.4kV, 50Hz, $\Delta / y, 3\varphi$ core type x'mer has the following data: **10**

Width of HV winding = 2.5 mm, width of LV winding = 16 mm, Height of coils = 0.5m, length of mean turn = 0.9 m, HV winding turns = 830, width of duct between HV & LV windings = 15 mm.

i) Calculate the leakage reactance of the transformer referred to the HV side.

ii) If LV winding is split up into two parts with one part on each side of the HV coil, calculate the leakage reactance referred to the HV side. Assume that there is duct of 15 mm wide between HV winding and each part of the LV winding.

OR

6. a) Explain different mechanical forces acts on the transformer. **8**

b) A 200 kVA, 11000/230V, 50Hz, $1-\varphi$ core type transformer has the following data: **8**

EMF induced per turn = 18 V, Depth of LV winding and HV winding is 35 mm & 25 mm respectively width of duct = 15 mm, length of coil = 0.5 m, length of mean turn of coil winding = 1.5 m, equivalent resistance as referred to the HV side = 1Ω Calculate, p.u. regulation at 0.8 p.f. lag & at full load.

7. a) Discuss briefly about the various stator slots used in induction motor. **8**

b) In the design of 30 HP, $3-\varphi$, 400V, 960 rpm, 50Hz, delta connected induction motor, **8**

Assume the specific magnetic loading of 0.46 Wb/m. Specific electric loading of 25,000 AT/m. Full load efficiency of 86%, p.f. = 0.87. Estimate the following.

i) Stator core dimensions

ii) Number of stator slots & winding turns.

OR

8. Following design data are provided for, 4 pole, 400V, delta connected 10kw, squirrel cage induction motor: $3-\varphi$. **16**

Stator bore diameter = 15cm, Axial length of stator = 9cm, No. of stator slots stator current / Phase = 11.5 Amp. Current density in bar and end rings are $5A/mm^2$ & $6A/mm^2$ respectively length of bar = 14 cm, Use copper for rotor bars & end rings $2.1\times10^{-8}\Omega m$. Design suitable cage rotor giving bars & end ring dimensions. Also determine rotor speed.

9. a) Find the main dimension of 2500 kVA, 187 rpm 50Hz, $3-\varphi$, 3kV, salient pole synchronous generator. The generator is to be a vertical water wheel type. The specific magnetic loading is $0.6\,wb/m^2$ & specific electric loading is 34000 At/m. Use circular poles with ratio of core length to pole pitch is 0.65. Specify the type of pole construction used if the runaway speed is about twice the peripheral speed. **8**

b) Define short circuit ratio. What is the effect of SCR on the performance of synchronous machine? **8**

OR

10. a) Write a short note on different methods for elimination of harmonics from the generated voltage in synchronous generator. **8**

b) Determine the main dimensions of 12 MVA, 13.8 kV, 50Hz, 1500 rpm, 3-Phase, Y connected alternator. The following particulars are provided, **8**

Average gap density = $0.60\,wb/m^2$

Ampere conductor / meter = 42000

Peripheral speed = 80m / sec.

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