TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

DEGREE OF BACHELOR OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE2508: ELECTRICAL MACHINES DESIGN **PAPER 2**

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

DATE: SEPTEMBER 2018

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 30 marks)

(a) A totally enclosed 3 phase induction motor has a temperature rise of 20^0C after 30 minutes of operation and 35^0C after 60 minutes while operating on full load.

(i) Determine the temperature rise of the machine after 2 hours on full load.

(ii) If a fan is fitted which cools the external surface of the machine resulting in the final steady temperature rise of 80% of the original value, determine the temperature rise from cold after one hour operation on full load. **8Marks**

(b) (i) Explain the technical reasons why slow speed alternators have very large diameters.

(ii) Two alternators of similar rating are lying in a machine shop. One of them is a salient pole alternator and another is a cylindrical rotor type. How will you distinguish them?

4Marks

(c) (i) Explain what is specific magnetic loading and specific electric loading?

(ii) Explain why synthetic insulating materials are fast replacing natural materials in insulating electrical machines. **5Marks**

(d) A 500kVA 3 phase 415 volts 1490rpm 50Hz generator of 95% efficiency and power factor of 0.85 is designed to operate in a 27^0C ambient temperature and atmospheric pressure of 747mm barometric. For the generator to operate well, the cooling air outlet temperature must be kept at 38^0C.

(i) Find the quantity of air in m^3/sec that should be circulated for cooling.
(ii) Design a cooling fan assuming a fan efficiency of 32.5% and pressure of 975N/m^2? 10 Marks

(e) List the main advantages of using silicon steel in the design of the magnetic circuit of electrical rotating machines. Also state preferred percentages of silicon. **3Marks**

Question TWO

(a) Insulating materials are very important in electrical machines design; explain the qualities required for good performance. **6Marks**

b) Briefly explain how magnetostriction vibration in transformers can be eradicated in redesign of this machine? **3Marks**

c) (i) Find the amount of cooling air required per minute when the inlet temperature of a 3 phase 11kV, 240kVA alternator working at full load inlet cooling temperature is 26.5^0C. The efficiency of the alternator is 92% and its power factor is 0.81 lagging. The temperature of the air at the outlet is 62.5^0C. Use standard specific heat and weight of air. **6Marks**

(ii) What are the causes of poor regulation in an alternator and what is the possible remedy **2Marks**

d) Briefly discuss three types of cooling methods that are used in electrical machines. **3Marks**

Question THREE

a) The design of two motors is required: one is to be used in an oil refinery, the other is to be used mounted horizontally running a cooling tower fan on a warehouse roof.
Explain the type of enclosure suitable for each situation and their cooling methods. **4Marks**

b) A three phase induction motor is overheating after a rewinding process and cannot carry the original load. State the possible reasons and the remedy. **4Marks**

c) (i) Find the main dimensions of D and L of a 3 phase induction motor 20hp, 415volts, 50Hz, 4 poles with efficiency of 96% and a power factor of 0.82 and magnetic loading of 0.53Wb/m^2 and

specific electric loading of 34500ac/m. Assume the length of the core is equal to the pole pitch and winding factor is 0.97.

(ii) Explain the terms continuous rating and intermittent rating as used in machine design and give two practical applications of each. **12Marks**

Question FOUR

a) After design of a 450kW 3phase 415 volts 50Hz a.c machine had a total weight of iron of 1.15 metric tons and total weight of copper as 870 kilograms. If the core losses are 8.25watts per kilogram and the copper losses are 22.5 watts per kilogram while the stray losses are 11.5% of the copper losses, calculate; Use 1 metric ton is equivalent to 1000kgs

(i) The volume of air in cubic meters per second required to cool the alternator if the temperature is to be maintained at 45^0C. Take air inlet temperature as 26^0C and the atmospheric pressure as 770mm. **8Marks**

(ii) If oil of CP = 0.54 is used as a cooling medium, calculate the amount of oil in litres per hour required to cool the machine. The oil temperature difference between the inlet and outlet is 9.6^0C and the pressure is 865N/m2. **3Marks**

(iii) Find the efficiency of the machine **2marks**

b) Briefly explain the advantage of using hydrogen as a coolant compared to air in large synchronous machines **3Marks**

c) Explain the key factors that limit the temperature of electrical machines and to what limit, stating examples **4Marks**

Question FIVE

a) Applying Kelvin's law, that is $\frac{P_1 v_1}{T_1} = \frac{P_2 V_2}{T_2}$ derive the cooling equation for volume of air and gas for cooling electrical machines **8Marks**

(i) What are the basic materials used in electrical machines design? **2Marks**

a) Explain the meaning of loss of life ratio as used in electrical machine design. **2Marks**

(ii) A 3 phase 25kW 415volts 50Hz AC induction motor with class E insulation is used to run a cooling tower fan in a fluctuating temperature environment. The machine operates 24hours daily and the temperature varies at 105^0C for 18 hrs and 125^0C for 6 hrs. Evaluate the loss of life ratio and the ultimate life span of the motor. **8Marks**