MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 412 POWER SYSTEMS III

DATE: 9/11/2020 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (COMPULSORY) (30 MARKS)

a) A 3-phase overhead transmission line has a series impendence of (10 +j30) Ω per phase. For receiving-end and sending-end voltages of 132 kV and 140 kV respectively,

i) draw the receiving-end power circle diagram, (2 marks)

and determine :

ii) the maximum real power delivered by the line and the load power factor under that condition. (1 mark)

iii) the capacity of shunt compensation equipment for supplying a load of 150MVA at 0.8 p.f lagging and the power angle (i.e angle between V_R and V_S) under that condition. (1 mark)

iv) the capacity of shunt compensation equipment to maintain the above voltage under no-load condition and (1 mark)

v) the unity p.f load that the line can supply with voltages at above values. (1 mark)

b) A thermal power plant has the data shown in Table 1

Table Question 1(b)

Maximum demand	20MW
Boiler efficiency	85%
Coal consumption	0.9Kg/KWh
Load factor	40%
Turbine efficiency	90%
Cost of one tonne of coal	Ksh.300

Determine

i) Thermal efficiency (3 marks)

ii) Coal bill per annum (3 marks)

c) The cost of a two-core feeder cable, including installation is $Ksh(90a + 20)$ per metre and the interest and depreciation charges are 10%. The cable is $2\ km$ in length and cost of energy is $4\ cents$ per unit. The maximum current in the feeder is 250 A and the demand is such that the copper loss is equivalent to what would be produced by the full current flowing for 6 months. If the resistance of a conductor of $1cm^2$ and 1 km length is 0.173Ω, calculate the most economical cross-sectional area.

(6 marks)

d) Name the turbine in:

i) Figure Question 1(d)(i) (2 marks)

ii) Figure Question 1(d)(ii) (2 marks)

iii) Figure Question 1(d)(iii) (2 marks)

e) With the aid of a suitable diagram, describe the principle of operation of Rod Gap Arrester. Also mention its limitations. (6 marks)

QUESTION TWO (20 MARKS)

a) i Sketch a well labeled diagram of a lightning surge, (1 mark)

ii List THREE harmful effects of lightning. (3 marks)

b) With the aid of suitable diagrams, describe the development, initiation, progression and termination of a lightning stroke. (8 marks)

c) An overhead transmission line having a surge impedance 500Ω branches into two lines having a surge impedance of 40Ω and 60Ω respectively. If a traveling wave of vertical

front and magnitude 100kV travels along the overhead line, calculate, immediately after the travelling wave has reached the fork, the magnitude of :

i) voltage in the overhead line (2 marks)

ii) current in the overhead line (2 marks)

iii) voltage in the two branches (2 marks)

iv) current in the two branches (2 marks)

QUESTION THREE (20 MARKS)

a) Sketch diagrams to illustrate the direction of air-blast in relation to the arc for the following types of air-blast circuit breakers:

i) Axial-blast type (2 marks)

ii) Cross-blast type (2 marks)

iii) Radial-blast type (2 marks)

b) Figure Question 3(b) illustrates a form of arc control in an oil circuit breaker. Give its name and describe how it facilitates arc control and extinction. (8 marks)

c) A 50Hz, 11kV, 3-phase alternator with earthed neutral has a reactance of 5 ohms per phase and is connected to a bus-bar through a circuit breaker. The distributed capacitance upto circuit breaker between phase and neutral is 0.01 μF. Calculate:

i) Peak re-striking voltage across the contacts of the breaker (2 marks)

ii) Frequency of oscillations (2 marks)

iii) The average rate of rise of re-striking voltage upto the first peak (2 marks)

QUESTION FOUR (20 MARKS)

a) State ONE advantage and TWO disadvantages of steam power stations. (3 marks)

b) With the help of a schematic diagram, explain the structure of a diesel power station. (7 marks)

c) Discuss the steam power station under the following subheadings

i) Supply of fuel (1 mark)

ii) Availability of water (1 mark)

iii) Transportation facilities (1 mark)

iv) Cost and type of land (1 mark)

v) Nearness to load Centre (1 mark)

d) A diesel engine power plant has one 700 kW and two 500 kW generating units. The fuel consumption is 0.28kg per KWh and the calorific value of fuel oil is 10200kcal per kg. The plant capacity is factor is 40%. Determine the overall efficiency of the plant. (5 marks)

QUESTION FIVE (20 MARKS)

a) An 100 kV, 2μs rectangular surge travels along the line terminated by an inductance of 1 mH. Calculate the voltage across the inductance and reflected voltage wave if the surge impedanace of the line is 500Ω (6 marks)

b) A star-connected, 3-phase, 10 MVA, 6·6 kV alternator is protected by circulating current protection, the star point being earthed via a resistance r. Estimate the value of earthing resistor if 85% of the stator winding is protected against earth faults. Assume an earth fault setting of 20%. Neglect the impedance of the alternator winding. (7 marks)

c) An air-blast circuit breaker is designed to interrupt a transformer magnetizing current of 11 A (r.m.s.) chops the current at an instantaneous value of 7 A. If the values of L and C in the circuit are 35·2 H and 0·0023 μF, find the value of voltage that appears across the contacts of the breaker. Assume that all the inductive energy is transferred to the capacitance.

(7 marks)

Figure Question 1(d)(i)

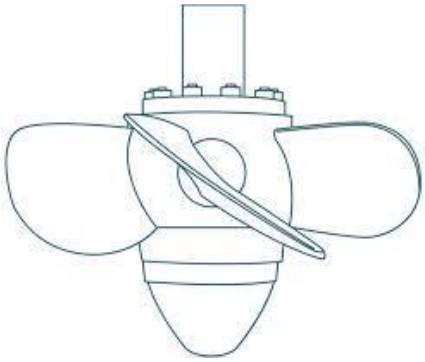

Figure Question 1(d)(ii)

Figure Question 1(d)(iii)

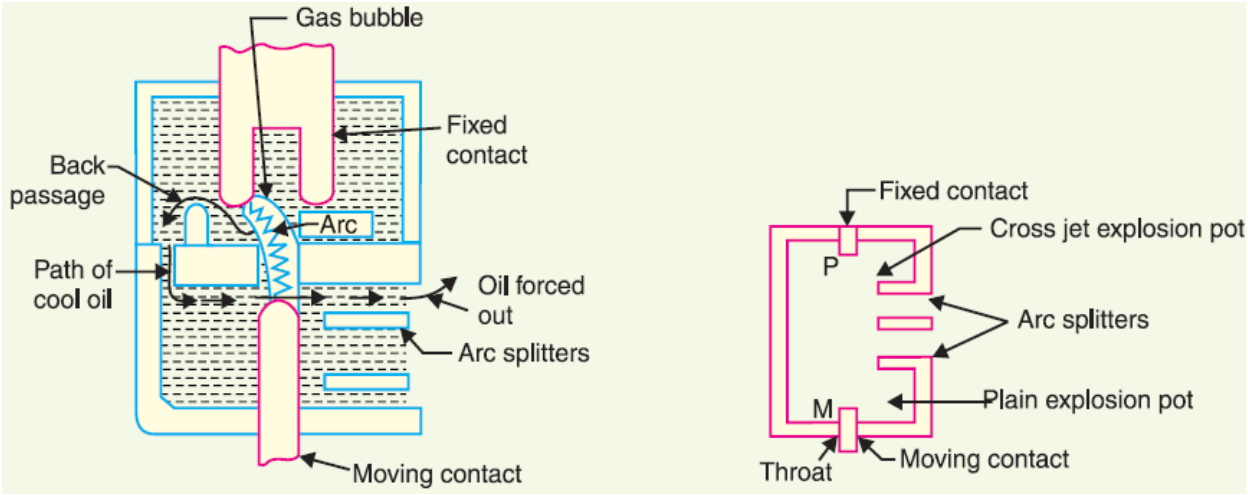

Figure Question 3(b)