The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX6235 Thermal Power Generation**
Academic Year	:	2015/16
Date	:	23rd November 2016
Time	:	1330-1630h
Duration	:	**3 hours**

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any **5 questions** including **only one question from part A.**
4. Use **separate answer books** for part A and B.

PART A

(1) (a) A 480V, 200kVA, 0.8 power factor lagging, 60Hz, two-pole, Y-connected synchronous generator has a synchronous reactance of 0.25Ω and an armature resistance of 0.03Ω. At 60Hz, its friction and windage losses are 6kW and its core losses are 4kW. The field circuit has a DC voltage of 200V and the maximum I_f is 10A. The resistance of the field circuit is adjustable over the range from 20Ω to 200Ω. The Open Circuit Current (OCC) of this generator is shown in figure Q1.

(i) What is the field current (I_f) required to make *VT* (Terminal Voltage) equal to 480V when the generator is running at no load? (02 marks)

(ii) What is the internal generated voltage of this machine at rated condition? (02 marks)

(iii) What is the field current required to make *VT* equal to 480V when the generator is running at rated conditions? (02 marks)

(iv) Calculate the power and the torque that the generator's prime mover is capable of supplying. (02 marks)

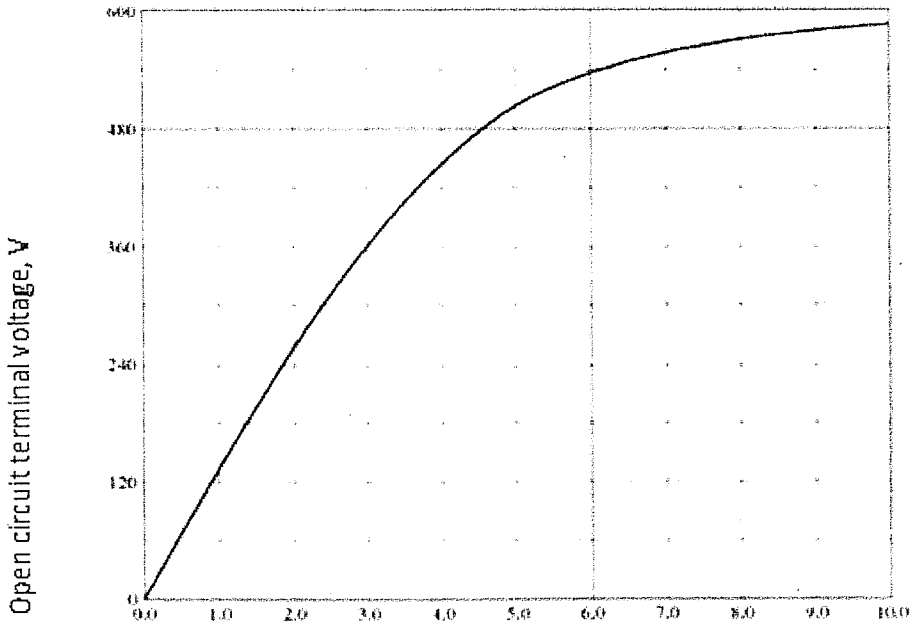


Figure Q1

(b) (i) Explain the mechanical and electrical consideration when selecting a synchronous generator. (04 marks)

(ii) Name and define five name plate parameters of synchronous generator. (04 marks)

(iii) List the advantages of nuclear power plants over conventional thermal power plants. (04 marks)

(2) (a) Draw the layout of a hydro – electric power plant and briefly explain the working of any two of its main components. (04 marks)

(b) A 12-kVA, 415 V, 3-phase, Y-connected, synchronous generator has a winding resistance of 0.12 Ω per phase and a synchronous reactance of 4.8 Ω per phase. Determine the voltage generated (exciting emf) by the machine when it is delivering full-load at 0.8 power-factor lagging at rated voltage. Calculate the voltage regulation for rated load at 0.8 power-factor(leading). (08 marks)

(c) A pair of synchronous machines, on the same shaft, may be used to generate power at 60 Hz from the given source of power at 50 Hz. Determine the minimum number of poles that the individual machines could have for this type of operation and find the shaft-speed in r.p.m

(04 marks)

(d) P=3 V_p I_p cosØ; where P is the power output, V_p is the phase voltage and I_p is the phase current. Using the phasor diagram explain, what will happen to source voltage (emf), power factor angle and power angle, when the field current keeps on reducing. (04 marks)

PART B

(3) The following data refer to a regenerative gas turbine plant in which the compression is carried out in one stage and expansion is carried out in two stages with reheating to the original temperature.

Capacity of the gas turbine plant = 6 MW
Temperature at which air is supplied = 30ºC
Suction, and exhaust pressure = 1 bar
Pressure ratio = 6
Maximum temperature limit = 747ºC
Isentropic efficiency of compressor = 80%
Isentropic efficiency of each turbine = 100%
Effectiveness of heat exchanger = 0.72
Calorific value of fuel used = 18500 kJ/kg

Assume C_p = 1.15 kJ/kgK and γ = 1.33 throughout the cycle.

(i) Determine the reheat pressure assuming turbine work output is maximized.
(ii) Calculate the thermal efficiency of the cycle neglecting mass of the fuel.
(iii) Calculate the mass flow rate of air supplied.
(iv) Determine the fuel consumption of the plant in kg per hour. (20 marks)

(4) (i) What are the two main types of feed water heaters used in steam power plants? Explain them briefly. (06 marks)

(ii) A power generating station is designed to provide a power output of 200 MW. The superheat outlet pressure of the boiler is to be 170 bar and the temperature 600°C. After expansion through the first stage of the turbine to a pressure of 40 bar, 15% of the steam is extracted for feed heating in an open feed water heater. The remainder is reheated to 600°C and is then expanded through the second turbine stage to a condenser pressure of 0.035 bar. Neglect feed pump work and assume generator efficiency as 0.9.

(a) Calculate the continuous steam rating of the boiler in kg per hour. (10 marks)

(b) If there is a 15°C rise in the cooling water temperature, what is the rate of flow of the cooling water in the condenser? (04 marks)

- Take enthalpy of saturated liquid water at 0.035 bar as 112 kJ/kg.
- Cp for water – 4.187 kJ/kgK
- h-s chart is provided.

(5) (i) What is a "Utility boiler"? Explain briefly. (05 marks)

(ii) What are the advantages of having " bent tubes' in water tube boilers? (04 marks)

(iii) There are many types of valves fitted on boilers. Name five of them with their locations on the boiler. (05 marks)

(iv) In an oil burners fuel oil must be converted into minute droplets so that oil may be quickly vapourized in the combustion space. What are the three mechanisms that can be used for this purpose? (06 marks)

(6) (i) What are the two main types of steam turbines?
Explain their constructional and functional differences. (10 marks)

(ii) Practical gas turbine cycles deviate considerably from the corresponding theoretical cycles. Explain the basic assumptions made in the analysis of ideal gas turbine cycles. (10 marks)

(7) (i) Give examples for the following types of reactors.

(a) Reactor fueled with natural uranium.

(b) Reactor fueled with enriched uranium. (06 marks)

(ii) Figure Q7 shows one such reactor fueled with enriched uranium.

Identify the reactor and discuss its core construction, moderators, control and cooling features. (14 marks)

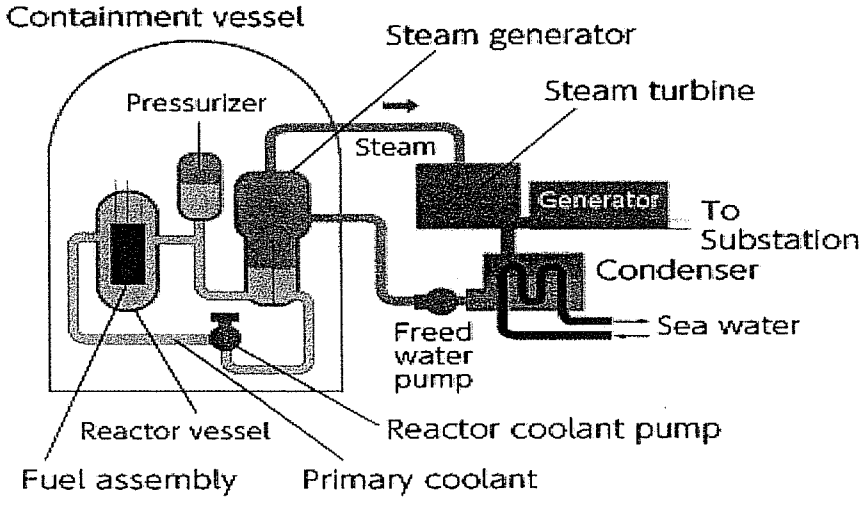


Figure Q7

(8) (i) A city requires 1200 MWh of electrical energy per day. It is to be supplied by a reactor which converts nuclear energy into electrical energy with an overall efficiency of 24 %. If the reactor uses nuclear fuel of U^{235}, calculate the mass of U^{235} needed for one days operation.

(10 marks)

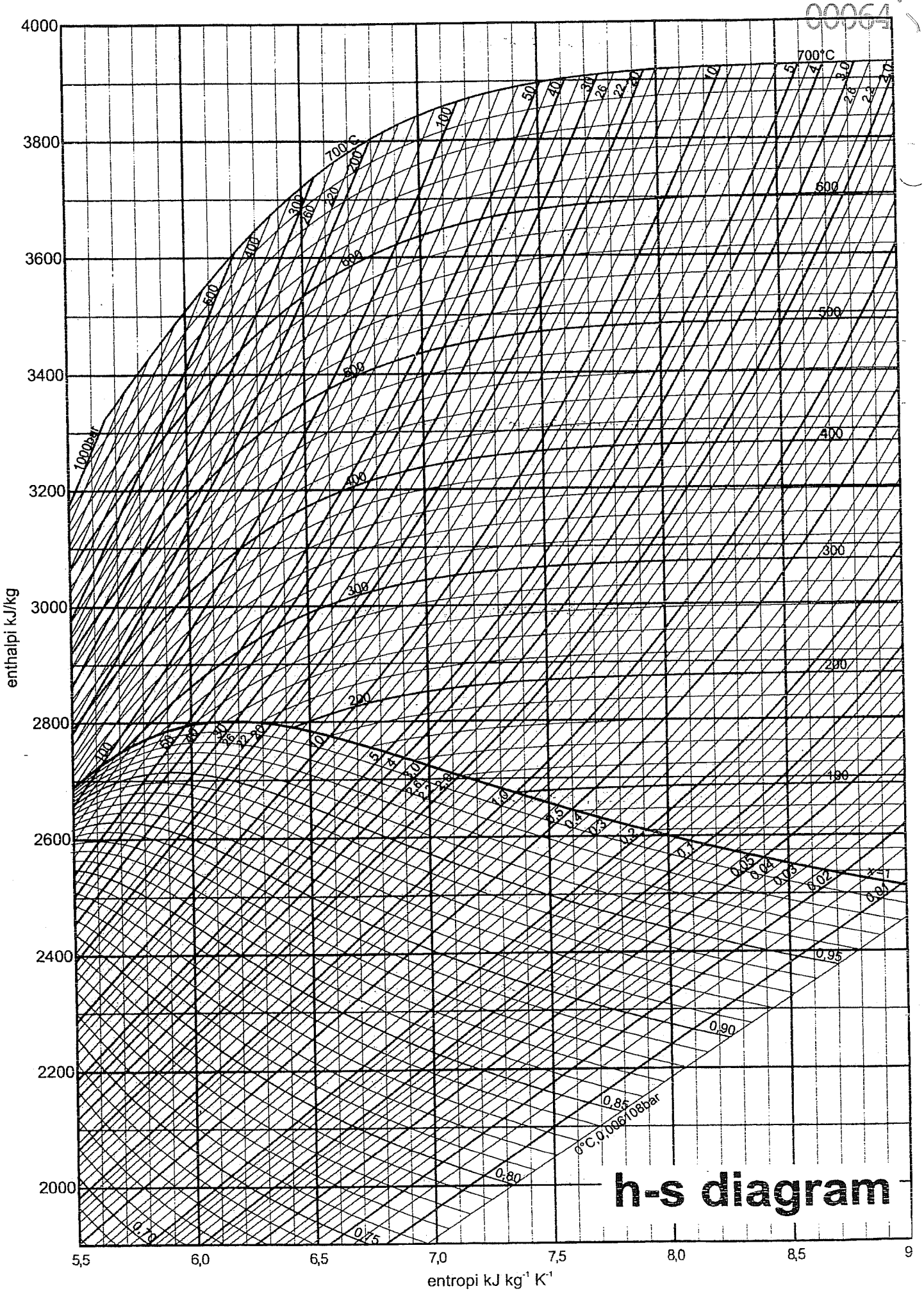
(iv) Discuss the problem of health hazards from nuclear radiation.

(07 marks)

(iii) All radiation workers should wear measuring devices which indicate their exposure to radiation. Name three different instruments that are used in nuclear power plants to measure radioactive dose.

(03 marks)

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h-s diagram
enthalpi kJ/kg
entropi kJ kg⁻¹ K⁻¹
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
5,5
6,0
6,5
7,0
7,5
8,0
8,5
9
700°C
1000bar
0°C,0,006108bar
x=1