THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 06
FINAL EXAMINATION – 2011/2012
THERMAL POWER GENERATION – MEX6335

DATE : 27th FEBRUARY 2012
TIME : 0930 HRS – 1230 HRS
DURATION : THREE HOURS

ANSWER FIVE QUESTIONS INCLUDING ONE QUESTION FROM PART A.

PART A

(1) (i) Mention the power angle which gives the maximum power for a given excitation in a synchronous generator.

(3 marks)

(ii) 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.

(4 marks)

(iii) A 9-kVA, 208 V, 3-phase, Y-connected, synchronous generator has a winding resistance of 0.1 ohm per phase and a synchronous reactance of 5.6 ohms 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).

(5 marks)

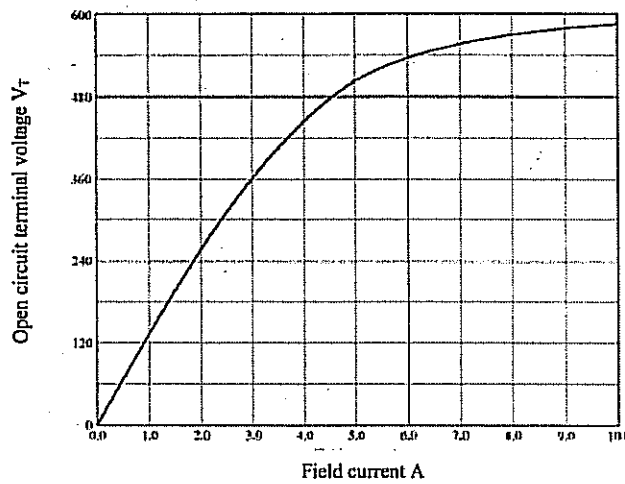
(iv) Describe the generator voltage & frequency.

(3 marks)

(v) Give the layout of a hydro – electric power plant and list the advantages and disadvantages of hydro power plants; specially address the environment point of view.

(5 marks)

(2) (i) A 480V 200kVA 0.80-power factor lagging 50Hz two pole Y connected synchronous generator has a synchronous reactance of 0.25 Ω and armature resistance of 0.03 Ω. At 50Hz, its friction and windage losses are 6 kW 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 20 to 200 Ω. The OCC of this generator is shown in figure.



(a) How much field current is required to make V_T equal 480V when the generator is running at no load?.

(b) What is the internal generated voltage of this machine at rated conditions?.

(c) How much field current is required to make V_T equal 480V when the generator is running at rated conditions?.

(d) How much power and torque must the generator's prime mover be capable of supplying?.

(8 marks)

(ii) List the advantages and disadvantages of thermal power plants specially environment point of view.

(4 marks)

(iii) Draw a sketch of synchronous generator and name the main parts of it and describe the working principle of synchronous generator.

(4 marks)

(iv) What are the main parameters which should be considered when selecting a generator?.

(4 marks)

PART B

(3) (i) The following data relates to a steam power plant.

Capacity of the plant - 100 MW

Capital cost - Rs 200 $x10^8$

Maximum demand – 75 MW

Rate of Interest and depreciation - 14% on capital

Annual cost of the fuel oil, Salaries and maintenance - Rs 150 x 10^7 per year

Load factor - 50%

Determine the cost of generation per unit of kWh. (10 marks)

(ii) In power plant terminology, what is understood by combined cycle operation?. Does Cogeneration make sense?. If yes, explain briefly.
(10 marks)

(4) (i) List the five operating variables that strongly affect the thermal efficiency of an open cycle gas turbine.
(05 marks)

(ii) In an open cycle gas turbine plant, two stage compression with intercooling, one reheating stage and a heat exchanger are employed. The air is drawn in at a pressure and temperature of 1 bar and 27°C. The overall pressure ratio of compression is 6:1. The temperature of the gases at inlet to the High Pressure (HP) turbine is 560°C and the gases are reheated to 560°C after expansion and then fed to the Low Pressure (LP) turbine. The HP turbine drives the compressors and the LP turbine drives the alternator. The exhaust from the LP turbine passes through a heat exchanger which transfers heat to the air leaving the HP compressor.

Determine,

(a) exit temperature and pressure of HP Turbine
(b) temperature of compressed air after the heat exchanger
(c) thermal efficiency of the plant

- Neglect mass of fuel
- Assume perfect intercooling between compression stages
- Assume isentropic expansions and compressions.
- You may use following data

Thermal ratio of heat exchanger = 0.75.
C_p for air = 1.005 kJ/kgK,
C_p for combustion gas = 1.16 kJ/kgK, $\gamma = 1.4$

(3 x 5 marks)

(5) A design for a steam power plant includes:

- A boiler delivering saturated steam at 55 bar
- A superheater, bringing steam temperature up to 500°C
- A high pressure (HP) turbine with isentropic efficiency 80% and exhausting at 12 bar
- A reheater, bringing steam temperature up to 500°C
- A low pressure (LP) turbine with isentropic efficiency 85% and exhausting at 0.06 bar
- A condenser, bringing steam to saturated liquid state at the LP turbine outlet pressure
- A feed pump, with isentropic efficiency 90% bringing the pressure of the feed water up to 55 bar before entry to the boiler

(i) Sketch the T-S diagram for the cycle.
(ii) Calculate the net work output, the external heat supplied and hence the thermal efficiency of the cycle. Take h_f at 0.06 bar as 152 kJ/kg.
(iii) Calculate the work ratio.

(20 marks)

(6) (i) Discuss the factors which go in favour of nuclear power plant as compared to other types of power plants.

(10 marks)

(ii) How waste is disposed of in a nuclear power station?. What are the main difficulties in handling radioactive waste?.

(10 marks)

(7) (i) Explain with the help of a neat diagram the arrangement of the Fluidized Bed Combustion (FBC) system.

(08 marks)

(ii) What is the function of 'draft' in a boiler?. Enumerate different types of draft available for a boiler.

(08 marks)

(iii) Why boiler blow-down is required?.

(04 marks)

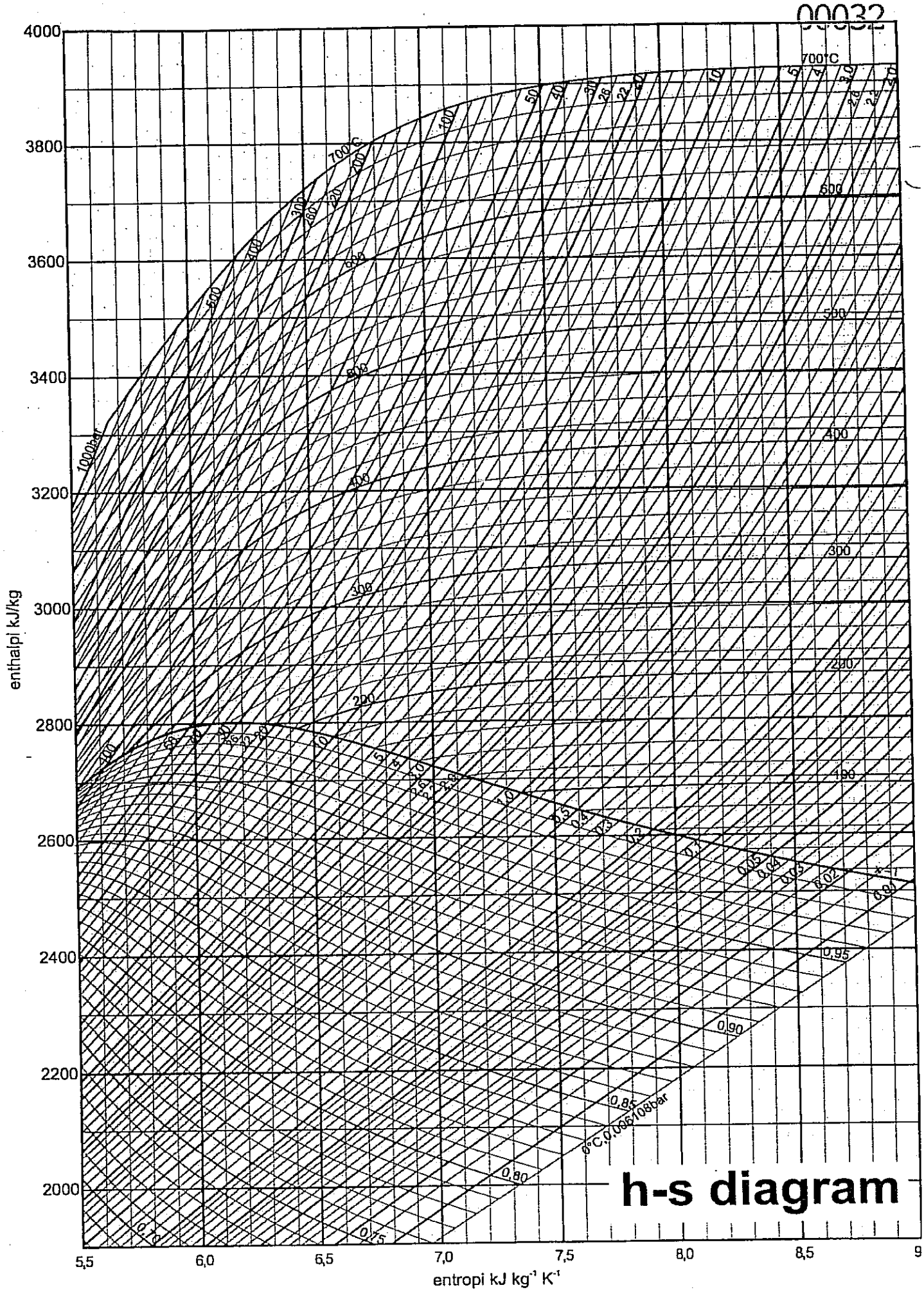
(8) (i) Write a note on the nuclear fuel cycle, explaining in detail the different stages of the cycle.

(10 marks)

(ii) A railway engine is driven by atomic power at an efficiency of 40% and develops an average power of 1600 kW during 8 hour run from one station to another. Determine how much U^{235} would be consumed on the run if each atom on fission releases 200 Mev.

(10 marks)

ALL RIGHTS RESERVED


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