The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	**:**	**DMX7301 Thermal Power Generation**
Academic Year	:	2021/22
Date	:	13th February 2023
Time	:	0930-1230hrs
Duration	:	**3 hours**

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of Eight **(8)** questions in **four (4)** pages.
3. Answer any **Five (5) questions** including **only one (1)** question from **Part B**.
4. All questions carry equal marks.
5. Use separate answer books for Part **A** and Part **B**.
6. Answer for each question should commence from a new page.
7. This is a Closed Book Test (**CBT**).
8. Answers should be in clear handwriting.
9. Do not use red colour pen.
10. h-s chart is provided.

PART A

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

Capacity of the plant - 200 MW

Capital cost - Rs 800 $\times 10^8$

Maximum demand – 150 MW

Rate of interest and depreciation - 18% on capital

Annual cost of the fuel oil, salaries, and maintenance - Rs 900 x 10^7 per year

Load factor - 50%

Determine the cost of generation for one kWh.

(ii) What are the types of thermal power plants suitable for daily peaking duties? Discuss the reasons for certain types of thermal power plants that are incapable of daily peaking operations.

(02) (i) Explain "Governing of steam turbines".

(ii) Steam at 70 bar and 450°C is supplied to a steam turbine. After expanding to 25 bar in high pressure (HP) stage, it is reheated to 420°C at constant pressure. Next it is expanded to an intermediate pressure of 10 bar and part of the steam is bled at this pressure to heat the feed water to a temperature of 180°C in an open feed water heater. The remaining steam expands from this pressure to a condenser pressure of 0.07 bar in the low pressure (LP) stage.

Isentropic efficiencies for all stages of turbine – 100%
Generator efficiency - 96%
Boiler efficiency - 96%
Mechanical efficiency - 90%

a) Estimate the quantity of steam bled per kg of flow.
b) Calculate the cycle efficiency.

Saturated liquid enthalpy at 0.07 bar and 10 bar are 163.4 kJ/kg and 762.6 kJ/kg respectively. Neglect the feed pump work. Use the h-s chart provided.

(03) (i) Gas turbines are generally divided into two basic types from the point of view of their application. What are these types and their main differences?

(ii) The following data has been given for a regenerative gas turbine plant.

Isentropic efficiency of the turbine and the compressor – 100%
Combustion efficiency of the boiler – 95%
Generator efficiency – 96%
Pressure ratio - 5: 1
Mass flowrate of air – 20kg/s
Heat exchanger effectiveness - 80%
Maximum cycle temperature – 725°C
The ambient temperature and pressure of air - 27°C and 1bar respectively.

Determine,
(a) Thermal efficiency of the cycle
(b) Fuel consumption in kg/s
(c) Specific fuel consumption in kg/kWh

Assume no pressure loss in the heat exchanger and in the combustion chamber.

Calorific value of fuel - 43500 kJ/kg.
γ - 1.4 throughout the cycle
Cp – 1.05 kJ/kgK throughout the cycle

(04) (i) What are the various accessories required for boiler operation? Briefly explain four of them.

(ii) Why is boiler blow-down required?

(iii) Write short notes on any **two** of the following.
Fire tube boiler
Utility boiler
Factor of safety in a boiler

(05) (i) Write an account of Boiling Water Reactors (BWR) discussing their core construction, moderators, control and cooling features.

(ii) "The principal risks associated with nuclear power arise from health effects of radiation". Comment on this statement.

(06) (i) How waste is disposed in a nuclear power station? What are the main difficulties in handling radioactive waste?

(ii) State the principles governing radiation protection standards.

(iii) What are the main mechanisms of interaction of gamma rays with matter? Explain.

(iv) Calculate the number of fissions in uranium per second required to produce 2 kW of power if energy released per fission is 200 MeV.

PART B

(07) (a) How does a salient-pole rotor differ from a cylindrical rotor in synchronous machines?

(b) Where are the salient-pole type of synchronous machines used?

(c) Explain with proper phasor diagrams the operation of a 3-phase synchronous machine with normal excitation at the following conditions:
(i) The machine is floating on the supply bus.
(ii) The machine is working as a synchronous motor at no load.

(d) 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 rpm.

(e) A power plant with single phase AC generator supplies the following loads:

- Lighting load of 20 kW at unity power factor.
- Induction motor load of 100 kW at pf of 0·7 lagging.
- Synchronous motor load of 50 kW at pf of 0·9 leading.

Draw the phasor diagram. Hence, calculate the total kW and kVA delivered by the generator and the power factor at which it works.

(08) (a) Draw typical generator capability curve and name its limits.

(b) A 4-ploe turbo-alternator rotates at 1800 rpm. Calculate the frequency of the generated voltage.

(c) Draw and explain the equivalent circuit of alternator.

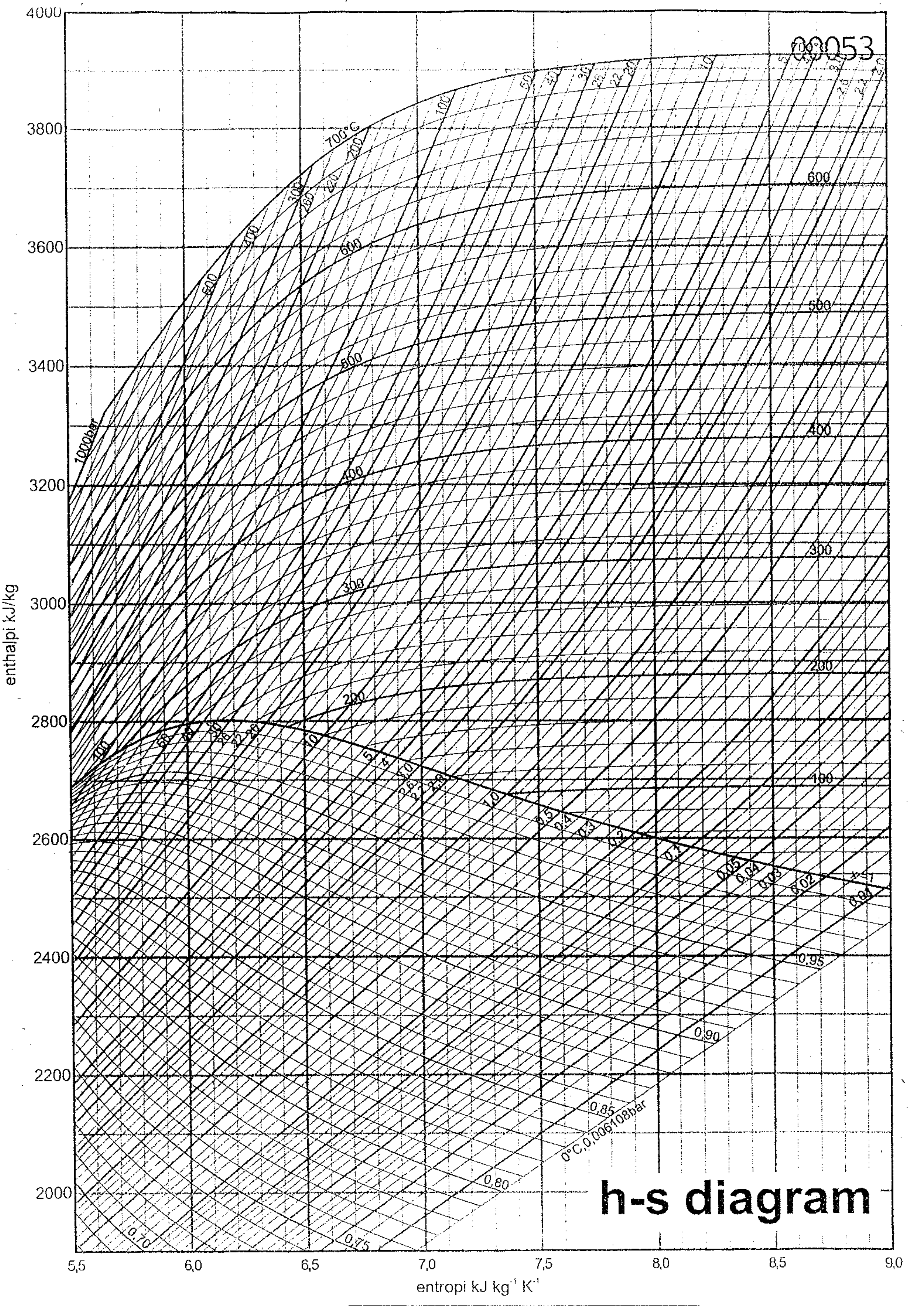
(d) A 400V, 10 kVA, 3-phase alternator with star-connected stator winding has an effective armature resistance per phase of 1.0 Ohms. The alternator generates an open circuit voltage per phase of 90 V with a field current of 1.0 A. During the short-circuit test, with 1.0 A of field current, the short circuit current flowing in the armature is 15 A. Calculate,

i Synchronous impedance.

ii Synchronous reactance.

iii If the alternator is supplying a load current of 15 A at 0.8 power factor lagging, to what value would the terminal voltage rise if the load is thrown-off.

iv Regulation at 0.8 power factor lagging and unit power factor.


00053
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
9,0
1000bar
700°C
600
500
400
300
200
100
x=1
0,95
0,90
0,85
0,80
0,75
0,70
0°C,0,006108bar
1,0
0,5
0,4
0,3
0,2
0,1
0,05
0,04
0,03
0,02
0,01