

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



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX7301 Thermal Power Generation
Academic Year	: 2023/2024
Date	: 22 nd February 2025
Time	: 0930-1230hrs
Duration	: 3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of Five **(5)** questions. Answer all questions.
3. Answer for each question should commence from a new page.
4. This is a Closed Book Test **(CBT)**.
5. Answers should be in clear handwriting.
6. Do not use red colour pen.
7. h-s chart is provided.

Question 1

- (i) A 35 MW power plant generated a total amount of power equal to 110 GWh during a particular year. If the time lost due to planned maintenance and breakdown maintenance during that year is 26 days and 500 hrs respectively, determine the effective plant factor. 06 marks
- (ii) How is the efficiency of a steam power plant improved through a regenerative cycle? 02 marks
- (iii) The net power output of the turbine in an ideal reheat-regenerative steam cycle is 100MW. Steam enters the high pressure (HP) turbine at 90 bar, 550°C and expands to 7 bar. After expansion in the HP turbine, a portion of the steam goes to an open heater, and the balance is reheated to 400°C. Then steam enters the low-pressure ((LP) turbine and expands to 0.07 bar. Neglect feed pump work. Assume 100% isentropic efficiency for turbines. The saturated liquid enthalpy at 7 bar and 0.07 bar are 697 kJ/kgK and 163 kJ/kgK respectively. 12 marks
- Determine,
- a) Steam flow rate to the HP turbine.
 - b) Thermal efficiency of the cycle.
 - (c) The rate of flow of the cooling water in the condenser, if there is a 12°C rise in the temperature of the cooling water.

Question 2

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(i) In power plant terminology; what is understood by combined cycle operation? Does Cogeneration make sense? If yes, explain briefly. 04 marks

(ii) List four advantages of closed cycle gas turbine plant. 04 marks

(iii) Helium is used as the working fluid in the modified Brayton cycle. Gas enters the compressor at 27°C and 20 bar and is discharged at 60 bars. The gas is heated to 1000°C as it passes through a High-Temperature Gas-cooled Reactor (HTGR) before expanding through the turbine. After expansion in the turbine, the hot turbine exhaust is sent through the pre-cooler and cooled down to the temperature of 27°C.

Assume

- 2% pressure loss through both the HTGR and the pre-cooler.
- The turbine and the compressor are to be 100% efficient.
- C_p for helium as 5.1926 kJ/kg K and the ratio of specific heats = 1.667.

Determine the following.

- Temperature at the end of compression and expansion.
- Heat supplied, the heat rejected, and the network per kg helium.
- Thermal efficiency.
- Flow rate if the plant is to have a net output of 1000MW.

12 marks

Question 3

(i) "Steam turbines are sometimes required to operate at reduced power or power greater than the normal service power rating." Describe the methods adopted to achieve these conditions. 03 marks

(ii) What is blow down? Why is it needed? 03 marks

(iii) Describe the functions of safety valves and steam traps used in boilers. 05 marks

(iv) What type of boilers should be used in applications where high pressures and high capacities are required?. Give reasons. 04 marks

(v) Explain the different types of combustion systems that are used in the open cycle gas turbines. 05 marks

Question 4

- (i) A city requires 1500 MWh of electric energy per day. It is to be supplied by a reactor which converts nuclear energy into electric energy with an efficiency of 20 percent. If the reactor uses nuclear fuel of U_{235} , calculate the mass of U_{235} needed for one day's operation. 05 marks
- (ii) Write a note on the nuclear fuel cycle, briefly explaining the different stages of the cycle. 06 marks
- (iii) Discuss the problem of health hazards from nuclear radiation. 06 marks
- (iv) Unlike the acute effects, the delayed effects are not observed in all those who are exposed to radiation but will appear years after the exposure. What is the necessary information to quantify the delayed effects of radiation? 03 marks

Question 5

- (i) Draw a typical generator capability curve and label its limits. 04 marks
- (ii) What are the essential features of a synchronous machine? 02 marks
- (iii) In an OUSL electrical lab practical, it is necessary to supply 300kW of power at 60Hz. However, the only available power sources operate at 50Hz. To achieve this, it is decided to use a motor-generator set consisting of a synchronous motor driving a synchronous generator. How many poles should each of the two machines have to convert 50Hz power to 60Hz power? 06 marks
- (iv) A 3-phase, 5kVA, 400V, four-pole, 50Hz, star-connected synchronous machine has negligible stator winding resistance and a synchronous reactance of 8Ω per phase at rated terminal voltage. This synchronous machine is operated as a synchronous motor from the 3-phase, 400V, 50Hz power supply. The field excitation is adjusted so that the power factor is unity when the machine draws 3kW from the supply.
 - (a) Find the excitation voltage and the power angle. Draw the phasor diagram for this condition.
 - (b) If the field excitation is held constant and the shaft load is slowly increased, determine the maximum torque (i.e., pull-out torque) that the motor can deliver. 08 marks

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