



Study Programme : Bachelor of Science (Honours) in Engineering
 Name of the Examination : Final Examination
Course Code and Title : **DMX 4202 Applied Thermodynamics I**
 Academic Year : 2023/2024
 Date : 15th February 2025
 Time : 0930-1230 hrs
 Duration : 3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of five (05) questions. All questions carry equal marks.
3. **Answer all five (05) questions.**

Question 01

A steam power plant operates with two closed feed heaters as shown in Figure 1. In the feed heaters, feed water has its liquid enthalpy raised to that of the corresponding bled steam, and the bled steam is condensed but not undercooled.

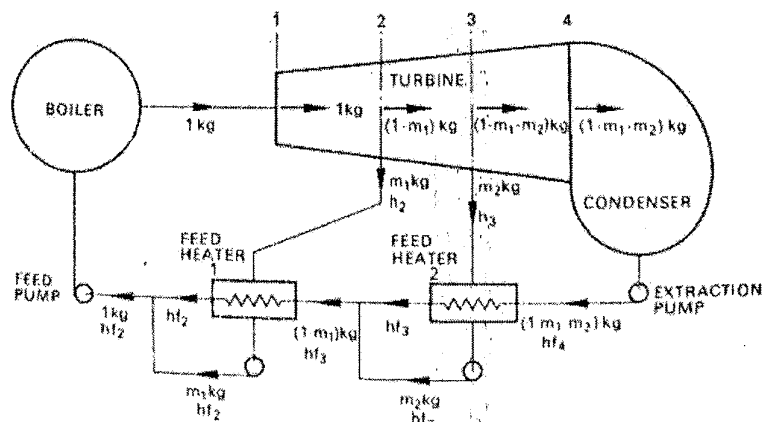


Figure 1

Operational Parameters:

- Initial state: 70 bar, 500 °C
- First bleeding: 20 bar
- Second bleeding: 5 bar
- Condenser pressure: 0.5 bar

Considering h_f at 20 bar: 909 kJ/kg, h_f at 5 bar: 640 kJ/kg and h_f at 0.5 bar: 340 kJ/kg.

You may neglect the pump work. h-s diagram is provided.

- a) Draw the T-s diagram and determine the actual enthalpy values after each expansion stage. [4 marks]
- b) For the first feed heater at 20 bar:
- Write the energy balance equation. [2 marks]
 - Calculate the mass of steam bled (m_1). [4 marks]
- c) For the second feed heater at 5 bar:
- Write the energy balance equation. [2 marks]
 - Calculate the mass of steam bled (m_2). [4 marks]
- d) Calculate the thermal efficiency of the cycle. [4 marks]

Question 02

- a) Briefly explain the difference between impulse turbine and reaction turbine [4 marks]
- b) The steam from the nozzles of a single wheel impulse turbine discharges with a velocity of 600 ms^{-1} and at 30° to the plane of the wheel. The blade wheel rotates at 4000 rev/min and the mean blade radius is 600 mm. The axial velocity of the steam at exit from the blades is 164 ms^{-1} and the blades are symmetrical. Calculate,
- the blade angles. [4 marks]
 - the diagram work per unit mass flow rate of steam. [5 marks]
 - the diagram efficiency. [4 marks]
 - the blade velocity coefficient. [3 marks]

Question 03

Steam enters a group of convergent- divergent nozzles at a pressure of 2.2 MN/m^2 and with a temperature of $260 \text{ }^\circ\text{C}$. Equilibrium expansion through the nozzles to an exit pressure of 0.4 MN/m^2 . Up to the throat of the nozzles the flow can be considered as frictionless. From throat to exit, however, there is an efficiency of expansion of 85%. The rate of steam flow through the nozzles is 11 kg/s .

Using the h-s chart for steam and assume the expansion index for dry saturated steam is 1.135. Assume that the specific volumes of steam at the throat as $0.154 \text{ m}^3/\text{kg}$ and at the exit $0.605 \text{ m}^3/\text{kg}$.

Determine:

- I. the throat and exit velocities. [12 marks]
- II. the throat and exit areas. [8 marks]

Question 04

A regenerative-reheat cycle has air entering at 1 bar, 300 K into compressor having intercooling in between the two stages of compression. Air leaving first stage of compression is cooled up to 290 K at 4 bar pressure in intercooler and subsequently compressed up to 8 bar. Compressed air leaving second stage compressor is passed through a regenerator having effectiveness of 0.80. Subsequent combustion chamber yields 1300 K at inlet to turbine having expansion up to 4 bar and then reheated up to 1300 K before being expanded up to 1 bar. Exhaust from turbine is passed through regenerator before discharged out of cycle. Consider the fuel having heating value of $42,000 \text{ kJ/kg}$

By using the above data

- I. draw the T-s diagram for the process. [3 marks]
- II. calculate the total compressor work. [4 marks]
- III. calculate the total turbine work. [4 marks]
- IV. calculate the heat added. [3 marks]
- V. calculate the cycle thermal efficiency. [3 marks]
- VI. calculate the fuel-air ratio. [3 marks]

Consider compression and expansion to be isentropic and air as working fluid throughout the cycle and $C_p = 1.005 \text{ kJ/kg}$ and $\gamma = 1.4$.

Question 05

A single stage, single acting, reciprocating air compressor has a bore of 200 mm and a stroke of 300 mm. It runs at a speed of 500 revolutions per minute. The clearance volume is 5% of the swept volume and the polytropic index is 1.3 throughout. Intake conditions are 97 kN/m^2 and 20°C and the compression pressure is 550 kN/m^2 . Free air conditions 101.325 kN/m^2 and 15°C .

Determine

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| I. The free air delivered in m^3/min . | [5 marks] |
| II. The volumetric efficiency. | [4 marks] |
| III. The air delivery temperature. | [3 marks] |
| IV. The cycle power. | [4 marks] |
| V. The isothermal efficiency, neglecting clearance. | [4 marks] |

