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December 2024

B.Tech. (ME) (Third Semester)

Thermodynamics (PCC-ME-301/21)

Time : 3 Hours] [*Maximum Marks : 75*

Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail. Different sub-parts of a question are to be attempted adjacent to each other. Use of steam table and Mollier diagram is allowed.

Part A

1. (a) What is displacement work ? **1.5**

(b) What is the difference between intensive and extensive properties ? **1.5**

(c) On a hot summer day, a student turns his fan on when he leaves his room in the morning. When he returns in the evening, will the room be warmer or cooler than the neighboring rooms ? Why ? Assume all the doors and windows are kept closed. **1.5**

(d) Why is there no temperature change when an ideal gas is throttled ? **1.5**

(e) What is the difference between the critical point and the triple point ? **1.5**

(f) Define the thermal efficiency of a heat engine cycle. Can this be 100%. **1.5**

(g) What is the physical significance of the two constants that appear in the van der Waals equation of state ? **1.5**

(h) Show that entropy is a property of the system. **1.5**

(i) What is second law efficiency and how does it differ from first law efficiency ? **1.5**

(j) For the same compression ratio and heat rejection, which cycle is most efficient : Otto, Diesel or Dual ? Explain with p-v and T-s diagrams. **1.5**

Part B

2. (a) Air enters a compressor at 1 bar, 30°C, which is also the state of environment. It leaves at 3.5 bar, 141°C.

Determine : **5**

(i) Whether the compression is adiabatic or polytropic.

(ii) If not adiabatic, the polytropic index.

(b) The value of characteristic constant for a gas is 4.1 kJ/kg K and specific heat at constant pressure is 14.25 kJ/kg K. 5 m^3 of this gas at a pressure of 1 bar and 20° C are compressed adiabatically to 5 bar. The compressed gas is then expanded isothermally to original volume. **10**

Calculate :

(i) The final pressure of the gas after expansion

(ii) The quantity of heat added from the beginning of compression to the end of expansion.

(iii) The quantity of heat that must be added or subtracted to reduce the gas after expansion to the original state of pressure, volume and temperature.

3. (a) State Kelvin-Planck statement and Clausius statement of the second law of thermodynamics. Also explain one application each of both statements. **10**

(b) A platinum resistance thermometer has a resistance of 2.8 ohm at 0° C and 3.8 ohm at 100° C. Calculate the temperature when the resistance indicated is 5.8 ohm. **5**

4. Air at a temperature of 15°C passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800° C. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650° C. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500° C. If the air flow rate is 2 kg/s. **15**

Calculate :

(i) The rate of heat transfer to the air in the heat exchanger,

(ii) The power output from the turbine assuming no heat loss

(iii) The velocity at exit from the nozzle, assuming no heat loss.

5. (a) Show that the "adiabatic mixing of two fluids is irreversible" using the application of entropy principle. 8

(b) What do you understand by 'useful work' ? Derive expression for useful work for a closed system and a steady flow system which interact only with the surroundings. 7

6. (a) Draw the phase equilibrium diagram for a pure substance on p-T coordinates. Why does the fusion line for water have negative slope ? 5

(b) Calculate the total heat of 5 kg of steam at a pressure of 8 bar having dryness fraction of 0.8. Also calculate heat in kJ required to convert this steam into dry and saturated steam. 5

(c) Explain the difference between an ideal gas and a real gas. What are the reasons of deviation of a real gas from an ideal gas ? **5**

7. (a) Show that efficiency of the Otto cycle depends only on the compression ratio. **5**

(b) Derive the expression for air standard thermal efficiency of diesel cycle. Also write all the assumption made while deriving air standard thermal efficiency. **10**