C 58181 (Pages • 2) Name.....

Reg. No.....

FOURTH SEMESTER B.TECH. (ENGINEERING) DEGREE EXAMINATION JUNE 2009

ME 04 403—THERMODYNAMICS

(2004 Admissions)

Time : Three Hours Maximum : 100 Marks

Answer **all** *questions.*

Part A

I. (a) Explain what do you understand by thermodynamic equilibrium.

(b) Define Enthalpy, why does the enthalpy of an ideal gas depend only on temperature ?

(c) Write the following statements of the second law of thermodynamics :—

(i) Kelvin-Planck statement and

(ii) Clausius statement.

(d) What do you understand by entropy principle ?

(e) What do you understand by triple point ?

(f) What is the generalized compressibility chart and explain it ?

(g) What are the approximate chemical compositions of gasoline, diesel fuel and natural gas ?

(h) What is the degree of reaction ? What are its limiting values ?

(8 × 5 = 40 marks)

Part B

II. (a) Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7 m/s velocity, 100 kPa pressure and 0.95 m^3/kg volume and leaving at 5 m/s, 700 kPa, and 0.19 m^3. The internal energy of the air leaving is 90 kJ/kg greater that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. (i) Calculate the rate of shaft work input to the air in kW. (ii) Find the ratio of the inlet pipe diameter to outlet pipe diameter.

Or

(b) A fluid confined in a cylinder by a spring-loaded, frictionless piston so that the pressure in the fluid is a linear function of the volume ($P = a + bV$). The internal energy of the fluid is given by the following equation U = 34 + 3.15 pu), where U is kJ, P in KPa, and V in m^3. If the fluid changes from an initial state of 170 kPa, 0.03 $m.^3$ to a final state of 400 kPa, 0.06 m^3, with no heat work other that done on the piston, find the direction and magnitude of work and heat transfer.

(15 marks)

Turn over

III. (a) A reversible heat engine operates between two reservoirs at temperatures of 600° C and 40° C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40° C and – 20°C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ.

(i) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C.

(ii) Reconsider (i) given that the efficiency of the heat engine and the COP of the refrigerator are each 40 % of their maximum possible values.

Or

(b) Establish the inequality of Clausius $\oint \frac{dQ}{T} \leq 0$.

IV. (a) Draw the phase equilibrium diagram for a pure substance on T-S plot with relevant constant property lines.

Or

(b) The pressure on a block of copper of 1 kg. is increased from 10 bar to 1000 bar in a reversible process maintaining the temperature constant at 15° C. Determine

(i) Work done on the copper during the process.

(ii) Change in entropy.

(iii) The Heat transfer.

(iv) Change in internal energy.

(v) $(C_p - C_v)$ for this change of state.

Assume the following data :—

β (Volume expansivity) = 5×10^{-5}/K.

K_T (Isothermal compressibility) = 8.6×10^{-12} m^2/N.

V_s (Specific volume) = 0.114×10^{-3} m^3/kg.

V. (a) Determine the adiabatic flame temperature when liquid octane at 25° C burned with 300 % theoretical air 25° C in a steady flow process.

Or

(b) (i) Explain how the Orsat apparatus could be used to obtain the mole fractions of the flue gas constituents.

(10 marks)

(ii) What are the higher and the lower heating values of a fuel ? How do they differ ?

(5 marks)

[4 × 15 = 60 marks]