APPLIED HEAT

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A gas in a cylinder is heated at constant volume from a temperature of 387°C to 568°C and then further heated at constant pressure to 827°C.

The change in specific entropy in the first process is 0.182 kJ/kgK.

After the heating processes the gas expands isentropically to 10 times V_1 and a temperature of 17°C.

(a) Sketch PV and Ts diagrams to show the process (2)

(b) Calculate EACH of the following:

(i) Cv, CP and γ; (9)

(ii) the change is specific entropy in the constant pressure process; (2)

(iii) the specific work in the isentropic process. (3)

2. In an air standard dual combustion cycle, the initial volume compression ratio is 13/1.

The maximum and minimum temperatures are 1500 K and 300 K, respectively.

The maximum and minimum pressures are respectively 67 bar and 1.13 bar.

(a) Sketch the processes on p-V and T-s diagrams. (2)

(b) Calculate EACH of the following:

(i) the temperature at all points; (10)

(ii) the thermal efficiency; (2)

(iii) the mean effective pressure. (2)

Note: For air γ= 1.4 and Cp= 1.005kJ/kgK Cv=0.718kJ/kgK

3. A single acting single stage air compressor runs at 300 rpm and has a clearance volume equal to 7% of the swept volume.

The compressor delivers 50 m^3 of air per hour measured at 1.013 bar and 0°C.

The suction pressure and temperature are 0.98 bar and 23°C (T_1 and T_4) respectively, and the discharge pressure and temperature are 6.6 bar and 170°C (T_2 and T_3), respectively.

(a) Sketch the cycle on a pressure-volume diagram. (2)

(b) Calculate EACH of the following:

(i) the volume induced per cycle; (5)

(ii) the swept volume; (4)

(iii) the index of compression; (3)

(iv) the indicated power. (2)

Note: For Cp= 1.005kJ/kgK Cv=0.718kJ/kgK

4. A boiler generates 5000 kg of steam per hour at 15 bar. The steam temperature is 325°C and the feedwater temperature is 48°C.

If the fuel supplied has a calorific value of 45.5 MJ/kg and is supplied at a rate of 0.11 kg/s. On exiting the boiler, the steam is further heated to 450°C before being throttled to 10 bar.

(a) Calculate the boiler efficiency. (10)

(b) Find the supplied heat required in the superheater. (3)

(c) Draw the process on a pressure enthalpy diagram. (3)

5. A vapour compression refrigeration system operates between the pressures of 4.625 bar and 8.053 bar.

R717 refrigerant enters the compressor dry saturated and is isentropically compressed. Upon leaving the condenser it is undercooled by 6 K. The mass flow rate is 0.8 kg/s

(a) Sketch the cycle on pressure-specific enthalpy and Temperature-specific entropy diagrams. (2)

(b) Calculate EACH of the following:

(i) The dryness fraction of the refrigerant entering the evaporator; (3)

(ii) The temperature leaving the compressor; (5)

(iii) The compressor power. (4)

(c) Explain the application of intermediate liquid cooling (2)

6. An LNG carrier has five spherical tanks each of diameter 36 m. They contain liquefied gas at a temperature of-163°C. The tanks are insulated with 60 cm thickness of material of fibreglass with a thermal conductivity of 0.04 W/mK.

The outside surface heat transfer coefficient is 8 W/m^2K and the outside air temperature is 28°C.

(a) Calculate the total rate of heat gain. (7)

(b) Find the external surface temperature. (4)

(c) Calculate the total percentage mass evaporated each day. (5)

Note: $\rho = 1000kg/m^3$ *Latent heat of evaporation is 515kJ/kg*

7. Butane (C_4H_{10}) is burned with 12% excess air.

(a) Analyse the percentage of dry products by volume. (14)

(b) Define the HCV. (2)

8. An impulse turbine has a nozzle at the entrance angle is 16°, the blade velocity is 360 m/s, and the blades are symmetrical and have an angle of 34°.

If the blade velocity coefficient is 0.94 and the mass flowrate of the steam is 1.67 kg/s.

(a) Calculate the nozzle exit velocity if the change in enthalpy across the nozzle is 490 kJ/kg. (2)

(b) Sketch a blade velocity diagram labelling all significant angles and velocities. (3)

(c) Using Fig Q8, calculate the diagram power. (11)

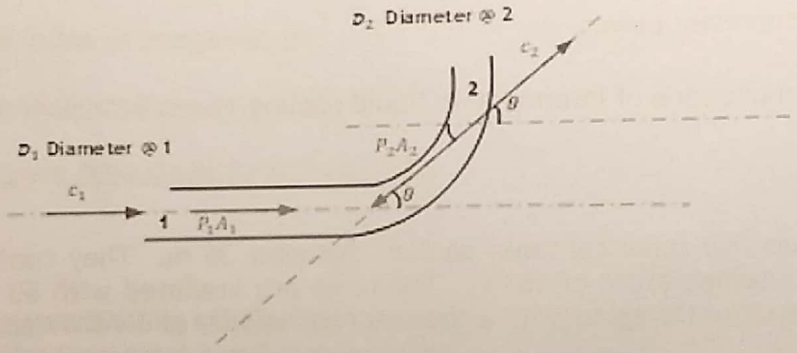

Fig Q8

9. A bend of constant cross-sectional area which turns through 75 degrees is fitted in a horizontal section of a 600 mm diameter fresh water-cooling system.

The cooling system pressure is 3 bar and the flowrate is 0.85 m3/s. The pressure loss due to each bend is negligible.

Calculate EACH of the following:

(a) the net force acting on the axis ox; (6)

(b) the net force acting on the axis oy; (6)

(c) the magnitude of the resultant force acting on the bend; (2)

(d) the direction of the resultant force. (2)