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 pressure from a temperature of 387°C to 568°C and then cooled at constant volume to 427°C.

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

   After the cool processes the gas expands isentropically to 5 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; (10)

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

   (iii) the specific heat in the constant pressure process. (2)

2. For air standard Diesel cycle the volume compression ratio is 8/1.

   The maximum and minimum temperature are respectively 1500 K and 279 K, and the minimum pressure is 0.95 bar.

   (a) Sketch a pV and Ts graph of the cycle. (2)

   (b) Calculate EACH of the following:

   (i) the temperature at all points; (7)

   (ii) the air standard efficiency of the cycle; (4)

   (iii) the mean effective pressure. (3)

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

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3. A single-acting, TWO stage reciprocating air compressor is designed for minimum work with perfect intercooling, and the LP cylinder has a volumetric efficiency of 94%. The compressor delivers 5.8 kg/min of air from an initial condition of 1.0135 bar and 18°C.

In each stage the clearance volume is 4% of the respective swept volume, and the index for all compressions and expansions is n = 1.37.

The speed of rotation is 420 r/min.

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

(b) Determine EACH of the following:

(i) the delivery pressure; (5)

(ii) the power; (5)

(iii) the volume per cycle for the LP stage. (4)

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

4. In a steam plant, using reheat, the turbine receives the steam at a pressure and temperature of 20 bar and 300°C respectively. The steam isentropically expands in the first stage until it is just dry saturated.

It is then reheated at constant pressure to 250°C and is isentropically expanded in the second stage to a condenser pressure of 1 bar.

The feed pump work can be neglected, there is no undercooling in the condenser.

(a) Sketch the T-s diagram for the cycle. (2)

(b) Calculate the thermal efficiency of the process. (14)

5. A vapour compression refrigeration system using R134a operates between the pressures of 6.6525 bar and 32.433 bar.

It enters the compressor with 10 K of superheating and compressed through a compressor with an isentropic efficiency of 92%.

No undercooling takes place in the condenser.

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

(b) Calculate EACH of the following:

(i) the temperature leaving the compressor; (11)

(ii) the coefficient of performance. (3)

6. A fruit juice carrier has 2 spherical tanks each of radius 12 m. They contain liquid at a temperature of 3°C. The tanks are insulated with 600 mm thickness of material of fibreglass with a thermal conductivity of 0.04 W/mK.

The outside surface heat transfer coefficient is 2 W/m^2K and the outside air temperature is 30°C.

Calculate EACH of the following:

(a) the total rate of heat lost; (7)

(b) the external surface temperature; (4)

(c) the total percentage mass evaporated each 28 days. (5)

Note: Density= $1250\ kg/m^3$ *Latent heat of evaporation is 2700 kJ/kg.*

7. An unknown hydrocarbon fuel combusts with dry air, the resulting products have the following dry volumetric products, 11% CO_2, 1.5% CO, 2% O_2 and 85.5% N_2.

(a) Calculate the percentage excess air. (10)

(b) Determine the partial pressure of the water vapour and dew point. (3)

(c) Describe the difference between HCV and LCV values. (3)

Note: Air contain 21% Oxygen by volume and atmospheric pressure is $1.0135x10^5Pa$

8. A single stage impulse turbine has a mean blade diameter of 1.2 m, and the speed of rotation is 5093 rev/min. The nozzle angle is 17 degrees to the plane of rotation and the steam leaves the nozzles at 900 m/s. The blade velocity coefficient is 0.91 and there is no axial thrust.

The steam mass flow rate is 0.05 kg/s. Calculate EACH of the following:

(a) the velocity of the blades; (2)

(b) the blade inlet angle; (6)

(c) the blade outlet angle; (4)

(d) the power output. (4)

9. A horizontal pipe carrying water tapers from 500 mm diameter to 100 mm diameter. The volumetric flowrate is 0.1 m^3/s, before increasing again to a diameter of 330 mm with a difference in height of 7 m.

(a) Calculate the velocities at all points. (6)

(b) Determine the pressure difference between point 1 and 2 and between point 2 and point 3. (10)

Note: the density of water is 1000kg/m^3