Sem III / Rev / Mech / Thermodynamics / Dec-09

**Con. 5207–09.** **(REVISED COURSE)** **SP–7304**

**(3 Hours)** **[Total Marks : 100**

N.B.: - 1) Question No. 1 is compulsory.
2) Attempt any four out of remaining six questions.
3) Use of steam table, gas table and Mollier Chart is permitted.
4) Assume suitable data if required.

1. Solve any five of the following.
a) Show that internal energy is property of system. 20
b) Steam at 15 bar and 300$^0$C is throttled to 10 bar before supplying to steam turbine. It then undergoes isentropic expansion to 1 bar in the turbine. Determine isentropic heat drop and the condition of steam at exit from the turbine. Use enthalpy- entropy chart.
c) State and explain first low of thermodynamic for closed system.
d) A gas undergoes a reversible non-flow process according to the relation p= (-3V +15) where V is the volume in m$^3$and p is the pressure in bar. Determine work done when the volume changes from 3 to 6 m$^3$.
e) What is cut-off ratio? How does it affect the air standard efficiency of a diesel cycle?
f) Define the terms a) Sonic Velocity and Mach number b) Stagnation temperature and Stagnation pressure.
g) Define i) availability ii) unavailability iii) Dead state iv) Irreversibility

2. a) 60 liters of an idle gas at 290 K and 1 bar is compressed adiabatically to 10 bar. It is then cooled at constant volume and further expanded isothermally so as to reach the condition from where it started. Evaluate 1) pressure at the end of constant volume cooling, 2) change in internal energy during constant volume process, 3) net work done and heat transfer during the cycle. Assume $C_P$ =14.25kJ/kgK and $C_V$ = 10.15kJ/kgK 12

b) Develop the following expression for the heat transfer from a mass of gas undergoing reversible expansion process obeying the polytropic law, $pV^n$ = constant

$$Q_{1-2} = \frac{\gamma - n}{\gamma - 1} \text{ x Polytropic work done}$$ 08

3. a) Define Joule -Thomson coefficient, inversion point and inversion curve. 04

b) In a steady flow process, the fluid flows through a machine at the rate of 15 kg/min. The entrance and exit parameters of the machine are Velocity 5 m/s and 8 m/s , Pressure 100 kPa and 700 kPa, Specific volume 0.45 m$^3$ /kg and 0.125 m$^3$/kg resp. The working fluid leaves the machine with internal energy 160 kJ/kg greater than that at entrance and during the process 7200kJ/min of heat is lost to the surrounding. Assuming entrance and exit pipe to be at the same level, calculate the shaft work and the ratio of inlet pipe diameter to outlet pipe diameter. 10

c) Show that the work done in a steady flow process is given by $-\int pdv$. 06

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4. a) State the Kelvin plank and Clausius statements of the second law of thermodynamics, and establish the equivalence between them. 08

   b) A reversible engine receives heat from two constant temperature sources at 870K and 580K. It rejects 3000kJ/min to a sink at 290K. The engine develops 85 kW. Determine the heat supplied by each source and the efficiency of the engine. 08

   c) Define entropy and show that for an irreversible process

   $$\int ds > \int \frac{\delta Q}{T}$$ 04

5. a) In a counter flow heat exchanger 0.25 kg/s of water is heated from 30°C to 60°C by hot gases which enter at 180°C and leave at 80°C. Make calculations for the mass flow of gases, heat transferred and loss of available energy due to this heat transfer. Take for gases Cp= 1.08 kJ/kg K and ambient temperature= 27°C. 10

   b) Derive an expression of air standard efficiency for Otto cycle. 10

6. a) In an air standard Diesel cycle, the compression ratio is 15 and the fluid properties at the beginning of compression are 100 kPa and 300K. For a peak temperature of 1600K, calculate a) the percentage of stroke at which cut off occurs, b) the cycle efficiency and, c) the work out per kg of air. 10

   b) A steam turbine working on Rankine cycle is supplied with dry saturated steam at 25 bar and the exhaust takes place at 0.2 bar. For a steam flow rate of 10kg/s, determine 1) quality steam at end of expansion, 2) turbine shaft work, 3) power required to drive the pump, 4) work ratio,5) Rankine efficiency. 10

7. a) Draw schematic diagram of regenerative Rankine cycle. Also represent this on T-S diagram. 04

   b) A supersonic plane flies at 2000 km/hr at an altitude of 9 km above sea level in standard atmosphere. If the pressure and density of air at this altitude are stated to be 30 $kN/m^2$ absolute and 0.45$kg/m^3$, make calculations for the pressure, temperature and density at the stagnation point on the nose of the plane. Take R = 287J/kg K and $\gamma$ =1.4. 10

   c) A lump of steel of mass 8 kg at 1000K is dropped in 80 kg of oil at 300K. Make calculations for the entropy change of steel, the oil and the universe. Take specific heats of steel and oil as 0.5 kJ/kg K and 3.5 kJ/kg K, respectively. 06

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