B. MECH ENGG. FIRST YEAR, 2ND SEMESTER EXAMINATION 2017

THERMODYNAMICS

Time: Three hours **Full Marks: 100**

Answer **question No. 1 (Compulsory)** and **any four questions** from the rest

Answer to all parts of a question must be together

NB: Assume any data, if not furnished, consistent with the problem. Use of relevant tables and charts are permitted.

1. a) Compare heat and work highlighting their similarities and differences.
   b) Show the following processes for a pure substance with proper labeling:
   i)) Isothermal process from compressed liquid zone to superheated vapor zone on p-v plane.
   ii) Isobaric process from superheated vapor zone to sub-cooled liquid zone on T-s plane.
   c) Prove that pv^k = constant for an adiabatic process where k is the ratio of the specific heats.
   d) A cyclic engine operating between two thermal reservoirs has a thermal efficiency of 0.5. What is the COP of the same system if reversed to use as a refrigerator ?
   e) Define thermal equilibrium

4+6+5+3+2

2. a) Explain sublimation process with reference to the p-T and T-v diagram.
   b) Explain 'critical point' with proper diagrams.
   c) In the turbine of a gas turbine unit the gases flow through the turbine at 17kg/s and the power developed by the turbine is 14 MW. The specific enthalpies of the gases at inlet and outlet are 1200 kJ/ kg and 360 kJ/ kg respectively with corresponding velocities at 60m/s and 120 m/s. Calculate the rate at which heat transfer takes place from the turbine, Find out the diameter of the inlet pipe if the specific volume at inlet is 0.5 m^3/ kg.

4+4+12

3. a) State the first law of Thermodynamics for a system undergoing a non-cyclic process. Prove that internal energy is a property of the system.
   b) Steam at 0.6 MPa, 200^0 C enters an insulated nozzle with a velocity of 50 m/s. It leaves at a pressure of 0.15 MPa and a velocity of 600 m/s. Determine the final temperature if the steam is superheated in the final state or the quality if it is saturated.

8+12

[Turn over

4. a) Show that no heat engine can have higher efficiency than that of a reversible engine for given two heat reservoirs.

   b) Two Carnot engines A and B are operating in series. a rejecting heat directly to B. Engine A receives 200 KJ at a temperature of 421^0 C. Engine B rejects heat at temperature 4.4^0 C. If the work output of A is twice that of B, find i) intermediate temperature between A and B , ii) efficiency of each engine, iii) heat rejected to the cold sink

8+ 12

5. a) Establish the Maxwell Relationships.

   b) Derive the Clapeyron equation

   c) Explain the isenthalpic expansion of a real gas for different inlet pressure and temperature with the significance of inversion curve.

8+6+6

6 . a) A 1 kg sample of moist air initially at 21^0 C and 1 bar with 70 % relative humidity is cooled to 5^0 C at constant pressure. Determine the initial humidity ratio, dew point temperature and the amount of water that is condensed during the process.

b) Calculate the stoichiometric air-fuel ratio of the combustion of coal of following composition by mass: C 90%, H_2 3%, O_2 2.5%, N_2 1%, S 0.5%, Ash 3%.

10+10

7. Write short notes on any **four (4)**:
   a) Entropy generation
   b) Thermodynamic wet bulb temperature
   c) Throttling process
   d) Carnot cycle
   e) p-v-T surface
   f) Exergy of open system

5 x 4