BACHELOR OF ENGINEERING (CIVIL ENGINEERING) FIRST YEAR FIRST SEMESTER EXAMINATION 2024

Thermodynamics and Heat Power

Time: - 3 hours Full Marks:-100

Answer any five questions

All parts of the same question must be answered together
Data, consistent with the problem may be assumed if necessary

1. Answer the following questions: 20
a) Define the following terms: enthalpy, phase, and entropy.
b) Show that the enthalpy of a fluid before throttling is equal to that after throttling.
c) What do you mean by irreversible process? State causes of irreversibility.
d) Define thermal efficiency of a heat engine cycle. Can this be 100%?

2. a) Derive an expression of cycle efficiency for Diesel cycle with relevant parameters. 10
b) An engine working on the Otto cycle has an air standard cycle efficiency of 56% and rejects 544 kJ/kg of air. The pressure and temperature of air at the beginning of compression are 0.1 MPa and 60^0C respectively. Compute (i) the compression ratio of the engine, (ii) the work done per kg of air, (iii) the pressure and temperature at the end of compression, and (iv) the maximum pressure of the cycle. 10

3. a) Derive an expression of displacement work for a reversible polytropic process (pv^n=*const.*). 6
b) A fluid is 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 $U = 34 + 3.15pV$, where U is in kJ, p in kPa, and V in cubic metre. 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 work other than done on the piston, find the direction and magnitude of the work and heat transfer. 14

4. a) What is steam nozzle? Derive an expression of exit velocity for flow through steam nozzle. 8
b) In a gas turbine unit, the gases flow through the turbine is 15 kg/s and the power developed by the turbine is 12MW. The enthalpies of gases at the inlet and outlet are 1260 kJ/kg and 400 kJ/kg respectively. The velocity of gases at the inlet and outlet are 50 m/s and 110 m/s respectively. Calculate: (i) The rate at which heat is rejected to the turbine, (ii) the area of the inlet pipe given that the specific volume of the gases at the inlet is 0.45 m^3/kg. 12

5. a) Prove that the violation of the Kelvin-Plank statement leads to the violation of the Clausius statement of the 2nd law of thermodynamics. 8
b) A reversible heat engine operates between two reservoirs at temperatures of 600^0C and 40^0C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40^0C and -20^0C. The heat transfer to the heat engine is 2000 kJ and the network output of the combined engine refrigerator plant is 360kJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40^0C. 12

6. a) State and prove the Clausius' theorem. 10

b) 1.0 kg of water at -1°C is brought into contact with a heat reservoir at 100°C. When the water has reached 100°C, find the entropy change of the water, of the reservoir and of the universe. 10

7. Write short note on the followings (***any four***): 20

a) PMM1, b) Steady flow system, c) Carnot cycle, d) Otto cycle, e) Thermodynamic equilibrium.