INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date_____ **FN/AN, Time: 2/3 Hrs., Full Marks** 60 , **Deptt** Mechanical

No. of Students 66 , **Mid/~~End~~ Autumn/~~Spring~~ Semester Examination**

Sub. No. ME 40603 **Sub. Name** Applied Thermofluids - II

4 **Yr. B.Tech.(H) / B.Arch.(H) / M.Sc./M.Tech(Dual), Instruction**

Steam Tables to be Provided

All questions carry equal marks.

1. The efficiency of a Rankine cycle depends on the temperature in the condenser. This raises the question whether better efficiencies can be obtained by locating power plants at places where the ambient temperature is lower. To examine this consider two locations where the ambient temperatures are 20°C and 0°C. Calculate the efficiency of the ideal Rankine cycle with superheat at these two locations. Assume that at each location the temperature in the condenser is 15°C higher than the ambient temperature, the temperature of steam entering the turbine is 450°C and the quality of steam at exit from the turbine is 0.9.

2. A water-tube drum type boiler operates at a pressure of 80 bar. Water enters the riser tubes at a temperature of 285°C. At the top of the riser the void fraction is 0.8. The slip factor is 1.5. What is the quality of steam at riser exit? The riser tubes are 15 m long and of 4 cm internal diameter. If the velocity of water at riser bottom is 1 m/s what are the velocities of steam and water at riser top? At what height from the riser bottom does the water reach saturation temperature? Assume that the rate of heat transfer per unit length can be assumed to be constant over the entire length of the riser tubes. If the temperature of combustion gases outside the riser tubes is 1650°C what is the overall heat transfer coefficient based on inside area of the tubes?

3. In an impulse-reaction turbine write down the expressions for the enthalpy change across the fixed and moving vanes, the shaft work produced and the gross stage efficiency. Assuming similar blade sections for both fixed and moving rows and making suitable assumptions, obtain an expression for the optimum blade speed. In such a turbine the enthalpy drop across any one row of blades is 8 kJ/kg and the outlet angle of the blades with the tangential direction is 20°. Assume that the carry over coefficient ϕ is 0.85 and the nozzle efficiency η_n for any row of blades is 0.95. What is the optimum blade speed? What is the tangential component of absolute velocity at exit from the moving blades? What is the inlet angle of the blades?

4. A mixture of methane and ethane, containing 4 moles of methane for each mole of ethane, is burned with 200 percent theoretical air. How many kgs of air are required for each kg of fuel? Assume atomic weights of hydrogen, carbon, nitrogen and oxygen are 1, 12, 14 and 16. Assume that air can be considered to be a mixture of 21.0% oxygen and 79.0% nitrogen by volume. If the reactants are all at 25°C, assuming that the combustion occurs at constant pressure under adiabatic conditions and that combustion is complete, what is the temperature of the products of combustion? The enthalpy of formation, at 25°C, 100 kPa, of methane, ethane, carbon dioxide and water(vapour) are -74 873, -84 740, -393 522 and -241 826, all in kJ/kmol, in that order. The specific heats at constant pressure of carbon dioxide, water vapour, oxygen and nitrogen are 0.842, 1.872, 0.922 and 1.042, all in kJ/kg-K, in that order and can be assumed to be constant. State any assumptions made.