ME 354 Thermodynamics 2

Final Exam July 1996

Aids allowed: text, 1 page crib sheet, calculator

Time Limit: 3 Hours

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Problem #1 (10 marks)

Carbon dioxide (CO_2) and oxygen (O_2) in a 1:2 molar ratio enter a reactor operating at steady state in separate streams at 1 atm, 700 R and 1 atm, 1000 R, respectively. An equilibrium mixture of CO_2, CO, and O_2 exists at 1 atm. If the *mole fraction* of CO in the exiting mixture is 0.025, determine the rate of heat transfer from the reactor per mole of CO_2 entering.

Problem #2 (10 marks)

Air enters the compressor of a gas turbine at 100 kPa, 300 K, and a volumetric flow rate of 5 m^3/s. The air is compressed in two stages to 1200 kPa, with intercooling to 300 K between the stages at a pressure of 350 kPa. The air is then heated in a combustor such that the turbine inlet temperature is 1400 K. The expansion occurs in two stages, with reheat to 1340 K between the stages at a pressure of 350 kPa. The compressor and turbine stage efficiencies ar 87 and 85%, respectively. Draw a *T-s* diagram locating all state points. Summarize the pressures and temperatures at all state points in a Table. Determine

(a) the thermal efficiency of the cycle

(b) the net power developed, in kW

Note: You may assume that air is a perfect gas with constant specific heats.

Problem #3 (10 marks)

Moist air enters a dehumidifier at 80 $^\circ F$, 1 atm, and ϕ=60% and exits at 58 $^\circ F$, 1 atm, and ϕ=90% with a volumetric flow rate of 10,000 ft^3/min. The stream then mixes adiabatically with a moist air stream at 95 $^\circ F$, 1 atm, and ϕ=40% having a volumetric flow rate of 2000 ft^3/min. A single moist-air stream exists the mixing chamber. Determine at steady state

(a) the rate at which water is removed from the moist air passing through the dehumidifier

(b) the temperature, in $^\circ F$, and the relative humidity of the moist air at the mixing chamber exit

Problem #4 (10 marks)

The figure below provides data for a boiler and air preheater operating at steady state. Methane (CH_4) entering the boiler at 537 R, 1 atm is burned completely with 170% of theoretical air. Ignoring stray heat transfer and kinetic and potential energy effects, determine the temperature of the combustion air entering the boiler from the preheater.