CANKAYA UNIVERSITY

FACULTY OF ENGINEERING AND ARCHITECTURE

MECHANICAL ENGINEERING DEPARTMENT

ME 211 THERMODYNAMICS I

CHAPTER 7 EXAMPLES

1)A system consists of 5 kg of water at 10°C and 1 bar. Determine the exergy, in kJ, if the system is at rest and zero elevation relative to an exergy reference environment for which $T_0 = 20^0 C$ *and* $p_0 = 1 bar$.

2) A rigid, insulated tank contains 0.6 kg of air, initially at 200 kPa, 20°C. The air is stirred by a paddle wheel until its pressure is 250 kPa. Using the ideal gas model with $c_v = 0.72 kJ / kg.K$, determine, in kJ,

(a) the work,

(b) the change in exergy of the air,

(c) the amount of exergy destroyed.

Ignore the effects of motion and gravity, and let $T = 20\,^0C$, $p_0 = 100\,kPa$

3)Two kilograms of water in a piston–cylinder assembly, initially at 2 bars and 120°C, are heated at constant pressure with no internal irreversibilities to a final state where the water is a saturated vapor. For the water as the system, determine the work, the heat transfer, and the amounts of exergy transfer accompanying work and heat transfer, each in kJ. Let $T_0 =$ 20°C, $p_0 =$ 1 bar and ignore the effects of motion and gravity.

4)Steam at $8000\,kPa, 320\,^0C$ enters a valve operating at steady state and undergoes a throttling process. Determine the exit temperature, in ^0C and the exergy destruction rate, in kJ/ kg of steam flowing, for an exit pressure of $4000\,kPa$. Assume $T_0 = 20\,^0C, p_0 = 100\,kPa$

5) At steady state, steam with a mass flow rate of 4.5 kg/s enters a turbine at 430 °C and 4MPa and expands to 400 kPa. The power developed by the turbine is 2126 kW. The steam then passes through a counterflow heat exchanger with a negligible change in pressure, exiting at 430°C. Air enters the heat exchanger in a separate stream at 1.1 bar, 547°C and exits at 1 bar, 327 °C. The effects of motion and gravity can be ignored and there is no significant heat transfer between either component and its surroundings. Determine:

(a) the mass flow rate of air, in kg/s.

(b) the rates of exergy destruction in the turbine and heat exchanger, each in kJ/s.

Let $T_0 = 4\,^0C$ $p_0 = 1 bar$.

6) Steam enters a turbine operating at steady state at $p_1 = 12MPa$, $T_1 = 700\,^0C$ and exits at $p_2 = 0.6\,MPa$. The isentropic turbine efficiency is 88%. Property data are provided in the accompanying table. Stray heat transfer and the effects of motion and gravity are negligible. Let $T_0 = 300\,K, p_0 = 100\,kPa$. Determine

(a) the power developed and the rate of exergy destruction, each in kJ per kg of steam flowing,

(b) the exergetic turbine efficiency.

state	P(MPa)	T (^{0}C)	h(kJ/kg)	s (kJ/kg.K)
Turbine inlet	12	700	3858.4	7.0749
Turbine exit	0.6	($\eta_t = 0.88$)	3017.5	7.2938

7) Hydrogen (H_2) at 25 bar, 450 ^0C enters a turbine and expands to 2 bar, 169 ^0C with a mass flow rate of 0.2 kg/s. The turbine operates at steady state with negligible heat transfer with its surroundings. Assuming the ideal gas model with *k*= 1.37 and ignoring the effects of motion and gravity, determine

(a) the isentropic turbine efficiency.

(b) the exergetic turbine efficiency.

Let T_0 =25°C, $p_0 =$ 1 atm.

8) Refrigerant 134a enters a counter-flow heat exchanger operating at steady state at -20°C and a quality of 35% and exits as saturated vapor at -20°C. Air enters as a separate stream with a mass flow rate of 4 kg/s and is cooled at a constant pressure of 1 bar from 300 K to 260 K. Heat transfer between the heat exchanger and its surroundings can be ignored, as can the effects of motion and gravity.

(a) Sketch the variation of the temperature of each stream with position.

Locate T_0 on the sketch.

b) determine mass flow rate of R134a

(b) Determine the rate of exergy destruction within the heat exchanger, in kW.

(c) Devise and evaluate an exergetic efficiency for the heat exchanger.

Let T_0 = 300 K, p_0 = 1 bar.