Homework #9

MEMS 0051 - Introduction to Thermodynamics

Assigned April 11th, 2020
Due April 18th, 2020

Problem #1

Steam enters a turbine at 6,000 [kPa], 400 °C, 10 [m/s] at a rate of 4,600 [kg/hr]. The turbine produces 1,000 [kW] of mechanical power. The fluid then exits the turbine at 10 [kPa] at 50 [m/s] with a quality of 90%. Calculate the rate of heat transfer between the turbine and surrounding in [kW].

Problem #2

An air compressor draws air at 100 [kPa] and 290 [K] through a 0.1 [m^2] opening at a velocity of 6 [m/s]. The air then exits the compressor at 700 [kPa] and a temperature of 450 [K] with a velocity of 2 [m/s]. The compressor rejects heat to the surroundings at a rate of 180 [kJ/min]. Calculate the necessary power input, in [kW].

Problem #3

Steam enters the turbine at 10 [MPa] and 500 °C and expands to 500 [kPa]. It is then reheated to 450 °C before entering a second turbine, where it expands to 15 [kPa]. Saturated liquid exits the condenser at 15 [kPa]. The net power produced is 1,000 [MW]. If the efficiency of the turbines is 85%, and that of the pump is 95%, determine:

a) The thermal efficiency (net work per heat input)
b) The backwork ratio (work of the pump per compressor)
c) The mass flow rate of steam
d) The rate of heat supplied to the boiler
e) The rate of heat rejected from the condenser

Problem #4

Refrigerant R-134a is the working fluid for a refrigeration cycle. The mass flow rate of the refrigerant is 1 [kg/s]. The compressor has an isentropic efficiency of 95%, and valve operate adiabatically, and can be modeled as a throttle device. The following state data are known.

State 1:	State 2:	State 3:	State 4:
P_1=150 [kPa]	P_2=500 [kPa]	x_3=0	T_4=-10 °C
T_1=-10 °C			x_4=0.5

Determine:

a) The coefficient of performance of this cycle.
b) The rate of entropy generation through the expansion valve (i.e. throttle).