CANKAYA UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL ENGINEERING DEPARTMENT

ME 211 THERMODYNAMICS I

CHAPTER 4 EXAMPLES

1) Air enters one-inlet, one-exit control volume at 8 bar, 600 K and 40 m/s through a flow area of 20 cm^2. At the exit, the pressure is 2 bar, the temperature is 400 K and the velocity is 350 m/s. The air behaves as ideal gas. For steady-state operation, determine;
   a) mass flow rate, in kg/s,
   b) the exit flow area, in cm^2

2) R134a at 700 kPa and 100 °C enters an adiabatic nozzle with a velocity of 20 m/s and leaves at 320 kPa and 30 °C. Find the exit velocity and the ratio of the inlet to exit areas.

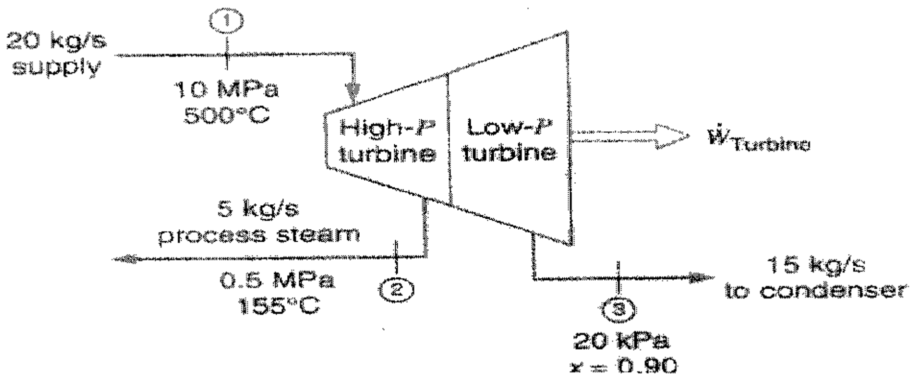
3) Air enters an insulated diffuser operating at steady state with a pressure of 1 bar, a temperature of 300 K and a velocity of 250 m/s. At the exit, the pressure is 1.13 bar and the velocity is 140 m/s. Potential energy effects can be neglected. Using the ideal gas model,
   a) the ratio of exit flow area to the inlet flow area
   b) the exit temperature in K

4) Air is to be compressed from 120 kPa and 310 K to 700 kPa and 430 K. a heat loss of 20 kJ/kg occurs during the compression. $\Delta ke=0$. The mass flow rate is 90 kg/min. Find the required power input.

5) Air expands through a turbine from 10 bar, 900 K to 1 bar, 500 K. The inlet velocity is small compared to exit velocity of 100 m/s. The turbine operates at steady-state and develops an output of 3200 kW. Heat transfer between the turbine and its surroundings and potential energy effects are negligible. Calculate the mass flow rate of air in kg/s and the exit area in m^2.

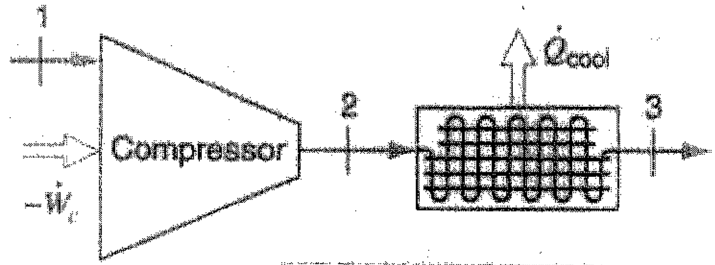
6)

Cogeneration is often used where a steam supply is needed for industrial process energy. Assume a supply of 5 kg/s steam at 0.5 MPa is needed. Rather than generating this from a pump and boiler, the setup in figure is used to extract the supply from the high-pressure turbine. Find the power the turbine now cogenerates in this process.

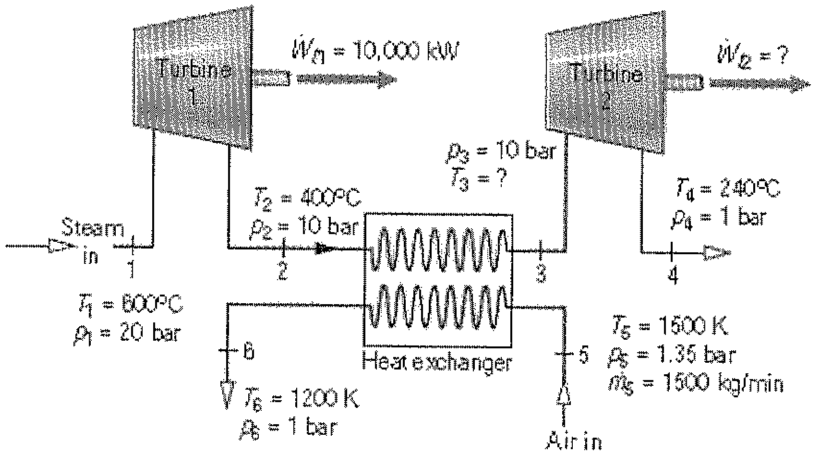


7)

The compressor in a plant (see figure) receives carbon dioxide at 100 kPa, 280 K, with a low velocity. At the compressor discharge, the carbon dioxide exits at 1100 kPa, 500 K, with velocity of 25 m/s and then flows into a constant-pressure aftercooler (heat exchanger) where it is cooled down to 350 K. The power input to the compressor is 50 kW. Determine the heat transfer rate in the aftercooler.



8) Separate streams of steam and air flow through the turbine and heat exchanger arrangement shown in Fig.P4.108. Steady-state operating data are provided on the figure. Heat transfer with the surroundings can be neglected, as can all kinetic and potential energy effects. Determine:
(a) $T3$, in K,
(b) the power output of the second turbine, in kW.



9)A pump steadily delivers water through a hose terminated by nozzle. The exit of the nozzle has a diameter of 2.5 cm and is located 4 m above the pump inlet pipe, which has a diameter of 5 cm. The pressure is equal to 1 bar at both the inlet and the exit, and the temperature is constant at 20°C. The magnitude of the power input required by the pump is 8.6 kW and the acceleration of gravity is $g=9.81\ m/s^2$. Determine the mass flow rate delivered by the pump in kg/s.

10)R-134-a is throttled from 800 kPa and 25°C to a final temperature of -20 °C. Find the pressure and internal energy of the refrigerant at the final state.

11)Ammonia enters a heat exchanger operating at steady-state as superheated vapor at 14 bar, 60°C, where it is cooled and condensed to saturated liquid at 14 bar. The mass flow rate of the refrigerant is 450 kg/h. a separate stream of air enters the heat exchanger at 17°C, 1 bar and exits at 42°C, 1 bar. Ignoring heat transfer from the outside of the heat exchanger and neglecting kinetic and potential energy effects, determine mass flow rate of the air, in kg/min.

12)The cooling coil of an air-conditioning system is a heat exchanger in which air passes over tubes through which R-22 flows. Air enters with a volumetric flow rate of 40 m^3/min at 27°C, 1.1 bar, and exits at 15°C, 1 bar. Refrigerant enters the tubes at 7 bar with a quality of 16% and exits at 7 bar, 15°C. Ignoring heat transfer from the outside of the heat exchanger and neglecting kinetic and potential energy effects, determine at steady-state;

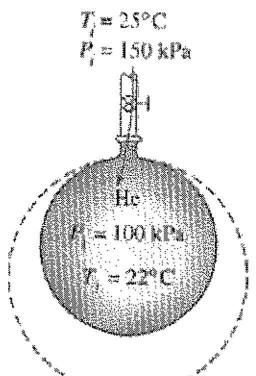
a) the mass flow rate of refrigerant, in kg/min
b) the rate of energy transfer, in kJ/min, from the air to the refrigerant

13) A rigid insulated tank which is initially evacuated is connected through a valve to a supply line that carries steam at 1 MPa and 300 ^{0}C .Now the valve is opened and steam is allowed to flow slowly into the tank until the pressure reaches 1 MPa at which point the valve is colosed. Determine the final temperature inside the tank.

14) A 0.2 m^3 tank initially contains R-134a at 8°C and 60% quality. The valve to a supply line is opened and refrigerant at 1 MPa and 120°C is allowed to enter the tank until the pressure reaches 800 kPa, when the valve is closed. At this point, the refrigerant in the tank is saturated vapor. Find:

a) the final temperature in the tank,
b) the mass of refrigerant that has entered the tank
c) the heat transfer between the system and surroundings

15)A balloon initially contains 65 m^3 of helium gas at atmospheric conditions of 100 kPa and 22°C. Now helium from a large tank at 150 kPa and 25°C is added to the balloon until the pressure in the balloon is 150 kPa. During the filling process the volume varies linearly with pressure. If not heat transfer takes place during the process, find the final temperature in the balloon.



16) A 0.2 m^3 tank initially contains R-134a at 8°C and 60% quality.The valve to a supply line is opened and refrigerant at 1 MPa and 102°C is allowed to enter the tank until the pressure reaches 800kPa, when the valve is closed.At this point,the refrigerant in the tank is saturated vapor. Find

a) the final temperature in the tank,
b) the mass of refrigerant that has entered the tank
c) the heat transfer between the system and surroundings