

4-65 **EES** Steam at 3 MPa and 400°C enters an adiabatic nozzle steadily with a velocity of 40 m/s and leaves at 2.5 MPa and 300 m/s. Determine (a) the exit temperature and (b) the ratio of the inlet to exit area A_1/A_2 .

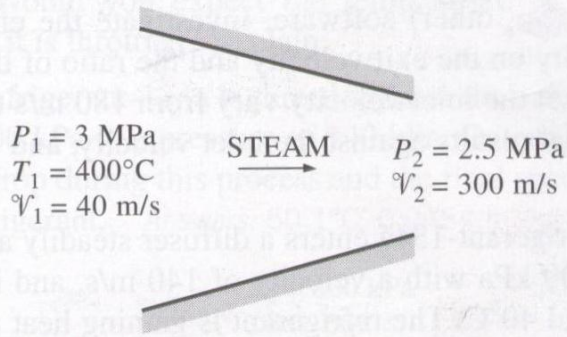


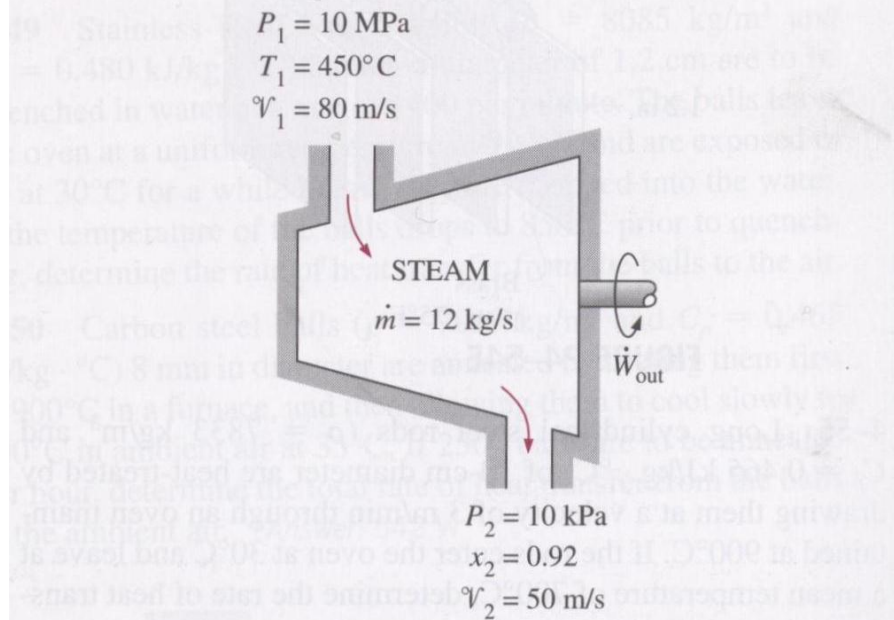
FIGURE P4-65

4-66 Air at 600 kPa and 500 K enters an adiabatic nozzle that has an inlet-to-exit area ratio of 2:1 with a velocity of 120 m/s and leaves with a velocity of 380 m/s. Determine (a) the exit temperature and (b) the exit pressure of the air.

Answers: (a) 436.5 K, (b) 330.8 kPa

4-79 Steam flows steadily through an adiabatic turbine. The inlet conditions of the steam are 10 MPa, 450°C, and 80 m/s, and the exit conditions are 10 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 12 kg/s. Determine (a) the change in kinetic energy, (b) the power output, and (c) the turbine inlet area.

Answers: (a) -1.95 kJ/kg, (b) 10.2 MW, (c) 0.00446 m²



4-81 Steam enters an adiabatic turbine at 10 MPa and 400°C and leaves at 20 kPa with a quality of 90 percent. Neglecting the changes in kinetic and potential energies, determine the mass flow rate required for a power output of 5 MW.

Answer: 6.919 kg/s

4-86 Refrigerant-134a enters an adiabatic compressor as saturated vapor at -20°C and leaves at 0.7 MPa and 70°C . The mass flow rate of the refrigerant is 1.2 kg/s. Determine (a) the power input to the compressor and (b) the volume flow rate of the refrigerant at the compressor inlet.

4-88E Air is compressed from 14.7 psia and 60°F to a pressure of 150 psia while being cooled at a rate of 10 Btu/lbm by circulating water through the compressor casing. The volume flow rate of the air at the inlet conditions is 5000 ft³/min, and the power input to the compressor is 700 hp. Determine (a) the mass flow rate of the air and (b) the temperature at the compressor exit. *Answers: (a) 6.36 lbm/s, (b) 801 R*

4-94C The valve of an initially evacuated, adiabatic rigid tank is opened, and air at 30°C flows in. When the pressure inside the tank reaches atmospheric pressure, the air temperature in the tank increases to 150°C. Explain what caused this temperature rise.

4-95C When a can that contains a refrigerant at 500 kPa and 25°C is slightly opened and refrigerant is allowed to escape, a layer of ice forms outside the can. Explain how that happens.

4-96C The valve of an insulated rigid vessel containing air at a high pressure is slightly opened, allowing some air to escape. Will the temperature of air in the tank change during this process? How?

4-96 Refrigerant-134a is throttled from the saturated liquid state at 800 kPa to a pressure of 140 kPa. Determine the temperature drop during this process and the final specific volume of the refrigerant. *Answers: 50.1°C, 0.0454 m³/kg*

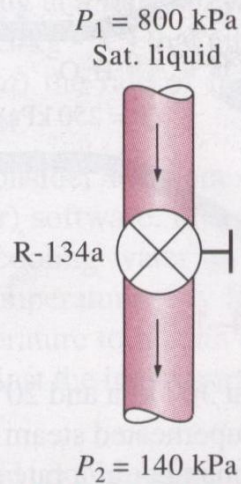


FIGURE P4-96

4-97 **EES** Refrigerant-134a at 800 kPa and 25°C is throttled to a temperature of -20°C . Determine the pressure and the internal energy of the refrigerant at the final state. *Answers: 133 kPa, 78.8 kJ/kg*

4-104 A hot-water stream at 80°C enters a mixing chamber with a mass flow rate of 0.5 kg/s where it is mixed with a stream of cold water at 20°C . If it is desired that the mixture leave the chamber at 42°C , determine the mass flow rate of the cold-water stream. Assume all the streams are at a pressure of 250 kPa . *Answer: 0.864 kg/s*

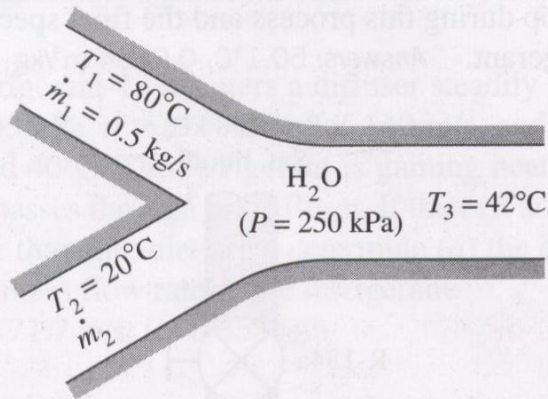


FIGURE P4-104

4-112 Refrigerant-134a at 800 kPa , 70°C , and 8 kg/min is cooled by water in a condenser until it exists as a saturated liquid at the same pressure. The cooling water enters the condenser at 300 kPa and 15°C and leaves at 30°C at the same pressure. Determine the mass flow rate of the cooling water required to cool the refrigerant. *Answer: 27.0 kg/min*

4-114 Steam enters the condenser of a steam power plant at 20 kPa and a quality of 95 percent with a mass flow rate of 20,000 kg/h. It is to be cooled by water from a nearby river by circulating the water through the tubes within the condenser. To prevent thermal pollution, the river water is not allowed to experience a temperature rise above 10°C. If the steam is to leave the condenser as saturated liquid at 20 kPa, determine the mass flow rate of the cooling water required.

Answer: 17,866 kg/min

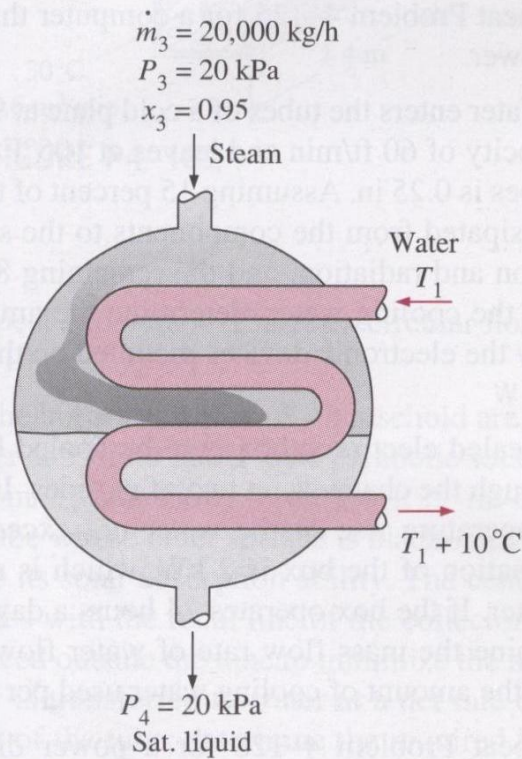


FIGURE P4-114

4-124E Steam is to be condensed on the shell side of a heat exchanger at 90°F. Cooling water enters the tubes at 60°F at a rate of 115.3 lbm/s and leaves at 73°F. Assuming the heat exchanger to be well-insulated, determine the rate of heat transfer in the heat exchanger and the rate of condensation of the steam.

4-141 A hair dryer is basically a duct in which a few layers of electric resistors are placed. A small fan pulls the air in and forces it through the resistors where it is heated. Air enters a 1200-W hair dryer at 100 kPa and 22°C and leaves at 47°C. The cross-sectional area of the hair dryer at the exit is 60 cm². Neglecting the power consumed by the fan and the heat losses through the walls of the hair dryer, determine (a) the volume flow rate of air at the inlet and (b) the velocity of the air at the exit. *Answers: (a) 0.0404 m³/s, (b) 7.31 m/s*

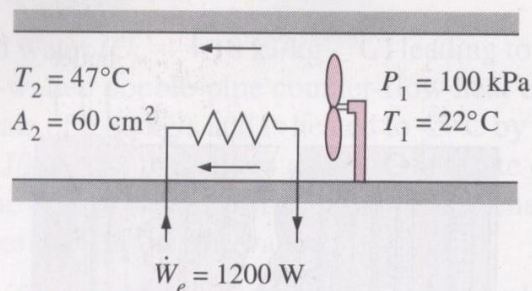


FIGURE P4-141

4-144E Air enters the duct of an air-conditioning system at 15 psia and 50°F at a volume flow rate of 450 ft³/min. The diameter of the duct is 10 in., and heat is transferred to the air in the duct from the surroundings at a rate of 2 Btu/s. Determine (a) the velocity of the air at the duct inlet and (b) the temperature of the air at the exit.

4-149 A 2-m³ rigid tank initially contains air at 100 kPa and 22°C. The tank is connected to a supply line through a valve. Air is flowing in the supply line at 600 kPa and 22°C. The valve is opened, and air is allowed to enter the tank until the pressure in the tank reaches the line pressure, at which point the valve is closed. A thermometer placed in the tank indicates that the air temperature at the final state is 77°C. Determine (a) the mass of air that has entered the tank and (b) the amount of heat transfer. *Answers: (a) 9.58 kg, (b) $Q_{out} = 339$ kJ*

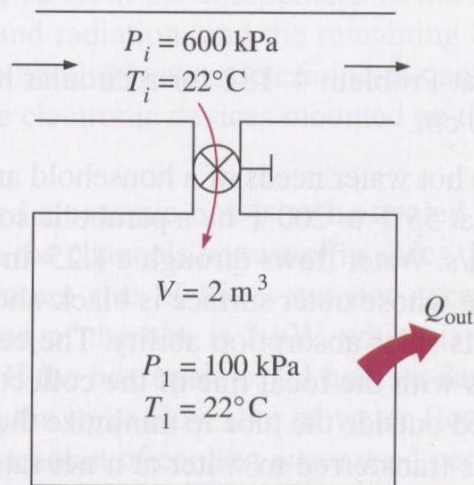


FIGURE P4-149

4-150 A 0.2-m³ rigid tank initially contains refrigerant-134a at 8°C. At this state, 60 percent of the mass is in the vapor phase, and the rest is in the liquid phase. The tank is connected by a valve to a supply line where refrigerant at 1 MPa and 120°C flows steadily. Now the valve is opened slightly, and the refrigerant is allowed to enter the tank. When the pressure in the tank reaches 800 kPa, the entire refrigerant in the tank exists in the vapor phase only. At this point the valve is closed. Determine (a) the final temperature in the tank, (b) the mass of refrigerant that has entered the tank, and (c) the heat transfer between the system and the surroundings.

4-151E A 4-ft³ rigid tank initially contains saturated water vapor at 250°F. The tank is connected by a valve to a supply line that carries steam at 160 psia and 400°F. Now the valve is opened, and steam is allowed to enter the tank. Heat transfer takes place with the surroundings such that the temperature in the tank remains constant at 250°F at all times. The valve is closed when it is observed that one-half of the volume of the tank is occupied by liquid water. Find (a) the final pressure in the tank, (b) the amount of steam that has entered the tank, and (c) the amount of heat transfer.

Answers: (a) 29.82 psia, (b) 117.5 lbm, (c) 117,540 Btu

4-153 An insulated, vertical piston-cylinder device initially contains 10 kg of water, 8 kg of which is in the vapor phase. The mass of the piston is such that it maintains a constant pressure of 300 kPa inside the cylinder. Now steam at 0.5 MPa and 350°C is allowed to enter the cylinder from a supply line until all the liquid in the cylinder has vaporized. Determine (a) the final temperature in the cylinder and (b) the mass of the steam that has entered. *Answers: (a) 133.6°C, (b) 9.78 kg*

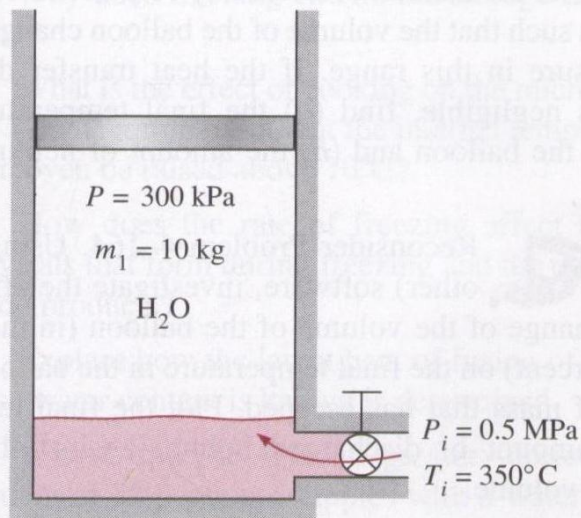


FIGURE P4-153

4-155 A 0.3-m³ rigid tank is filled with saturated liquid water at 200°C. A valve at the bottom of the tank is opened, and liquid is withdrawn from the tank. Heat is transferred to the water such that the temperature in the tank remains constant. Determine the amount of heat that must be transferred by the time one-half of the total mass has been withdrawn.

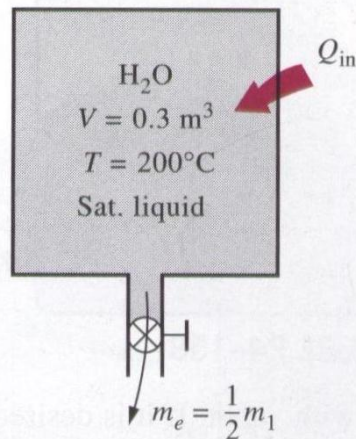


FIGURE P4-155

4-157E A 4-ft³ rigid tank contains saturated refrigerant-134a at 100 psia. Initially, 20 percent of the volume is occupied by liquid and the rest by vapor. A valve at the top of the tank is now opened, and vapor is allowed to escape slowly from the tank. Heat is transferred to the refrigerant such that the pressure inside the tank remains constant. The valve is closed when the last drop of liquid in the tank is vaporized. Determine the total heat transfer for this process.

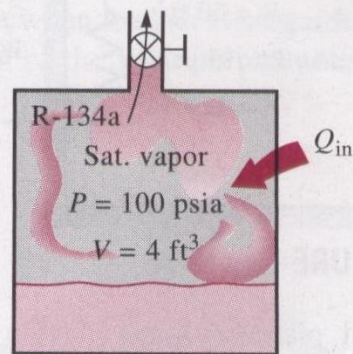


FIGURE P4-157E

4-159 A 4-L pressure cooker has an operating pressure of 175 kPa. Initially, one-half of the volume is filled with liquid

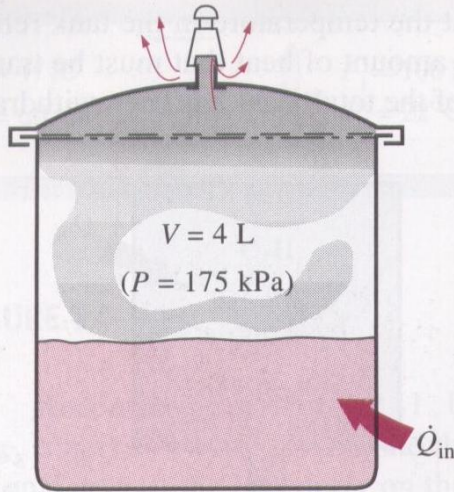


FIGURE P4-159

and the other half with vapor. If it is desired that the pressure cooker not run out of liquid water for 1 h, determine the highest rate of heat transfer allowed.

4-161E An insulated 60-ft³ rigid tank contains air at 75 psia and 120°F. A valve connected to the tank is now opened, and air is allowed to escape until the pressure inside drops to 30 psia. The air temperature during this process is maintained constant by an electric resistance heater placed in the tank. Determine the electrical work done during this process.

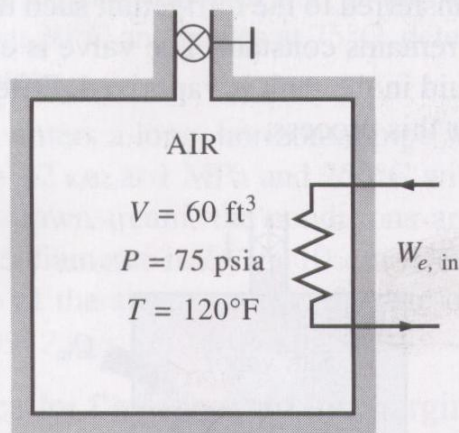


FIGURE P4-161E