Indian Institute of Technology Kanpur
ESO 201 A: Thermodynamics
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Tutorial- 9

Q.8-18

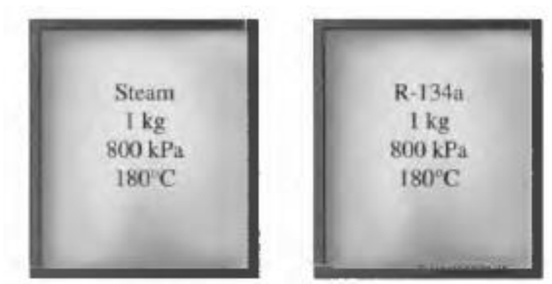
A heat engine that receives heat from a furnace at 1200˚C and rejects waste heat to a river at 20˚C has a thermal efficiency of 40 percent. Determine the second-law efficiency of this power plant.

Q.8-23

A house that is losing heat at a rate of 50,000 kJ/h when the outside temperature drops to 4°C is to be heated by electric resistance heaters. If the house is to be maintained at 25°C at all times, determine the reversible work input for this process and the irreversibility.

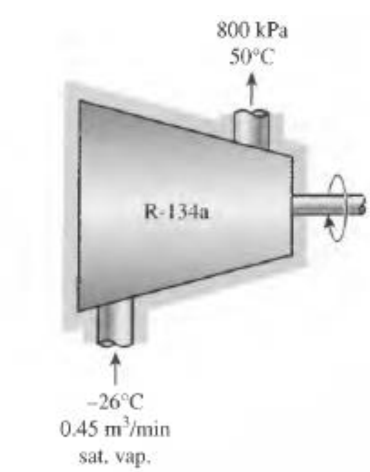
Q.8-31

Which has the capability to produce the most work in a closed system—1 kg of steam at 800 kPa and 180˚C or 1 kg of R-134a at 800 kPa and 180˚C ? Take T_0 = 25˚C and P_0 =100 kPa.



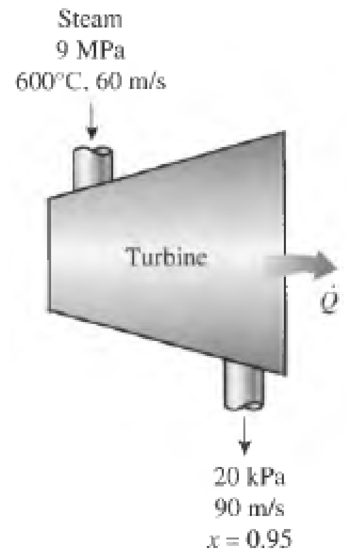
Q.8-66

Refrigerant-134a enters an adiabatic compressor at -26˚C as a saturated vapor at a rate of 0.45 m^3/min and leaves at 800 kPa and 50˚C. Determine *(a)* the power input to the compressor, (*b*) the isentropic efficiency of the compressor, and (c) the rate of exergy destruction and the second-law efficiency of the compressor. Take T_0 = 27˚C.



Q.8-90

Steam enters a turbine at 9 MPa, 600˚C, and 60 m/s and leaves at 20 kPa and 90 m/s with a moisture content of 5percent. The turbine is not adequately insulated and it estimated that heat is lost from the turbine at a rate of 220 kW. The power output of the turbine is 4.5 MW. Assuming the surroundings to be at 25˚C, determine *(a)* the reversible power output of the turbine, *(b)* the exergy destroyed within the turbine, and (c) the second-law efficiency of the turbine.*(d)* Also, estimate the possible increase in the power output of the turbine if the turbine were perfectly insulated.



Homework-9

Q 8-19

Consider a thermal energy reservoir at 1500 K that can supply heat at a rate of 150,000 kJ/h. Determine the exergy of this supplied energy, assuming an environmental temperature of 25°C.

Q 8-36

An insulated piston-cylinder device contains 0.8 L of saturated liquid water at a constant pressure of 120 kPa. An electric resistance heater inside the cylinder is turned on, and electrical work is done on the water in the amount of 1400 kJ. Assuming the surroundings to be at 25°C and 100 kPa, determine *(a)* the minimum work with which this process could be accomplished and *(b)* the exergy destroyed during this process.

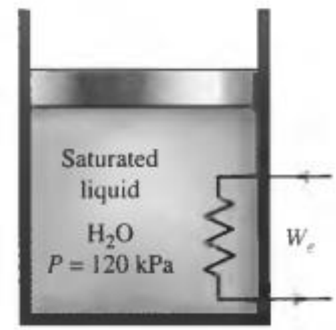


FIGURE P8–36

Q 8-40

A piston-cylinder device initially contains 2 L of air at100 kPa and 25°C. Air is now compressed to a final state of600 kPa and 150°C. The useful work input is 1.2 kJ. Assuming the surroundings are at 100 kPa and 25°C, determine *(a)* the exergy of the air at the initial and the final states, (*b*) the minimum work that must be supplied to accomplish this compression process, and (c) the second-law efficiency of this process.

Q 8-45

An iron block of unknown mass at 85°C is dropped into an insulated tank that contains 100 L of water at 20°C.At the same time, a paddle wheel driven by a 200-W motor is activated to stir the water. It is observed that thermal equilibrium is established after 20 min with a final temperature of24°C. Assuming the surroundings to be at 20°C, determine *(a)* the mass of the iron block and (*b*) the exergy destroyed during this process.

Q 8-61

Steam enters an adiabatic turbine at 6 MPa, 600°C, and 80 m/s and leaves at 50 kPa, 100°C, and 140 m/s. If the power output of the turbine is 5 MW, determine *(a)* the reversible power output and (*b*) the second-law efficiency of the turbine. Assume the surroundings to be at 25°C.

Q 8-86

Liquid water at 200 kPa and 15°C is heated in a chamber by mixing it with superheated steam at 200 kPa and200°C. Liquid water enters the mixing chamber at a rate of4 kg/s, and the chamber is estimated to lose heat to the surrounding air at 25°C at a rate of 600 kJ/min. If the mixture leaves the mixing chamber at 200 kPa and 80°C, determine *(a)* the mass flow rate of the superheated steam and (*b*) the wasted work potential during this mixing process.

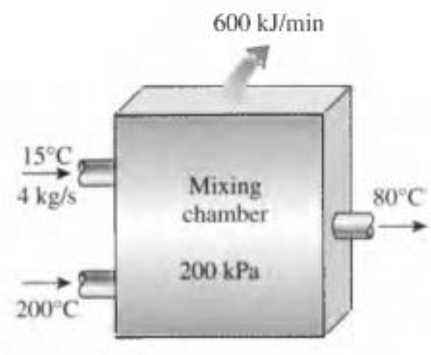


FIGURE P8–86

Q 8-92

Liquid water at 15°C is heated in a chamber by mixing it with saturated steam. Liquid water enters the chamber at the steam pressure at a rate of 4.6 kg/s and the saturated steam enters at a rate of 0.23 kg/s. The mixture leaves the mixing chamber as a liquid at 45°C. If the surroundings are at 15°C, determine *(a)* the temperature of saturated steam entering the chamber, *(b)* the exergy destruction during this mixing process, and (c) the second-law efficiency of the mixing chamber.

FIGURE P8–92