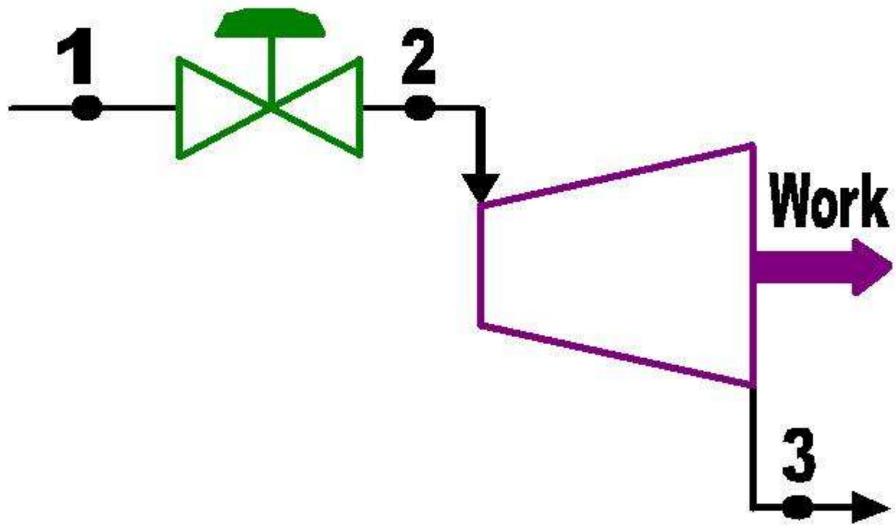
Thermodynamics: Homework A – Set 6
Jennifer West (2004)

Problem 1



Consider the process shown. The steam line conditions at piont 1 are 2 MPa, 400 °C. The pressure at point 2 is 1.5 MPa. The turbine exhaust is at 100 kPa, 100 °C. The steam flow is **M**kg/s, and the turbine is well insulated.

M = 100 kg/s

Question 1 of 4:
What is the specific enthalpy of the stream at point 3?

A. 419.04 kJ/kg
B. 2676.1 kJ/kg
C. 2257.0 kJ/kg
D. 2676.2 kJ/kg
E. None of the above

Question 2 of 4:
What is the net work output of the turbine in MW?

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Question 3 of 4:
What is the turbine efficiency, expressed as a percentage?

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Question 4 of 4:
Assume that the turbine is adiabatic and reversible and that the conditions at points 1 and 2 remain unchanged. What would have to be the discharge pressure from the turbine to produce the same amount of work as in Question 2?

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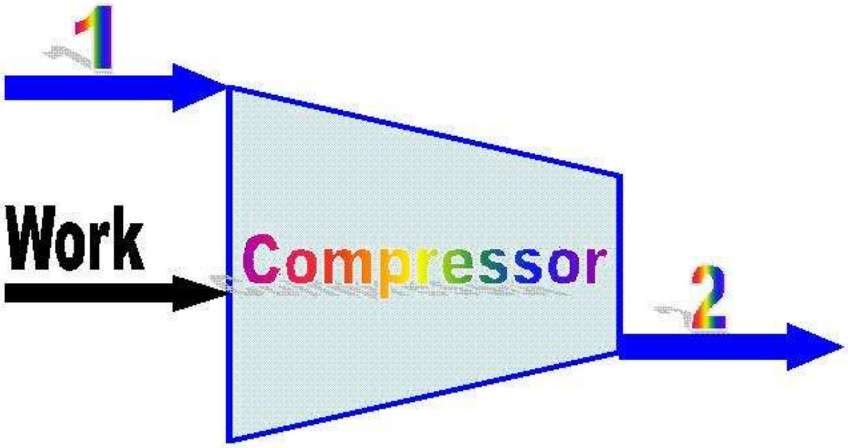
Problem 2



Refrigerant-22 enters a well insulated compressor as saturated vapor at -4 °C and exits at 8 bars. The mass flow rate is **M** kg/s.
M = 1 kg/s

Question 1 of 3:
What is the outlet temperature, in ^oC?

A. -4^oC
B. 40 ^oC
C. 13.54 ^oC
D. -21.17 ^oC
E. 25.56 ^oC

Question 2 of 3:
What is the minimum work required for the process in kW?

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Question 3 of 3:
If the refrigerant exits at 40^oC, at the exit pressure of 8 bar, determine the compressor efficiency, expressed as a percentage.

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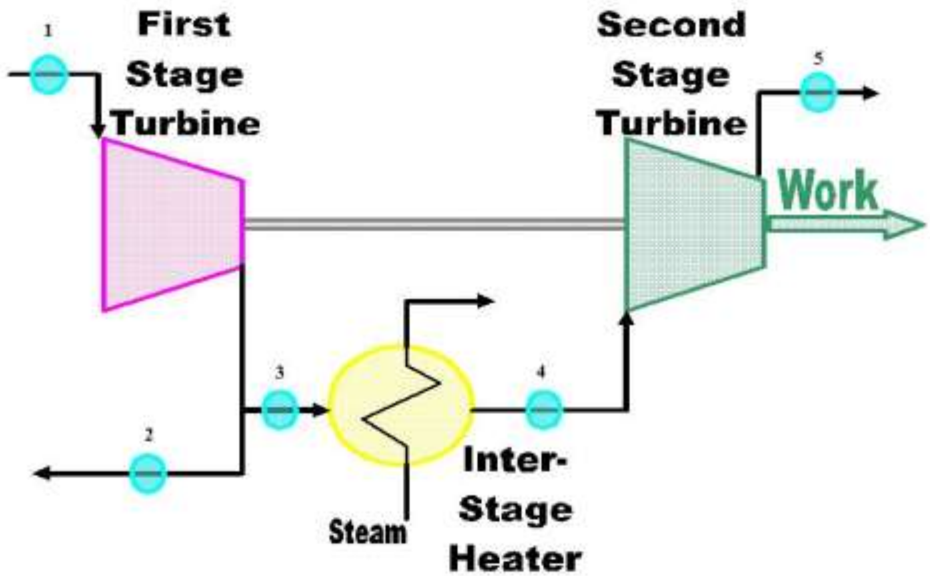
Problem 3



Consider the two-stage steam turbine with interstage heating shown in the figure. Assume a constant pipe diameter in the heater and assume that the efficiency of each stage is **n** %.

Additional Stream information is:

P1 = 24 MPa   P2 = 1.5 MPa P4 = 1.5 MPa P5 = 30 kPa
T1 = 600 C   T4 = 360 C
m1 = 12 kg/s   m2 = 2 kg/s

(Note that m is for mass flow rate!)

N = 80 %

Question 1 of 3:
What is the specific enthalpy of state 4?

A. 2589 kJ/kg
B. 3169.2 kJ/kg
C. 3500 kJ/kg
D. 2845.2 kJ/kg
E. 3694.1 kJ/kg

Question 2 of 3:
What is the rate of heat transfer in the interstage heater, in kJ/s?

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Question 3 of 3:
What I the power for the two-stage turbine, in MW?

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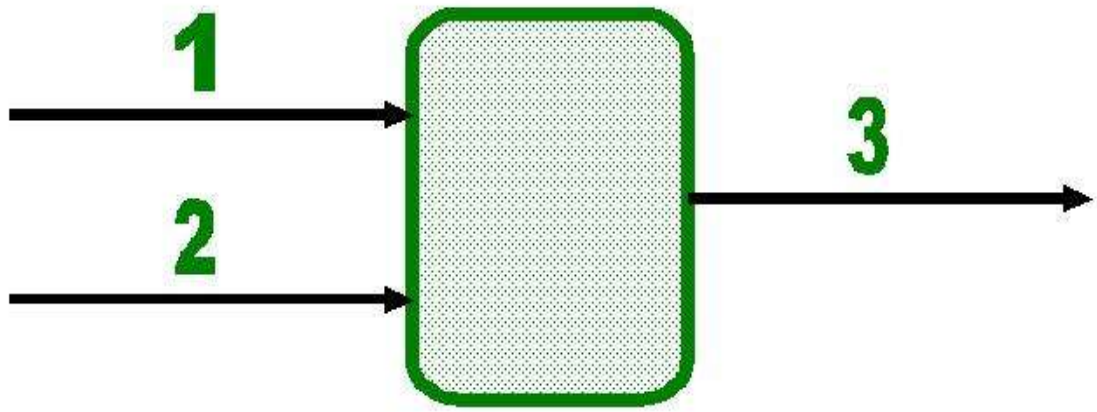
Problem 4



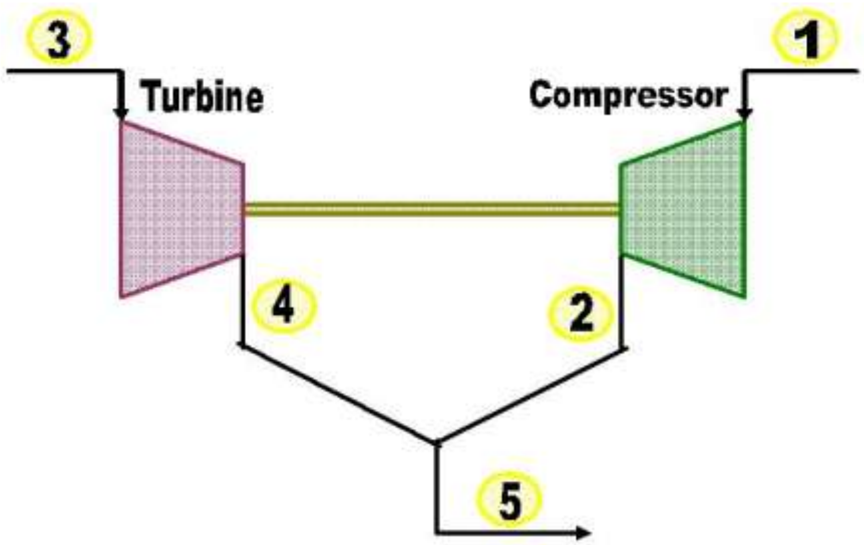
One type of feedwater heater for preheating the water before entering a boiler operates on the principle of mixing the water with steam. You may assume the heater is well insulated. Assume that m3 is 2kg. The properties of the states are as specified:

State 1	***State 2***	***State 3***
Water	Steam	Water
P = 800 kPa	P = 800 kPa	P = 800 kPa
T = 38 C	x = 0.9	T = 150 C

Question 1 of 1:
Is this process possible?

A. Yes
B. No

Problem 5



Consider the process shown. The turbine produces just enough power to drive the compressor, and both exit streams then mix together. The compressor has an efficiency of 70%. The turbine has an efficiency of **n** %. Stream 3 of refrigerant 134a enters the turbine at 100 C, x = 1.0 (saturated). Refrigerant 134a enters the compressor in stream 1 at -20 C, x = 1.0 (saturated). Also note that P2 = P4 = P5 = 1.0 MPa.

n = 70%

Question 1 of 2:
What is the Specific enthalpy of the stream at point 3?

A. 259.13 kJ/kg
B. 235.31 kJ/kg
C. 357.28 kJ/kg
D. 102.23 kJ/kg
E. 615.20 kJ/kg

Question 2 of 2:
What is the ratio of the mass flow rate of stream 3 to the mass flow rate of stream 1 (m3/m1)?

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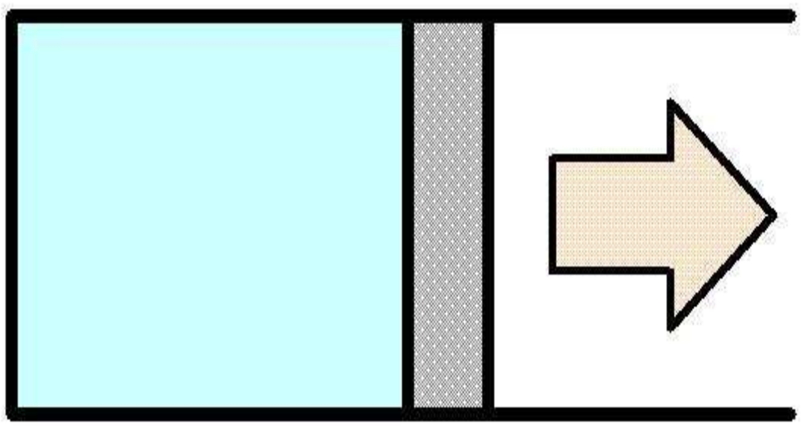
Problem 6:

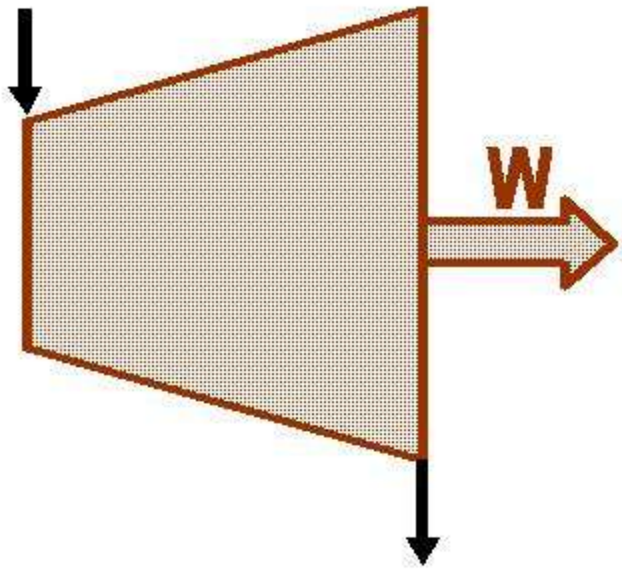


A system consisting of 10 kg of refrigerant 134a is initially at 100 °C, 70% quality. This system then expands to a pressure of 200 kPa as a result of receiving 220 kJ of heat transfer from a large source at 110 °C. It is claimed that the system does 80 kJ of work on its surroundings during this process.

Question 1 of 1:
Is this claim possible, and if so what is the change in specific entropy for system?

A. Yes, 0.3164 kJ/(kg*K)
B. Yes, -0.9156 kJ/(kg*K)
C. Yes, -0.1952 kJ/(kg*K)
D. No, -0.6971 kJ/(kg*K)
E. No, -0.9156 kJ/(kg*K)

Problem 7



Air enters an adiabatic gas turbine at 1590 °F, 40 psia and leaves at 15 psia. The turbine efficiency is 80 % and the mass flow rate is **M** lbm/h.

M = 2500 lbm/h

Question 1 of 3:
What is the specific enthalpy of the initial state, in Btu/lbm?

A. 205.5 Btu/lbm
B. 618.3 Btu/lbm
C. 386.7 Btu/lbm
D. 518.61 Btu/lbm
E. 107.34 Btu/lbm

Question 2 of 3:
What is the work produced, in hp?

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Question 3 of 3:
What is the exit temperature, in ^oF?

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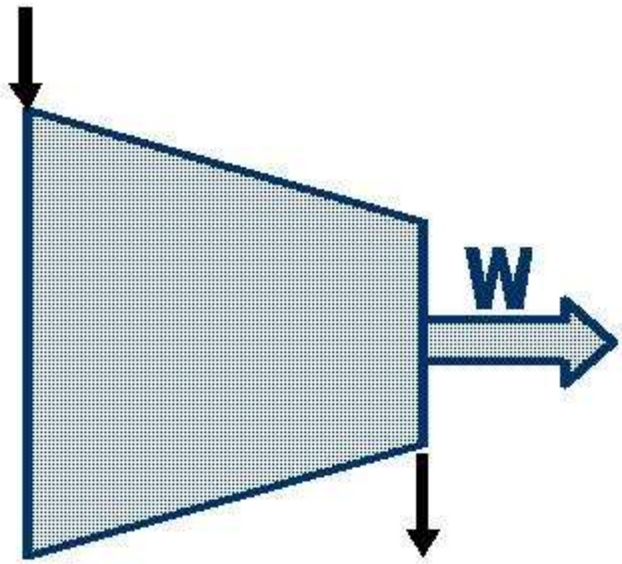
Problem 8



M lbm/min of ethylene oxide is to be compressed from 70 °F and 1 atm to 250 psia. The compressor has an efficiency of 75%. The molar heat capacity of ethylene oxide is given by:

Cp = 10.03 + 0.0184*T

where Cp [=] Btu/(lbmole°F) and T [=] °F*

M = 1 lbm/min

Question 1 of 2:
What is the initial pressure of the system?

A. 40.3 psia
B. 250 psia
C. 131.2 psia
D. 1 psia
E. None of the above

Question 2 of 2:
What is the horsepower required for this process?

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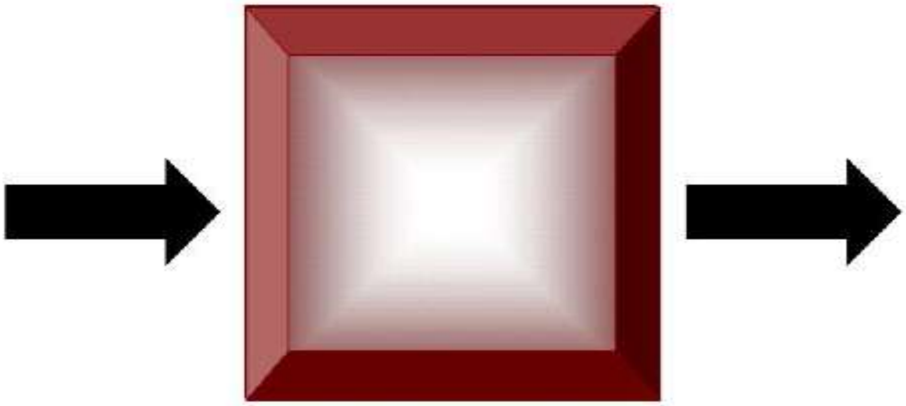
Problem 9



A friend claims that he has invented a flow device to increase the superheat of the steam and solicits your financial backing. He is secretive about details but boasts that he can feed steam at 20 psia, 250 °F and obtain steam at 450 °F, 1 atm. The device also yields liquid water at 212 °F, 1 atm. It receives no additional heat or work from the surroundings, but heat losses may be anticipated. The ratio of product steam to product water is 10:1.

Question 1 of 2
Will you invest money, and why or why not?

A. Yes, minimal heat losses occur
B. No, minimal heat losses occur
C. Yes, heat must be input
D. No, heat must be input
E. Yes, minimal work is required

Question 2 of 2:
How much heat, if any, does this process require lb of stream fed?

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