THERMODYNAMICS

Problem 1

Use the steam tables to compare the heats of vaporization at 0.1, 100, and 10000 kPa. Compare the saturated liquid specific volumes at these pressures. What do you conclude about the influence of pressure on these properties?

****

Problem 2

A new inert gas appears to be well-suited for converting thermal energy from the exhaust heat of an engine manifold into mechanical energy via an Erickson engine. In order to design the cycle you need to determine the specific heats, the ideal gas constant, and the entropy (all as a function of temperature) of this gas. The gas can be assumed to behave as an ideal gas. Design a simple experiment which will, with accompanying analysis, provide the necessary property data.

****

Problem 3 (ME405f15q2)

Air at 60 °C and 700 kPa is confined in an uninsulated 0.3 m^3 vessel. A propeller is driven inside the vessel by a 50-W electric motor. After a period of 1 hour the air temperature dropped to 40 °C. Find the heat transfer in kJ per hour.

Answer: Q = - 211.6 kJ

****

Problem 4

Ten kilograms of compressed air is stored in a tank at 250 kPa and 50 °C. The tank is heated to bring the air temperature to 200 °C. What is the final tank pressure, and how much heat was added?

Answer: P_2 = 366 kPa; Q = 1089.5 kJ

****

Problem 5

As a new engineer, you are given the task of determining the mechanical efficiency of a pump driven by an electric motor. The test setup has an inlet and outlet diameter of 8 cm and 12 cm, respectively. The test fluid is an oil having a density of 800 kg/m^3. At a flow rate of 0.15 m^3/s, the pressure rise across the pump is 600 kPa and the motor (90 % efficient) draws 35 kW of electric power. Is the instrumentation sufficient to determine the mechanical efficiency of the pump? If so, what is the mechanical efficiency of the pump? If not, what additional information is required?

Answer: η_P = 35 %

****

Problem 6

An inventor claims to have built an engine that operates on a cycle, receives 1000 kJ at 500 °C, produces work, and rejects 350 kJ at 50 °C. Is this claim valid? Why or Why not?

Answer: No.

****

Problem 7

An ideal gas cycle is composed of four processes with air as the working fluid:

1-2: Isentropic compression from 100 kPa and 27 °C to 1 MPa.

2-3: Isobaric heat addition of 2800 kJ/kg.

3-4: Isochoric heat rejection to 100 kPa.

4-1: Isobaric heat rejection to state (1).

(a) Show the cycle on a P-v and T-s diagram.

(b) Calculate the maximum temperature in the cycle.

(c) Calculate the thermal efficiency.

Assume the specific heats are constant at the room temperature value.

Answer: T_{max} = 3360 K: η_{th} = 21 %

****

Problem 8

Air enters a wind tunnel nozzle at 90 °C, 250 kPa, and a velocity of 40 m/s. The entrance area is 3 m^2. If the heat loss per unit mass is 5 kJ/kg and the exit pressure and temperature are, respectively, 120 kPa and 43 °C, what are the exit velocity and area?

Answer: V_2 = 294 m/s; $A_2 = 0.408\ m^2$

****

Problem 9

A steam turbine has an efficiency of 90% and a theoretical isentropic power of 100 kW. What is the actual power output?

Answer: 90 kW

****

Problem 10

Consider an office room that is being cooled adequately by a 12,000 Btu/h window air conditioner. It has been decided to convert this room into a computer room. Several computers, terminals, and printers with a total rated power of 3.5 kW will be installed. The facility has several 4000 Btu/hr air conditioners in storage that can be installed to meet the additional cooling requirements. Assuming a usage factor of 0.4 (i.e., only 40% of the rated power will be consumed at any given time) and additional occupancy of four people, each generating heat at a rate of 100 W, determine how many of these air conditioners need to be installed in the room.

Answer: 2

****

Problem 11

A 1.2 kWe compressor moves R134a through a residential heat pump at a rate of 0.018 kg/s. The refrigerant enters the heat pump condenser at 800 kPa and 35 °C and exits at 800 kPa as saturated liquid. Determine

(a) the COP of the heat pump, and

(b) the rate of heat absorption from the outside air.

Answer: COP = 2.64; Q_L = 1.96 kW

****

Problem 12 (ME405f22h4)

An ideal gas that has a constant specific heat of c_p = 0:26 Btu/(lbm.R) undergoes an expansion process in a steady-flow machine with a mass flow rate of 100 lbm/h. The machine is water-cooled. The water mass flow rate is 10 lbm/h. During the process the gas temperature drops from 200 to 100 F and the water temperature rises from 70 to 100 F. Ignoring changes in potential and kinetic energies for the gas, calculate the work of the gas in Btu per hour and watts. [c_p for water = 1 Btu/lbm.R]

Answer: 0.672 kW = 2296.72 Btu/h

****

Problem 13 (ME436s17q2)

A cryogenic manufacturing facility handles liquid methane at 115 K and 5 MPa at a rate of 0.280 m^3/s. A process requires dropping the pressure of the liquid methane to 1 MPa, which is accomplished by throttling the liquid methane by passing it through a valve (flow restrictor). A recently hired engineer proposes to replace the throttling valve with a turbine in order to produce power while dropping the pressure to 1 MPa.

(a) Determine the maximum power that the turbine can produce

(b) Determine how much this turbine could save the facility in electricity costs per year if the turbine operates continuously and if the facility pays $0.075 per kWh on average for electricity.

Answer: (a) $\dot{W}_T$ = 1123 kW

(b) $600,000 per year

****

Problem 14 (ME436s15q2)

Through combustion of a fossil fuel at 3500 °R (1670 °C), an engine receives energy at a rate of 3000 Btu/s (3165 kW) to heat steam to 1500 °R (560 °C). There is no energy loss in the combustion process. The steam, in turn, produces 1000 Btu/s (1055 kW) of work and rejects the remaining energy to the surroundings at 500 °R (4.6 °C).

(a) What is the thermal efficiency of the plant?

(b) What are the reversible work and the Carnot efficiency corresponding to the source and sink temperatures?

(c) What is the irreversibility?

(d) What is the second-law efficiency?

(e) What would the irreversibility and the second-law efficiency be if the working fluid were processed by a Carnot engine rather than by the real engine?

Answer:

(a) η_{th} = 33.3 %

(b) η_C = 85.7 % ; W_{rev} = 2713 kW

(c) I = 1658 kW

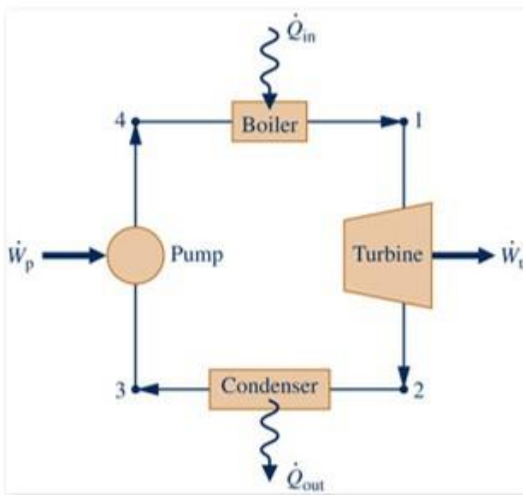
(d) η_{II} = 38.9 %

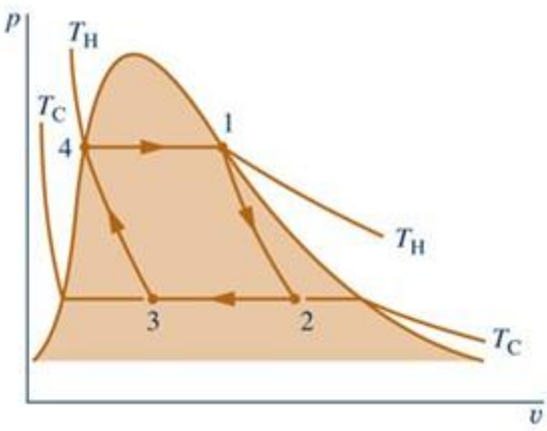
(e) I = 603 kW; η_{II} = 77.8 %

****

Problem 15 (ME435s15h2)

The figure gives the schematic of a vapor power plant in which water steadily circulates through the four components shown. The water flows through the boiler and condenser at constant pressure, and through the turbine and pump adiabatically. Kinetic and potential energy effects can be ignored.





Process 4-1: Boiler: Constant pressure at 1 MPa from saturated liquid to saturated vapor.

Process 2-3: Condenser: Constant pressure at 20 kPa from x_2 = 88 % to x_3 = 18 %.

(a) Find $\frac{\dot{W}_T}{\dot{m}} = \frac{\dot{W}_{12}}{\dot{m}}$ in kJ/kg

(b) Find $\frac{\dot{Q}_{out}}{\dot{m}} = \frac{\dot{Q}_{23}}{\dot{m}}$ in kJ/kg

(c) Find $\frac{\dot{W}_P}{\dot{m}} = \frac{\dot{W}_{34}}{\dot{m}}$ in kJ/kg

(d) Find $\frac{\dot{Q}_{in}}{\dot{m}} = \frac{\dot{Q}_{41}}{\dot{m}}$ in kJ/kg

(e) Find the thermal efficiency of the cycle and compare with the Carnot efficiency.

From thermodynamic property tables:

State 4: P_4 = 1MPa = 10 bar; sat. liq.; T_4 = 179.9 °C $v_4 = 0.0011273\ m^3/kg$ u_4=761.68 kJ/kg

State 1: P_1 = 1 MPa = 10 bar; sat. vapor; T_1 = 179.9 °C $v_1 = 0.1944\ m^3/kg$ u_1 = 2583.6 kJ/kg

State 2: P_2 = 20 kPa = 0.2 bar x_2 = 88 % T_2 = 60.06 °C

$v_f = 0.0010172\ m^3/kg$ $v_g = 7.649\ m^3/kg$ u_f = 251.38 kJ/kg u_g = 2456.7 kJ/kg

$v_2 = v_f + x_2 (v_g - v_f) = 6.731\ m^3/kg$ $u_2 = u_f + x_2 (u_g - u_f) = 2192.1$ kJ/kg

State 3: P_3 = 20 kPa = 0.2 bar x_3 = 18% T_3= 60.06 °C

$v_f = 0.0010172\ m^3/kg$ $v_g = 7.649\ m^3/kg$ u_f = 251.38 kJ/kg u_g = 2456.7 kJ/kg

$v_3 = v_f + x_3 (v_g - v_f) = 1.378\ m^3/kg$ $u_3 = u_f + x_3 (u_g - u_f) = 648.3$ kJ/kg

Answer:

(a) $\frac{\dot{W}_T}{\dot{m}}$ = 391.5 kJ/kg

(b) $\frac{\dot{Q}_{out}}{\dot{m}}$ = - 1649.9 kJ/kg

(c) $\frac{\dot{W}_P}{\dot{m}}$ = - 113.38 kJ/kg

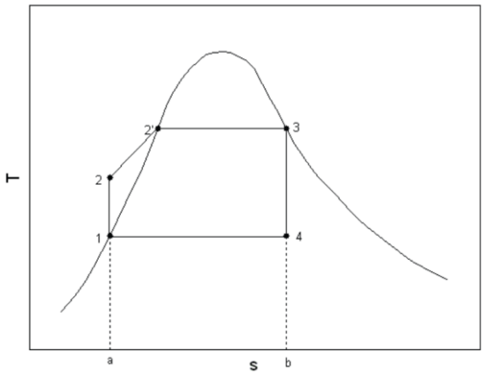
(d) $\frac{\dot{Q}_{in}}{\dot{m}}$ = 2015.2 kJ/kg

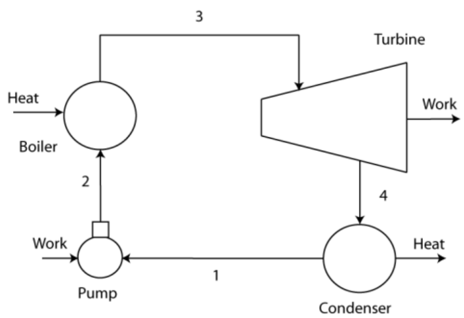
(e) η_C = 26.5 % ; η_{th} = 18.08 %

****

Problem 16 (ME405f15h3)

An ideal Rankine cycle with isentropic compression and expansion operates between a maximum pressure of 4 MPa at the turbine entry and 100 kPa in the condenser. Calculate the thermal efficiency for this cycle. Compare to the Carnot efficiency based on the temperature differences between extremes in the cycle.





Answer: η_{th} = 25.3 %; η_{Carnot} = 28.8 %

****

Problem 17 (ME436s16q2 / ME436s18q3 / ME405s18q3 / ME436s19h3 / ME405s19h3 / ME436s22q3 / ME405s22q3 / ME405s23h4)

500 liters of oxygen is given with pressure of 1000 kPa and temperature of 30 °C. The oxygen will be compressed isothermally (constant temperature) to the 1/5th of its original volume.

(a) What is the new pressure of the gas at the end of the process?

(b) What is the work done by the outer neighboring medium during the gas is being compressed?

(c) What is the change of the internal energy of the gas?

(d) What is the heat transmitted to the gas during the process?

Answer: (a) P_2 = 5000 kPa

(b) W = - 804.72 kJ

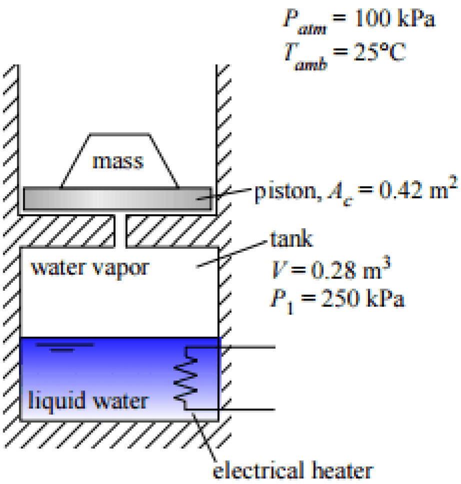
(c) ΔU = 0

(d) Q = - 804.72 kJ

****

Problem 18 (ME436s16h4)

An elevator system consists of a well-insulated tank having a volume of V = 0.28 m^3 containing two phase water at P_1 = 250 kPa. At the start of the lifting process, the liquid in the tank occupies 50 % of the tank volume, with the remainder being vapor. At the top of the tank is a short pipe that connects the tank to a piston-cylinder device, as shown in the Figure



There is negligible pressure loss when vapor flows through this pipe and the volume of the pipe is negligible. The cross-sectional area of the piston is A_c = 0.42 m^2. At the start of this process, the piston is floating very near (but not touching) the bottom of the cylinder. Then, the electric heater in the tank is switched on. The piston is observed to rise z = 2.5 m in the cylinder, at which time the heater is switched off. Thermal losses may be assumed to be negligible during the lifting process.

a) Determine the combined mass of the piston and the mass that is on the piston.
b) Determine the quality of the water in the tank before the heating element is engaged.
c) Determine the quality of the water at the completion of the lifting process.
d) Determine the work done by the steam as a result of expansion during the lifting process.
e) Determine the total electrical energy provided to the water.
f) Determine the temperature of the steam in the piston-cylinder device at the completion of the process.
g) Determine the total exergy destroyed during the lifting process.
h) Determine the Second-Law efficiency of the lifting process.

Answer: (a) m = 6422 kg

(b) x_1 = 0.148 %

(c) x_2 = 1.26 %

(d) W = 262.5 kJ

(e) Q = 3184.2 kJ

(f) T_1 = 127.41 °C = T_2

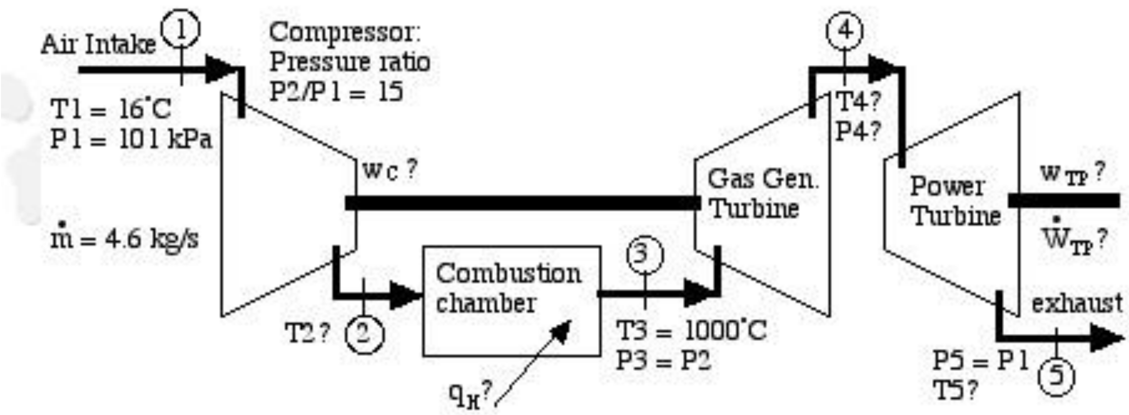
(g) X_{dest} = 2185.4 kJ

(h) η_{II} = 33.1 %

****

Problem 19 (ME436s16m1-2)

Consider the schematic diagram of a helicopter engine shown in the figure below:



Notice that there are two turbines operating on independent output shafts. The High Pressure (first) turbine, named the Gas Generator Turbine, is directly connected by a shaft to the compressor. Its sole purpose is to drive the axial/centrifugal compressor, thus the energy output of this turbine must equal the energy consumed by the compressor. The Low Pressure (second) turbine, named the Power Turbine, is connected via gearing to the helicopter rotor.

Assume that the compressor and both turbines are isentropic, and that the combustion process occurs at constant pressure (isobaric). Using the information shown on the schematic diagram above, do the following:

a) Sketch the entire process on a *T-s* diagram, clearly showing the 5 stations (states) on the diagram and the relevant isentropic and constant pressure lines.

b) Determine, the temperature at the outlet of the compressor, T_2, and the energy consumed by the compressor, w_C.

c) Determine the heat energy, q_H, absorbed by the working gas in the combustion chamber.

d) Determine the temperature, T_4, and the pressure, P_4, at the outlet of the gas generator turbine.

e) Determine the temperature, T_5, and energy output, w_{PT}, of the power turbine.

f) Given that the mass flow rate of the working gas through the system is 4.6 kg/s, determine the power output of the power turbine.

Use the following:

First law: $q - w = \Delta h$

For an ideal gas with constant c_p and isentropic process: $\Delta h = c_p \Delta T$ and $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$

$k = 1.354$ and $c_p = 1.099$ kJ/kg.K

Answer: (b) $w_C = -328$ kJ/kg

(c) $q_H = 754$ kJ/kg

(d) $T_4 = 975$ K; $P_4 = 546$ kPa

(e) $T_5 = 627$ K ; $w_{PT} = 382.5$ kJ/kg

(f) $\dot{W}_{PT} = 2360$ hp

****

Problem 20 (ME436s17q4)

A plant receives $Q_{H1} = 25$ kW at $T_{H1} = 825$ °C. The plant also receives $Q_{H2} = 50$ kW at $T_{H2} = 240$ °C. The plant rejects heat to the environment at $T_0 = 20$ °C and produces power $W_{out} = 12$ kW. Determine

a) The first-law (thermal) efficiency; and

b) The second-law efficiency of the plant.

Answer: $\eta_{th} = 0.16$; $\eta_{II} = 0.302$

****

Problem 21

A balloon full with helium floats at somewhere several kilometers height of the atmosphere of the Earth. The volume of the balloon is 800 m^3 at the mentioned height. Temperature and pressure of the helium fill is equal to the temperature and pressure of the air neighboring the balloon, which are - 50 °C and 5.26 10^3 Pa, respectively. How many moles of helium are in the balloon? What is the mass of the helium gas? (Molar mass of the helium is M = 4 g/mol).

What was the volume of the balloon on the surface of the Earth when someone just started it? The temperature of the gas was 0 °C and the pressure of the helium was 10^5 Pa on the surface.

Answer: n = 2269.66 mol, V_0 = 51.51 m^3

****

Problem 22

There is gas in a gas container. A valve on the container will be opened and a quarter of the gas quantity will be released to the outer range. Due to this process the temperature of the gas will be decreased by 20 %. What is the decrease of the gas pressure?

Answer: 40 %

****

Problem 23

8.31 Wh (Watthours) heat is transmitted to 1 mole single atomic ideal gas. The gas temperature is 27 °C and the pressure is constant during the process (slow process). What is the new temperature? What is the change of the internal energy of the gas? What is the work done during the gas is surrounding?

Answer: (1739.307 K, ΔU = 17949.60 J, W = 11966,40 J

****

Problem 24

500 liters of oxygen is given with pressure of 10^6 Pa and temperature of 30 °C. The oxygen will be compressed isothermally to the $1/5^{th}$ of its original volume.

(a) What is the new pressure of the gas at the end of the process?

(b) What is the work done by the outer neighboring medium during the gas is being compressed?

(c) What is the change of the internal energy of the gas?

(d) What is the heat transmitted to the gas during the process?

Answer: ΔU = 0, W = 804718.956 J, Q = - W, P = 5 10^6 Pa

****

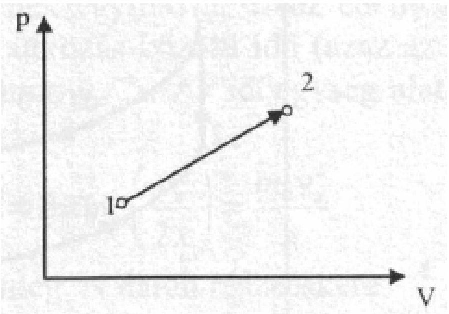
Problem 25

Air is compressed from 10 liters to 2 liters using two different ways. First way is use of adiabatic and second way is use of isothermal way. Work done by the neighbor medium during the adiabatic process is W_a. Work done by the neighbor medium during the isothermal process is W_i. What is the higher value, W_a or W_i? Explain the problem graphically! What is the ratio of W_a and W_i?

Answer: $W_a > W_i$

****

Problem 26



An unknown, general thermal process on a given amount of air will be made. The process is plotted on the Figure. Does the temperature of the air decrease or increase during the process? What is the work done by the gas during its surrounding? Data are: $P_1 = 10^5$ Pa, $P_2 = 1.4\ 10^5$ Pa, $V_1 = 0.07\ m^3$, $V_2 = 0.11\ m^3$.

Answer: Increasing, W=4800 J

****

Problem 27

How many moles of gases are in a gas tank if the volume of the tank is 10 m^3, and the pressure and the temperature of the medium are 0.9 10^5 Pa and 17 °C, respectively?

Answer: n = 373.5 moles

****

Problem 28

Nitrogen gas will be compressed keeping the temperature constant. Data for the gas: number of moles is 1 mol, temperature is 40 °C, pressure is 1.2 10^5 Pa. The final volume is 13 liters. What is the final pressure of the nitrogen? M = 28 g/mol.

Answer: $2\ 10^5$ Pa

****

Problem 29

In a sleeping room there is approximately 2500 moles of air. What is the change of the internal energy of the air during the temperature of the room is decreasing from 24 °C to 12 °C? The pressure is kept constant. (Use the air as a double atomic gas.)

Answer: $\Delta U = -\ 6.23\ 10^5$ J

****

Problem 30 (ME405s23q4 / ME405f23q3)

During an adiabatic process the work done by the neighbor medium on the oxygen gas is 146 kJ. The mass of the oxygen gas is 32 kg. The specific heat is 0.66 kJ/kg.K.

(a) What is the change of the internal energy of the gas? M = 32 g/mol.

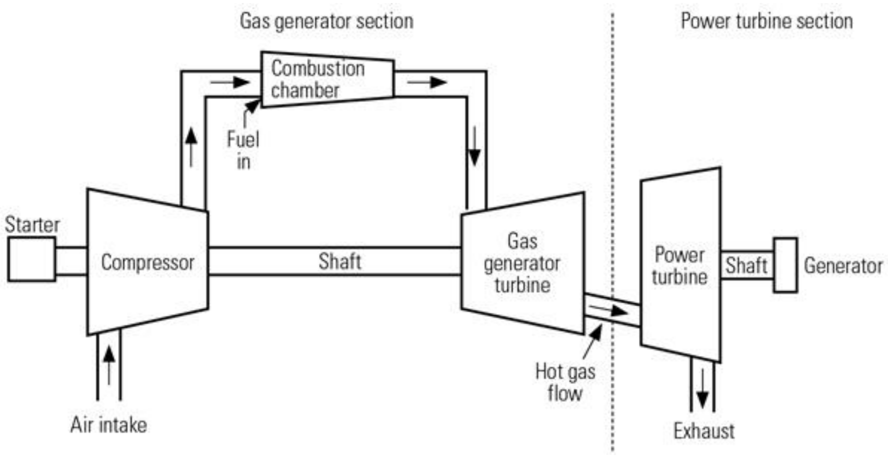
(b) What is the change of the gas temperature during the process?

Answer: (146 kJ ; 7 °C)

****

Problem 31 (ME436s18f-4 / ME405s18f-4)

Consider a turbine which is required to drive the compressor of a gas turbine engine (Gas generator turbine) as shown.



Assume that the gas leaving a combustion chamber enters the turbine at P_1 = 1500 kPa and T_1 = 927 °C and exits at P_2 = 400 kPa and T_2 = 627 °C, with 50 kJ/kg of heat loss transferred to the surroundings at T_0 = 25 °C. (Be careful with the sign. It is heat flowing out of the system,) Assuming that the gas is pure air, determine

(a) the actual work output;

(b) the entropy generated by this process;

(c) the available reversible work output; and

(d) the Second Law efficiency (η_{II}) of this turbine.

Relations:

First law: $q - w = \Delta h$

Ideal gas: $\Delta h = h_2 - h_1 = c_p\ \Delta T = c_p\ (T_2 - T_1)$

$$s_1 - s_2 = c_p\ \ln\left(\frac{T_1}{T_2}\right) - R\ \ln\left(\frac{P_1}{P_2}\right)$$

For air: c_p = 1.14 kJ/kg.K and R = 0.287 kJ/kg.K

$$s_{gen} = \Delta s - \frac{q}{T_0} = s_2 - s_1 - \frac{q}{T_0} = R\ \ln\left(\frac{P_1}{P_2}\right) - c_p\ \ln\left(\frac{T_1}{T_2}\right) - \frac{q}{T_0}$$

$$w_{rev} = h_1 - h_2 - T_0\ (s_1 - s_2) = c_p\ (T_1 - T_2) - T_0\left[c_p\ \ln\left(\frac{T_1}{T_2}\right) - R\ \ln\left(\frac{P_1}{P_2}\right)\right]$$

Answer:

(a) w_{act} = 292 kJ/kg

(b) s_{gen} = 0.219 kJ/kg.K

(c) w_{rev} = 357.3 kJ/kg

(d) η_{II} = 0.82

****

Problem 32 (ME436s19q3 / ME405s19q3)

Compare the inlet steam mass and volume flow rates in kg/s and m^3/s of

(a) a fossil-fuel power plant turbine with an isentropic efficiency of 0.9 receiving steam at 15 MPa and 540 °C, and

(b) a nuclear power plant turbine with an isentropic efficiency of 0.88 and receiving saturated steam at 540 K.

Each turbine produces 1000 MW_m, and exhausts to 10 KPa.

Answer: (a) 812 kg/s

****

Problem 33 (ME436s19f-3 / ME405s19f-3)

Steam at 3 MPa and 300 °C leaves the boiler (state 2) and enters a high-pressure turbine (in a reheat cycle) and is expanded to 300 kPa (state 3). The steam is then reheated to 300 °C (state 4) and is expanded in the second stage turbine to 10 kPa (state 5). It is then condensed (state 6) and pumped back into the boiler (state 6).

(a) Draw a nice schematic diagram of the cycle, identify all the states (1 through 6), and show all energy transfers.

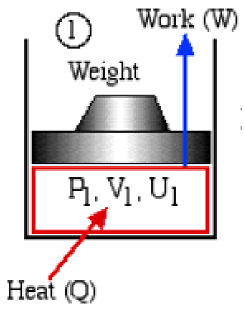
(b) Assuming reversible processes, show the cycle on a nice T-s diagram

(c) Define the thermal efficiency of the cycle (give an equation and identify symbols) assuming you know all the properties at all the states.

(d) Define the second-law efficiency of the cycle (give an equation and identify symbols)

****

Problem 34 (ME436s21q4 / ME405s21q4)

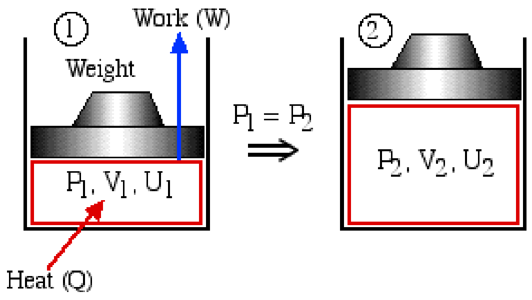


A cylindrical container which has a volume of 0.1 m^3 is fitted with a plunger enclosing 0.5 kg of H_20 at 0.4 MPa. Find the properties of the H_2O at this state 1.

Hint: First decide whether you have all liquid (water), all vapor (steam) or a mixture, using thermodynamic tables.

****

Problem 35 (ME436s21h4 / ME405s21h4 / ME436s22h4 / ME405s22h3)



A cylindrical container which has a volume of 0.1 m^3 is fitted with a plunger enclosing 0.5 kg of steam at 0.4 MPa. Calculate the amount of heat transferred (to the system) and the work done (by the system) when the steam is heated to 300 °C at constant pressure.

First Law: $Q - W = \Delta U = U_2 - U_1 = m\,(u_2 - u_1)$

$m = 0.5$ kg

$Q = m\,(h_2 - h_1)$ and $W = m\,(P_2 v_2 - P_1 v_1) = m\,P_1\,(v_2 - v_1)$

Find the properties from thermodynamic tables:

****

Problem 36 (ME436s21f-2 / ME405s21f-2)

Water flows in a round channel (diameter D = 2 cm, length L = 2.5 m) at 0.5 kg/s and 5 MPa. The flow is subject to a heat flux that varies axially as $\dot{q}(x) = \dot{q}_{max} \sin\left(\frac{\pi x}{L}\right)$ where $\dot{q}_{max} = 300\ \text{kW/m}^2$. The inlet temperature is 260°C.

Find the axial location, x_{sat}, at which the coolant becomes saturated.

Useful properties of saturated water at 5 MPa: $c_p = 4.18$ kJ/kg.K, $T_{sat} = 264$°C.

First law: $\dot{m}\,\frac{dh}{dx} = \dot{q}(x)\,\pi\,D$

Hint: Integrate from $x = 0$ to $x = x_{sat}$ and solve for x_{sat}.

****

Problem 37 (ME405s23m-3)

Air in a closed vessel of fixed volume 0.15 m^3 exerts pressure of 12 bar at 250 °C. If the vessel is cooled so that the pressure falls to 3.5 bar, determine

(a) the final pressure;

(b) heat transfer; and

(c) change of entropy.

List the assumption in your solution.

Note: R = 0.287 , $c_p = 1.005$ kJ/kg.K , $c_v = 0.750$ kJ/kg.K,

$$\Delta S = m\left[c_p \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right)\right]$$

Answer: (a) 350 kPa ; (b) – 333.4 kJ ; (c) – 1.06 kJ/K

****

Problem 38 (ME405f23q4)

Consider water in a Rankine power cycle with reheat. The first turbine has water enter at P_3 = 8000 kPa, T_3 = 500 °C. The water expands to 600 kPa, undergoes reheat, and then expands again to 10 kPa. The mass flow rate is m = 2.63 10^5 kg/hr. We have η_T = 0.88 for each turbine, and η_P = 0.80. for the pump.

(a) Show a schematic diagram of the power plant;

(b) Show the processes on a T-s diagram;

(c) Find the net power generated;

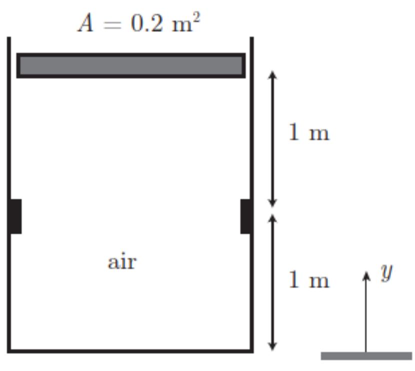
(d) Find thermal efficiency of the cycle; and

(e) Find the heat transfer in the condenser.

Answer: (c) 1.023 10^5 kW (d) η_{th} = 0.36 (e) 1.8 10^5 kW

****

Problem 39 (ME405f23h3)



Given air in a cylinder with stops and a frictionless piston with area A = 0.2 m^2, stop height of 1 m, and total height of 2 m, at initial state P_1 = 200 kPa and T_1 = 500 °C with cooling, find

(a) the temperature when the piston reaches the stops, and

(b) the pressure if the cooling continues to T = 20 °C.

Answer: (a) T_2 = 387 K (b) P_3 = 152 kPa

****

Problem 40 (ME405f24q3)

A fixed mass m of carbon monoxide (CO) gas at T_0 = 30 °C is confined in a piston-cylinder system. The gas undergoes a reversible isothermal process (constant temperature), that is the pressure changes according to the relation P V = m R T . The initial and final volumes are V_1 = 0.1 m^3 and V_2 = 0.15 m^3 and the initial pressure is P_1 = 500 kPa.

Determine:

a) The mass of CO in the system.
b) The pressure P_2 at the end of the process.
c) The total work required for the process.
(d) The total heat exchange.

Answers: (a) m = 0.56 kg; (b) P_2 = 333.3 kPa; (c) ${}_1W_2$ = 20.27 kJ; (d) Q = 20.27 kJ

****

Problem 41 (ME405f24qh3)

Helium, initially at temperature T_1 = 0 °C undergoes a reversible process in a closed system, where the pressure changes according to the relation $P = A V^3 + B$. The initial and final volumes are V_1 = 0.1 m^3 and V_2 = 0.2 m^3, and the corresponding pressures are P_1 = 100 kPa and P_2 = 40 kPa. For the relevant temperature range, helium behaves as an ideal gas. As for all noble gases, its specific heat is constant, c_v = 3 R. Determine:

a) The mass of helium in the system.
b) The temperature at the end of the process.
c) The total work required for the process. Show the process in a p-V- diagram.
d) The total heat exchange.

Answers: (a) m = 0.018 kg; (b) T_2 = 214 K; (c) ${}_1W_2$ = 7.64 kJ; (d) Q = 1.02 kJ

****