Name Joe Munoz

Thermodynamics
MET 300

Instructor: Nathan Luetke

Test 2

Summer 2024

Take home – Due July 15 at 11:59 pm.

- ***Late tests will be penalized 20% and not accepted after 6:00 am July 16***
- **Upload your completed test to Canvas as a single word document or pdf file and include your name on the first page – you will lose 5 points if either of these requirements are not met. It is your responsibility to verify that it is not corrupted and can be open. Be sure that when you scan it in it is dark enough to be read when printed out. Be sure to hit SUBMIT once you have uploaded it.**

90 points – Solutions to the three test problems
10 points – Homework 2.1 and 2.2

1. What you turn in should be only your own work. You cannot discuss the exam with anyone, except me. Email me if you have any questions.
2. This is intended to be open book/open notes.
3. You should be explicit and organized in your answers, I can only grade what I see on the paper. Use drawings and figures when needed and clearly identify your final answers
4. Cheating is completely wrong. The ODU Student Honor Pledge reads: "I pledge to support the honor system of Old Dominion University. I will refrain from any form of academic dishonesty or deception, such as cheating or plagiarism." By attending Old Dominion University you have accepted the responsibility to abide by this code. This is an institutional policy approved by the Board of Visitors. It is important to remind you the following part of the Honor Code:

IX. PROHIBITED CONDUCT
A. Academic Integrity violations, including:
1. *Cheating*: Using unauthorized assistance, materials, study aids, or other information in any academic exercise (Examples of cheating include, but are not limited to, the following: using unapproved resources or assistance to complete an assignment, paper, project, quiz or exam; collaborating in violation of a faculty member's instructions; and submitting the same, or substantially the same, paper to more than one course for academic credit without first obtaining the approval of faculty).

Problem 1 (30 points)

Air is heated inside a 500 m^3 rigid container from an initial pressure and temperature of 500 kPa and 400 K to a final pressure of 1.2 MPa. Determine the change in internal energy (kJ) and the change in enthalpy (kJ) using:

i. Constant specific heat at room temperature $C_v = .718 \frac{KJ}{Kg \cdot K}$ $C_p = 1.005 \frac{KJ}{Kg \cdot K}$

ii. Variable specific heat

500 KPa
400K

$V_1 = 500 m^3$
$P_1 = 500$ KPa
$T_1 = 400K$

$V_2 : 500 m^3$
$P_2 = 1.2$ mPa
$T_2 = ? \rightarrow 960K$

$P_2 V_2 = m R T_2$

$$T_2 = \frac{1200 KPa \cdot 500 m^3}{.2870 \frac{KJ}{Kg \cdot K} \cdot 2177.65 Kg} = 960K$$

$P_1 V_2 = m R T_1$

$$m = \frac{P_1 V_1}{R_1 T_1} = \frac{500 KPa \cdot 500 m^3}{.2870 \frac{KJ}{Kg \cdot K} \cdot 400K} = 2177.65 Kg$$

i. $\Delta U = m \cdot C_v \cdot (T_2 - T_1) = 2177.65 Kg \cdot .718 \frac{KJ}{Kg \cdot K} (960K - 400K) = \boxed{875609.6 KJ}$

$\Delta h = m \cdot C_p \cdot (T_2 - T_1) = 2177.65 Kg \cdot 1.005 \frac{KJ}{Kg \cdot K} \cdot (960K - 400K) = \boxed{1225609.6 KJ}$

ii Δu : $u @ 400K = 286.16 \frac{KJ}{Kg}$

$u @ 960K = 725.02 \frac{KJ}{Kg}$

$\Delta U = m (u_2 - u_1) = 2177.65 Kg \cdot (725.02 \frac{KJ}{Kg} - 286.16 \frac{KJ}{Kg}) =$

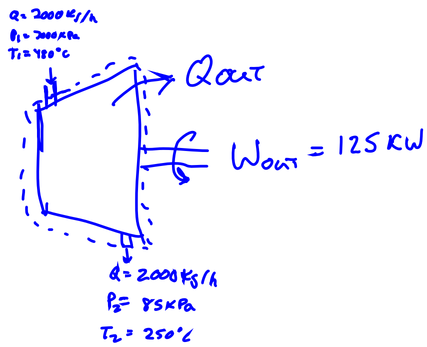
$\boxed{\Delta U = 955705.6 KJ}$

Δh : $h @ 400K = 400.98 \frac{KJ}{Kg}$ $h @ 960K = 1000.55 \frac{KJ}{Kg}$

$\Delta h = m (h_2 - h_1) = 2177.65 Kg (1000.55 \frac{KJ}{Kg} - 400.98 \frac{KJ}{Kg}) = \boxed{1305683.8 KJ}$

Problem 2

Argon flows steadily through a turbine at a rate of 2,000 kg/h, entering at 7,000 kPa and 480°C and leaving at 85 kPa and 25°C. If the power generated by the turbine is 125 kW, determine the rate of heat loss from the argon (kJ/s).



Ar: $\left.\begin{array}{l} R = .2081 \\ C_p = .5203 \\ C_v = .3122 \end{array}\right\} \frac{kJ}{kg \cdot K}$

$$\dot{m} = 2000 \frac{kg}{h} \cdot \frac{1\,h}{3600\,s} = .555\ kg/s$$

$$T_1 = 480°C + 273.15 = 753.15\,K$$

$$T_2 = 25°C + 273.15 = 298.15\,K$$

$$\cancel{(\dot{Q}_{in}} - \dot{Q}_{out}) - (\dot{W}_{out} - \cancel{\dot{W}_{in}}) + \sum \dot{m}_{in}\left(h + \cancel{\frac{V^2}{2}} + \cancel{gz}\right) - \sum \dot{m}_{out}\left(h + \cancel{\frac{V^2}{2}} + \cancel{gz}\right) = \cancel{\frac{d}{dt}}(U + KE + PE)$$

$$-\dot{Q}_{out} - \dot{W}_{out} + \dot{m}(h_1 - h_2) = 0$$

$$-\dot{Q}_{out} - \dot{W}_{out} + \dot{m}\{c_p(T_1 - T_2)\} = 0$$

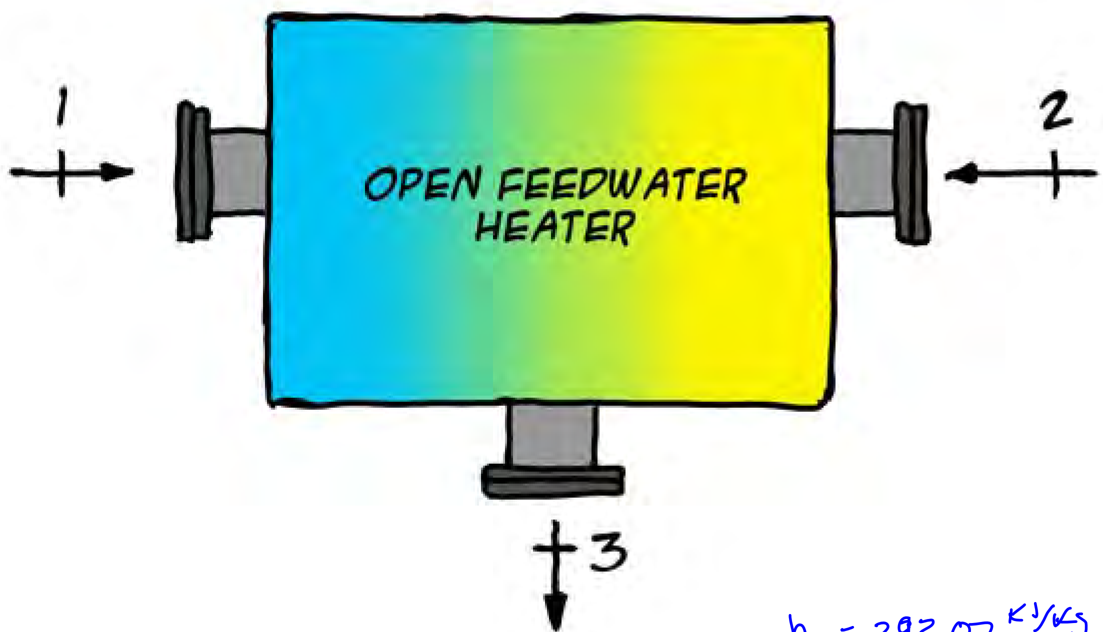
$$Q_{out} = -W_{out} + \dot{m}(c_p(T_1 - T_2))$$

$$Q_{out} = -125 \frac{kJ}{s} + \left(.555 \frac{\cancel{kg}}{s} \cdot .5203 \frac{kJ}{\cancel{kg \cdot K}}(753.15\,K - 298.15\,K)\right)$$

$$Q_{out} = \boxed{6.38 \frac{kJ}{s} \text{ Loss rate}}$$

Problem 3

An open feedwater heater is a mixing chamber commonly found in steam power plants. Refer to the figure and table below to determine the specific enthalpy (kJ/kg) and temperature (°C) of the water entering the adiabatic open feedwater heater at entrance number 2.



$h_1 = 293.07\ KJ/Kg$

Entrance (1)	25 kg/s of H_2O at 3,500 kPa and 70°C
Entrance (2)	H_2O at 3,500 kPa
Exit (3)	40 kg/s of H_2O at 3,500 kPa and 200°C

$h_3 = 852.26\ KJ/Kg$

$\sum \dot{m}_{in} h_{in} = \sum \dot{m}_{out} h_{out}$

$\dot{m}_1 + \dot{m}_2 = \dot{m}_3 \quad m_2 = m_3 - m_1 = 40\ Kg/s - 25\ Kg/s = 15\ Kg/s$

$\dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_3 h_3$

$$h_2 = \frac{m_2 h_3 - m_1 h_1}{m_2} = \frac{40 \cancel{\frac{Kg}{s}} \cdot 852.26 \frac{KJ}{Kg} - 25 \cancel{\frac{Kg}{s}} \cdot 293.07 \frac{KJ}{Kg}}{15 \cancel{Kg}}$$

$$\boxed{h_2 = 1784.24 \frac{KJ}{Kg}}$$

h_2 @ 3500 KPa is Between h_f + h_g, so the water @ entrance 2 is saturated mixture @ the satured temp for 3500 KPa.

$$\boxed{T_{entry2} = 242.56\ °C}$$