$\frac{m}{m_o} = \frac{1}{2}$ / R is known / Cv is known

$T = 227\,k$

$m\frac{du}{dt} + u\frac{dm}{dt} = \frac{dm}{dt}(u + PV)$

$\frac{du}{PV} = \frac{dm}{m}$; $du = c_v dT$; $PV = RT$

$\Rightarrow \frac{c_v dT}{RT} = \frac{dm}{m}$

Notre Dame University. Department of Mechanical Engineering

Test #3-MEN210 (Thermodynamic I) *Open book:1hr10*

Dr. Gabi Nehme. PhD **Spring-2006**

Problem#1(15pts)

A steam turbine is used to produce work with its surroundings at 300K. The steam enters the turbine at 1MPa, 300°C and exits as Sat-Vapor at 15kpa. Find the thermodynamic efficiency and the amount of intensive work lost by the turbine.

Problem#2(15pts)

A large tank filled with air is exhausted rapidly (adiabatically and ideally) into a room at 300K and 1 atm. The initial pressure in the tank is 5 atm. Find the final temperature of the air in the tank after half of the mass has been exhausted.

Problem#3(15pts)

Explain in very short schematic the first and second law operation of a heat engine cycle. Give formulas.

2nd law $\frac{Q_H}{T_H} - \frac{Q_L}{T_L} = -\sigma$; $\sigma = 0$ if Rev

Problem#4(20pts)

A volume of gas expands reversibly and isothermally at a temperature of 300K. The initial pressure is 110 bar and the final pressure is 10 bar. Over this range of conditions, the gas is well described by the following truncated, pressure-explicit equation of state. Z=1+P (b/RT) where b=constant.

Sketch the graph showing the path of this process between the initial and final states on a pressure versus volume diagram. Show the 300K isotherm for this gas. Indicate the pressure at which V→∞ and the volume at which P→∞.

Problem#5(35pts)

A heat exchanger is insulated and has two inlets and one outlet. At inlet one, water vapor enters at 5 MPa and 430°C. At inlet two, Liquid water enters at 10 MPa with an internal energy of 416.11 kJ/kg. The mass flow rate is 15kg/s at each inlet. A mixer of streams put 5 KW into the system. Exit pressure is 10 MPa.

Find the entropy production of the Heater.

$S_1 = 6.744$

$S_2 = 1.2999$

$S_3 = 4.1118$

$S_{gen} = m_3 S_3 - m_2 S_2 - m_1 S_1$

≈ 2.64

GOOD LUCK

NOTRE DAME UNIVERSITY
Zouk Mosbeh - Lebanon

Name: ℓ

Course N°: MEN 210

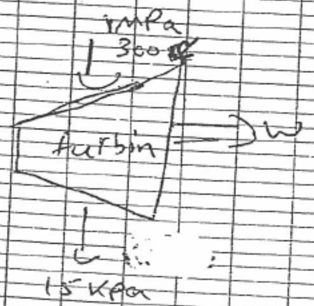
Grade: 82

ID:

Section: Dr. Nehme

Date: 23-05-06

problem 1



$\eta = \frac{W_{ac}}{W_s}$

$W_{ac} = \eta W_s$

first law: $w = h_e - h_i$

$h_i = 3051.15$

$h_e = 2599.06$

$w_{act} = 3051.15 - 2599.06 = 452.09$

for ideal turbine

2nd law $s_e = s_i = 7.1228$

$W_s = h_i - h_{es}$

h_{es} @ 15 kPa & $s = 7.1228 = 0.7548 + x$ (7.2536)

$x = 0.8779$

$h_{es} = 225.91 + 0.8779(2373.14)$

$= 2309.3$

$W_s = 3051.15 - 2309.3 = 741.8$

$\eta_{turbine} = \frac{W_{ac}}{W_s} = \frac{452.09}{741.8} = 0.6094$ OK

Extra W lost $= W_s - W_{ac} = 741 - 452.09$

$= 289.71$

-4

lose, but not this

[signature]

Problem # 2

C.V = tank

initial : P_1, m_1

final : T_F, $\frac{m_1}{2}$, P_2

process : transient

5 atm | 1 atm, 300 K

first law: $m_2 u_2 - m_1 u_1 = Q_{1-2} - W_{1-2}$

Q = 0 adiabatic

W = 0 no work

$m_2 u_2 = m_1 u_1$

$\frac{m_1}{2} u_2 = m_1 u_1$

$u_2 = 2 u_1$

ok

but ... rate equation

8

second law:

~~$m_2 s_2 - m_1 s_1 = \int \frac{\dot{Q}}{T} dt + S_{gen}$~~

~~$\left(\frac{dS}{dt}\right)_{C.V} = \ldots + \sum \dot{m}_i s_i - \sum \dot{m}_e s_e$~~

~~Q = 0 adiabatic~~

~~Sgen = 0 ideal~~

~~$s_2 = s_1$~~

$u_1 = 214.36$ kJ/kg

$u_2 = 428.7$

table A 7.1

580	419.87
T_2	428.7
600	435.1

$T_2 = 591$ K

Problem 3

~~$q = du + P\,dv$~~

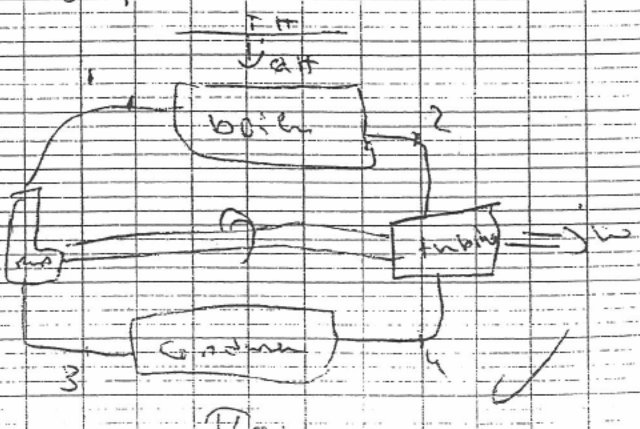
$q_{1-2} = (u_2 - u_1) + w_{1-2}$

$dq = du + P\,dV$

$u = C_v(T)$

$P = \frac{RT}{V}$

$q = \int C_v\,dT + \int \frac{RT}{V}\,dv$



$\frac{\dot{Q}_L}{T_L}$

$q_{1-2} = RT \ln \frac{V_2}{V_1}$

from 2-3 adiabatic expansion

$m_2 s_2 - m_1 s_1 = \int \frac{\delta Q}{T} + S_{gen}$

where $S_{gen} = 0$

$Q = 0$

$s_2 = s_1$

$s_2 - s_1 = 0 = C_{v0} \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}$

3-4, 4-1 same as from 1-2

Little about S_{gen}

-2

problem 4

$Z = 1 + \frac{P}{RT}(b)$

initial state $T = 300K$ $P = 110\ bar = 110{,}000\ kPa$

$Z = 1 + \frac{110{,}000\ b}{300 \times R} = 1 + 366.7 \frac{b}{R}$

final state $T = 300K$ $P = 10\ bar = 10{,}000$

$Z = 1 + \frac{10{,}000\ b}{300 \times R} = 1 + 33.3 \frac{b}{R}$

$Z = 1 + \frac{P b}{RT}$

$\frac{PV}{mRT} = 1 + \frac{Pb}{RT}$

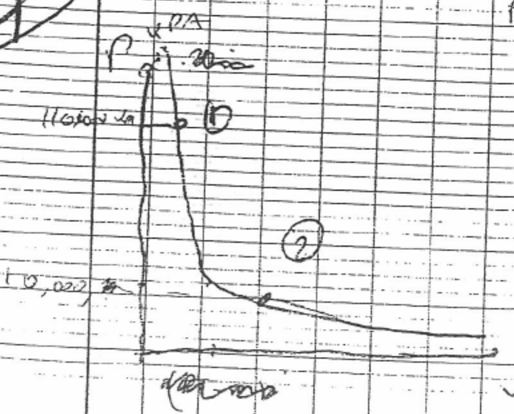
$\frac{PV - mPb}{RT} = 1$

$P(V - mb) = RT = const$ (T constant, R const)

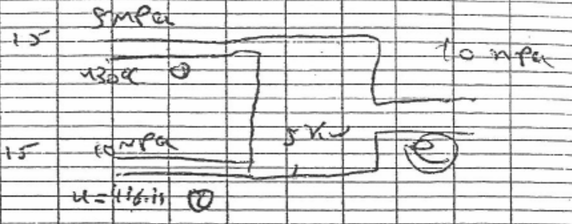
as $V \to \infty$ $P \to 0$

as $P \to \infty$ $V \to (V = b)$

-4



Problem 5



C.m : $m_e = m_1 + m_2$

Process: Steady state (use steam tables)

First law

$$\dot{Q} + \sum \dot{m}_i h_i = \dot{W}_{c.v} + \sum \dot{m}_e h_e$$

~~$\dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_e h_e$~~

$$\dot{Q} + \dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_e h_e$$

$$\dot{m}_e = \dot{m}_1 + \dot{m}_2$$

400	3195
430	h_1
450	3316

$$\frac{20}{50} = \frac{3316 - h_1}{121}$$

$$h_1 = 3267.6$$

inlet 2 T = 100°C (compressed)

$$h_2 = 426.48$$

$$5 + 15(3267.6) + 15(426.48) = 30\, h_e$$

$$h_e = 1847.2$$

at 10 MPa the outlet is sat

$$h_e = 1847.2 = 1407.53 + x(1317.14)$$

$$x = 0.3338$$

$$s_e = 3.3595 + 0.3338(2.2545)$$

$$= 4.11$$

$$\frac{20}{50} = \frac{6.8185 - s_1}{6.8185 - 6.6458}$$

$$s_1 = 6.74942$$

$$s_2 = 1.2992$$

2nd law $S_{gen} = \dot{m}_e s_e - \dot{m}_1 s_1 - \dot{m}_2 s_2$

$$= 30(4.11) - 15(6.74942) - 15(1.2992)$$

$$= 123.3 - 101.24 - 19.38$$

$$\boxed{S_{gen} = 2.68\ kJ/kg\,K}$$