THE DEBATE CLUB

NDU

**Notre Dame University. Department of Mechanical Engineering**

**Test #2-MEN210 (Thermodynamic I)** *Open book: 1hr*

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

**Problem # 1 (25pts)**

A rigid tank is electrically wired and contains ideal gas. The energy going into the tank is at a rate 75 W and energy leaves the system at a rate of 20 W. If the mass of the gas is 2 kg and the temperature changes over 10 minutes is 40 K. Find $C_v$ in kJ/kg.K.

**Problem # 2 (15pts)**

Temperature, Pressure and Heat are state functions. True or false? Explain in details.

**Problem # 3 (30pts)**

Consider a piston weighing 990 g which contains 10 g or 0.347 mole of air at 1 atm and 25° C. Calculate the effects of performing 100 J of work on the air-containing piston for the following situations. State any assumptions and show all units.

a) Find the maximum possible elevation if all the work is used to raise the cylinder and its contents vertically.

b) Find the maximum possible final velocity if all the work is used to accelerate the cylinder and its contents.

c) Find the maximum possible pressure of air if the piston is compressed ishotermally.

**Problem # 4 (30pts)**

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.

Locate the states on P-V diagram and find the exit temperature of the stream.

THE DEBATE CLUB

GOOD LUCK

NOTRE DAME UNIVERSITY
Zouk Mosbeh - Lebanon

Name:

Course N°: MEN210

Grade: 9/

ID:

Section: B

Date: 06-04-06

THE DEBATE CLUB

problem 1

$$\dot{E} = \dot{E}_{in} - \dot{E}_{out} = 75 - 20 = 55 W = 55 J/s$$

$$dE = \dot{E} \times 10 min \times 60 \frac{sec}{min} = 33 kJ$$

$$dE = dU + dKE + dPE$$

$$dE = dU \quad 0 \quad 0$$

$$dU = 33 kJ$$

$$du = \frac{33}{2} = 16.5 kJ$$

$$du = C_v dT$$

$$C_v = \frac{du}{dT} = \frac{16.5}{40} = 0.4125$$

problem #2

Temperature and pressure are state function because they define the state. If you know the Temp. & the pres. ~~of the~~ you can know it phase (solid, liquid, gas) & but heat canot a state function thus it doesn't define the state. If we know the heat loss or gained, we can't know the phase or the state. heat is a function of work & inthalpy, KE, PE, U so it doesn't define state. so statement is false.

## problem 3

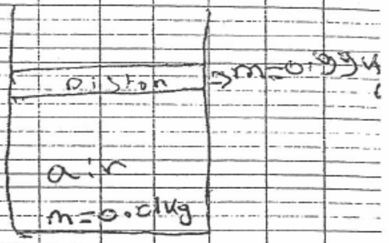
Control mass ; All air in piston

initial state : $P_1\ T_1\ V_1$ , m

Final state ; $P_2\ T_2\ V_2$ , m

process : mass is constant

Model : A7.1 property Air




P = 100 kPa
T = 25 °C

a) analysis : First law of thermodyneics

$$Q_{1-2} - W_{1-2} = m_t(u_2 - u_1) + \frac{1}{2} m_t (V_2^2 - V_1^2) + m_t g (Z_2 - Z_1)$$

a) max elivation : no work done to increase KE dKE = 0
no work for internal energy du = 0

$$Q_{1-2} - W_{1-2} = m_t g (Z_2 - Z_1)$$

$$0 - 0.1\ kJ = \frac{(0.99+1)\ 9.8066}{1000} (Z_2 - Z_1)$$

$$\boxed{dz = 10.19\ m}$$ Z1 = 0 so Z2 = 10.19 m

b) max velocity no work to elevation PE = 0
no work to energy du = 0

$$Q_{1-2} - W_{1-2} = \frac{1}{2} m_t (V_2^2 - V_1^2)$$

$$-(-0.1\ kJ) = \frac{1\ (0.99+1)}{2 \times 1000} (V_2^2 - V_1^2)$$

$$V_2^2 - V_1^2 = 200 \qquad V_1 = 0$$

$$\boxed{V_2 = 14.14\ m/s}$$

c) if max pressure: for maximum pressure we have the max U

$KE = 0$ , $PE = 0$

$Q_{1-2} - W_{1-2} = m_{1-2}(u_2 - u_1)$

$W = \int_{V_1}^{V_2} P\,dV$ $\quad P = \frac{nRT}{V}$

$= -\int_{V_1}^{V_2} \frac{nRT}{V} dv$ $T = ct$

$W = -nRT \int_{V_1}^{V_2} \frac{dV}{V}$

$= -mRT \ln \frac{V_2}{V_1}$

$= -nRT \ln \frac{P_1}{P_2}$

$= 1.12$ [illegible]

From Table A7.1 [illegible]

@ 298 K 0.1 MPA $u = 213.04$ kJ/kg

$u_1 = 213.04$

$0.1 = 0.01(u_2 - 213.04)$

$10 = u_2 - 213.04$

$u_2 = 223.04$ kJ/kg

The temperature is the same 25°C but the u is increased so the pressure must increase. what is it

problem 4

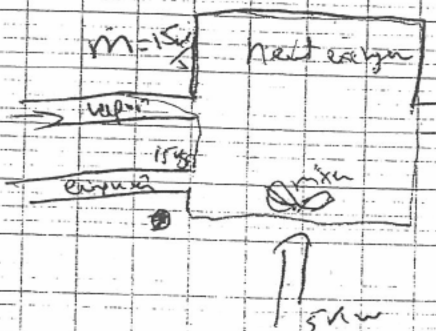
control volume: heat exchanger

inlet: vapor, liquid ...

outlet: fixed mc,

~~initial: fixed~~

~~final: fixed~~




process: steady state process

model: steam table

Analysis: 1st law of thermodynamics

$$\dot{Q} + \sum \dot{m}_i (h_i + \frac{1}{2}V_i^2 + gZ_i) = \sum \dot{m}_e (h_e + \frac{1}{2}V_e^2 + gZ_e) + \dot{W}$$

solution: inlet ① ⇒ 5MPA . 430°c superheated

Table B1.3 interpolating: $\frac{450-430}{450-400} = \frac{3316.15 - h}{3316.15 - 3195.64}$

$h_v = 3268$ kJ/kg

Inlet 2 : 10MPA u = 416.11 water subcooled T = 100°C

$h_f$ = 426.48 kJ/kg

Assumption : heat exchanger : W = 0

No KE , No PE

$\dot{m}_e = \Sigma \dot{m}_i = 2\dot{m}_i$

$\dot{m}_i(h_1) + \dot{m}_i(h_2) = \dot{m}_e h + W$

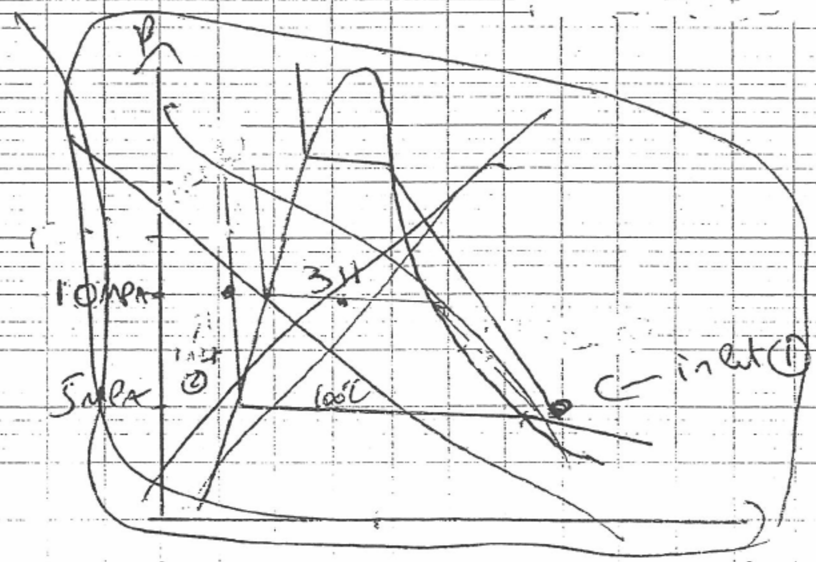
$\dot{m}_i(h_1 + h_2) = 2\dot{m}_i h$ — 5

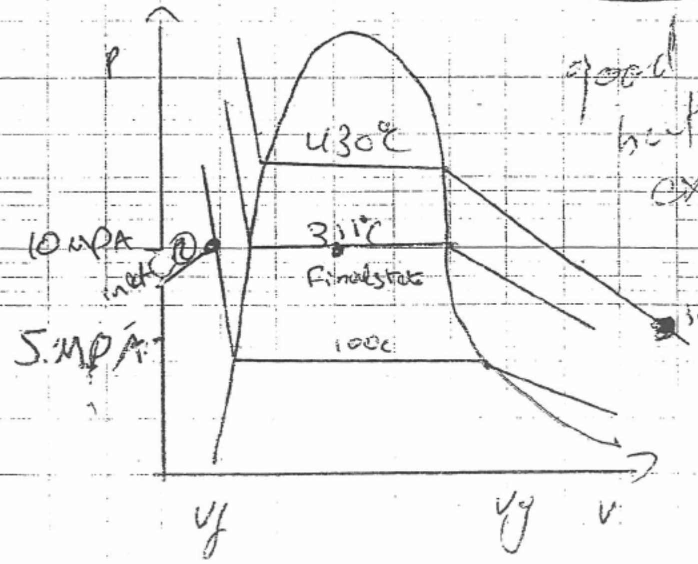
$2\dot{m}_i h = 15(426.48 + 3268) + 5$

$h = 1847$ kJ/kg

from B1.2 @ 10MPA $h_f$ = 1407 , $h_g$ = 2724

$h_f < h < h_g$ so it is sat. @ 311.06°C




good but little explanation needed

-2