Chapter 3 연습문제 계속...

- Example 3
  Consider super heated vapor contained in a fixed container at
  p= 6 MPa, T= 300 °C (일정한 용기)

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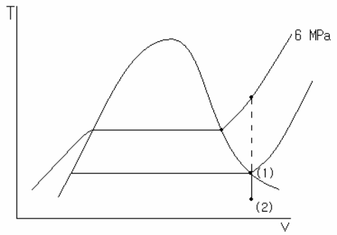
(1) Find P and T at which the steam becomes saturated upon cooling.
(i.e. constant volume cooling!)



Answer to 3.1

Look up steam table p. 389, superheated steam (과열증기)

$$v_{sat} = 0.03616$$

Then find T_{sat} at ν_{sat}=0.03616.
i.e. look up saturated table (포화증기표, ν_g)

p	T	ν_g
5	263.99	0.03944
6	275.64	0.03244

Upon interpolation, (補間)
~P= 5.4 Mpa
~T= 269°C

(2) Determine the state of steam when T becomes 20 C.
(수증기의 상태) Volume remains constant!

As shown in the figure, state (2) is inside the saturation dome.

- When T=20°C, saturated table (p. 380) gives,
- p= 2.339 , ν_f= 0.001002 , ν_g= 57.79

$$v = x_{(2)} v_g + (1-x) v_f$$

$$= v_f + x_{(2)} v_{fg}$$

$$0.03616 = 0.001002 + x_{(2)}(57.79 - 0.001002)$$

or

$$\boxed{x_{(2)} = 0.000608}$$

- Homework Set #3 (due 3/23)
- 3-2, 3-4, 3-6, 3-8, 3-10, 3-12, 3-14
- Next we will learn about the First Law of Thermodynamics!!!

Chapter 4

- 1st Law of Thermodynamics in the Closed System

$$\Delta Q \equiv \Delta E + \Delta W$$

$$(\delta Q = dE + \delta W)$$

Perfect differential
완전미분

Non-perfect differential
불완전 미분 (Path dependent)

- In general, total energy E,
  E = U (internal energy) + KE + PE

$$KE = \frac{1}{2} m v^2$$

$$PE = mg(z_2 - z_1)$$

- If the system is static,
  KE = PE = 0

$$\Delta Q = \Delta U + \Delta W$$

- Conservation of Energy
  (1) For a cycle process,

$$\oint \delta Q = \overbrace{\oint dU}^{0} + \int \delta W$$

$$\oint \delta Q = \oint \delta W$$

"한 Cycle 동안 System에 주어진 Net Heat는 System이 행한 Net Work와 같다."

$$Q_1 - Q_2 = W_{net}$$

Q_1 = Cycle 과정 중 System으로 준 열량.
Q_2 = Cycle 과정 중 System으로부터 방출된 열량.
W_{net} = System이 행한 Net Work.

(2) Energy conservation in Isolated (고립) System.
→ 주위와 열이나 일을 교환하지 않는 밀폐 system

Q_{12}= 0, W_{12}= 0
→ $E_2 - E_1$= 0

If static, $U_2 - U_1$= 0

(3) Internal energy
Extensive property:
That is. it depends on the mass of the system.

(4) Enthalpy: thermodynamic property
Defined $H = U + pV$ total enthalpy

Or, per unit mass
specific enthalpy

$$h = u + pv$$

One reason for introducing enthalpy at this time is that although the steam tables list values for internal energy, many other tables and charts of thermodynamic properties give values for enthalpy but not for the internal energy.

For saturated steam, we know that

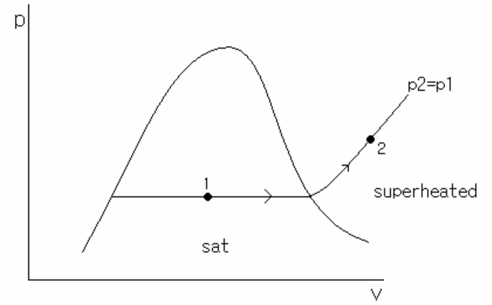
$v = (1-x)v_f + xv_g$ specific volume
$u = (1-x)u_f + xu_g$ specific internal energy
$h = (1-x)h_f + xh_g$ specific enthalpy

Look up of steam table

- Example 1

  A cylinder fitted with a piston has a volume of $0.1m^3$ and contains 0.5 kg of steam at 0.4 Mpa. Heat is transferred to the system until the temperature is 300°C, while the pressure remains constant.

  Find $\Delta Q = \Delta U + \Delta W$



$$\Delta W_{12} = \int_1^2 p\,dV = p\int_1^2 dV = p(V_2 - V_1)$$
$$= m(p_2 v_2 - p_1 v_1)$$

(Method 1) Consider the First Law,

$$\Delta Q_{12} = m(u_2 - u_1) + \Delta W_{12}$$
$$= m(u_2 - u_1) + m(p_2 v_2 - p_1 v_1)$$
$$= m(h_2 - h_1)$$

Since p = constant

Steam table look up, enthalpy

(Method 2)

From steam table, internal energy

$$u_1 = u_f + x_1 u_{fg}$$
$$u_2 = 2804.8$$

$$\Delta Q_{12} = U_2 - U_1 + \Delta W_{12}$$
$$= m(u_2 - u_1) + 91.0 = 771.1kJ$$

From last time...

- Recall the 1st Law of Thermodynamics from last time,

$$\delta Q = dU + \delta W$$
$$= dU + pdV$$

Neglect KE, PE change

With assumptions:

a simple compressible substance & quasi-equilibrium process.

We find that this expression can be evaluated for two separate cases.

(1) Constant Volume

The specific heat ≡ The amount of heat required per unit mass to raise the temperature by 1 degree.

$$c_v = \frac{1}{m}\left(\frac{\delta Q}{\delta T}\right)_v = \frac{1}{m}\left(\frac{\partial U}{\partial T}\right)_v = \left(\frac{\partial u}{\partial T}\right)_v$$

(2) Constant Pressure, $\delta Q = dH \quad (H = U + pV)$ for constant p.

$$c_p = \frac{1}{m}\left(\frac{\delta Q}{\delta T}\right)_p = \frac{1}{m}\left(\frac{\partial H}{\partial T}\right)_p = \left(\frac{\partial h}{\partial T}\right)_p$$