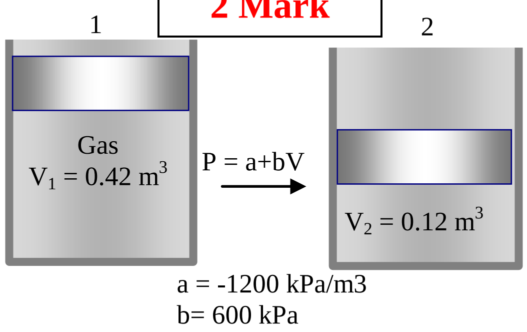
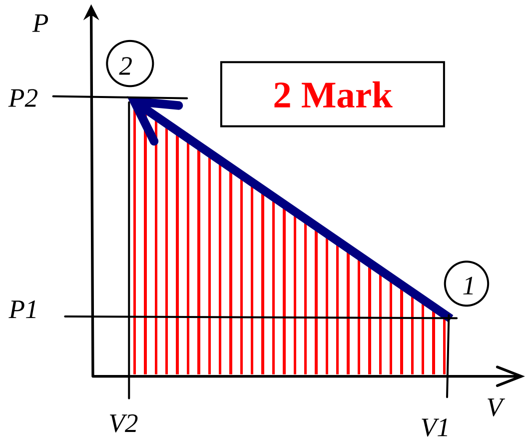
ชื่อ-สกุล..รหัส .... เลขที่ ....

1) A gas is compressed from the initial volume of 0.42 m^3 to the final volume of 0.12 m^3. During the quasi-equilibrium, the pressure change with the volume according to the relation P = aV + b, where V is in m^3, a = -1200 kPa/m^3 and b = 600 kPa.
   a) Sketch the graph of P-V diagram
   b) What is the meaning of area under the P-V relation?
   c) Using integrating method, calculate the amount of work during this compression process.

2 Mark





System: gas, Closed system

Assumption: Ideal Gas, neglect ΔKE, ΔPE **1 Mark**

Solution

(b) Boundary work: $W = \int PdV$

Therefore, Area under P-V diagram represent ${}_1W_2$ answer **1 Mark**

(c) $${}_1W_2 = \int PdV = \int (aV+b)dV$$
$$= a/2[V_2^2 - V_1^2] + b[V_2 - V_1]$$

$a/2[V_2^2-V_1^2]$ = (-1200 kPa/m^3)/2 x [$0.12^2 - 0.42^2$] = 97.2 kJ

$b[V_2-V_1]$ = (600 kPa)(0.12 – 0.42) = - 180 kJ

${}_1W_2$ = 97.2 kJ – 180 kJ = -82.8 kJ

The work done on the system is 82.8 kJ Answer **3 Mark**

1 Mark

ชื่อ-สกุล...รหัส .... เลขที่ ....

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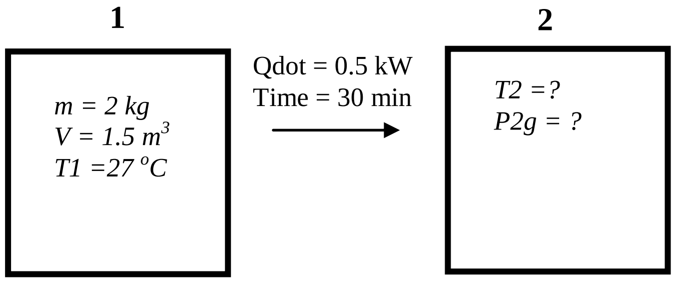
2) Air of amount 2 kg in a rigid container 1.5 m^3 receives heat rate at the amount of 0.5 kW for the period of 30 minutes. The gas constant R = 0.2870 kJ/kg•K and the C_P = 1.005 kJ/kg•K which are constant. The heating process starts with the temperature of the air at T_1 = 27 ˚C. Determine

a) The final temperature (in the unit of ˚C).

b) The value of final pressure (in the form of gage pressure, Pa) if P_{atm} = 1 bar.



1 Mark

System: Air, Closed system, Constant volume

Assumption: Ideal gas

1 Mark

Analysis:

1st Law: $_1Q_2 = {}_1W_2 + m(u_2-u_1)$, $_1W_2 = 0$

$_1Q_2 = mC_v(T_2-T_1)$

Relation: $C_p - C_v = R$

$T_2 = T_1 + {}_1Q_2/mC_v$ (1)

2 Mark

Heat added, $_1Q_2 = Q_{dot} \times t$ (2)

State 2: $P_2V = mRT_2$ (3)

$P_{2g} = P_2 - P_{atm}$ (4)

2 Mark

Solution:

$_1Q_2 = Q_{dot}$ x t = (0.5 kW)(30 mim)(60 s/min)

= 900 kJ

C_v = $C_p - R$ = (1.005 – 0.287)kJ/kgK = 0.718 kJ/kgK

eqn (1),

$_1Q_2/mC_v$ = (900 kJ)/(2kg x 0.718 kJ/kgK) = 626.7 K

T_2 = T1 + $_1Q_2/mC_p$ = (27 ^{o}C +273) + 626.7 K = 926.7 K

= 653.7 ^{o}C Answer

2 Mark

P_2= mRT_2 / V = (2kg x 0.287 kJ/kgK x 926.7 K) / (1.5 m^3)

= 354.7 kPa

= 3.547 Bar

P_{2g} = $P_2 - P_{atm}$ = (3.547 – 1.0) Bar = 2.547 Bar

= 254.7 kPa Answer

2 Mark

ชื่อ-สกุล..รหัส .... เลขที่ ....

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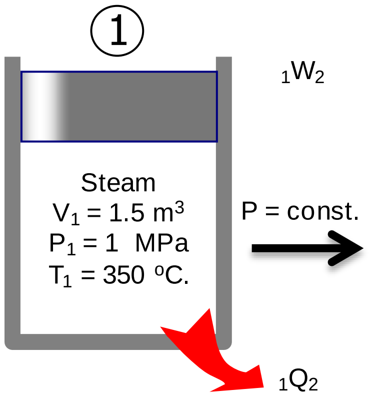
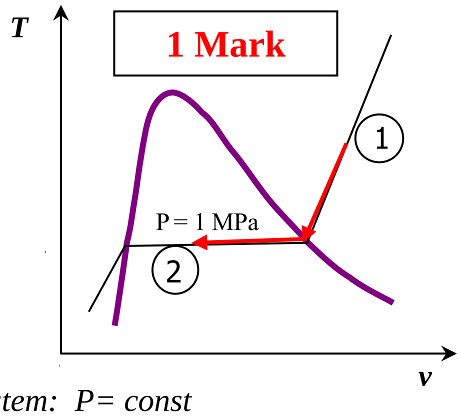
3. A piston-cylinder device contains steam initially at 1 MPa, 350°C, and 1.5 m³. Steam is allowed to cool at constant pressure until one-third of the mass of the steam condensed. Show the process on a T-v diagram with respect to saturation lines *(1 mark)* and determine,

(a) the mass of the steam *(1 marks)*
(b) the quality (*x*) at the final state, *(1 mark)*
(c) the amount of work during the process, *(3 marks)*
(d) the amount of heat transfer. *(3 marks)*

(การทำงานอย่างเป็นลำดับขั้นตอนที่ดี การเขียนอย่างเรียบร้อยดูง่ายและสะอาด 1 คะแนน)





System	*Water in the Piston-Cylinder: Closed System: P= const*
Assumption	*Neglect change in KE, PE*
Analysis	$m = V_1/v_1$
	$-_1Q_2$ *until ½ m condensed* → *mixture:* $x_2 = m_{vap}/m$
	$_1W_2 = mP_1(v_2 - v_1)$
	$_1Q_2 = U_2 - U_1 + {_1W_2}$

Solution

(a) Find mass of the steam:

State 1 $P_1 = 1$ *MPa*, $T_1 = 350\ ^oC$, Table A-5 $T_1 > T_{sat}$ --> *Superheated vapor*

Table A-6 $v_1 = 0.2825$ m³/kg; $u_1 = 2{,}875.2$ kJ/kg

$V_1 = 1.5$ m³

$m = V_1/v_1 = (1.5\ m^3)/(0.2825 m^3/kg)$

the mass of steam is 5.31 kg ***Answer*** **1 Mark**

(b) Find the steam quality

State 2 $P_2 = P_1 = 1$ *MPa and 1/3m condensed* --> $m_{vap} = 1/3m$ **1 Mark**

therefore; quality, x = m_{vap}/m = 2/3 = 0.6667 ***Answer***

(c) Find Work : Boundary work: Process $P = c$; $_1W_2 = mP_1(v_2 - v_1)$

Table A-5 $v_f = 0.001127$ m³/kg; $v_g = 0.19444$ m³/kg

$v_2 = v_f + xv_{fg} = (0.001127 + 0.6667x\ 0.19444) = 0.1300$ m³/kg

$_1W_2$ = (5.31kg)(1000 kPa)(0.1300 - 0.2825) m³/kg = -809.7 kJ

The work done on the system during the process is **809.7 kJ** ***Answer*** **3 Mark**

(d) Find Heat

1st Law: $_1Q_2 = m(u_2 - u_1) + {_1W_2}$

Table A-5 at 1 MPa u_f = 761.68 kJ/kg; u_{fg} = 1,822.0 kJ/kg

$u_2 = u_f + xu_{fg}$ = (761.88 + 0.6667 x 1,822.0) = 1,976.3 kJ/kg

$m(u_2 - u_1)$ = (5.31kg)(1,976.3 - 2,875.2) kJ/kg = -4,772.7 kJ

then, $_1Q_2$ = (-4,772.7 kJ) + (-809.7 kJ) = -5,582.4 kJ

The amount of heat transfer out of the steam is **5,582.4 kJ** ***Answer*** **3 Mark**

Sommai Priprem

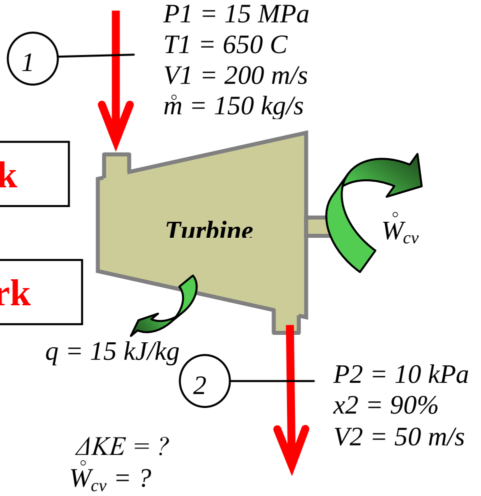
1 Mark

ชื่อ-สกุล..รหัส .... เลขที่ ....

4. Steam flows steadily through a turbine. The inlet conditions of the steam are 15 MPa, 650°C, and 200 m/s, and the exit conditions are 10 kPa, 90 percent quality, and 50 m/s. The mass flow rate of the steam is 150 kg/s. Heat loss from the turbine is 15 kJ/kg steam. State any assumptions made. Show the process on a T-v diagram with respect to saturation line and determine

(a) the change in kinetic energy,

(b) the power output of the turbine.



Solution

Assumption: *SSSF process, ΔPE = 0*

Analysis:

ΔKE = m(ke2-ke1) (1) **1 Mark**

1st law: q + h1 + ke1 = w + h2 + ke2

w = q + (h1-h2) - (ke1-he2) (2) **1 Mark**

W = mw (3)

Property:

State 1: *P1 = 15 MPa, T1 = 650 C*

T > Tsat --> superheat

Table A-6, *v1 = 0.0268* m^3*/kg*

h1 = 3,712.30 kJ/kg **1 Mark**

State 2: *P2 = 10 kPa, x2 = 90 % --> mixture*

Table A-5 *vf = 0.001452 m3/kg,*

vg = 0.018026 m3/kg

v2 = vf + x vfg = ***0.0163686 m3/kg***

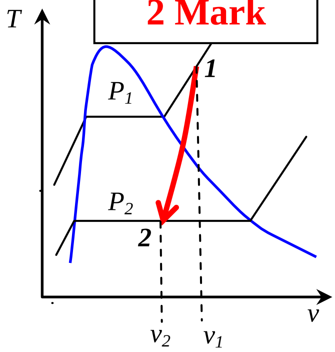
1 Mark *hf = 191.83 kJ/kg, hfg = 2392.8 kJ/kg*

h2 = hf + xhfg = ***2,345.35 kJ/kg***

T-v diagram: *State 1 → superheated vapor at* P_1

State 2 → Mixture at P_2 *and* $v_2 < v_1$

2 Mark



(a) *ΔKE = m(ke2-ke1)*

(ke2-ke1) = 1/2{(50m/s)^2 - (200m/s)^2)}/1000 = -18.75 ***kJ/kg***

m = 150 kg/s

ΔKE = m(ke2-ke1) = (12 kg/s)(-1.95 kJ/kg) = -2,812.50 *kW* **1 Mark**

Change in kinetic energy (decreased) = ***2,812.5*** ***kW*** *Answer*

(b) from eqn 2 *w = q + (h1-h2) - (ke1-he2)*

q = -15 kJ/kg

(h1- h2) = 3712.3 kJ/kg - 2345.35 kJ/kg

= 1367.0 kJ/kg

ke1-ke2 = 18.75 kJ/kg

w = (-15kJ/kg)+(1,367.0kJ/kg)-(-18.75kJ/kg)

= 1,370,7 kJ/kg

W = mw = (150 kg/s)(1,370,7kJ/kg)

= ***205,605 kW***

Power output from the turbine is ***205.6 MW*** **2 Mark** *Answer*

1 Mark