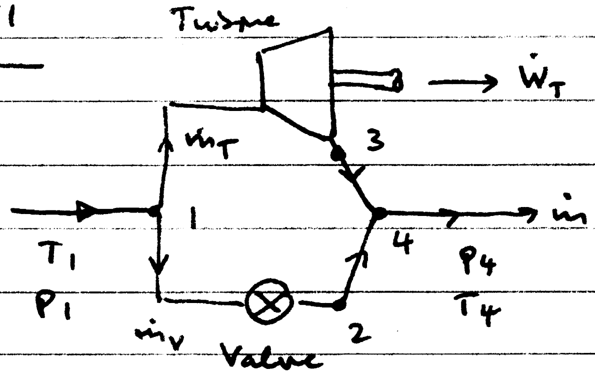
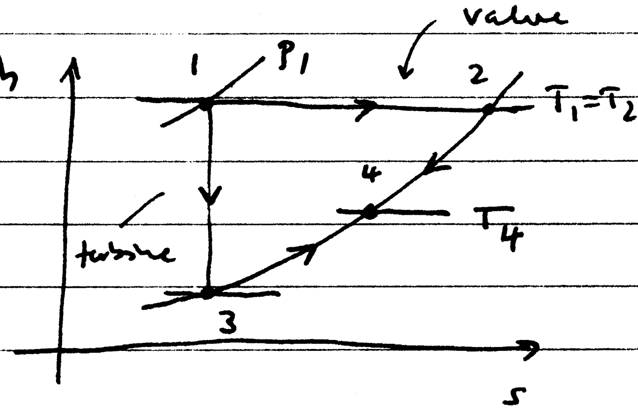
T1

16.Unified Spring 2008



Assume:
- adiabatic, ideal turbine
- steady-state
- ideal gas, const. spec. heats
- neglect ΔKE, ΔPE



Note: $p_3 = p_2 = p_4$ mixing at const. pressure

1st law throttle: $h_1 = h_2$
(lost work!)

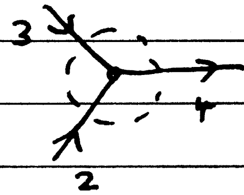
find: $\dot{m}_T$, $\dot{W}_T$

- ad. rev. expansion through turbine: $T_3 = T_1 \left(\frac{p_3}{p_1}\right)^{\frac{\gamma-1}{\gamma}}$ $\underline{T_3 = 470.7\,K}$

- throttle: $\underline{T_2} = T_1 = \underline{644.3\,K}$ (1st law)

- cons of mass: $\dot{m}_T + \dot{m}_V = \dot{m}$

- 1st law CV:

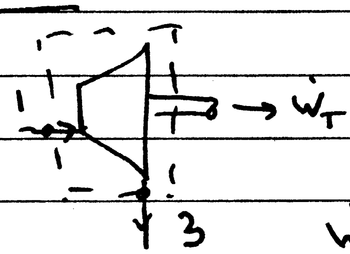


$0 = \dot{m}_T h_3 + \underbrace{\dot{m}_V}_{\dot{m} - \dot{m}_T} h_2 - \dot{m} h_4$

$\dot{m}_T = \dot{m} \frac{h_2 - h_4}{h_2 - h_3} = \dot{m} \frac{T_2 - T_4}{T_2 - T_3}$

$\underline{\dot{m}_T = 7.26\ \text{kg/s}}$

- 1st law CV



$0 = -\dot{W}_T + \dot{m}_T (h_1 - h_3)$

$\dot{W}_T = \dot{m}_T c_p (T_1 - T_3)$; $\underline{\dot{W}_T = 1.26\ \text{MW}}$

Concepts: 2 phase media, def. of quality

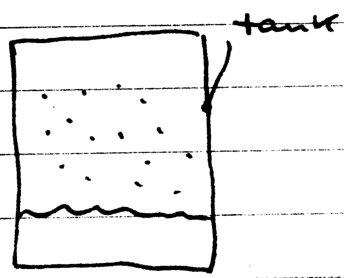
a) $\bar{v} = v_g(T)\, x + (1-x)\, v_f(T)$

$x = 10\%$, $v_f(T=100°C) = 0.001044\ m^3/kg$

$v_g(T=100°C) = 1.6729\ m^3/kg$

$\bar{v} = 0.16823\ m^3/kg$

b)



$V = 2m^3$

$V_f = 0.5m^3$

so $V_g = 1.5m^3$

$p_g = p_f = p = 50\ kPa$

$\rightarrow v_f = 0.00103\ m^3/kg$

$v_g = 3.24\ m^3/kg$

so $m_f = \frac{V_f}{v_f} = 485.44\ kg$, $m_g = \frac{V_g}{v_g} = 0.463\ kg$

hence $m = m_f + m_g$, $x = \frac{m_g}{m}$

$x = 0.095\%$

$m = 485.9\ kg$

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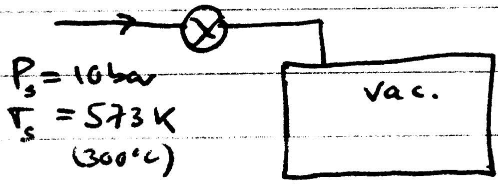
T3

16. Unified Spring 2008



Concepts:
- 1st law
- flow work / enthalpy
- 2phase media

a) 1s law CM : $u_f - u_i = -(-p_s v_s)$ flow work done on steam

CM → 1 kg of steam

~~initially: $u_i = u_s$~~

~~(insulated vessel~~ → q=0)

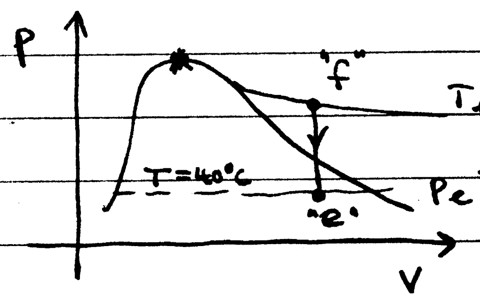
$u_f = u_s + p_s v_s \longrightarrow u_f = h_s$

$h_s(p_s, T_s) = 3051.2$ kJ/kg , $u_f(T_f) = h_s \longrightarrow T_f = 456.2$°C

(page 7) (table p.7) interpolate

b) because flow work was done on the steam (see a))

c)



steam cooled (condensing) at constant volume (valve closed, same amount of steam → v=const)

find p(T=40°C) on vapor-pressure curve

$p_e = 7.384$ kPa

d) 1st law:

$du = dq - p\,dv^{\nearrow 0}$ $u_{"e"} - u_{"f"} = q$ $u_{"f"} = 3051.2$ kJ/kg

find $v_{"f"}$ from table p.7 $v_{"f"} = 0.3333$ m³/kg

$v_{"f"} = v_{"e"} = v_g(40°C)\,x + (1-x)\,v_f(40°C)$ $x = \dfrac{v_{"f"} - v_f(40°C)}{v_g(40°C) - v_f(40°C)} = 0.017$

$u_{"e"} = u_g(40°C)\,x + (1-x)\,u_f(40°C) = 206.1$ kJ/kg

$q = u_{"e"} - u_{"f"}$; $q = -2845.1$ kJ/kg heat rejected