University of Technology

Department of Laser & Opto-electronic Engineering

Final Examination 2011-2012

Subject:Thermo.&fluid mechanics ***Class:2nd year***

Division:Laser Engineering ***Time:3 hours***

Examiner: Assist. Prof Khalid Salem ***Date: 5/6/2012***

Answer five questions only

Q1) A) One kg of a certain gas is at 0.11 MN/m^2 & 15°C. It is compressed isothermally until its volume is 0.1 m^3. Calculate the final pressure and temperature. Calculate also work done , change in internal energy and heat transfer, assume $C_v = 0.6$ kJ/kg.K C_p =0.94 kJ/kg.K . (6 marks)

B) A gas whose pressure, volume and temperature are 275 KN/m^2, 0.09 m^3 and 185°C, respectively ,has its state changed at constant pressure until its temperature becomes 15°C. How much heat is transferred from the gas and how much work is done on the gas during the process also obtain the difference in specific internal energy take R=0.29kJ/kg.K, $C_p = 1.005$kJ/kg.K (6 marks)

Q2)In a steady flow system , a substance flows at a rate of 4 kg/sec ,it enters with a velocity of 300 m/sec , a specific internal energy 2100 kJ/kg , pressure of 620KN/m^2 and specific volume 0f 0.37 kg/m^3 . At the exit the velocity is 150 m/sec, specific internal energy 1500 kJ/kg, pressure of 130KN/m^2 and specific volume of 1.2 kg/m^3 .The fluid has a heat loss to the surrounding of 30 kJ/kg as it passes through the turbine. The difference in height between inlet and outlet is 10 meters; determine the power developed by the turbine in MW. (12 marks)

Q3) The volumetric analysis of a gas is as follows: H_2 60%, N_2 20%, O_2 20%.This gas is mixed with air in proportions 1 volume of gas to 2 volume of air. Take the molar specific heat capacities at constant volume for diatomic gas =20.9 kJ/kg mol K. Assume that air contains 21% oxygen by volume and the remainder is N_2 .If the air-gas mixture is kept at 25°C and 150 KPa for temperature and pressure respectively. Determine for the air-gas mixture: a) the mean relative molecular mass of the mixture(M_{av}) (2 marks)

b) The value of the adiabatic index of the mixture (γ). (2 marks)

c) The characteristic gas constant for the mixture(R). (2 marks)

d) The density of air . (2 marks)

e) The partial pressure and mass fraction of N_2 in the mixture. (4 marks)

Q4) For the velocity meter shown in fig1, derive an equation that relate R and V_1 .If R=2 cm and the diameter of the pipe D_1=20 cm, what is the volume flow rate in m^3/s . (12 marks)

Q5) For a large tanks shown in fig2, what is the value of the distance R. (12 marks)

Q6) A) Change the polytropic index (n) in the equation PV^n =Constant , from zero to ∞ ,plot P-V diagram, show the possible processes. (6 marks)

B) Prove that $C_v = \dfrac{R}{\gamma - 1}$, where γ-adiabatic index, R- characteristic gas constant , C_v-specific heat at constant volume . (6 marks)

Fig 1

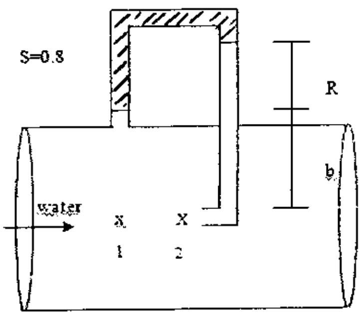
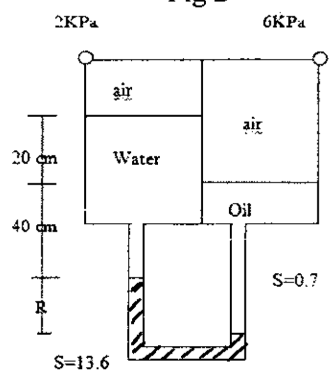
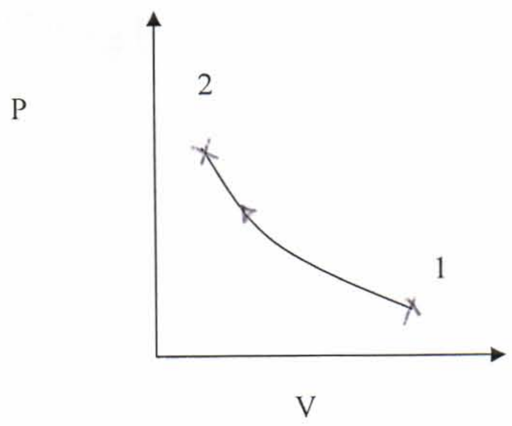


Fig 2



2012/2011 دور اول أجوبة اسئلة الثرمو + الموائع
المرحلة الثانية ليزر

Q1)
A)



R=Cp-Cv=0.94-0.6
= 0.34 kJ/kg.K

$$P_2 = \frac{mRT_2}{V_2} = \frac{1x0.34x1000x(273+15)}{0.1} = 979200 \text{ N/m}^2$$

$T_2 = T_1 = 288\ ^\circ K$

$$w = PV\ln\frac{V_2}{V_1} = mRT\ln\frac{P_1}{P_2} = 1x0.34x1000x288\ \ln\frac{0.11}{0.9792} = -214078 \text{ J}$$

Q=W since $\Delta U=0$ in isothermal process

B) $m=\frac{P_1V_1}{RT_1} = \frac{275000x0.09}{290(273+185)} = 0.186$ kg

$Q=mCp(T_2-T_1)$
=0.186x1005(288-458)
=-31780 J

$$V_2 = \frac{mRT_2}{P_2} = 0.0566m^3$$

$W=p(V_2-V_1)=275000(0.0566-0.09)=-9190J$

$\Delta u = q - w$

$$= \frac{-31780}{0.186} + \frac{9190}{0.186} = -121451.61 \frac{J}{kg}$$

Q2)

The steady state flow energy equation is

$$q + u_1 + P_1 v_1 + \frac{V_1^2}{2} + gz_1 = w + u_2 + P_2 v_2 + \frac{V_2^2}{2} + gz_z$$

$$-30000 + 2100x1000 + 620x1000x0.37 + \frac{300^2}{2} + 10x10 = w + 1500x1000 + 130x1000x1.2 + \frac{150^2}{2}$$

$$w = 676750 J/kg$$

But

$$Power = \dot{m} w$$

=4x676750=2707000 Watts=2.707 MW

Q3)

$$\text{Mav} = \frac{1(0.2x28 + 0.6x2 + 0.2x32) + 2x(0.79x28 + 0.21x32)}{3} = 23.62 \text{ kg/kg.mol}$$

$$\bar{C}_{vav} = \frac{\sum n\bar{C}_v}{\sum n} = \left(\frac{1x(0.3 + 0.6 + 0.1) + 2x(0.79 + 0.21)}{3}\right)x20 = 20 \frac{kJ}{kg.mol.K}$$

$$Rm = \bar{C}_p - \bar{C}_v$$

$$\bar{C}_{pav} = 8.3143 + 20 = 28.3143 \frac{kJ}{kg.mol.K}$$

$$\gamma = \frac{\bar{C}_{pav}}{\bar{C}_{vav}} = \frac{28.3143}{20} = 1.4157$$

$$R_{av} = \frac{R_m}{M_{av}} = \frac{8.3143}{23.62} = 0.352 \frac{kJ}{kg.K}$$

$$P_{air} = \frac{P_t}{n_T} n_{air} = \frac{150}{3} x2 = 100 \frac{KN}{m^2}$$

$$R_{air} = \frac{R_m}{M_{air}} = \frac{8.3143}{(0.21x32 + .79x28)} = \frac{8.3143}{28.84} = 0.28829 \frac{kJ}{kg.K}$$

$$\rho_{air} = \frac{P_{air}}{R_{air} T} = \frac{100x1000}{288.29(273 + 25)} = 1.164 \frac{kg}{m^3}$$

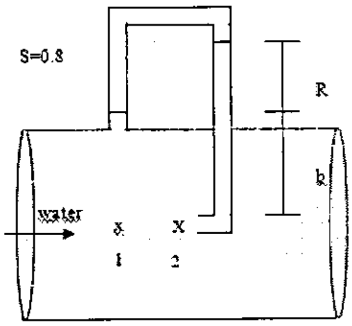
$$P_{N2} = \frac{P_T}{n_T} n_{N2} = \frac{150}{3}(0.2 + 2x0.79) = 89 \frac{KN}{m^2}$$

$$m_T = n_T M_{av} = 3x23.62 = 70.8 kg$$

$$m_{N2} = 28(0.2 + 2x0.79) = 49.84 kg$$

$m_{N2}\% = \frac{m_{N2}}{m_T}$ = 7[illegible].5%

Q4)



Bernoulli equation between 1&2, neglect loss then

$$\frac{P_1}{\gamma_w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma_w} + \frac{V_2^2}{\gamma_w} + z_2 \qquad \text{eq(1)}$$

$z_1 = z_2$ and $V_2 = 0$ then eq(1) becomes

$$\frac{P_2 - P_1}{\gamma_w} = \frac{V_1^2}{2g} \qquad \text{eq(2)}$$

Pressure equation 1&2

$$P_1 - b\gamma_w - RS\gamma_w + (R+b)\gamma_w = p_2 \qquad \text{eq(3)}$$

Then

$$\frac{P_2 - P_1}{\gamma_w} = R(1-S) \qquad \text{eq(4)}$$

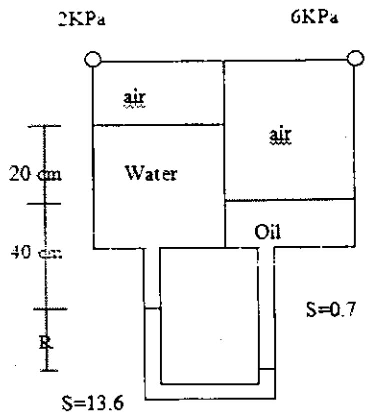
eq(2)=eq(4) then

$V_1 = \sqrt{2gR(1-S)}$

$V_1 = \sqrt{2x9.8x0.02(0.2)}$ =0.28 m/s

Q= $V_1 A$ =7.027($\pi \frac{D^2}{4}$) =0.28($\pi \frac{0.2^2}{4}$)= 0.0088 m^3/s

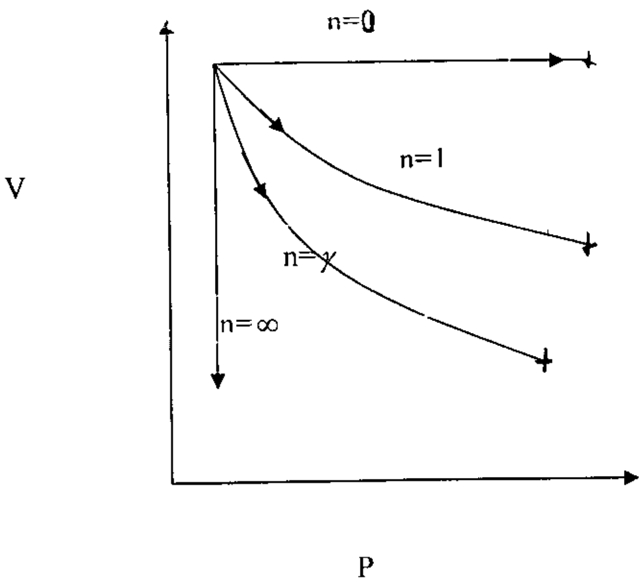
Q5)



$$2000+0.6\gamma_w+13.6R\gamma_w-0.7\gamma_w(R+0.4)=6000$$
$$(13.6-0.7)R\gamma_w=6000-2000-0.6\gamma_w+0.7x0.4\gamma_w$$

$$R=\frac{800}{12.9x10000}=0.0062m$$

Q6)



n=0 constant pressure process
n=1 isothermal process
n=γ adiabatic process
n=∞ constant volume process

B) Prove that $C_v = \frac{R}{\gamma - 1}$, where γ-adiabatic index, R- characteristic gas constant, C_v-specific heat at constant volume.

R=Cp-Cv

$$\gamma = \frac{Cp}{Cv}$$

then

$$\frac{R}{Cv} = \gamma - 1$$

$$C_v = \frac{R}{\gamma - 1}$$