THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 05 045
FINAL EXAMINATION 2005/2006
MEX5231 – THERMODYNMICS
DATE : 14th MAY 2006
TIME : 0930-1230 HOURS
DURATION : THREE HOURS

ANSWER FIVE QUESTIONS ONLY. ALL QUESTIONS CARRY EQUAL MARKS. YOU MAY OBTAIN TABLES OF THERMODYNAMIC AND TRANSPORT PROPERTIES OF FLUIDS OR MOLLIER DIAGRAM ON REQUEST.

Q1. A vapour compression refrigeration system, which uses R-12 as the refrigerant, has an evaporating temperature of -15°C and a condensing temperature of 25°C. The vapour is dry saturated when it enters the compressor and the vapour leaves the compressor in a superheated state. Determine the temperature of vapour at entry to the condenser and the coefficient of performance. Assume that the specific heat of the superheated vapour at constant pressure is 0.705kJ/kgK.
If the liquid refrigerant is sub cooled by 5°C before entry to the throttle value, determine the quality of vapour entering the evaporator and the new coefficient of performance. Assume that the specific heat of the liquid refrigerant is 0.97kJ/kgK.

Q2. A gas turbine unit takes air at 17°C and 1.01bar and works at a pressure ratio of 8/1. The compressor is driven by the H.P. turbine and the L.P. turbine drives an electric generator. The maximum cycle temperature is found to be 650°C. The isentropic efficiency of the compressor is given as 0.8, while the turbines could be treated as ideal. Draw a sketch of the GT unit and plot the cycle on a T-s diagram. Determine,

(a) the pressure and temperature of the gases entering the L.P turbine
(b) the net power developed by the unit per kg/s mass flow
(c) the work ratio and the thermal efficiency of the unit
(d) if you want to introduce a reheater to this GT engine, where would you place it? Plot the cycle with the reheater on a T-s diagram.

You should assume the following values for the processes:

	Compression	Combustion	Expansion
Cp (kJ/kg K)	1.005	1.15	1.15
Ratio of Specific heats	1.4	1.33	1.33

Q3. *(a)* A steam power plant operates on the Rankine cycle principle. The inlet conditions of the steam to the turbine are 35bar & 300^0C, while the condenser pressure is maintained at 0.1bar. The expansion process in the turbine may be assumed ideal. Show the cycle on a T-s diagram and calculate,

(i) the energy supplied at the boiler per 1kg of steam generation
(ii) dryness fraction of steam entering the condenser
(iii) the feed pump work
(iv) thermal efficiency and the work ratio for the cycle

(b) What would be the theoretical maximum thermal efficiency for the power plant?

Q4. The mass flow rate m through a cross sectional area A_1 of a convergent-divergent nozzle as shown in Figure Q5, is given by

$$\frac{m}{A_2}=\left[\left(\frac{2n}{1-n}\right)\frac{p_1}{v_1}\left\{\left(\frac{p_2}{p_1}\right)^{\frac{n+1}{2}}-\left(\frac{p_2}{p_1}\right)^{\frac{2}{n}}\right\}\right]^{\frac{1}{2}}$$

where n is the ratio of specific heats, V_1 is the specific volume at entry conditions, p_1 is the inlet pressure and p_2 is the pressure at cross section A_2. Show that

(m/A_2) will be maximum when, $\frac{p_2}{p_1}=\left[\frac{2}{n+1}\right]^{\frac{n}{n-1}}$

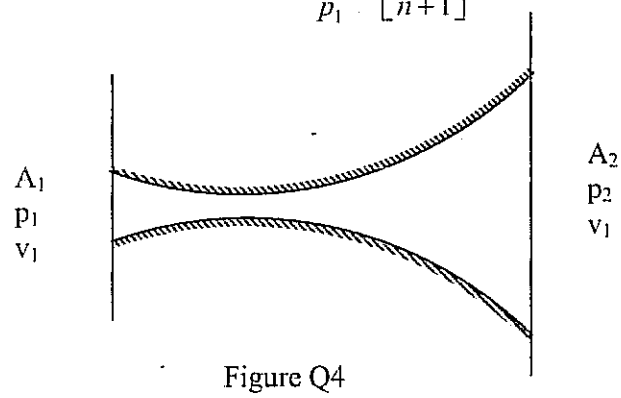


Figure Q4

Air expands in a propulsion nozzle from 3.5bar and 400°C to a pressure of 1.03bar at the rate of 16kg/s. Determine,

(a) the throat area required if the coefficient of discharge is 0.99 and the nozzle efficiency is 0.94
(b) the exit area and the exit velocity.

Assume that the inlet velocity is zero.

Q5. A furnace is fired with natural gas as the fuel. A section of the furnace wall, 2m×1.5m in size, is not insulated. The temperature at the outer surface of this section is measured to be 80°C. The air temperature in the furnace room is 30°C, and the combined convection and radiation heat transfer coefficient at the surface of outer surface is 10W/m^{2o}C. It is proposed to insulate this section of the furnace wall with glass wool insulation (k= 0.038W/m °C) in order to reduce the heat loss by 90 percent. Assuming the outer surface temperature of the metal section would still remain at 80°C, determine the thickness of the insulation needed.

Q6. The mean diameter of the blades an impulse turbine with a single row wheel is 1050mm and the speed is 3000rev/min. The nozzle angle is 18°, the ratio of blade speed to stream speed is 0.42 and the ratio of the relative velocity at outlet from the blades to that at inlet is 0.84. The outlet angle of the blade is to be made 3° less than the inlet angle. The stream flow is 8kg/s. Draw the velocity diagram for the blades and derive the

(a) resultant thrust on the blades
(b) tangential thrust on the blades
(c) axial thrust on the blades
(d) power developed in blades
(e) blading efficiency

Q7. The absorber surface of a solar collector, shown in Figure Q7, is made of a material with emmissivity of 0.09 and absorptivity of 0.87. Solar radiation is incident on the surface at a rate of 600W/m^2. The convection heat transfer coefficient is estimated to be 10W/m^2, while the effective sky temperature and the air temperature are 15° and 25°C. At a time when the absorber surface temperature is 70°C, determine the net rate of solar energy delivered by the absorber plate to the water.

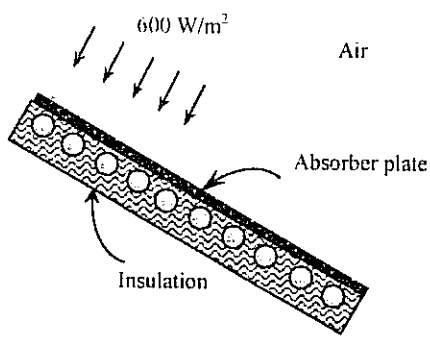


Figure Q7

Q8. *(a)* What do you understand by the term" adiabatic flame temperature"?

(b) What is the interaction between equivalence ratio and air to fuel ratio? Briefly discuss.

(c) Composition of coal from coal mine in mass basis as follows,

S =0.6% H=5.7% C = 79.2% O = 10% N=1.5% Ash = 3%

If this coal is burnt with 50% excess air, determine:

(i) The stoichiometric air to fuel ratio on mass basis and mole basis

(ii) The actual air to fuel ratio

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