THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 03
FINAL EXAMINATION 2005/2006
MED1203 – THERMODYNAMICS
DATE : 18th MARCH 2006
TIME : 0930 – 1230 HOURS
DURATION : THREE HOURS

YOU MAY OBTAIN TABLES OF THERMODYNAMIC AND TRANSPORT PROPERTIES OF FLUIDS ON REQUEST.

Part – B

1. *Part – B consists of* ***eight*** *questions. Answer* ***only five*** *questions.*
2. *All questions carry equal marks.*
3. *Time allocation for Part B is* ***2 hrs and 15 minutes.***
4. *Do not spend more than* ***20 – 25 minutes*** *for each question.*
5. *Hand over* ***Part B*** *separately.*

Q1 State the steady flow energy equation for an open air system.

12kg of air per minute enters a nozzle with negligible velocity and expand from a pressure of 6 bar to 2.5 bar. The temperature falls from 1200°C to 800°C in the process. Calculate;

1) velocity of the air as it leaves the nozzle.
2) nozzle exit area for the above mentioned mass flow rate.

Q2 Starting from the non-flow energy equation, show that, when a gas expands according to the law $PV^n = C$, the amount of heat transferred "Q" is given by

$$Q = \left(\frac{\gamma - n}{\gamma - 1}\right)\frac{mR(T_1 - T_2)}{(n-1)}$$

0.05kg of air at a temperature of 27°C and a pressure of 1 bar is compressed to one tenth of its volume according to the law PV^n = Constant. The pressure at the end of the compression is 18bar. The air is now heated at constant pressure until the volume is doubled.

Determine:

(1) polytropic index of the compression process (n)
(2) temperature at the end of compression

Q3 Rankine cycle with superheat but no reheat operates between a boiler pressure of 30bar and a condenser pressure of 0.04bar, with superheating to 450°C. the turbine has an isentropic efficiency factor (α) and the compression work has an isentropic efficiency factor (β).
Show that,

(1) the thermal efficiency(η) of the cycle is given by,

$$\eta = \frac{\left(1210\alpha - \frac{3}{\beta}\right)}{\left(3322 - \frac{3}{\beta}\right)}$$

(2) the work ratio(r_w) is given by, $r_w = 1 - \left(\frac{0.0025}{\alpha\beta}\right)$

Q4 A single acting reciprocating air compressor takes in ***m***kg of air at a pressure of P_1 and a temperature T_1 and compresses it to a pressure of P_2. Show that the work done(W) by the compressor per cycle is given by,

$$W = \left(\frac{n}{1-n}\right) mRT_1 \left(\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right)$$ where n is the polytropic index for compression and expansion.

A single acting reciprocating air compressor has a bore of 200mm and a stroke of 300mm. It receives air at 1 bar & 27°C and delivers it at 5bar. If the polytropic index of expansion and compression is 1.3 and the clearance volume is 5% of the swept volume, Determine;
(1) volumetric efficiency of the air compressor ,
(2) power required to drive the compressor if it runs at 600rev/min.

Q5 A certain fuel consists of 84% Carbon(C), 14% Hydrogen(H_2), and 2% Oxygen (O_2) by mass. If the fuel is burnt with 20% excess air and the combustion is complete, determine the volumetric composition of the products of combustion.
Assume that air contains 23% of O_2 and 77% of N_2 by mass
(Atomic masses: C−12, H−1, O−16, N−14)

Q6 Discuss the difference between laminar flow and turbulent flow.

A liquid chemical flows through a pipe of diameter 36mm at a rate of 0.5kg/s. Density and the viscosity of the liquid are 800kg/m^3 and 9.11×10^{-4}kg/ms respectively. Show that the flow of the liquid is laminar.
If the weighted mean temperature of the chemical is 90°C and the rate of heat transfer into the liquid is 5kW, calculate the length of the pipe in order to maintain the temperature of the pipe wall at 100°C. Take thermal conductivity of the liquid as 7.31×10^{-4}kW/mK and Nusselt number as 4.12.

Q7 In an ideal constant volume cycle (Otto cycle), the pressure and temperature at the beginning of the compression are100kPa and 60°C respectively. The volume ratio of compression is 5:1. The heat supplied during the cycle is 930kJ/kg of working fluid. Determine:
(1) maximum temperature attained in the cycle
(2) heat rejected during the cycle/kg of working fluid
(3) net work done during the cycle/kg of working fluid
(4) thermal efficiency of the cycle

Q8 What is meant by diagram factor with respect to a reciprocating steam engine.

A double acting single cylinder steam engine has a cylinder diameter of 250mm and a piston stroke of 320mm. The steam is supplied at a pressure of 0.3bar. The engine develops a net brake power of 15kW at a speed of 200rev/min, with a back pressure of 0.3bar. If the cut off ratio is 0.333 determine the diagram factor. Assume that the mechanical efficiency of the engine is 85%.