國立中山大學 102 學年度碩士暨碩士專班招生考試試題

科目名稱：熱力及熱傳導、熱輻射學【機電系碩士班甲組】 題號：438005

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘） 共 2 頁第 1 頁

1. **10%.** An ideal gas within a piston expands from the same initial state to the same final (specific) volume undergoes the adiabatic, isothermal, and isobaric processes, respectively. Please plot a p-v diagram to show the three processes, and show what process the work is done greatest and what process the work is done least. If the three processes occur in a gas turbine, please plot a p-v diagram to show the three processes occurs in a gas turbine and also discuss the work done from the greatest to the least. Assume the ideal gas with constant specific heats at room temperature.

2. **10%.** Please illustrate the meanings and working principles of a cogeneration, a combined gas-vapor power cycle, and a binary power cycle, respectively?

3. **15%.** A six-cylinder, four-stroke, spark-ignition engine operating on the ideal Otto cycle takes in air at 95 kPa and 17℃, and is limited to a maximum cycle temperature of 870℃. Each cylinder has a bore of 8.9 cm, and each piston has a stroke of 9.9 cm. The minimum enclosed volume is 14 percent of the maximum enclosed volume. How much power will this engine produce when operated at 2500 rpm? Use constant specific heats at room temperature. (The properties of air are k=1.4, R=0.287 kPa · m^3/kg · K, c_p=1.005 kJ/kg · K, and c_v=0.718 kJ/kg · K.)

4. **15%.** A certain gas obeys the equation of state

$$v = RT/P - a/T + b$$

where R is a gas constant, and a and b are also constants. Use this equation of state to derive an equation for the Joule-Thomson coefficient inversion line ($\mu_J = 0$). Please plot its P-T diagram and show several lines for constant h and the inversion line. [Note Joule-Thomson coefficient $\mu_J = (\partial T/\partial P)_h$]

5. **10 %.** A nozzle receives $\dot{m}$ =0.5 kg/s of air at a pressure P_1 of 2700 kPa and a velocity v_1 of 30 m/s and with enthalpy h_1 of 923 kJ/kg, and the air leaves at a pressure P_2 of 700 kPa and with an enthalpy h_2 of 666 kJ/kg.

You could use the following assumptions:

1. The flow rate is steady.
2. The work crossing the control volume is zero.
3. The change in potential energy from inlet to outlet can be neglected.

(a).**(3%)** To form an energy balance by 2nd Law to calculate the exit velocity $\boldsymbol{v_2}$, the mass flow rate and pressures given at inlet (state 1) and outlet (state 2) in this problem will be absent in the equation. Why?

(b).**(7%)** Determine the exit velocity $\boldsymbol{v_2}$ from the nozzle for flow where the heat loss q is 1.3 kJ/kg.

Hint: For (b), please derive the governing equation with the symbols listed in this question, and then insert numbers into the equation to calculate the exit velocity at the next step. The score will be partially given based on correctness of the equation you list even if the final solution is wrong.

6. **20 %.** There are two rods exposed to ambient air separately. The only difference between two rods is the length. Rod I has length L=300 mm, and Rod II is 100 mm. Except the length, the diameter, the base temperature (T_b), material properties (conductivity k) and flow conditions (convection heat transfer coefficient h) are identical. The diameters are 5 mm with one end maintained at T_b=100°C. The surfaces of the rods are both exposed to ambient air at T_∞=25°C with a constant convection heat transfer coefficient h=100 W/m^2·K. The conductivity k for both rods is 398 W/m·K.

(a).**(5%)** Please derive the governing equation:

$$\frac{d^2T}{dx^2} - m^2(T - T_\infty) = 0$$

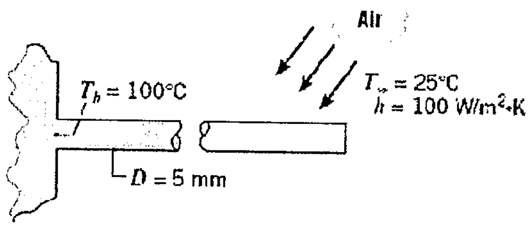
Where $m^2=hP/kA_c$ with P as perimeter and A_c as cross-section area

(b).**(2%)** Table listed below shows the temperature distribution based on different tip boundary conditions (Case A and B) at one end. Based on the governing equation in (a), only one boundary condition is not sufficient to solve the equation. Please write down the remaining boundary condition.

(c).**(5%)** Find the tip temperature at x=*300 mm* for Rod I for Case A and B.

(d).**(5%)** Find the tip temperature at x=*100 mm* for Rod II for Case A and B.

(e).**(3%)** The answers for (c) are all very similar while those for (d) are very different. Please make comments on this aspect.



Temperature distribution and heat loss for fins of uniform cross section

Case	Tip Condition ($x = L$)	Temperature Distribution θ/θ_b
A	Convection heat transfer: $h\theta(L) = -kd\theta/dx\vert_{x=L}$	$\dfrac{\cosh m(L-x) + (h/mk)\sinh m(L-x)}{\cosh mL + (h/mk)\sinh mL}$
B	Infinite fin ($L \to \infty$): $\theta(L) = 0$	e^{-mx}

$\theta \equiv T - T_\infty$ $\quad m^2 \equiv hP/kA_c$

$\theta_b = \theta(0) = T_b - T_\infty$ $\quad M \equiv \sqrt{hPkA_c}\,\theta_b$

Hint: ***$sinhx=(e^x-e^{-x})/2$, $cosh=(e^x+e^{-x})/2$***

7. **20%.** Consider a solid material has V as volume, A as surface area, ρ as density, c as heat capacity, k as conductivity. It is enclosed in a room with wall temperature T_{surr} and air temperature T_∞. You may also need the following coefficient: emissivity ε, absorptivity α, Boltzmann constant σ, and convection heat transfer coefficient h.

(a).(2%) Temperature T is in general function of space and time. However, the spatial effect sometimes can be dropped. In other words, the governing equation can be derived based on the balance of storage energy and surface heat flux. Please explain when you could consider temperature as function of time t only.

(b).**(5%)** Assume the surrounding is much larger than the solid material. Please write down the net rate of radiation heat transfer from the surface.

(c).**(2%)** Please write down the form for radiation heat transfer coefficient h_r.

(d).**(8%)** Derive an ordinary differential equation for T with respect to time t. Will the shape of the solid material affect the heat transfer process if V and A are fixed? Why?

(e).**(3%)** If the goal is to heat the solid material from initial temperature T_1 to final temperature T_2, please write down a criteria regarding when the convection can be dropped compared with radiation.

Hint: your answer for (d) will be dT/dt=convection term+radiation term