國立清華大學 102 學年度碩士班考試入學試題

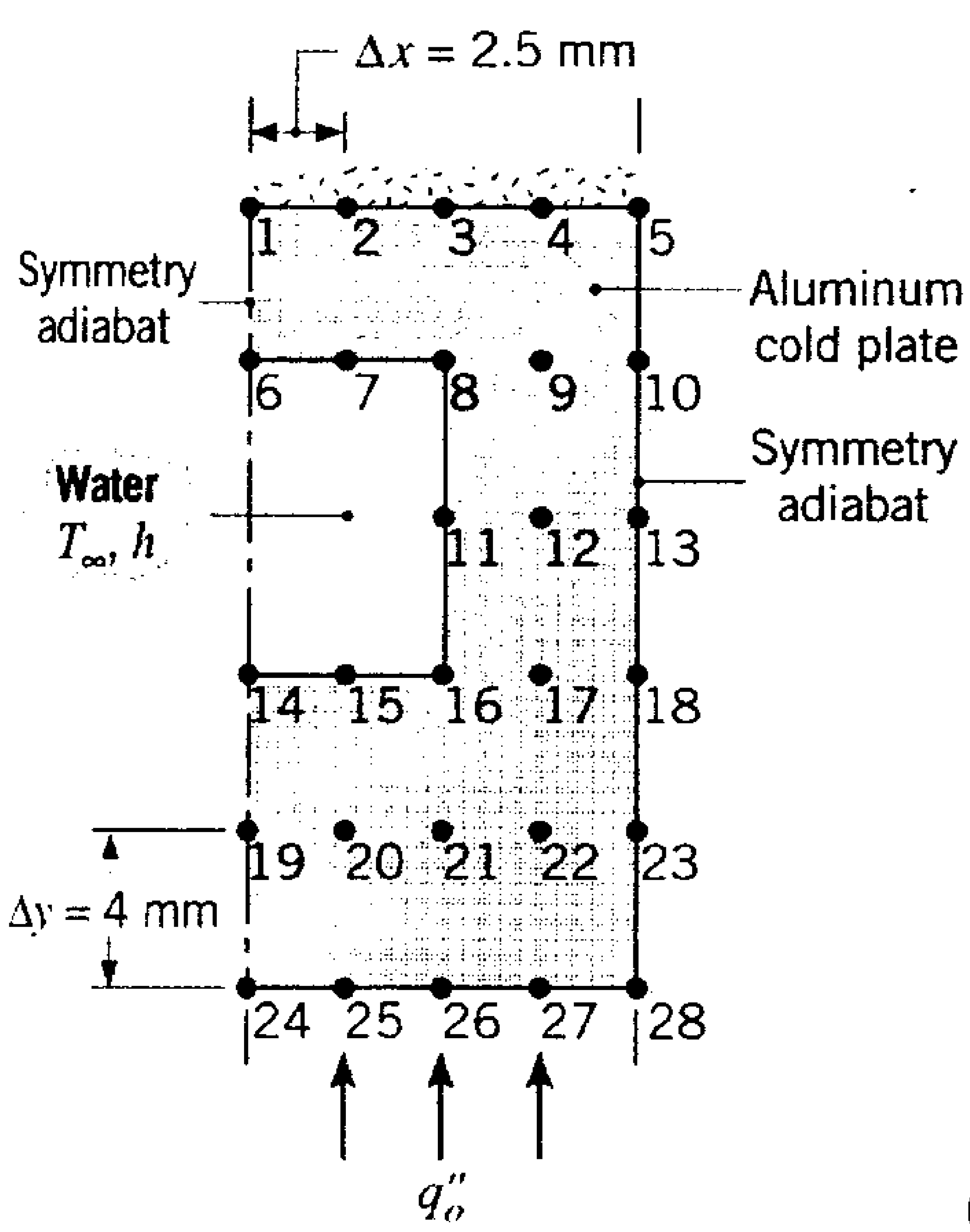
系所班組別：工程與系統科學系

考試科目（代碼）：熱傳學 (2604)

共 2 頁，第 1 頁　　*請在【答案卷、卡】作答

1. A cylindrical nuclear fuel rod is with a fuel pellet of radius r_f and uniform heat generation rate of g (W/m^3) during steady state operation. The fuel pellet is surrounded with an annular cladding with inner radius approximately equal to r_f and outside radius of r_c. The contact thermal resistance per unit area between the pellet and cladding is R_c (m^2K/W). The heat transfer coefficient due to fluid flow outside the fuel rod is h and the fluid temperature is T_∞. Determine the temperature at the fuel rod center during the steady state. (20%)

2. For the nodal network shown below for a unit part of a cold plate shown below, please using the control volume method to derive the nodal finite difference equations for T_{11}, T_{12} and T_{13}, respectively. Show your derivation. (20%)



(Figure from Incropera et al., Fundamentals of Heat and Mass Transfer, Sixth Ed., P251.)

3. A plane wall is initially at temperature T_i and for $t \geq 0$ the plane surface at x =0 is kept adiabatic while the surface at x =L is subject to fluid flow at temperature T_∞ and heat transfer coefficient of h. Determine the transient temperature distribution in the wall. (20%)

4. To enhance heat transfer from a silicon chip, a copper pin fin is attached to the surface of the chip. The pin length and diameter are L=12 mm and D=2 mm, respectively. Atmospheric air at υ=10 m/s and T_∞ = 300K is in cross flow over the pin. The surface of the chip and hence the base of the pin are maintained at a temperature of T_b=360 K (a) Determine the average convection coefficient the surface of the pin (b) Determine the fin heat transfer rate assume the fin tip is adiabatic. Assume the chip to have negligible effect on flow over the pin. (20%)

Hint：You may use the Churchill and Bernstein correlation

$$\overline{Nu}_D = 0.3 + \frac{0.62\,\mathrm{Re}_D^{1/2}\,\mathrm{Pr}^{1/3}}{\left[1+(0.4/\mathrm{Pr})^{2/3}\right]^{1/4}}\left[1+\left(\frac{\mathrm{Re}_D}{282000}\right)^{5/8}\right]^{4/5}$$

The air properties may be approximated as $\upsilon = 17.4\times10^{-6}\,\mathrm{m}^2/\mathrm{s}$；

$k_f = 0.0274$ W/mK；$\alpha = 24.7\times10^{-6}\,\mathrm{m}^2/\mathrm{s}$

The thermal conductivity for copper is 400 W/mK.

5. A counter flow, concentric tube heat exchanger is designed to heat water with a flow rate of 0.2 kg/s from 20 to 50℃ using hot oil, which is supplied to the annulus at 120℃ and discharged at 110℃. The thin-walled inner tube material is with high thermal conductivity and has a diameter of 20 mm. The heat transfer coefficient for the oil side is determined to be 100 $\mathrm{W/m^2K}$. Please determine (a) the total heat transfer rate, (b) the overall heat transfer coefficient, and (c) the length of the heat exchanger. (20%)

Hint:

$\mathrm{Nu}_D = 3.66$ if the flow is laminar in the tube, and

$$Nu_D = \frac{(f/8)(\mathrm{Re}_D - 1000)\,\mathrm{Pr}}{1+12.7(f/8)^{1/2}(\mathrm{Pr}^{2/3}-1)},\quad f = (0.790\ln(\mathrm{Re}_D) - 1.64)^{-2}$$ if the flow is turbulent.

Water properties at 35℃ are $C_p = 4178$ kJ/kgK, $\mu = 725\times10^{-6}\,\mathrm{Ns/m^2}$, k = 0.625 W/mK (20%)