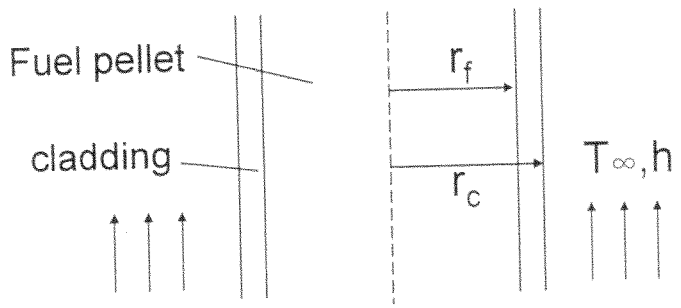
國　立　清　華　大　學　命　題　紙

98 學年度工程與系統科學系乙組碩士班入學考試

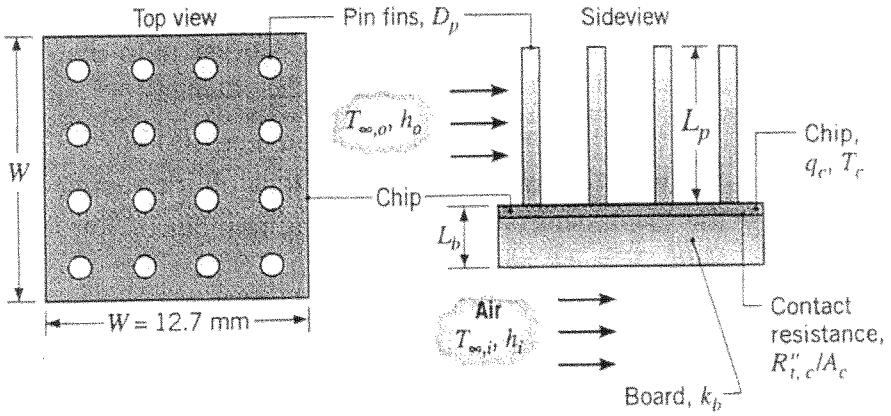
科目熱傳學 科目代碼 2704 共 4 頁第 1 頁 *請在【答案卷卡】內作答

1. Please derive the time-dependent, three dimensional heat diffusion equation in Cartesian coordinates. Define the variables used clearly. Please also describe the three basic types of boundary conditions for heat conduction. (20%)

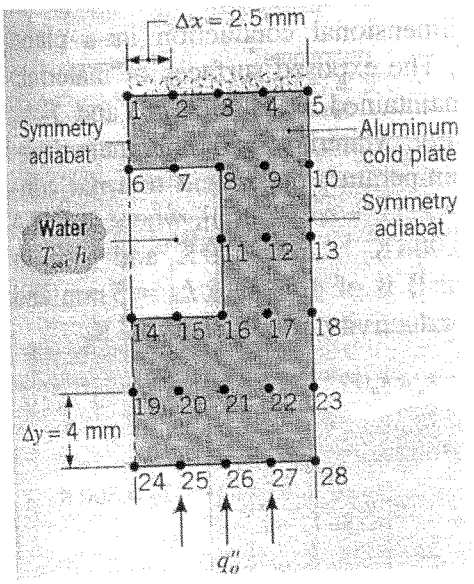
2. Consider a cylindrical fuel rod with fuel pellet inside coated with a cladding. The thermal conductivity for the pellet and cladding are k_f and k_c, respectively. The outside radius for the pellet and cladding is r_f and r_c, respectively. The volumetric heat generation In the pellet due to nuclear fission is uniformly at $\dot{g}$. The thermal contact resistance between the pellet and cladding is R''_c (m^2K/W) for a unit area of interface. The fuel rod is cooled by a coolant at T_∞ with a heat transfer coefficient h. Obtain an expression for the centerline temperature of the pellet. (20%)



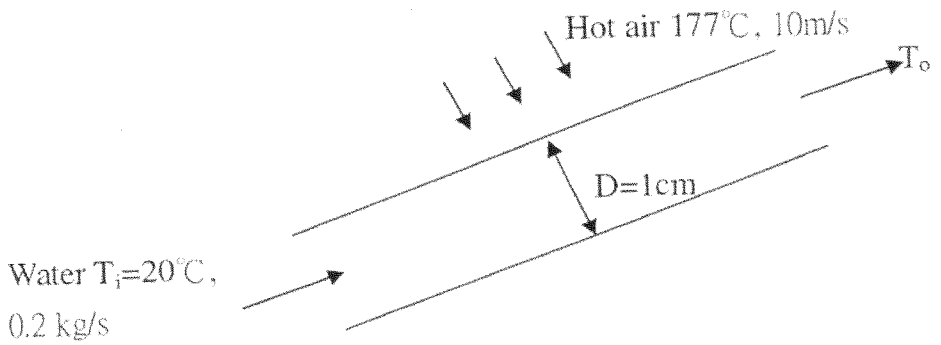
3. As more and more components are placed on a single integrated circuit. To maximize heat dissipation, it is proposed that a 4×4 array of copper fins be metallurgically joined to the outer surface of a square chip that is 12.7 mm on a side, as shown in the following figure. Determine the maximum heat dissipation rate from the chip if the maximum allowable chip temperature is 80℃. The pin diameter is 1.5 mm and length is 15 mm. The fins are exposed to a dielectric liquid with h_o =1000 W/m^{2}K and $T_{\infty,o}$ =20℃. Assume there is no heat dissipation from the tip of fins. The thermal contact resistance between the chip and the board is 10^{-4} m^{2}K/W, and the board thickness and thermal conductivity are L_b= 5mm and k_b =1 W/mK, respectively. The other surface is exposed to ambient air for which h_i = 40 W/m^{2}K and $T_{\infty,i}$ =20℃. The thermal conductivity for copper is 400 W/mK. (20%)



4. For the nodal network shown below for a unit part of a cold plate and consider steady state heat conduction, please derive the nodal finite difference equations for T_{11} and T_{12}, respectively, based on the energy balance method . Show your derivation. (20%)



5. Waste heat of exhaust hot air from a manufacturing process may be recovered by passing water through a thin-wall tube of 1 cm diameter as shown. Assume the temperature of the hot air is 177℃ in cross flow with a velocity of 10 m/s over the tube. The inlet and outlet temperature of water are 20℃ and 80℃, respectively, and the flow rate is 0.2 kg/s. Determine the length of the tube and the total heat transfer rate from air to water. (20%)



Hint: 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.

For external flow:

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

The water properties are:

ρ=992 kg/m^3 ; Cp=4.18×10^3 J/kgK; k=0.631 W/mK;

μ=**5.28×10^{-4}** kg/ms.

The air properties are: υ=26.4×10^{-6} m^2/s ; k=0.0338 W/mK ;

α=38.3×10^{-6} m^2/s