國 立 清 華 大 學 命 題 紙

96 學年度 工程與系統科學系 （所） 乙 組 碩士班入學考試

科目 熱傳學 科目代碼 2904 共 3 頁第 1 頁 *請在【答案卷卡】內作答

(1) (a) Suppose a person stated that heat can not be transferred in a vacuum. How do you respond? (5%)

(b) Please point out three modes for heat transfer and explain it (9%)

(c) Three materials with thermal resistance R_1, R_2, R_3 respectively, what is the total thermal resistance $R_{tot,s}$ if the composite material is consist of these three material in series, see figure 1 (3%) and what is the total thermal resistance $R_{tot,p}$ if the composite material is consist of these three material in parallel, see figure 2 (3%)

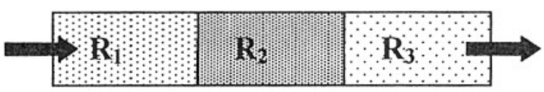


Figure 1. Three materials in series

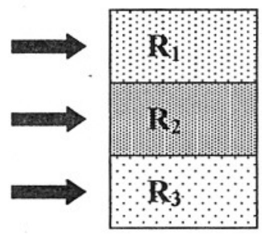
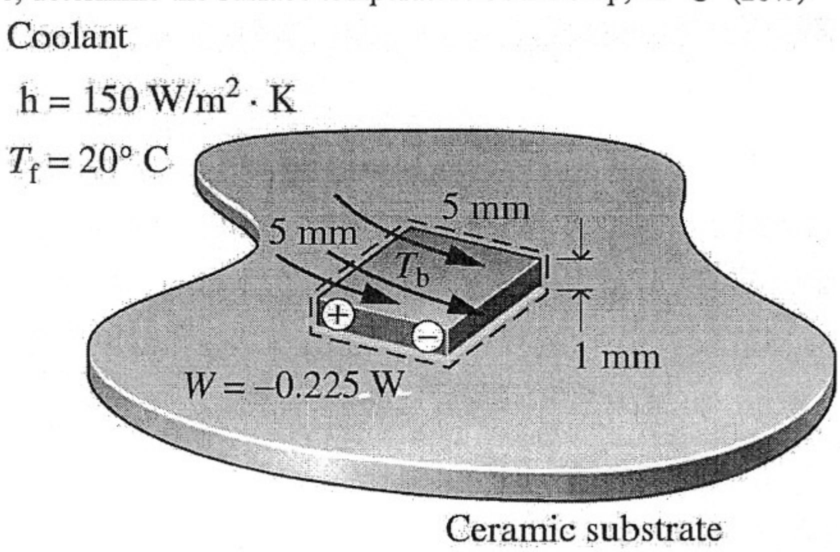
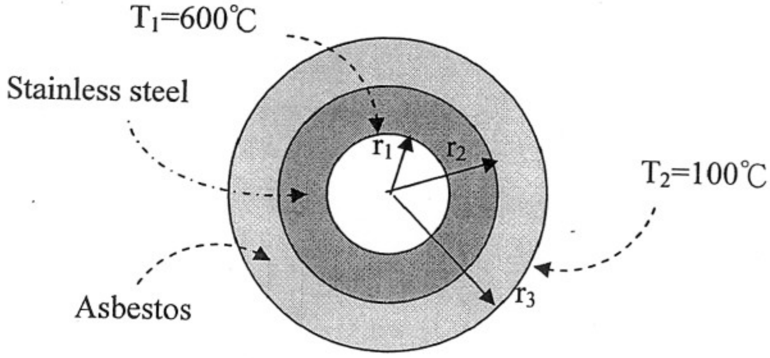


Figure 2 Three materials in parallel

(2) A silicon chip measuring 5 mm on a side and 1 mm in thickness is embedded in a ceramic substrate. At steady state, the chip has an electrical power input of 0.225W. The top surface of the chip is exposed to a coolant whose temperature is 20℃. The heat transfer coefficient for convection between the chip and the coolant is 150 $W/m^2, ^0K$. if heat transfer by conduction between the chip and the substrate is negligible, determine the surface temperature of the chip, in ℃ (20%).



(3) A thick-walled tube of stainless steel [18% Cr, 8% Ni, K_s=19 w/m,℃] with 2 cm inner diameter (ID) and 4 cm outer diameter (OD) is covered with a 3 cm layer of asbestos insulation [K_a=0.2 w/m,℃]. If the inside wall temperature of the pipe is maintained at 600℃, calculate the heat loss per meter of length. (20%)



(4) For a fully developed turbulent flow in smooth tubes, the following relation is recommended by Dittus and Boelter :

$$Nu_{,d} = 0.023\,\mathrm{Re}_{,d}^{\;0.8}\,\mathrm{Pr}^n$$

Where n=0.4 for heating of the fluid and n=0.3 for cooling of fluid

Sieder and Tate proposed for laminar heat transfer in tubes:

$$Nu_{,d} = 1.86(\mathrm{Re}_{,d}\,\mathrm{Pr})^{1/3}\left(\frac{d}{L}\right)^{1/3}\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

Where d is the diameter of the tube, L is the length of the tube and μ_w is the fluid viscosity evaluate at the wall temperature

Air (ideal gas) at 2 atm and 200℃ is heated as it flows through a tube with a diameter of 2.54 cm at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube if a constant-heat flux condition is maintained at the wall and the wall temperature is 20℃ above the air temperature, all along the length of the tube. (a) Is that the laminar flow or turbulent flow? (5%), (b) What is the heat transfer coefficient h in W/m^2,℃ (5%)? (c) How much the mass flow rate in Kg/s (5%)? (d) How much would the bulk temperature increase over a 3 m length of the tube (5%)?

$\overline{R} = 8.314 KJ/Kmol.^0K$,M_{air}=28.97Kg/Kmole, $C_{p,air}$=1.025KJ/Kg,^{0}K, $\mathrm{Pr} = \frac{C_p \mu}{K}$

$1atm = 1.0132\times10^5 NT/.m^2$, K_{air}=0.0386 W/m, ^{0}K, $\mu_{air} = 2.57\times10^{-5} Kg/m,s$

(5) A heated sphere of radius R is suspended in a large, motionless spherical body of fluid. It is desired to study the heat condition in the fluid surrounding the sphere. It is assumed that the free convection effects can be neglected.

(a) Set up the differential equation describing the temperature T in the surrounding fluid as a function of r, the distance from the center of the sphere. The thermal conductivity of the fluid K is constant. (5%)

(b) Integrate the differential equation and use the boundary conditions to determine the constants of integration (5%):

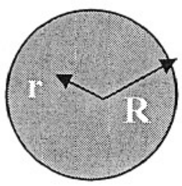
B.C. 1: at $r = R$, $T = T_R$ (surface temperature of the sphere),

B.C. 2: at $r = \infty$, $T = T_\infty$ (fluid temperature),

Navier-Stoke equation:

$$\rho C_P\left(\frac{\partial T}{\partial t} + v_r\frac{\partial T}{\partial r} + \frac{v_\theta}{r}\frac{\partial T}{\partial \theta} + \frac{v_\phi}{r\sin\theta}\frac{\partial T}{\partial \phi}\right) = K\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial T}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 T}{\partial \phi^2}\right] + 2\mu\left\{\left(\frac{\partial v_r}{\partial r}\right)^2 + \left(\frac{1}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{\partial v_r}{\partial r}\right)^2 + \left(\frac{1}{r\sin\theta}\frac{\partial v_\phi}{\partial \phi} + \frac{\partial v_r}{r} + \frac{v_\theta\cot\theta}{r}\right)^2\right\}$$
$$+ \mu\left\{\left[r\frac{\partial}{\partial r}\left(\frac{v_\theta}{r}\right) + \frac{1}{r}\frac{\partial v_r}{\partial \theta}\right]^2 + \left[\frac{1}{r\sin\theta}\frac{\partial v_r}{\partial \phi} + r\frac{\partial}{\partial r}\left(\frac{v_\phi}{r}\right)\right]^2 + \left[\frac{\sin\theta}{r}\frac{\partial}{\partial \theta}\left(\frac{v_\phi}{\sin\theta}\right) + \frac{1}{r\sin\theta}\frac{\partial v_\theta}{\partial \phi}\right]^2\right\}$$

(c) From the temperature profile, please evaluate the value of the Nusselt number for the sphere. $Nu = \frac{hD}{K}$. Where D is the sphere diameter, h is the heat transfer coefficient between the sphere and the fluid stream (10%)



$r = R$, $T = T_R$

$r = \infty$, $T = T_\infty$