國立中正大學
115學年度碩士班招生考試
試 題

[第3節]

科目名稱	輸送現象與單元操作
系所組別	化學工程學系

—作答注意事項—

※作答前請先核對「試題」、「試卷」與「准考證」之系所組別、科目名稱是否相符。

1. 預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。
2. 考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。
3. 入場後於考試開始40分鐘內不得離場。
4. 全部答題均須在試卷（答案卷）作答區內完成。
5. 試卷作答限用藍色或黑色筆（含鉛筆）書寫。
6. 試題須隨試卷繳還。

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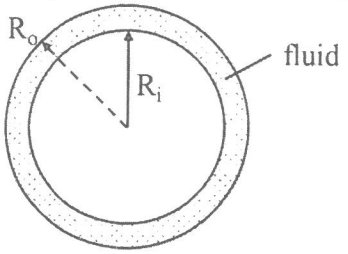
科目名稱：輸送現象與單元操作　　本科目共 2 頁　第 1 頁

系所組別：化學工程學系

1. A Newtonian fluid flows steadily through a concentric annular duct formed by an inner cylindrical rod and an outer cylindrical pipe.

   The outer pipe has a radius of R_o = 5.0 cm, and the inner rod has a radius of R_i = 4.0 cm. The average velocity of the fluid in the annular duct is 0.3 m/s.

   The fluid has viscosity μ = 0.02 Pa·s and density ρ = 1500 kg/m³.

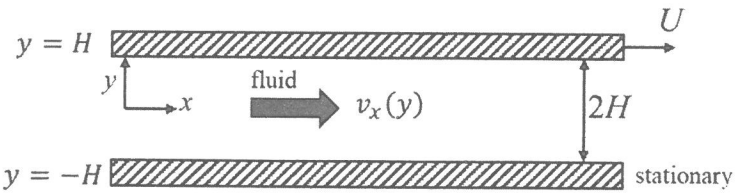
   

   (a) Determine the hydraulic diameter (D_H) of the annular duct. 【5 分】

   (b) Calculate the Reynolds number (Re) for the flow. 【5 分】

   (c) Determine whether the flow is laminar or turbulent. 【5 分】

2. A viscous liquid flows in steady state between two infinite, flat, parallel plates separated by a distance $2H$. The lower plate ($y = -H$) is stationary, while the upper plate ($y = H$) moves in the x direction with constant speed U. A constant pressure gradient $\partial P/\partial x$ is imposed. The flow is incompressible, Newtonian and fully developed. Gravity effects and end effects in the flow direction are negligible.

   (a) Use a shell momentum balance to derive the shear-stress distribution $\tau_{yx}(y)$ in the flow. 【10 分】

   (b) Obtain the velocity distribution $v_x(y)$ with appropriate boundary conditions. 【10 分】

   (c) Determine the location y where the maximum velocity occurs and the $\tau_{yx}(y) = 0$. 【5 分】

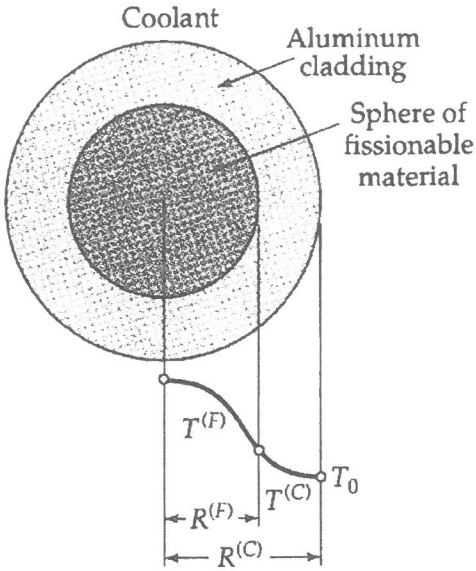
   (d) Obtain an expression for the average velocity $< v_x >$. 【10 分】

3. A spherical nuclear fuel element is shown below. The fissionable material is able to create volume rate of heat prodution of $S_n = S_{n0}\left[1 + b\left(\frac{r}{R^{(F)}}\right)^2\right]$, where S_{n0} and b are two positive constants.

   (a) Use the shell balance to derive the differential equations of heat conduction for the fissional material ($q_r^{(F)}$) and the aluminum cladding ($q_r^{(C)}$), respectively. 【10 分】

   (b) Use the boundary conditions at $r = 0$ and $r = R^{(F)}$ to solve the above equations. 【10 分】

   (c) Write down (without solving them) the corresponding temperature equations and boundary conditions that will be needed to solve the temperature profiles. 【5 分】



4. The figure below shows the build-up to the steady-state concentration profile for the diffusion of helium (substance A) through fused silica (substance B), where ω_A denotes the mass fraction of helium and ω_{A0} is the solubility of helium in fused silica.

(a) At steady state, write down the mass flux of helium in the y-direction, j_{Ay}, in differential form, given the diffusivity D_{AB} and system density ρ. 【5 分】

(b) Rewrite the same flux j_{Ay} in terms of ρ, ω_A, ω_B, v_{Ay}, and v_{By}, where v_{Ay}, and v_{By} are the individual velocities of substance A and B in the same direction and ω_B is the mass fraction of fused silica. 【10 分】

(c) Use the above two expressions of j_{Ay} to show that $D_{AB} = D_{BA}$. 【10 分】