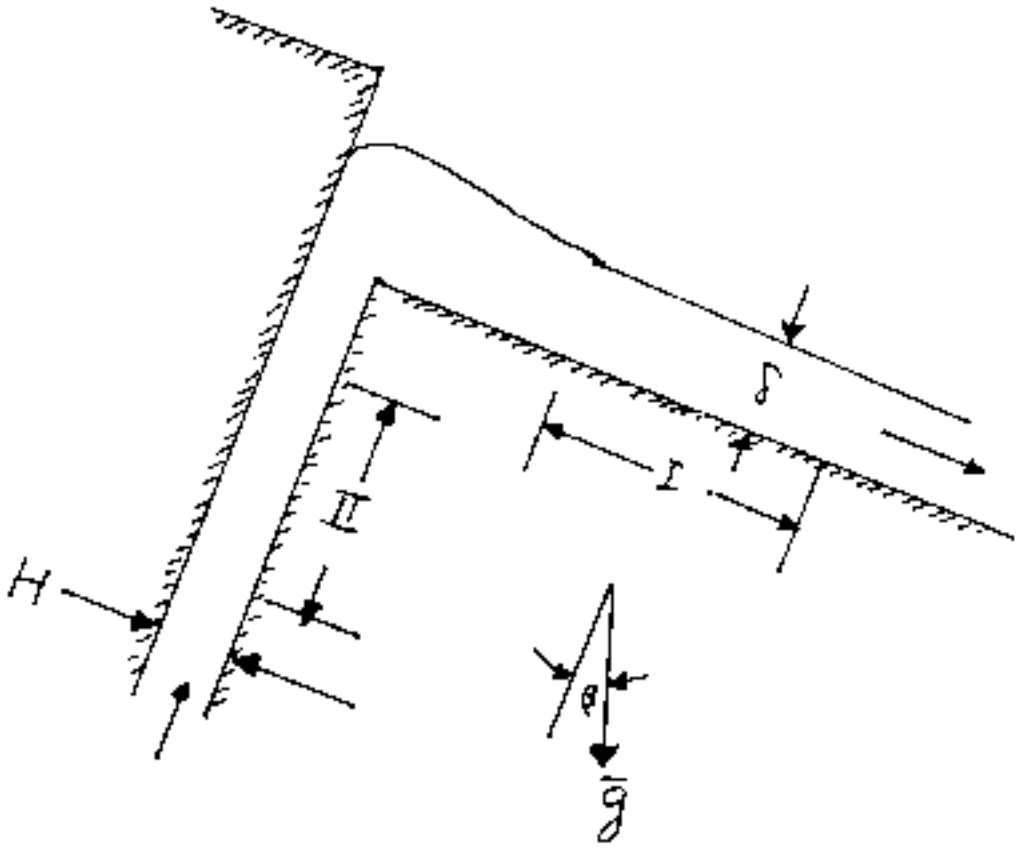
八十六學年度 化學工程學系 系（所） 甲 組碩士班研究生入學考試

科目 輸送現象及單元操作 科號 1601 共 3 頁第 1 頁 *請在試卷【答案卷】內作答

Problem 1 (20%)

A Newtonian liquid with viscosity μ and density ρ is flowing out of a slit and onto a slide as shown in the Figure. The slit gap and the film thickness on the slide are H and δ, respectively. The angle between the slit wall and the direction of gravity is β. It is assumed that the shell balance approach is applicable in both Sections I and II, determine the condition that $H=\delta$. You may define any geometric or operating variables if necessary.



Problem 2 (20%)

An equation of change of $\hat{U}$, the internal energy of a fluid per unit mass, is given as follows,

$$\rho\frac{D\hat{U}}{Dt} = -(\nabla\cdot\underline{q}) - p(\nabla\cdot v) - (\underline{\tau}:\underline{\nabla}v).$$

Here, ρ is the fluid density, $\underline{q}$ the heat flux vector, p the pressure, v the fluid velocity, $\underline{\tau}$ the shear stress tensor, and D/Dt the substantial time derivative.

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科目 輸送現象及單元操作 科號 1601 共 3 頁第 2 頁 *請在試卷【答案卷】內作答

(a) Give the physical meaning of the four terms, namely, $\rho D\hat{U}/Dt$, $-(\underline{\nabla}\cdot\underline{q})$, $-p(\nabla\cdot\underline{v})$, and $-(\underline{\tau}:\underline{\nabla}\underline{v})$, in the above equation. (8%)

(b) Why does the convection term not appear explicitly in the above equation? (2%)

(c) If the fluid is expanding, will this expansion contribute positively or negatively to the internal energy of the fluid ? (3%)

(d) Give an example in which the contribution made by the fourth term of the above equation is not negligible. (2%)

(e) Under what assumptions, can the second term of the above equation be converted to $k\nabla^2 T$, where k is the thermal conductivity of the fluid? (3%)

(f) Give the SI unit of k. (2%)

Problem 3 (20%)

(a) What are the basic assumptions of film theory in mass transfer? Obtain the relation between the mass transfer coefficient and the diffusivity of a component by film theory. Derive your result starting from your basic assumptions. You can build up the governing equation by considering the transfer of a component from a flat plate to a fluid. (10%)

(b) What are the basic assumptions of boundary layer theory in mass transfer? Obtain the relation between the mass transfer coefficient and the diffusivity of a component by boundary layer theory. You can build up the governing equation by considering the transfer of a component from a flat plate to a fluid flowing parallel to the flate plate. Derive your result starting from your basic assumptions. (10%)

Problem 4 (20%)

(a) In forced convection, $Nu = a\,Re^{m}\,Pr^{1/3}$, What is the corresponding equation in natural convection? Need to define every term in your answer.

(b) What is the physical meaning of Prandtl number? Why is this dimensionless number important in heat transfer operations?

(c) What is a 1-2 heat exchanger? Use a schematic diagram to illustrate your answer.

(d) Since the flow is neither pure cocurrent nor countercurrent in a 1-2 exchanger, how should we evaluate the "mean temperature difference" for such equipments? (i.e. ΔT_m term

in $q = U_i A_i \Delta T_m$ equation) use Thi, Tho, Tci, Tco for hot fluid/cold fluid inlet and outlet temperatures respectively if necessary.

(e) Under what circumstances would you suggest to use an extended surface or finned exchanger?

(4 points for each question in this problem)

Problem 5 (20%)

Absorption of acetone by water is carried out in a packed tower having a diameter of 0.40 m. The operating conditions are: 1 atm and 20°C. The gas contains 1.2 mol% acetone initially, and 0.20 mol% at the outlet. The gas flow rate is 15 kg mol inert air/h. Pure water at 60 kg mol/h is used to absorb acetone. The equilibrium relation is $y = 1.25\ x$, and $K'_y a = 3.74 \times 10^{-2}$ kg mol/s-m^3-mol frac.

(y: mole fraction of acetone in gas phase, x: mole fraction of acetone in liquid phase, K'_y: overall mass transfer coefficient, a: interfacial area per unit volume)

(a) Estimate the tower height. (10%)

(b) Estimate the minimum liquid flow rate. (5%)

(c) If the incoming water contains 0.05 mol% acetone initially, what will be the minimum liquid flow rate? (5%)