國立中央大學99學年度碩士班考試入學試題卷

所別：化學工程與材料工程學系碩士班 甲組(一般生)　科目：輸送現象與單元操作　共 2 頁 第 1 頁

本科考試可使用計算器，廠牌、功能不拘

＊請在試卷答案卷（卡）內作答

1. (15%) In a turbulent flow in a tube with a constant imposed pressure gradient. The actual velocity can be regarded as the sum of the mean value (designated by an overbar) and the fluctuation (designated by a prime).

$$u = \bar{u} + u'$$

The turbulent shear stress in a two-dimensional flow is given by

$$\overline{\tau_{yx}^{(t)}} = -\rho\varepsilon_M \frac{d\bar{u}_x}{dy} = \rho\overline{u_x' u_y'}$$

Expanding u_x' and u_y' in a Taylor series in x and y near the wall and with the aid of the continuity equation,

$$\frac{\partial u_x'}{\partial x} + \frac{\partial u_y'}{\partial y} = 0$$

show that, near the wall, $\varepsilon_M \sim y^3$+ higher-order terms in y. How does this compare with the mixing-length theory?

2. (20%) Answer the following questions

Below are two equations describing the property of an incompressible fluid and the change of fluid motion.

incompressible fluid $\quad \nabla \cdot u = 0$

Navier-Stokes (NS) equation $\quad \rho\dfrac{Du}{Dt} = \rho g - \nabla P + \mu\nabla^2 u$

(a) Explain the physical meaning of each term in the NS equation (4 %)

(b)In Cartesian coordinates, show that

$$u_x\frac{\partial}{\partial x} + u_y\frac{\partial}{\partial y} + u_z\frac{\partial}{\partial z}$$

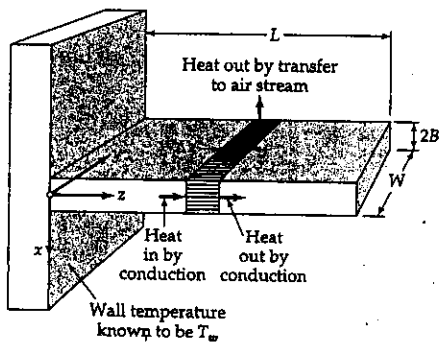
may be written $(u\cdot\nabla)$. What is the physical meaning of the term $(u\cdot\nabla)$?(4 %)

(c) In an incompressible flow, the volume of the fluid is constant. Using the continuity equation, $\nabla\cdot u=0$, show that the fluid volume change is zero. (4 %)

(d) For flow at very low speeds and with large viscosity (so-call creeping flows) such as occur in lubrication, it is possible to delete the inertia terms, Du/Dt, from the Navier-Stokes equation. For flows at high velocity and small viscosity it is not proper to delete the viscous term $\mu\nabla^2 u$. Explain this. (4 %)

(e) What are the physical meanings of velocity gradient (∇u) and divergence of the velocity $(\nabla\cdot u)$? (4 %)

3. (30%)

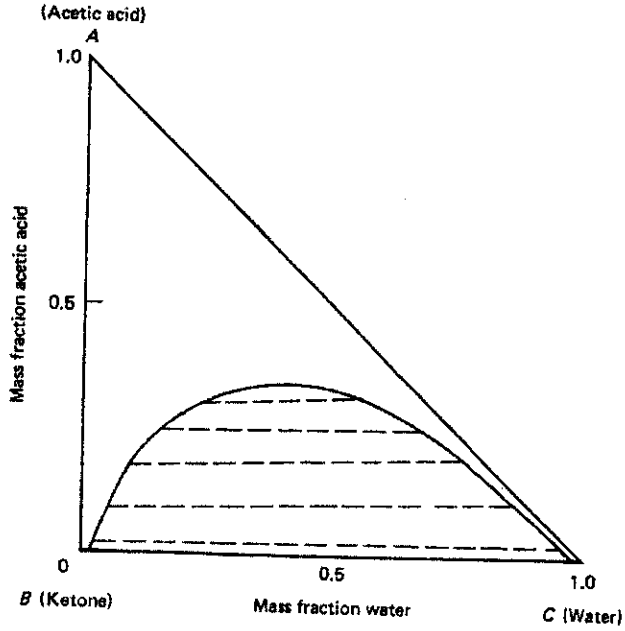


參考用

注意：背面有試題

For heat conduction in a cooling fin with B<<W and B<<L as shown in the above figure, where L is the height of fin, the wall temperature is T_w and the ambient air temperature is T_a. The thermal conductivity of fin is k and the heat transfer coefficient between fin and air is h. Please solve for the temperature distribution of fin and the fin effectiveness. Use the Cartesian coordinates defined in the figure and neglect the heat loss from the fin at the end (area 2BW) and at the edges (area 2BL+2BL).

4. (16 %) A feed containing 35 % by weight of acetic acid and 65 % methyl isobutyl ketone is contacted by pure water in a two-stage (i.e. stage 1 and stage 2) crosscurrent extraction process. The flow rate of the entering feed is 100 kg/min. Fresh water is added to each stage at a rate of 100 kg/min. Determine the compositions of the extract (i.e. y_1 and y_2) and raffinate (i.e. x_1 and x_2) phases after each stage and find the flow rates for all streams leaving (i.e. E_1, E_2, R_1 and R_2) the contractors using the ternary diagram provided below.



5. (10 %) Using the same ternary diagram provided above to sketch the equilibrium distribution curve of mass fraction of acetic acid in extract, y_A versus mass fraction of acetic acid in raffinate, x_A.

6. (9 %) Tetrabutylammonium nitrate in aqueous solution is diffusing across a thin membrane of n-heptyl cyanide into pure water. At a solution concentration of 0.005 mol/liter, the flux across the membrane is 1.6×10^{-10} mol/sec-cm^2. Assuming that transport is ionic, estimate the flux with a solution of 0.5 mol/liter.

參考用

注意：背面有試題