淡江大學103學年度碩士班招生考試試題

系別：化學工程與材料工程學系　　　科目：輸送現象與單元操作

考試日期：3月2日(星期日) 第2節　　　本試題共4大題，2頁

本試題雙面印刷

1. A constant density, Newtonian fluid flows steadily between two infinite, parallel plates as shown in Fig. 1. The bottom plate is stationary and the top plate (at z=h) is moving steadily in the x direction with velocity 'A'. The gravity is not important.
   (1) Please solve the pressure profile with all the assumptions and boundary conditions clearly stated. (15%)
   (2) Please solve the velocity profile with all the assumptions and boundary conditions clearly stated. (15%)

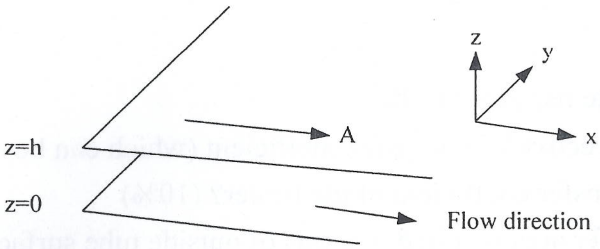

Fig. 1

Equation of continuity:

$$\frac{\partial \rho}{\partial t}+\frac{\partial(\rho v_x)}{\partial x}+\frac{\partial(\rho v_y)}{\partial y}+\frac{\partial(\rho v_z)}{\partial z}=0.$$

Equation of motion for a constant density and Newtonian fluid:

$$\rho\left(\frac{\partial v_x}{\partial t}+v_x\frac{\partial v_x}{\partial x}+v_y\frac{\partial v_x}{\partial y}+v_z\frac{\partial v_x}{\partial z}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 v_x}{\partial x^2}+\frac{\partial^2 v_x}{\partial y^2}+\frac{\partial^2 v_x}{\partial z^2}\right)+\rho g_x,$$

$$\rho\left(\frac{\partial v_y}{\partial t}+v_x\frac{\partial v_y}{\partial x}+v_y\frac{\partial v_y}{\partial y}+v_z\frac{\partial v_y}{\partial z}\right)=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v_y}{\partial x^2}+\frac{\partial^2 v_y}{\partial y^2}+\frac{\partial^2 v_y}{\partial z^2}\right)+\rho g_y,$$

$$\rho\left(\frac{\partial v_z}{\partial t}+v_x\frac{\partial v_z}{\partial x}+v_y\frac{\partial v_z}{\partial y}+v_z\frac{\partial v_z}{\partial z}\right)=-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 v_z}{\partial x^2}+\frac{\partial^2 v_z}{\partial y^2}+\frac{\partial^2 v_z}{\partial z^2}\right)+\rho g_z.$$

2. It is known that for fully developed turbulent flow in conduits with Re > 10000, 0.7 < Pr < 160, and L/d > 60, the following Chilton-Colburn analogy can be applied.

$$J_M=\frac{f}{2}=J_H=\frac{Nu}{Re\,Pr^{1/3}}=J_D=\frac{Sh}{Re\,Sc^{1/3}}$$

$$\left(\ f=\frac{\tau_w}{\frac{1}{2}\rho u^2}\qquad Nu=\frac{hd}{k_c}\qquad Re=\frac{\rho ud}{\mu}\qquad Pr=\frac{c_p\mu}{k_c}\qquad Sh=\frac{kd_h}{D}\qquad Sc=\frac{\mu}{\rho D}\ \right)$$

For the following correlation (Eq. (1)) commonly adopted for convective heat transfer through conduit wall in the turbulent flow regime, please suggest a correlation for estimating convective mass transfer coefficient. (10%)

$$Nu=0.023Re^{0.8}Pr^{\frac{1}{3}} \qquad (1)$$

背面尚有試題

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3. A tubular feedwater heater is being designed to heat 0.368 kg/s of water from 21°C to 90°C. Saturated steam at 923 kPa (176°C) is condensing on the outside of the tubes. The tubes are a copper alloy. Each tube has a 2.54 cm outside diameter and a 2.29 cm inside diameter. The water velocity inside the tubes is 0.9 m/s. For the steam outside the tube, the convective heat transfer coefficient can be assumed to be $13600 \frac{W}{m^2\,K}$. The heat transfer resistance of the tube is negligible. (For water, $C_p = 4.1864 \frac{kJ}{kg\,K}$ $\rho = 1000 \frac{kg}{m^3}$ $\mu = 0.5 \times 10^{-3} \frac{kg}{m\,s}$ $k_c = 0.65 \frac{W}{m\,K}$ Pr=3.37)

(1) What is the heat transfer rate required? (10%)

(2) What are the tube side convective heat transfer coefficient (which can be estimated using Eq. (1)) and the overall heat transfer coefficient of the heater? (10%)

(3) What is the total heat transfer area required in terms of outside tube surface area? (10%)

4. For the separation of a mixture using packed bed distillation column, the mass flux of species 'A' across the gas-liquid interface can be written as Eq. (2).

(1) Please explain Eq. (2) based on two-film theory. A diagram must be sketched with variables marked on it. (10%)

(2) Please provide the definition and dimension for each variable in Eq. (2). (10%)

(3) Please derive Eq. (3) and define the variable 'm'. (10%)

$$\begin{aligned} N_A &= k_G(y_{AG} - y_{Ai}) \\ &= k_L(x_{Ai} - x_{AL}) \\ &= K_{OG}(y_{AG} - y_A^*) \\ &= K_{OL}(x_A^* - x_{AL}) \end{aligned} \qquad (2)$$

$$\frac{1}{K_{OG}} = \frac{1}{k_G} + \frac{m}{k_L} \qquad (3)$$