九十學年度＿＿化學工程學＿＿系（所）＿＿＿＿組碩士班研究生招生考試

科目＿輸送現象及單元操作＿科號＿2101＿共＿2＿頁第＿1＿頁 *請在試卷【答案卷】內作答

Problem 1 (20%)

The shear stress (τ_{rz}) of a unidirectional power-law fluid (incompressible and steady) in a horizontal tube can be described as follows:

$$\tau_{rz} = m(\partial v_z / \partial r)^n$$

The z-component of the equation of motion in cylindrical coordinates is given as:

$$\rho\left(\frac{\partial \upsilon_z}{\partial t} + \upsilon_r \frac{\partial \upsilon_z}{\partial r} + \frac{\upsilon_\theta}{r}\frac{\partial \upsilon_z}{\partial \theta} + \upsilon_z \frac{\partial \upsilon_z}{\partial_z}\right) = -\frac{\partial p}{\partial z} - \left(\frac{1}{r}\frac{\partial}{\partial r}(r\tau_{rz}) + \frac{1}{r}\frac{\partial \tau_{\theta z}}{\partial \theta} + \frac{\partial \tau_{zz}}{\partial z}\right) + \rho g_z$$

(a)based on the equation of motion given above, write down the governing equation and the boundary condition to determine the velocity profile in the tube. (Hint: $\tau_{\theta z} = \tau_{zz} = 0$) (5%)

(b)determine the velocity profile in the tube, giving a constant pressure gradient ($\partial p / \partial z = -G$). (5%)

(c)draw the velocity profile for n=1, n>>1, and n<<1, respectively. (10%)

Problem 2 (20%)

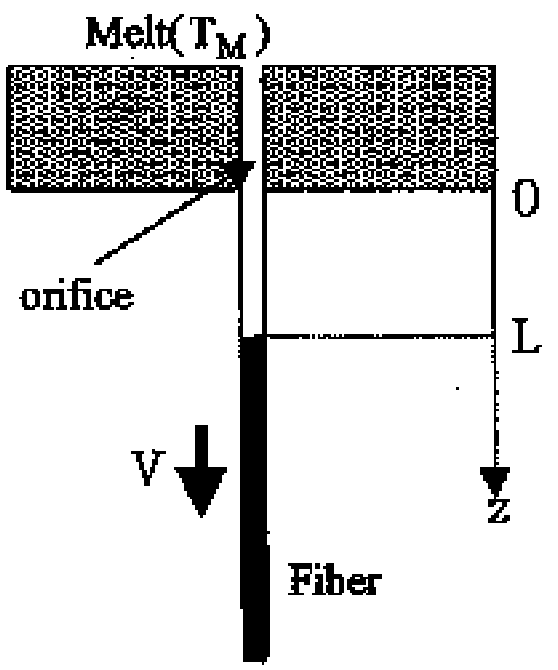
Inviscid melt spinning can be used to produce fine metal or ceramic fibers. As illustrated in the following figure, the melt leaves the orifice in the form of a filament and solidifies at a short distance L below the orifice outlet. The diameter of the fiber is determined by that of the orifice and the velocity V. Assume (1) negligible surface heat loss, (2) the temperature at the orifice is essentially the same as that of the bulk melt T_M, and (3) the melt solidifies with negligible undercooling, that is, at the melting point T_m,

(a) find the temperature distribution in the melt filament; (10%)

(b) show that the position of the melt-solid interface is given by

$$L = \frac{\alpha}{V}\ln\left[\frac{\rho H_f V\alpha}{\rho H_f V\alpha - kV(T_m - T_M)}\right]$$

where H_f is the heat of fusion (J/Kg) of the material and $\alpha = k/(\rho C_p)$. (10%)



Problem 3 (20%)

Short questions: (4% each)

(a) Give any two phenomena that may occur in daily life and can be explained based on mass transfer concepts.

(b) Give four driving forces that may cause mass diffusion.

(c) Why is it necessary to specify a reference velocity in reporting data on rates of diffusion?

(d) If the Schmidt number (Sc) of a fluid is greater than one, would the boundary layer thickness for momentum transfer (δ) thicker or thinner than the boundary layer thickness for mass transfer (δ_c)? Explain.

(e) For a species A possessive of a negative thermal diffusion coefficient, would this species move toward the hotter-region or colder region when placed in a non-uniform temperature field? Explain.

Problem 4(20%)

A double -tube heat exchanger is required to cool 20 kg/s of water from 360K to 340K by means of 25Kg/s cooling medium entering at 300K. If the overall heat transfer coefficient is constant at 2.0kW/m²·K, calculate the heat transfer area required if the heat exchanger is in (a) co-current flow arrangement; (8%) (b) counter-current flow arrangement; (8%) (c) based on the calculation, which flow arrangement, (a) or (b), should be recommended for practical operational installation? Why? (4%)

Data: the average specific heat for water and the cooling medium are both constant at 1.0 Btu/lb_m-R ; also, 1 Btu=1.055kW-s, 1 lb_m=0.454kg

Problem 5 (20%)

A solid is to be dried under constant drying conditions from a free moisture content of 0.3 kg water/kg dry solid to 0.01 kg water/kg dry solid. The dry solid weight is 100kg and the surface area available for drying is 4.0m². The drying rate in the constant-rate period is 1.5kg water/h-m², the critical free moisture content is 0.16kg water/kg dry solid. The drying rate in the falling-rate period is proportional to the free moisture content.

(I)Calculate the time for drying. (15%)

(II)If the drier uses hot air for drying, describe how the temperature of the solid changes as drying proceeds. (5%)