淡江大學97學年度碩士班招生考試試題

173-1

系別：化學工程與材料工程學系　　科目：輸送現象與單元操作

准帶項目請打「V」	
	簡單型計算機

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1. For turbulent flow in a smooth circular tube with a radius of R, the velocity profile varies according to the following expression at a Reynolds number of about 10^5:

$$v = v_{max}\left(\frac{R-r}{R}\right)^{1/7}$$

where r is the radial distance from the center and v_{max} the maximum velocity at the center.

(a) (15%)Derive the equation relating the average velocity (bulk velocity) v_{av} to v_{max} for an incompressible fluid. (*Hint*: The integration can be simplified by substituting z for $R-r$.

(b) (15%)Derive the equation to determine the value of α, the kinetic-energy velocity correction factor, for turbulent flow as follows:

$$\alpha = \frac{(v_{av})^3}{(v^3)_{av}}$$

Use the velocity profile in part (1) and substitute this into the following definition to obtain $(v^3)_{av}$:

$$(v^3)_{av} = \frac{1}{A}\iint_A (v^3)dA$$

2. (20%)
Derive the equation for steady-state laminar flow inside the annulus between two concentric horizontal pipes (z direction) with showing all the steps and the equation for the average velocity $(v_z)_{av}$. Also, find that the position where the maximum velocity occurs.

3. (15%)
Derive an equation which shows that the temperature varies hyperbolically with radius r for the steady-state conduction of heat in a hollow sphere.

4. (15%)
A plane wall with uniform internal heat generation of $\dot{q}$ W/m^3 is insulated at four surfaces with heat conduction only in the x direction. The wall has a thickness of $2L$ m. The temperature at the one wall at $x=+L$ and at the other wall at $x=-L$ is held constant at T_w K. Using the differential energy equation to derive the equation for the final temperature profile.

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73-2

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5. (20%)
In a well-stirred tank which has a steam heat transfer surface proportional to the amount of liquid in the tank, the governing equation is

$$\frac{d}{d\theta}(C_p wt) = GH + Ua(T - t)$$

where

C_p=heat capacity of the liquid
w=amount of water in the tank
t=liquid temperature
G=liquid feed rate
H=enthalphy of entering liquid
U=overall heat transfer coefficient
a=heating area
T=heating steam temperature
θ=time

(a) Explain how we get this equation.
(b) Show how the equation is transformed to

$$f\frac{dt}{df} + (Bf + 1)t = BfT + t_0$$

where

$H = C_p(t_0 - t^0)$
t^0=0=reference temperature
$a = Af$=exposed area
A=total heating area when tank is filled
f=fraction of the tank which is filled
$B = UA/GC_p$

(c) If we define $\varphi = (t - t_0)/(T - t_0)$, show that the final solution is

$$\varphi = 1 - \frac{1 - e^{-Bf}}{Bf}$$

with $\varphi = 0$ at $f = 0$.