國立中正大學九十八學年度碩士班招生考試試題

系所別：化學工程學系　　　　科目：輸送現象與單元操作

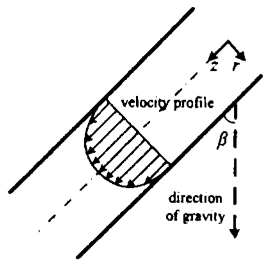
第2節　　

1.(25%) Consider the laminar flow of a fluid of constant density ρ in a circular tube inclined at an angle β to the vertical, as shown below. The fluid flow is influenced by both the pressure drop of ΔP and gravity. End effect is assumed to be neglected because the tube length L is relatively very large compared to the tube radius R.

(a) Please use the shell momentum balance to determine the steady-state shear stress distribution and the velocity profile for a Newtonian fluid of constant viscosity μ.

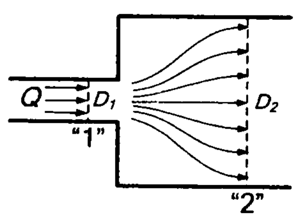
(b) Derive the average velocity and the mass flow rate.

(c) For a non-Newtonian fluid, its viscosity varies with pressure, following the relationship of $\mu = \mu_o e^{\alpha P}$, where μ_o and α are material parameters and P is pressure. Please derive the velocity profile for this non-Newtonian fluid.



2. (25%)(a) When the fluid flows through a pipe, some amount of energy of the fluid is lost due to friction. One viscous fluid flows in a horizontal smooth pipe 5cm in diameter and length 20m at a volume rate of Q = 1 liter/sec at 25°C. At this temperature the density of the fluid is ρ = 0.9 gcm^{-3} and its viscosity is 100 cp. Please determine the friction energy loss for this fluid.

(b) As an incompressible fluid of constant density ρ flows from a small pipe of diameter D_1 to a large pipe of diameter D_2 through a sudden expansion, as shown below, it causes the energy loss. In this case, the velocity profiles are assumed flat and the volumetric flow rate is Q. Determine the energy loss for a fluid.



3. (25%) An isothermal sphere 3 cm in diameter is kept at 80℃ in a large clay region. The temperature of the clay far from the sphere is kept at 10℃. How much heat must be supplied to the sphere to maintain its temperature if k_{clay}= 1.28 W/m-℃? (Hint: You must solve the boundary value problem not in the sphere but in the clay surrounding it.)

4. (25%) Gas A diffuses through a stagnant gas film to the surface of a nonporous cylinder catalyst, as shown below. Where it undergoes the reaction $2A \xrightarrow{k_1} B$. Gas B then diffuses from the catalyst surface and is swept away. Neglecting diffusion and reaction on the ends of the particle, derive an equation for the molar flux of A if the reaction is very fast.