5. TERMINAL VELOCITY OF FALLING PARTICLES

5.1 Numerical Methods

Solution of a single nonlinear algebraic equation..

5.2 Concepts Utilized

Calculation of terminal velocity of solid particles falling in fluids under the force of gravity.

5.3 Course Useage

Fluid dynamics.

5.4 Problem Statement

A simple force balance on a spherical particle reaching terminal velocity in a fluid is given by

$$v_t = \sqrt{\frac{4g(\rho_p - \rho)D_p}{3C_D\rho}} \qquad \textbf{(13)}$$

where v_t is the terminal velocity in m/s, g is the acceleration of gravity given by g = 9.80665 m/s^2, ρ_p is the particles density in kg/m^3, ρ is the fluid density in kg/m^3, D_p is the diameter of the spherical particle in m and C_D is a dimensionless drag coefficient.

The drag coefficient on a spherical particle at terminal velocity varies with the Reynolds number (Re) as follows (pp. 5-63, 5-64 in Perry[3]).

$$C_D = \frac{24}{Re} \qquad \text{for} \qquad Re < 0.1 \qquad \textbf{(14)}$$

$$C_D = \frac{24}{Re}(1 + 0.14Re^{0.7}) \qquad \text{for} \qquad 0.1 \le Re \le 1000 \qquad \textbf{(15)}$$

$$C_D = 0.44 \qquad \text{for} \qquad 1000 < Re \le 350000 \qquad \textbf{(16)}$$

$$C_D = 0.19 - 8\times10^4/Re \qquad \text{for} \qquad 350000 < Re \qquad \textbf{(17)}$$

where $Re = D_p v_t \rho/\mu$ and μ is the viscosity in Pa·s or kg/m·s.

(a) Calculate the terminal velocity for particles of coal with ρ_p = 1800 kg/m^3 and D_p = 0.208×10^{-3} m falling in water at T = 298.15 K where ρ = 994.6 kg/m^3 and μ = 8.931×10^{-4} kg/m·s.

(b) Estimate the terminal velocity of the coal particles in water within a centrifugal separator where the acceleration is 30.0 g.