C44081244
化工二甲
戴郁庭

11.17 A 25% scale model of an undersea vehicle that has a maximum speed of 16 m/s is to be tested in a wind tunnel with a pressure of 6 atm to determine the drag characteristics of the full-scale vehicle. The model is 3 m long. Find the air speed required to test the model and find the ratio of the model drag to the full-scale drag.

$$Re = \frac{L\rho V}{\mu}$$

$$Re|_m = Re|_p$$

$$\frac{L_m \rho_m V_m}{\mu_m} = \frac{L_p \rho_p V_p}{\mu_p}$$

$$V_m = V_p\left(\frac{L_p}{L_m}\right)\left(\frac{\rho_p}{\rho_m}\right)\left(\frac{\mu_m}{\mu_p}\right)$$

$$\frac{L_p}{L_m} = 4$$

$$V_m = 16 \times 4 \left(\frac{\rho_p}{\rho_m}\right)\left(\frac{\mu_m}{\mu_p}\right) \ \#$$

$$Eu = \frac{p}{\rho V^2} = \frac{\frac{F}{A}}{\rho V^2}$$

$$Eu|_m = Eu|_p$$

$$\frac{\frac{F_m}{A_m}}{\rho_m V_m^2} = \frac{\frac{F_p}{A_p}}{\rho_p V_p^2}$$

$$\frac{F_m}{F_p} = \left(\frac{A_m}{A_p}\right)\left(\frac{\rho_m}{\rho_p}\right)\left(\frac{V_m^2}{V_p^2}\right)$$

$$\frac{F_m}{F_p} = \left(\frac{1}{16}\right)\left(\frac{\rho_m}{\rho_p}\right)\left(\frac{1}{16^2}\right)(16^2)(4)^2\left(\frac{\rho_p}{\rho_m}\right)^2\left(\frac{\mu_m}{\mu_p}\right)^2$$

$$\therefore \frac{F_m}{F_p} = \left(\frac{\rho_p}{\rho_m}\right)\left(\frac{\mu_m}{\mu_p}\right)^2 \ \#$$

11.22 A coating operation is creating materials for the electronics industry. The coating requires (1) a specific volumetric flow rate Q, (2) solution density ρ, (3) solution viscosity μ, (4) substrate coating velocity v, (5) solution surface tension σ, and (6) the length of the coating channel L. Determine the dimensionless groups formed from the variables involved using the Buckingham method. Choose the groups so that Q, σ, and μ appear in one group only.

$$i = n - r$$

$6 - 3 = 3$ dimentionless groups

Q	$\left[\frac{L^3}{t}\right]$
ρ	$\left[\frac{M}{L^3}\right]$
μ	$\left[\frac{M}{Lt}\right]$
v	$\left[\frac{L}{t}\right]$
σ	$\left[\frac{M}{t^2}\right]$
L	$[L]$

$$\begin{cases} L = l \\ t = \frac{l}{V} \\ M = \rho l^3 \end{cases}$$

$$\text{for} \quad D_1 = \frac{Q}{\left(\frac{L^3}{t}\right)} = \frac{Q}{\frac{l^3}{\frac{l}{V}}} = \frac{Q}{l^2 V} \ \#$$

$$\text{for} \quad D_2 = \frac{\mu}{\frac{M}{Lt}} = \frac{\mu}{\frac{\rho l^3}{l\frac{l}{V}}} = \frac{\mu}{\rho V l} = Re^{-1} \ \#$$

$$\text{for} \quad D_3 = \frac{\sigma}{\frac{M}{t^2}} = \frac{\sigma}{\frac{\rho l^3}{\left(\frac{l}{V}\right)^2}} = \frac{\sigma}{\rho V^2 l} = We^{-1} \ \#$$