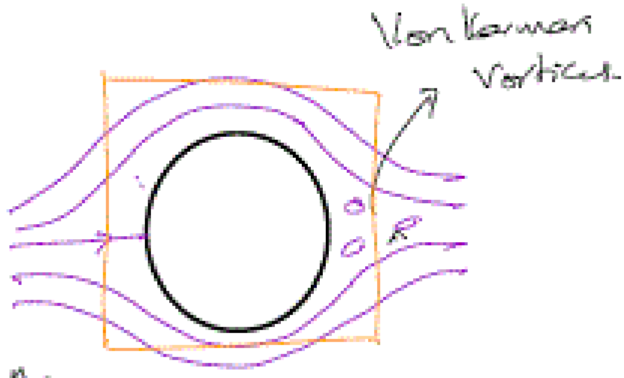
Flow over cylinder



$A_S = \pi D L$

$Re_D = \dfrac{\rho V D}{\mu} = \dfrac{V D}{\nu}$

$C_D = \dfrac{F_D/A}{\frac{1}{2}\rho u_\infty^2}$ → Projected Area.

Correlation from experimental data

$C_D = 10.41\, Re_D^{-0.6872}$ → $0.1 < Re_D < 4$

$C_D = 5.67\, Re_D^{-0.2511}$ → $4 < Re_D < 1000$

$C_D = 1$ → $1000 < Re_D < 5000$

$C_D = 0.310\, Re_D^{0.1525}$ → $5000 < Re_D < 10^4$

$C_D = 1.14$ → $10^4 < Re_D < 2 \times 10^5$

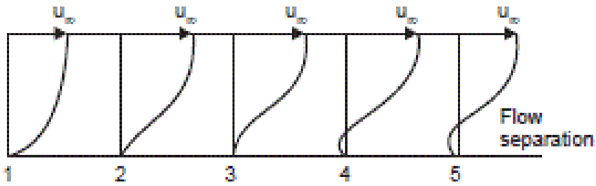


Fig. 8.1. Velocity distribution at various angular locations in flow across cylinders.

As the flow pattern affects the heat transfer, it is found to be difficult to provide a generalised analytical solution for the problem. The drag coefficient C_D is defined by

Drag force = $C_D\, A_f \dfrac{\rho u_\infty^2}{2}$. Where A_f is the frontal or projected area. (for a cylinder of length of L it is equal to $L.D$). It is not based on the wetted area. The nature of variation of drag coefficient for cylinder and sphere with Reynolds number is shown in Fig. 8.2. Reynolds number should be calculated with diameter D as the length parameter and is some times referred as Re_D.

Thus a simple and single correlation for C_D is difficult. The variation of local heat transfer coefficient with angular location for two values of Reynolds number is shown in Fig. 8.3.

For angles upto 80°, the variation of Nusselt number can be represented by

$$h_\theta = 1.14\, Re_D^{0.5}\, Pr^{0.4} \left[1 - \left(\frac{\theta}{90}\right)^3\right] \qquad ...(8.32(b))$$

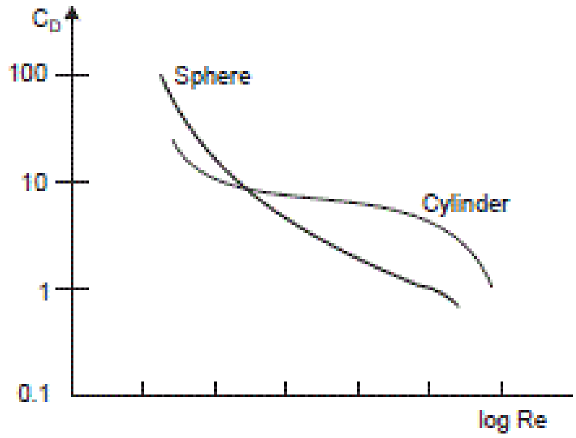


Fig. 8.2. Variation of C_D with Reynolds number for flow over cylinders and spheres.

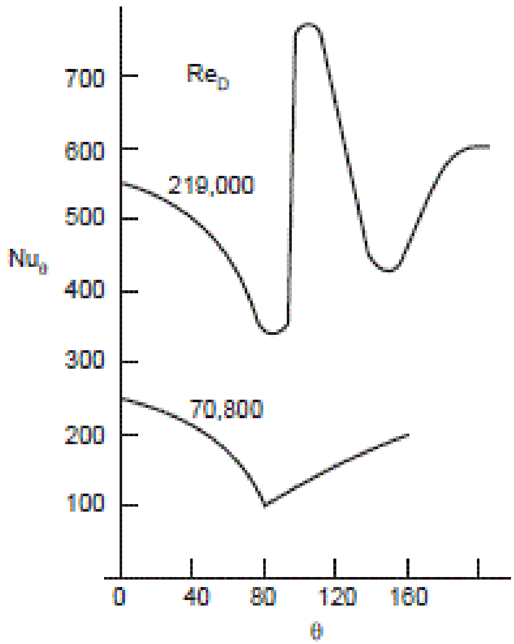


Fig. 8.3. Variation of Nusselt number with angular location.