CEN 212 FLUID MECHANICS

Assoc.Prof. Dr. Ayşe Karakeçili
Assoc.Prof. Dr. Hakan KAYI

Ankara University
Chemical Engineering Department

Flow Past Immersed Objects

Fluid flow:
1. Inside conduits or pipes ✔
2. **Around solid, immersed bodies**

The flow of fluids outside immersed bodies occurs in many chemical applications such as: flow past spheres in settling, flow through packed beds in drying and filtration, flow past tubes in heat exchangers and so on.

Flow of fluid:

- ✓ The solid may be at rest; the fluid flowing past it (packed beds)
- ✓ The fluid may be at rest; the solid moving through it
- ✓ Both may be moving

Relative velocity

Flow Past Immersed Objects

Friction factor (f):
for flow through conduits

$$f = \frac{wall\ shear}{density \times velocity\ head}$$

$$f = \frac{\tau_w}{\rho\left(v^2/2\right)}$$

Drag coefficient (C_D):
for immersed solids

$$C_D = \frac{F_D / A_p}{density \times velocity\ head}$$

$$\boxed{C_D = \frac{F_D / A_p}{\rho(v^2/2)}}$$

Flow Past Immersed Objects

For Re_p > 20
Separation occurs

For high Re ($10^3 < Re_p < 3 \times 10^5$)
C_D = 0.40-0.45
Front boundary layer is still laminar

For high Re ($Re_p > 3 \times 10^5$)
C_D = 0.10
Front boundary layer becomes turbulent