CHE 318 Lecture 18

Dimensionless Numbers In Mass Transfer

Dr. Tian Tian

2026-02-23

Recitation: What Have Learned So Far?

Topic 1: steady-state mass transfer

Governing equation

Geometry

Applications

Topic 2: unsteady-state mass transfer

Governing equation

Geometry

Applications

Topic 3: convective mass transfer (mass-transfer coefficient)

Governing equation

Geometry

Applications

Learning outcomes

After this lecture, you will be able to:

- **Recall** key governing equations from steady, unsteady, and convective mass transfer.
- **Describe** the roles of Reynolds, Schmidt, and Sherwood numbers in coefficient correlations.
- **Identify** how k_c', concentration, and flux are linked in convective mass transfer problems.

Dimensionless number 1: N_{Re}

- **Reynolds number** measures ratio between kinetic vs viscous forces of fluid flow
- L_D: characteristic length of system

$$N_{\text{Re}} = \frac{L_D v \rho}{\mu} \tag{1}$$

Meaning of N_{Re}

- N_{Re}: laminar flow vs turbulent flow
- Varies with characteristic length L_D (diameter for a pipe)

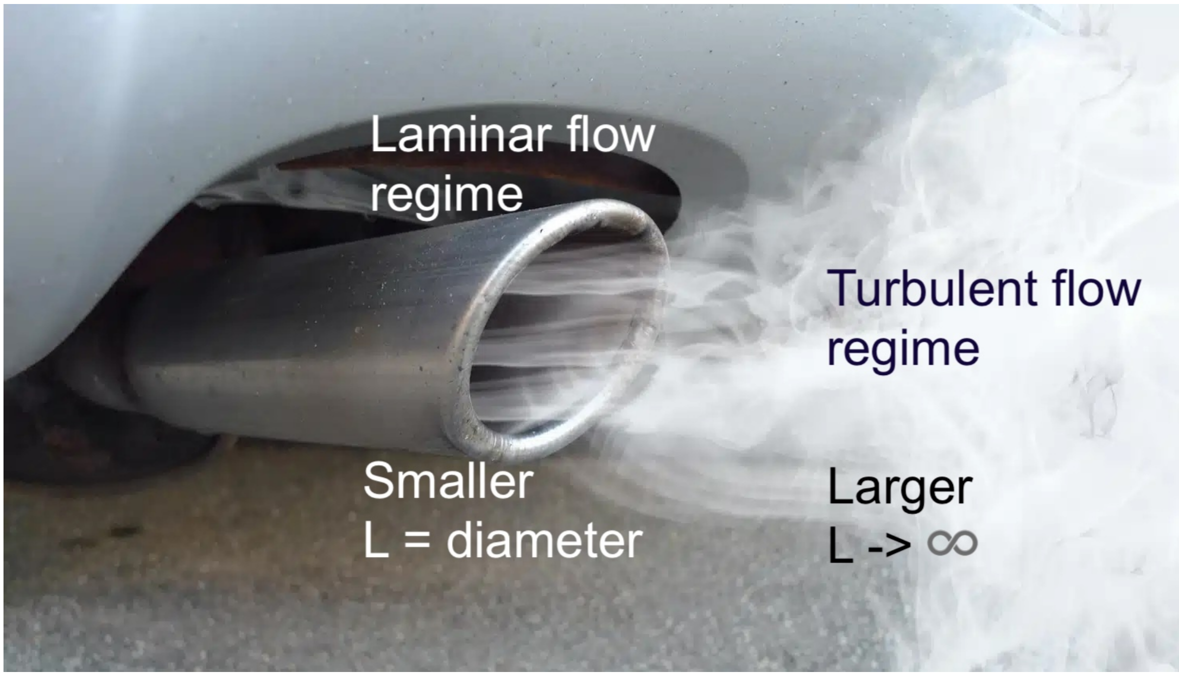

Figure 1: N_{Re} for exhaust pipe

Dimensionless number 2: N_{Sc}

- **Schmidt number**: ratio between momentum diffusivity and molecular diffusivity
- Related to ratio of hydrodynamic layer and mass transfer layer thickness

$$N_{\mathrm{Sc}} = \frac{\mu}{\rho D_{AB}} \tag{2}$$

Meaning of N_{Sc}

- N_{Sc}: fluid boundary layer thicker or mass transfer thicker?
- Similar to Prandt number in heat transfer
- $N_{Sc}^{1/3} = \frac{\delta}{\delta_c}$

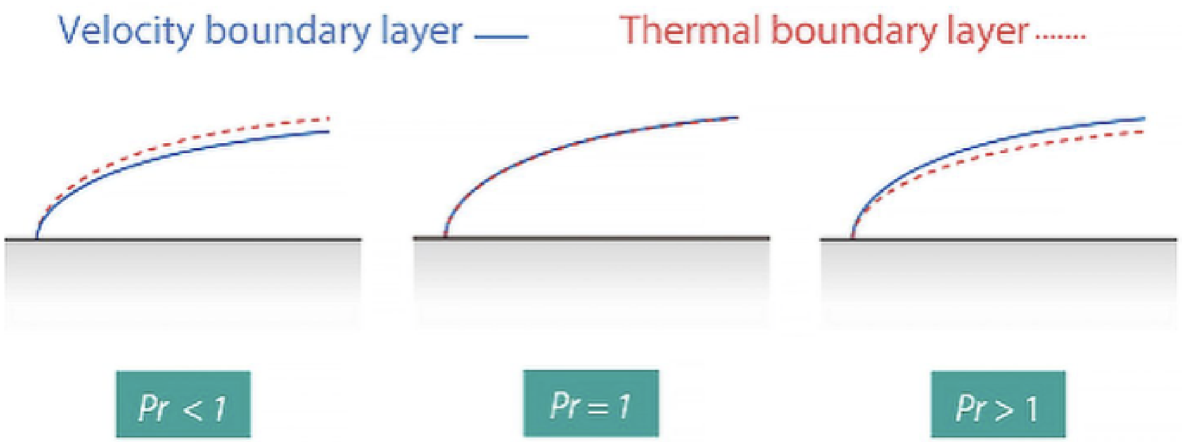

Figure 2: Analog of Prandt number

Dimensionless number 3: N_{Sh}

- **Sherwood number**: ratio between convective mass transfer and molecular mass transfer
- Has k_c' inside! –> Usually a back-calculated number

$$N_{\text{Sh}} = \frac{k_c' L}{D_{AB}} \tag{3}$$

How are k_c' correlated by dimensionless numbers?

- The combinations of these properties –> dimensionless number groups
- The Chilton-Colburn j_D-factor: link to N_{Sc}, N_{Sh}, N_{Re}

$$j_D = f/2 = \frac{k_c'}{v_{av}} (N_{\text{Sc}})^{2/3} \tag{4}$$

$$= \frac{N_{\text{Sh}}}{N_{\text{Re}} N_{\text{Sc}}^{1/3}} \tag{5}$$

General procedure to calculate k_c'

- Dimensionless numbers solely from geometry and property: N_{Re}, N_{Sc}
- Dimensionless number having k_c': N_{Sh}
- Link between them: j_D
- How to obtain j_D?
  - Expression for different geometry / fluid flow
  - Use Table / Chart

Summary

- Overview of dimensionless numbers to correlate mass transfer coefficients
- Dimensionless numbers: grouping different regimes
- Use table / charts to correct k_c (will discuss in Lecture 19)