Fundamental Physics for Food Technology and Innovation (4011106)

Kittipong Siengsanoh (Ph.D.Physics)

Department of Physics.
Faculty of Science and Technology.

Fluid Mechanics in Food Technology

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Overview of topics to be covered:

A. Understand basic principles of fluid mechanics
B. Apply fluid mechanics concepts to food processing
C. Calculate fluid flow parameters in food systems
D. Analyze fluid behavior in food processing equipment

Introduction to Fluid Mechanics

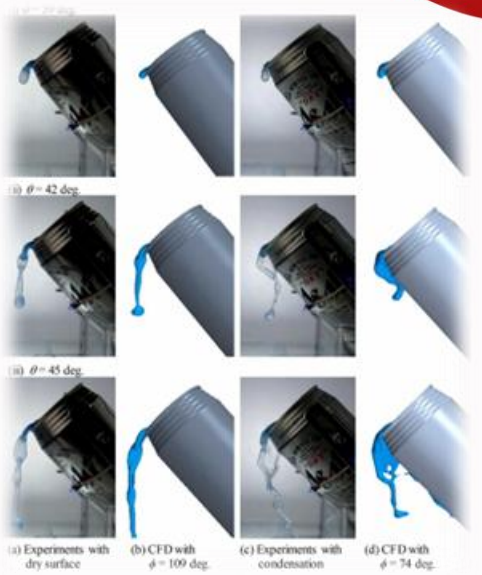

Figure 1: Fluid properties food industry

What is a Fluid?

- *Materials that flow under applied stress*
- *Both liquids and gases*
- *Key properties: density, viscosity, flow behavior*

Food Industry Applications:

- *Liquid food processing*
- *Mixing and pumping*
- *Heat exchangers*
- *Filtration systems*

Basic Fluid Properties

Key Properties:

1. Density (ρ)
   - *Mass per unit volume*
   - *Units: kg/m³*
2. Specific Gravity (SG)
   - *Ratio of fluid density to water density*
   - *Dimensionless*

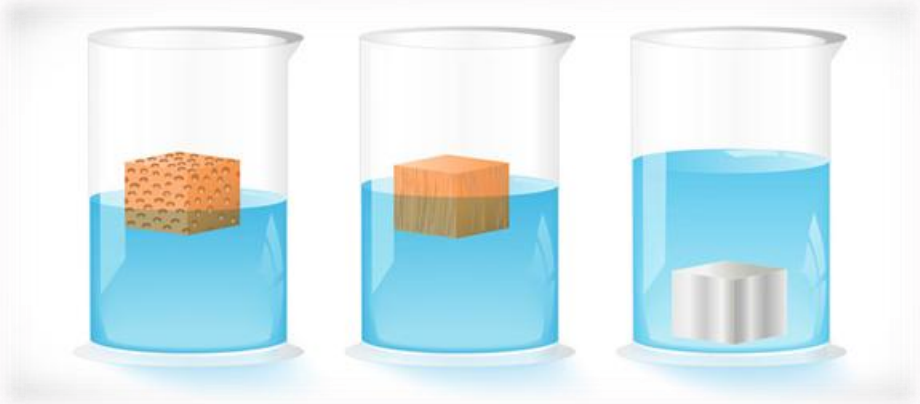

Figure 2: Density measurement food industry

Viscosity

Definition: Resistance to flow

Types:

1.Dynamic Viscosity (μ)

- *Units: Pa·s*
- *Symbol: μ (mu)*

2.Kinematic Viscosity (ν)

- $\nu = \mu/\rho$
- *Units: m²/s*

Figure 3: Viscosity measurement food processing

Viscosity

Food Applications:

- *Liquid foods*
- *Sauces and dressings*
- *Dairy products*

Figure 3: Viscosity measurement food processing

Fluid Flow Types

Flow Classifications:

1. Laminar Flow
   - *Smooth, orderly flow*
   - *Re < 2300*
2. Turbulent Flow
   - *Chaotic, mixing flow*
   - *Re > 4000*
3. Transitional Flow
   - *2300 < Re < 4000*

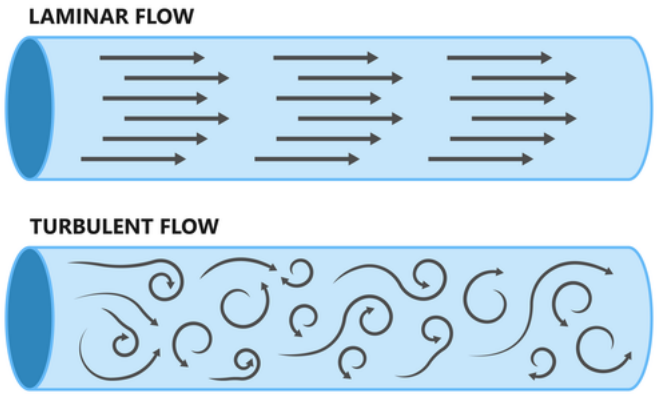

Figure 4: Laminar turbulent flow comparison

Reynolds Number

Reynolds Number (Re):

$Re = \rho vD/\mu$

Where:

- ρ = *density*
- v = *velocity*
- D = *pipe diameter*
- μ = *dynamic viscosity*

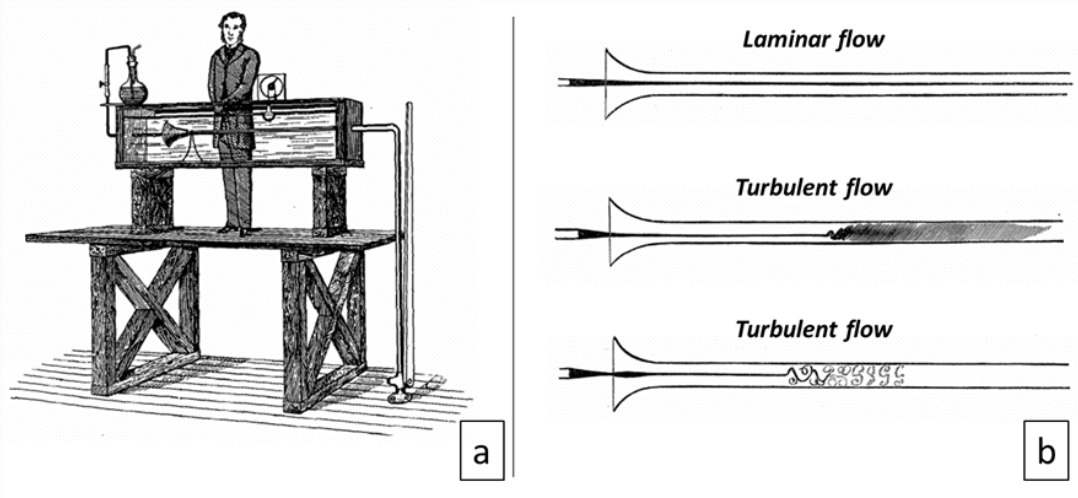

Figure 5: Reynolds number food processing

Reynolds Number

Applications:

- *Pipe flow design*
- *Mixing operations*
- *Heat exchanger design*

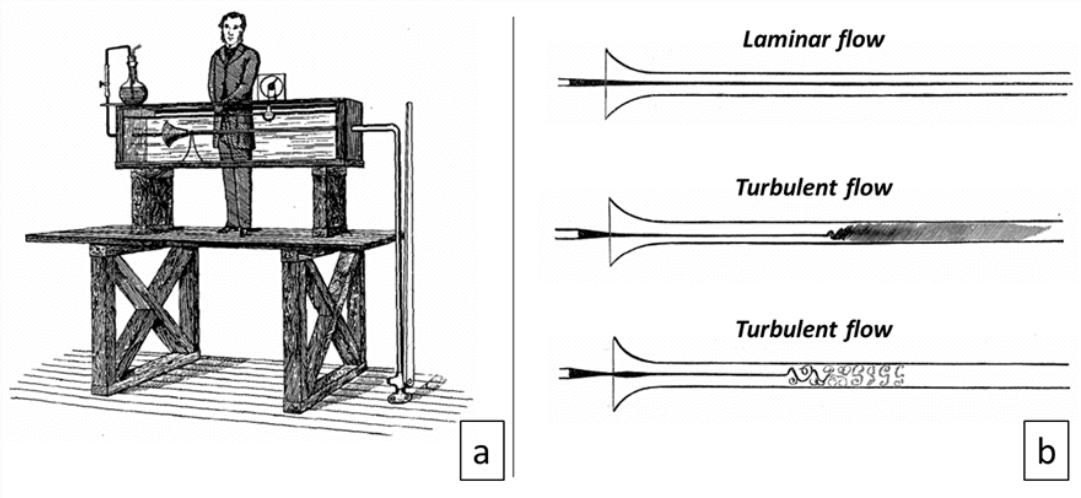

Figure 5: Reynolds number food processing

Bernoulli's Principle

Simplified Equation:

$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$

Where:

- P = *pressure*
- ρ = *density*
- v = *velocity*
- g = *gravitational acceleration*
- h = *height*

Figure 6:Bernoulli principle food industry

Bernoulli's Principle

Applications:

- *Pipe design*
- *Pump selection*
- *Flow rate calculations*

Figure 6: Bernoulli principle food industry

Practical Applications

Common Food Industry Applications:

1. *Pump Selection*
2. *Pipe System Design*
3. *Mixing Operations*
4. *Heat Exchangers*
5. *Filtration Systems*

Figure 7: Food processing equipment fluid mechanics

References.

1. Singh, R.P., & Heldman, D.R. (2014). Introduction to Food Engineering. Academic Press.
2. Fellows, P. (2017). Food Processing Technology: Principles and Practice. Woodhead Publishing.
3. Geankoplis, C.J. (2018). Transport Processes and Separation Process Principles. Prentice Hall.

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