



Fluid and Particle Dynamics

**The Engine Behind Chemical
Engineering Systems**

 Inspired by Section 6 of the Chemical Engineering Handbook

Why It Matters

Fluid and Particle Dynamics governs how liquids, gases, and solids move in chemical processes.

→ Topics include:

- Pipe flow
- Energy balances
- Compressible flow
- Turbulence
- Nozzles and mixing



⌚ Essential for industrial efficiency, design, and safety



Main Role in Chemical Engineering

1

Design of Process Equipment

🔧 Pumps, compressors, reactors, heat exchangers

🧪 Example: Coolant flow prevents overheating in reactors

2

Transport of Materials

🚚 Efficient movement of chemicals

🧪 Example: Slurry pipelines in wastewater

3

Mixing and Reaction Control

🌀 Influences reaction rates

🧪 Example: Agitation tanks in pharmaceuticals

4

Filtration and Separation

🧃 Removes unwanted particles

🧪 Example: Cyclone separators in pollution control



Importance in Daily Life

Application	Role of Fluid Dynamics
Showering/Plumbing	Pipe flow, pressure drop, velocity
Driving a Car	Fuel-air mixing in engine
Vacuuming	Dust particle separation via airflow
Medicine	Nebulizers Gas converting liquid to mist
Air Conditioning Systems	Duct compression and flow control



Mathematical Concepts – Continuity Equation

Continuity Equation – Conservation of Mass:

$$A_1 v_1 = A_2 v_2$$

- A: Cross-sectional area
 - v: Flow velocity
-  Used to model flow in varying pipe diameters



Bernoulli's Equation

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

- P: Pressure
 - ρ: Fluid density
 - v: Flow velocity
 - g: Gravity
 - h: Elevation
- ⚡ Balances pressure, velocity, and height

Used in nozzles, piping, and jets



Reynolds Number

$$Re = \frac{\rho v D}{\mu}$$

- D: Pipe diameter
- μ : Dynamic viscosity

📊 Interpreting Re:

- $Re < 2300 \rightarrow$ Laminar
- $Re > 4000 \rightarrow$ Turbulent

🔧 Helps design flow systems and predict energy losses



Navier-Stokes Equation (Advanced)

$$\rho \left(\frac{\partial \vec{v}}{\partial t} + \vec{v} \cdot \nabla \vec{v} \right) = -\nabla P + \mu \nabla^2 \vec{v} + \vec{F}$$

✓ Describes the full motion of fluids

🧠 Foundation of Computational Fluid Dynamics (CFD)



why It Matters in Industry

Efficiency

Lower energy usage in pumping

Safety

Prevents pressure build-ups or leaks

Cost Savings

Fewer maintenance and material losses

Scalability

From lab to industrial plant





Conclusion

Fluid and particle dynamics = the heartbeat of chemical processes.

From daily life to industry:

- It powers movement, mixing, and separation.
- Mathematical models like Bernoulli, Reynolds, and Navier-Stokes help optimize operations.

 Master the flow. Master the process.





Academic Articles & Journals

Continuity and Bernoulli's Equations in Industrial Flow Systems

[🔗 https://doi.org/10.1016/j.ijheatfluidflow.2015.11.006](https://doi.org/10.1016/j.ijheatfluidflow.2015.11.006)

Fluid Dynamics in Chemical Reactor Design

[🔗 https://doi.org/10.1016/j.ces.2019.03.046](https://doi.org/10.1016/j.ces.2019.03.046)

Cyclone Separator Design and Particle Flow

[🔗 https://doi.org/10.1016/j.powtec.2017.11.064](https://doi.org/10.1016/j.powtec.2017.11.064)

Thank You
Questions?

