Part 1. Fundamentals * tfc.snu.ac.kr

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ch. 1. Introduction

1.1 Nature of turbulent flows

(from Tennekes & Lumley)

- Most flows occuring in nature & engineering applications are turbulent.
- Laminar flow is the exception.

Characteristics of turbulent flow

① irregularity (or randomness)

→ This makes a deterministic approach to turbulence problems impossible.

→ Instead, rely on statistical methods.

② Diffusivity

→ causes rapid mixing and increased rates of momentum, heat and mass transfer

→ is very important in engineering applications.

→ prevents boundary-layer separation on airfoils
increases heat transfer rate
is source of skin friction
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contrail of a jet aircraft → not turbulent

③ Large Reynolds number $\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{1}{Re} \nabla^2 u_i$

- nonlinear interaction → no general solution.
  - ↳ makes turbulence research both frustrating and challenging.

④ Three-dimensional vorticity fluctuations.

- turbulence is rotational and 3-dimensional
  - ↳ high level of vorticity fluctuations

→ vorticity dynamics is very important.

- 2-D velocity field has no stretching of vorticity → decays.

⑤ Dissipation

- turbulent flows are always dissipative.

Mean energy → Large scale production → energy cascade → small scale dissipation

⑥ Continuum

- smallest scale >> molecular length scale (Kolmogorov scale)

⑦ Turbulent flows are flows.

- not a feature of fluids but of fluid flows.
- The characteristics of turbulence depend on its environment.

1.2 Study of turbulent flows

- turbulent flow — large scales ← depend on b.c.
  - small scales ← have universal char. indep. of flow geometry → turbulence theory

- studies on turbulent flows
  - discovery — Part 1. of this book
  - modeling — Part 2.
  - control — X