

Part 1. Fundamentals

* tfc.snu.ac.kr

노트 제목

2010-03-02

ch. 1. Introduction

1.1 Nature of turbulent flows

(from Tennekes & Lumley)

- Most flows occurring 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.

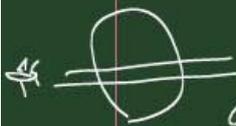
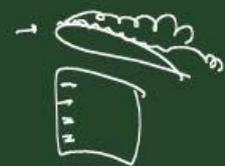
→ Instead, rely on statistical methods.

② Diffusivity

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

→ is very important in engineering applications.

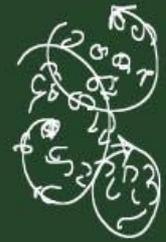
→ prevents boundary-layer separation on airfoils
increases heat transfer rate
is source of skin friction



contrail of a jet aircraft → not turbulent

- ③ Large Reynolds number $\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{1}{\rho} \nabla^2 u_i$
- nonlinear interaction \rightarrow 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
 \rightarrow vorticity dynamics is very important.
 - 2-D velocity field has no stretching of vorticity
 \rightarrow decays.

- ⑤ Dissipation
- turbulent flows are always dissipative.
- Mean energy \rightarrow Large scale production $\xrightarrow{\text{energy cascade}}$ Small scale dissipation



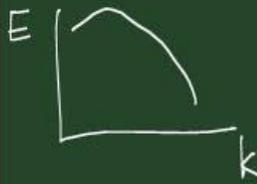
- ⑥ Continuum
- smallest scale \gg molecular length scale (Kolmogorov scale)
- ⑦ Turbulent flows are flows.
- not a feature of fluids but of fluid flows.
 - The characteristics of turbulence depend on its environment.

1.2

Study of turbulent flows



• turbulent flow - large scales \leftarrow depend on b.c.



small scales \leftarrow have^{ve} universal char.
indep. of flow geometry
turbulence theory

• studies on turbulent flows

- (discovery — Part 1. of this book
- modeling — Part 2.
- control — X