Date Sep 6th, 2017 (wednesday)

Basics for Fluid Flow Description

ABE 307

In major part of this course we are interested in analytical description of fluid flow, i.e deriving equations that describe fluids flowing in different scenario and solving those equations to get an idea about force field, velocity field etc. These are some basics that are used to start developing those equations.

1. Fundamental Physical Laws and Auxiliary Relations

Fundamental laws → Applicable to all types of flow and fluid (regardless of nature of fluid)

Auxiliary relations → Depends on nature of fluid

Fundamental Laws Applicable on all fluids

① Law of conservation of mass ⟶ Equation of continuity
② Newton's second law of motion → Momentum Theorem
③ First law of thermodynamics ⟶ Energy equation

Auxiliary Relations (Laws)
Applicable only on certain kind of fluid
(such as Newton's Law of viscosity applicable on molecular weight < 5000)

Caution : When you apply a principle to describe the nature of flow or develop analytical equations, be clear about the difference in scope about the applicability of fundamental physical laws (mass, momentum and energy) vs the auxiliary relations (which may or may not be applicable for the fluid/flow situation you are looking at).

2. Reference : Lagrangian vs Eulerian

Lagrangian → Follow a fluid particle through its course of flow.

Eulerian → Value of fluid variable at a given point in the space.

$V = v(a, b, c, t)$ — original position of particle

$V = v(x, y, z, t)$ — coordinate of observation.

3. Steady and Unsteady Flows

Fluid flow variables described by four independent variables (x, y, z, t) (Eulerian reference)

Steady state → fluid flow variable (such as velocity) independent of time (i.e. does not change with time).

Unsteady state → fluid flow variables dependent on time.

4. Streamlines and Pathlines

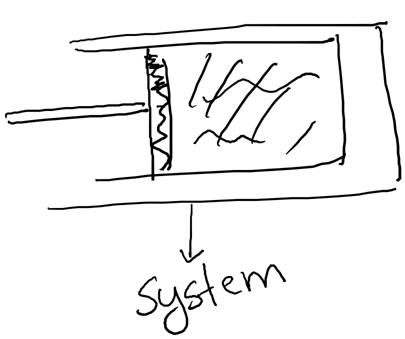
Streamline → Line drawn tangent to velocity vector at each point in the flow field.

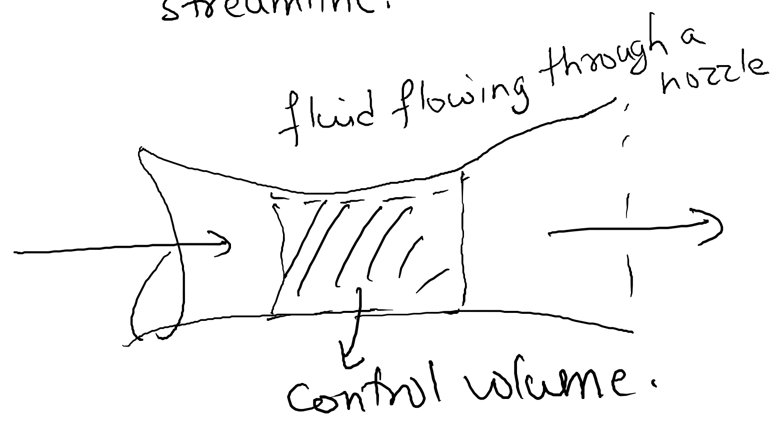
Pathline → Actual trajectory of a fluid element as it traverses the flow.

For steady state, Pathlines and streamlines coincide.

→ because for steady state flow all velocity vectors are invariant with time, the path of a fluid particle follows a streamline.

5. Systems and Control Volumes





- A control volume can be finite or infinitesimal
- We will obtain differential equations of fluid flow by the application of the fundamental laws and/or auxiliary relations using the infinitesimal or differential control volumes
- Boundary conditions will be important to get to the solution for a specific fluid flow situation