MEC516/BME516:
Fluid Mechanics I

Chapter 3: Control Volume Analysis
Part 8

RYERSON UNIVERSITY

Department of Mechanical & Industrial Engineering

Overview

Applications of the Bernoulli equation

- Static pressure and dynamic pressure

- Stagnation Point and Stagnation Pressure

- The Pitot Tube: An instrument for measuring local fluid velocity.

- Numerical Example: Air speed measurement in a wind tunnel using a Pitot Tube.
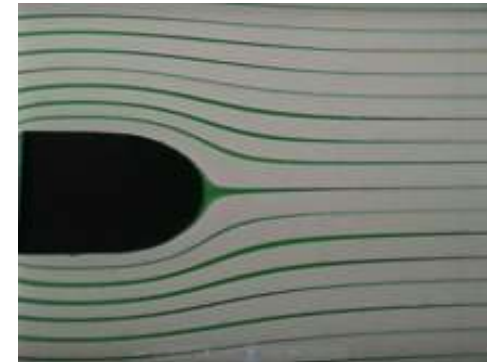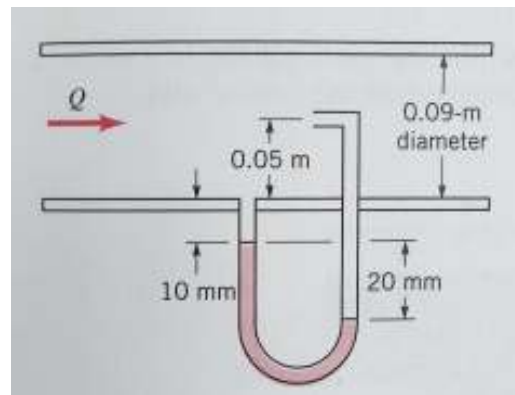
The Bernoulli Equation

- In the last video, we showed: $\dfrac{p}{\rho} + \dfrac{V^2}{2} + gz = const$ (on a streamline)

- Multiplying by density, ρ: $p + \rho\,\dfrac{V^2}{2} + \rho gz = const$

- Now all the terms have the units of pressure, N/m^2 or lb/ft^2. In this form:

    p is called the *static pressure*

    $\rho\,\dfrac{V^2}{2}$ is called the *dynamic pressure*

 ρgz is the *hydrostatic pressure gradient* (recall Chapter 2)

The Stagnation Point & Stagnation Pressure

- Consider the streamlines in a steady horizontal flow, shown below.

- The centre streamline impinges on the leading edge and the fluid decelerates to zero velocity at point (2).

- Applying B.E. between (1) and (2):

$$\frac{1}{2}\rho V_1^2 + p_1 = \frac{1}{2}\rho V_2^2 + p_2$$

$$0$$

So, $\quad p_2 = \frac{1}{2}\rho V_1^2 + p_1$

- kinetic energy is converted to pressure energy
- p_2 is called the *stagnation pressure*; $p_2 > p_1$.

Stagnation Point:
Fluid velocity $V_2 = 0$

V_1, p_1 ②   ① V_1, p_1
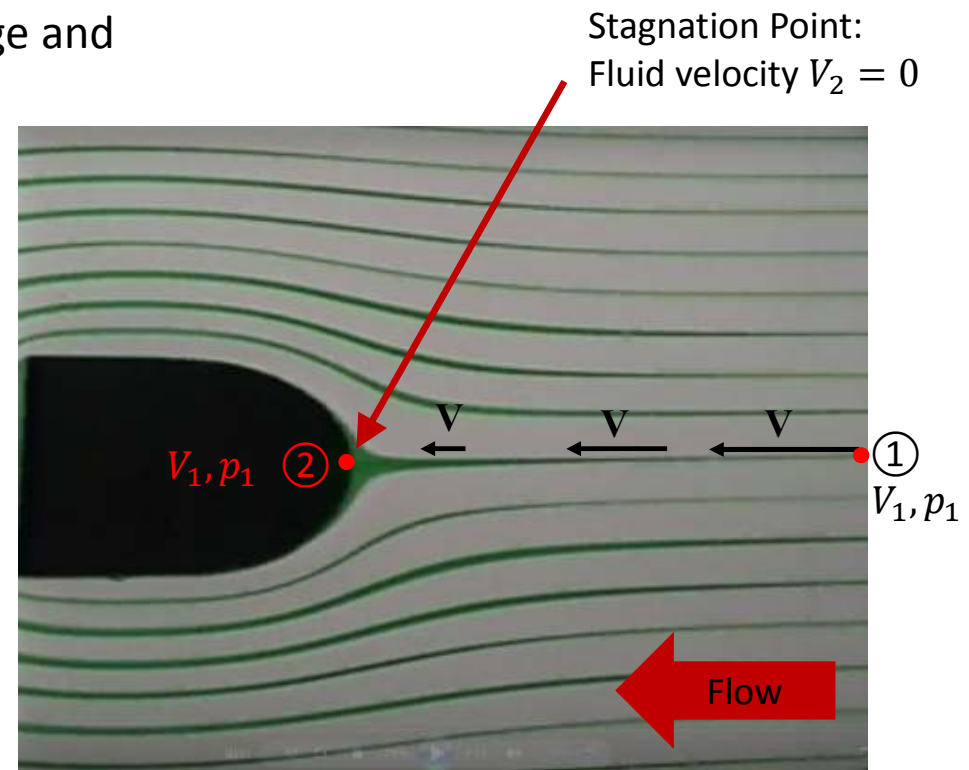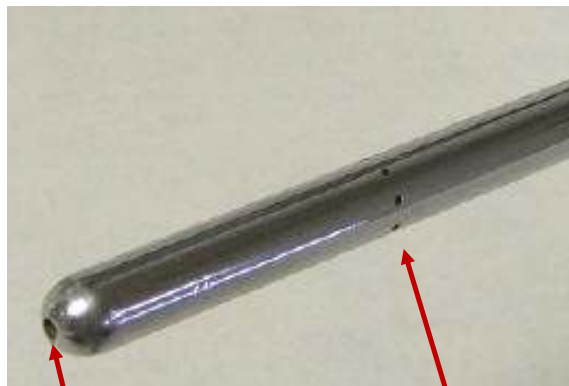
Flow

The Stagnation Point & Stagnation Pressure

- In part, flow stagnation is the source of the force on your hand, out the window of a moving car.

- A cause of aerodynamic drag, sometimes called "pressure drag".

Source: 1000awesomethings.com
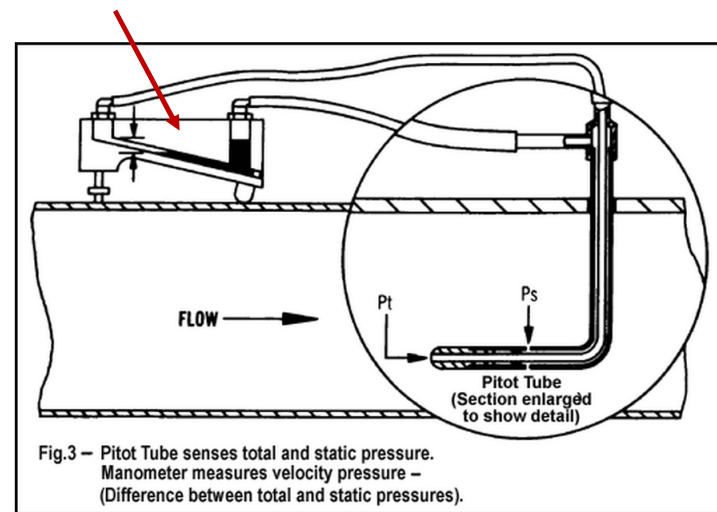
The Pitot Tube

- The Pitot Tube uses the difference between the stagnation and static pressure to measure the local fluid speed.
    - used by aircraft to measure airspeed.
    - used in wind tunnels

inclined manometer

Fig.3 — Pitot Tube senses total and static pressure. Manometer measures velocity pressure – (Difference between total and static pressures).

stagnation pressure port (at nose)

static pressure ports

Example

A Pitot Tube is connected to a manometer to measure the air velocity in a wind tunnel. If the specific gravity of the manometer fluid is SG=0.85, what is the air speed?

Air

$T_\infty = 25\ °C$

$p_{atm} = 98\ kPa$

V=?

20 mm