Obstruction-Type Flow Meters

ME 322 Lecture Slides, Winter 2007

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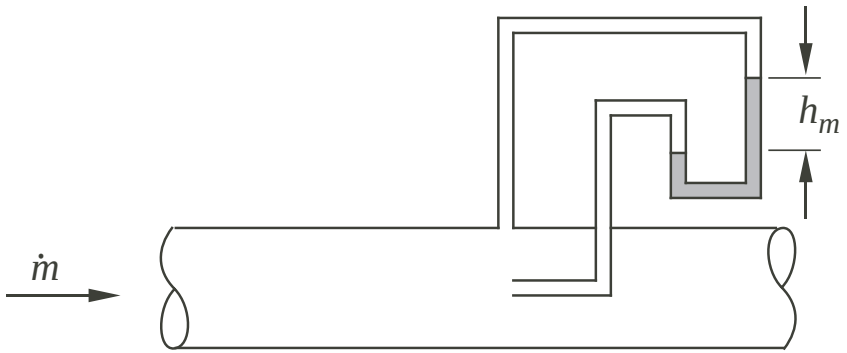
Overview of Flow Measurements

- Local: velocity, temperature and pressure at at point
- Integrated: mass or volume flow rate at a cross-section
- Global: flow visualization

Velocity Measurements At a Point (1)

Pitot probe



The dynamic pressure is

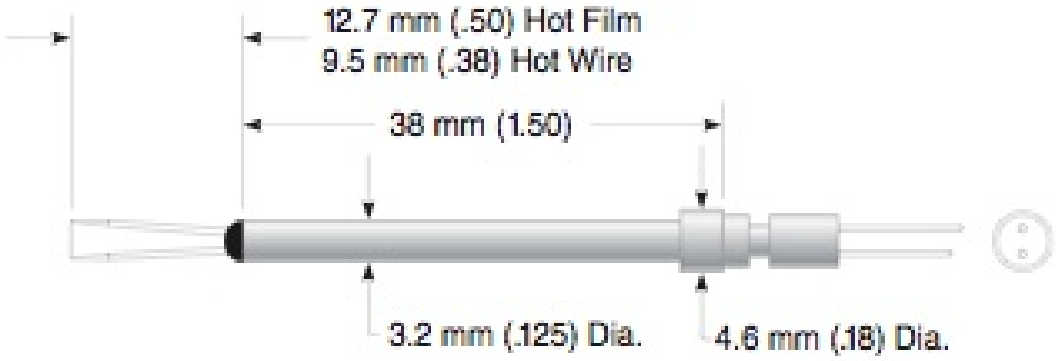
$$p_d = \frac{1}{2}\rho V^2 = \gamma_m h$$

Solve for the velocity

$$V = \sqrt{\frac{2\gamma_m h}{\rho}}$$

Velocity Measurements At a Point (2)

Thermal anemometer – hot wire anemometer



Source: TSI Thermal Anemometry Probe catalog

- Low cost sensors are ∼$1500 US in 2007
- Research-quality systems cost $30k and up

Velocity Measurements At a Point (3)

Optical systems

- Laser Doppler anemometer
- Particle image velocemetry

These systems

- Are more expensive than hot wire systems
- Require optical access
- Require seeding of the flow
- Are non-intrusive – no probe body disturbs the flow
- Are the only option in extreme environments
  - ▷ velocity field around a cell
  - ▷ velocity field in a rocket exhaust
  - ▷ velocity field inside the cylinder of a reciprocating engine

Pressure Measurements At a Point

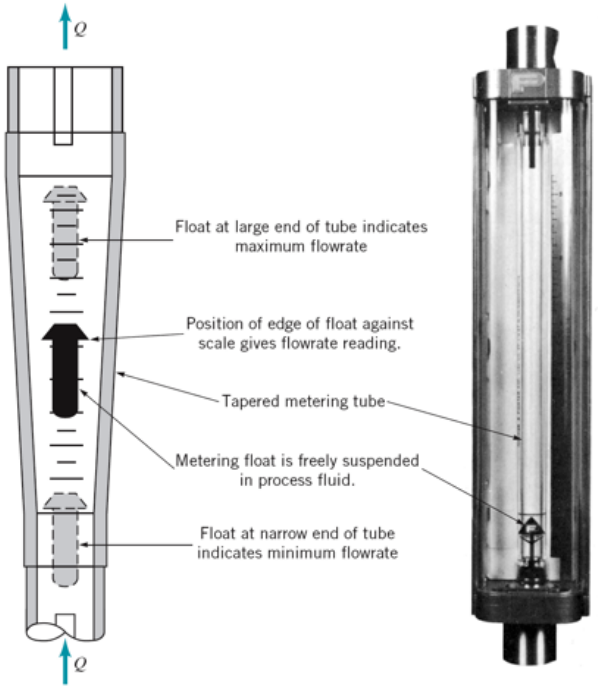
Pressure measurements require a *pressure tap* connected to a pressure sensor.

Pressure sensors

- manometer
  - ▷ Static pressure along walls
  - ▷ Total pressure (stagnation pressure) via piezometer
- Bourdon gages
- Pressure transducers
  - ▷ Strain gage type
  - ▷ Piezoelectric
  - ▷ Capacitance type

Volumetric Flow Rate Measurement (1)

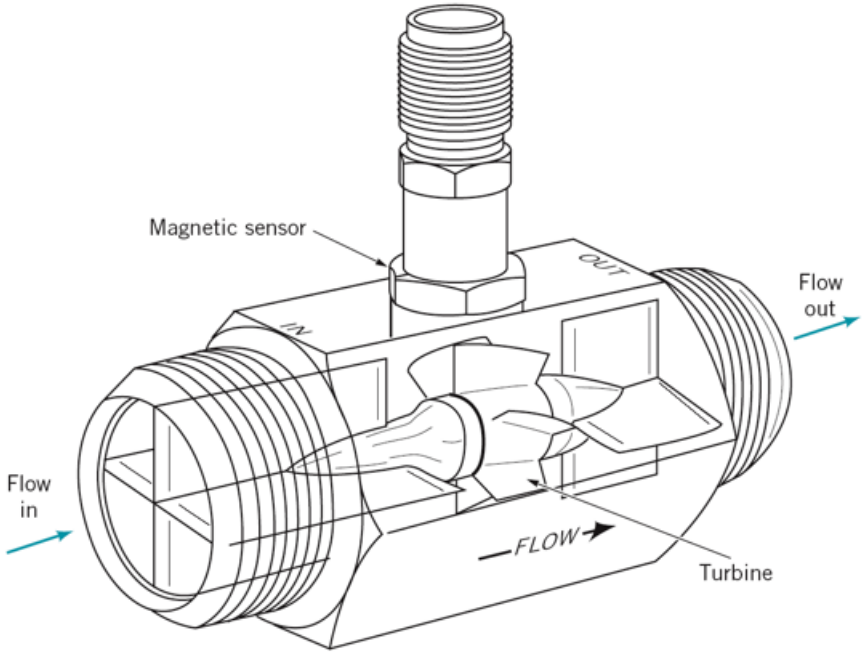
Rotameters, a.k.a. variable area meters



Source: Munson, Young and Okiishi, Figure 8.46

Volumetric Flow Rate Measurement (2)

Paddle wheel and turbine meters



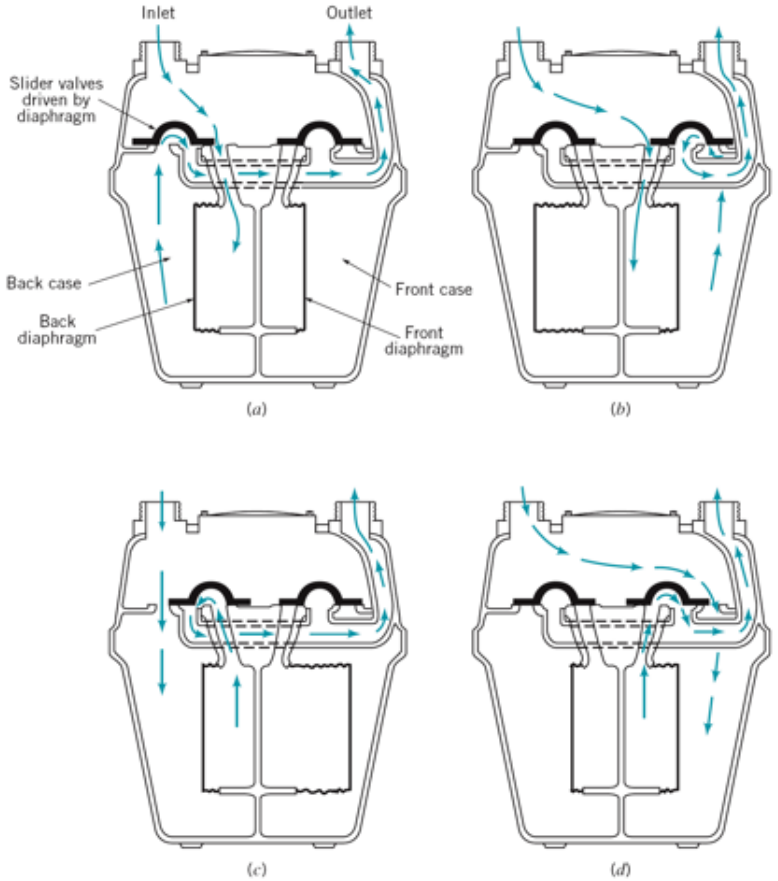
Source: Munson, Young and Okiishi, Figure 8.47

Volumetric Flow Rate Measurement (3)

- Metering pumps, e.g. gas clocks
- Capillary tubes — Laminar flow meters

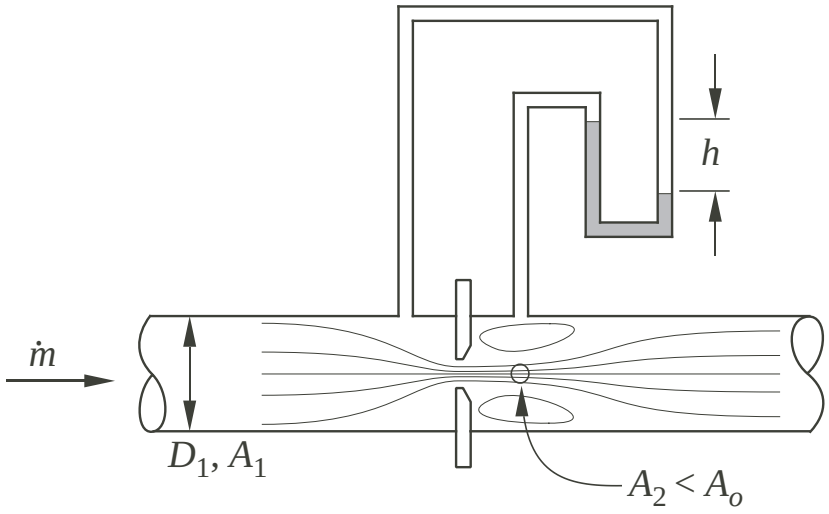
Volumetric Flow Rate Measurement (4)

Metering pumps
and gas clocks

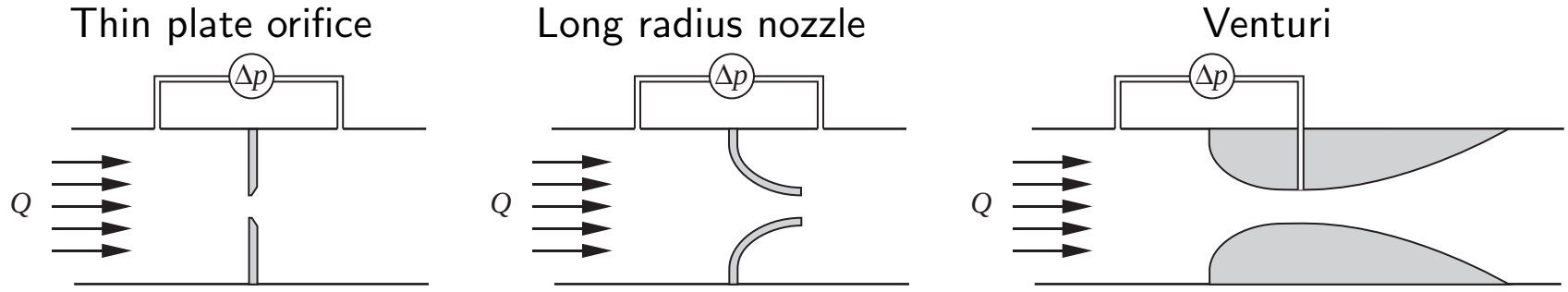


Source: Munson, Young and Okiishi, Figure 8.49

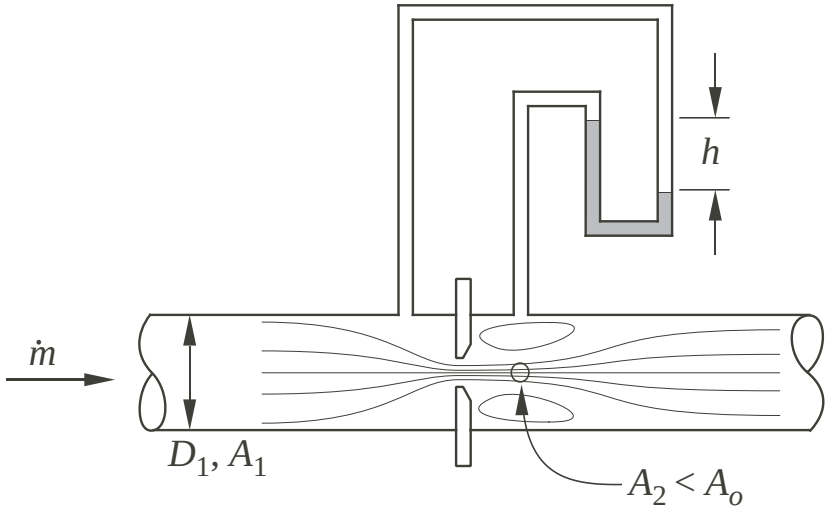
Obstruction Type Flowmeter (1)



Volumetric Flow Rate Measurement (2)



Volumetric Flow Rate Measurement (3)



Compute flow rate with

$$Q = C_o A_o \sqrt{\frac{2(p_1 - p_2)}{\rho(1 - \beta^4)}}$$

Meter Type	Typical C_o
Orifice	0.60
Nozzle	0.97
Venturi	0.98

where C_o is the discharge coefficient and $\beta = d_0/D_1$.