MEC516/BME516: Fluid Mechanics I

Chapter 3: Control Volume Analysis Part 9

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Overview

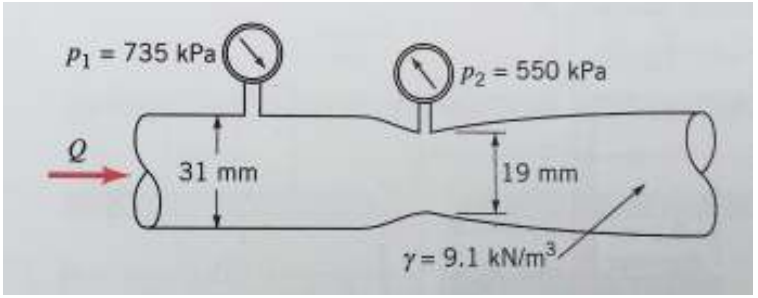
Applications of the Bernoulli equation

- Venturi Flow meters
  - Conversion: Pressure Energy → Kinetic Energy → Pressure Energy

Source: www.power-technology.com

- **Numerical Example**
  - Flow measurement using a Venturi meter.

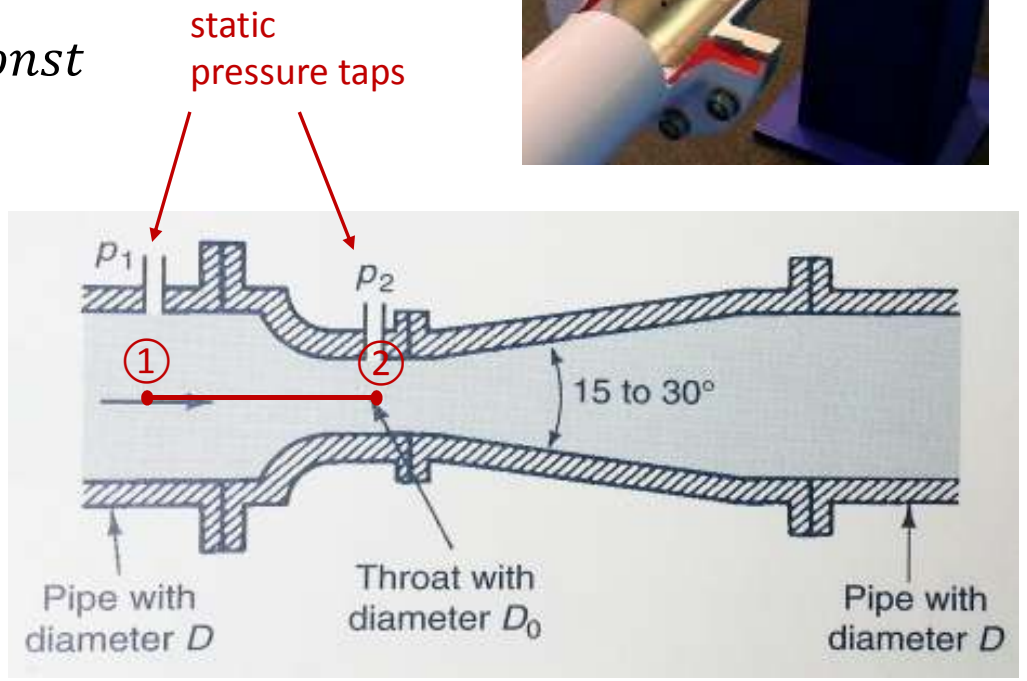
- Other "Bernoulli principle" flow meters:
  - Nozzle meters
  - Orifice plate meters



The Venturi Flow Meter

- A venturi meter consists of a transition section -- a smooth flow contraction followed by a smooth flow expansion.
- We can write the Bernoulli equation for two points on a streamline on the centreline of the pipe:

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



- Velocity ***increases*** at the throat:

$$V_2 > V_1$$

- Thus, pressure ***decreases*** at point ②:

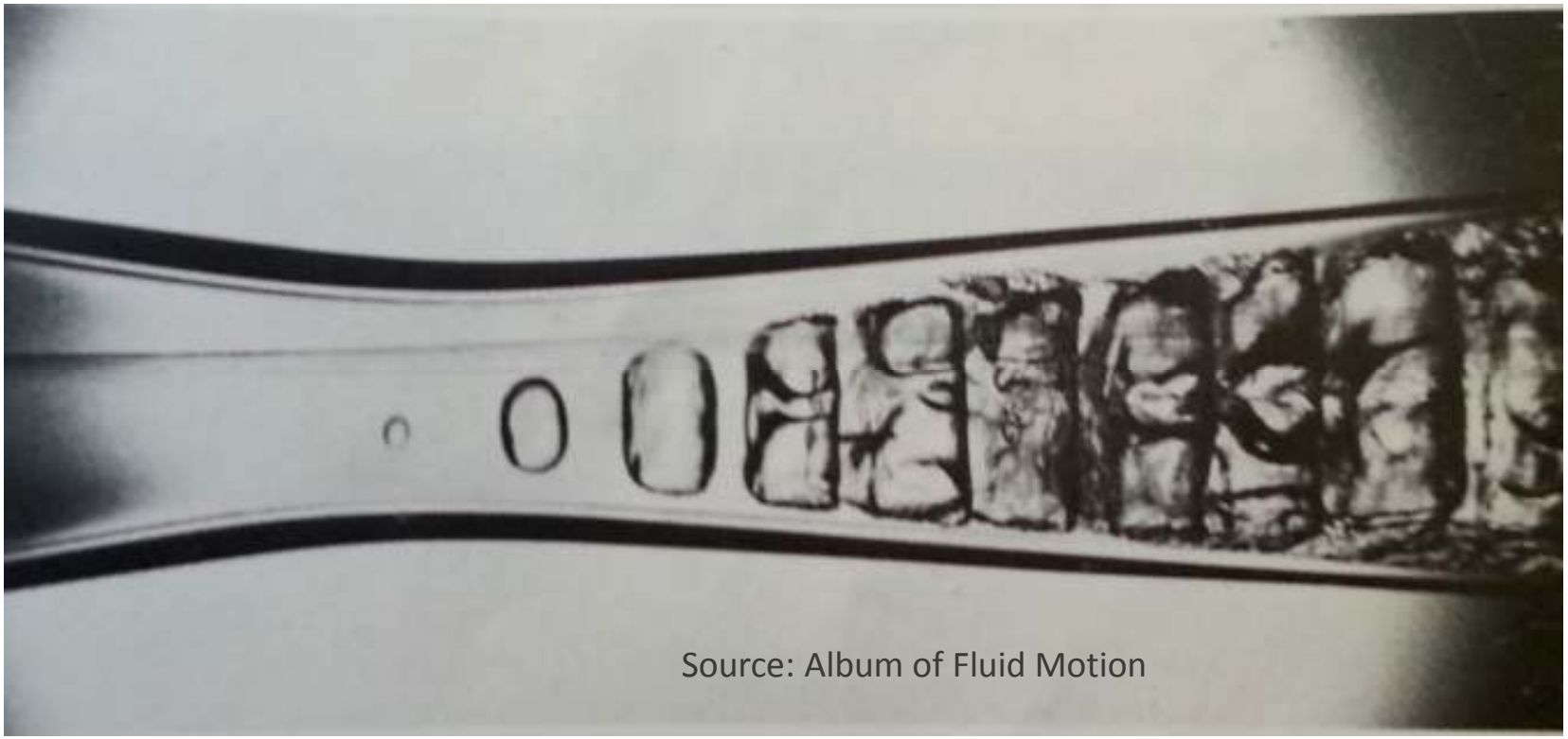
$$p_2 < p_1$$

- The differential pressure, $p_1 - p_2$ is used to measure the flow volume rate, Q

Cavitation in a Venturi

- The pressure at the throat can be low enough to cause boiling!
  i.e. cavitation if $p_2 < p_{sat}$

Water Flow



Source: Album of Fluid Motion

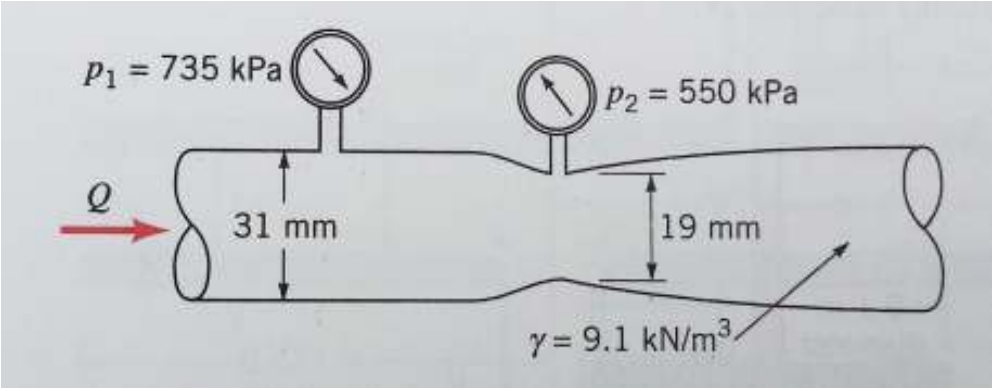
The Venturi Flow Meter

- Venturi meters are used for volume flow measurement in a wide range of applications, e.g. oil & gas industry, oil refineries, water treatment plants, etc.
- Smooth flow transition gives low pressure losses (lowers pumping power, saves $)

Source: www.power-technology.com

Example

The flow rate of fuel oil (γ=9100 N/m^3) is measured using a venturi flow meter at an oil refinery. The main pipe has an inside diameter of 31 mm and the throat of the meter has a diameter of 19 mm. Using the pressures shown in the sketch, calculate the volume flow (Q) rate of the oil.



Other Bernoulli Principle Flow Meters

Nozzle Flow Meter

- Differential pressure meter (like the venturi): $(p_1 - p_2) \sim Q^2$
- More pressure losses than venturi meter. Downstream turbulence. Pumping power costs ↑
- But, easier to manufacture and install.

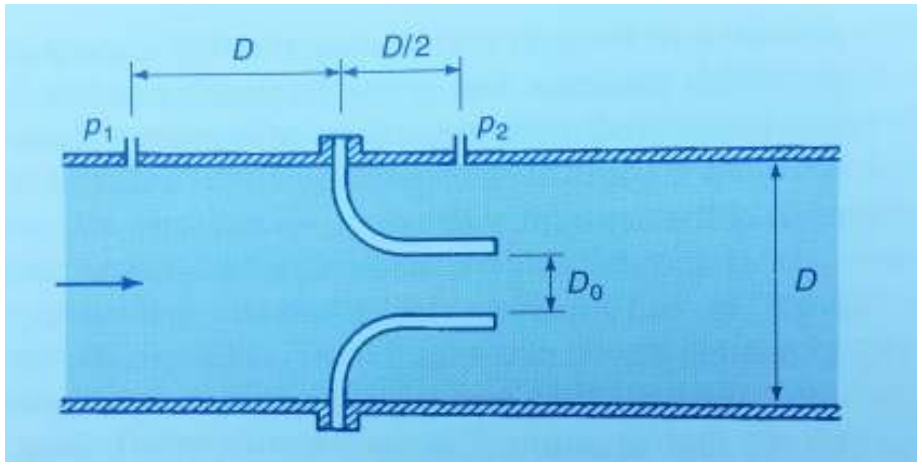


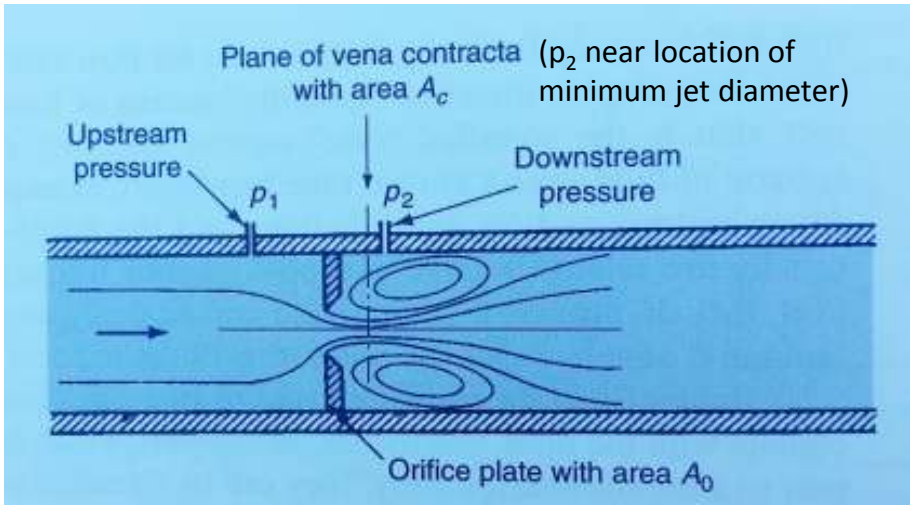
Image source http://www.fmcltd.uk.com

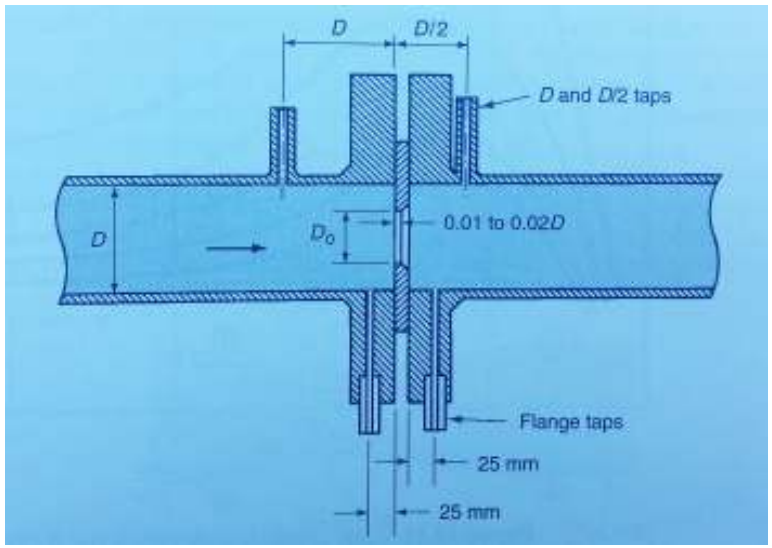
Other Bernoulli Principle Flow Meters

Orifice Plate Flow Meter

- Differential pressure meter: $(p_1 - p_2) \sim Q^2$
- Plate with a bevelled hole, inserted between flanges.
- High pressure loss, more than nozzle meter.
- But, very easier to manufacture and install.
- "*vena contracta*" (Latin: contracted vein)

Source: http://www.teleflo instruments and Controls





Source: http://scienceing.tumblr.com/post/65579591316

END NOTES

Presentation prepared and delivered by Dr. David Naylor.