Chapter 15

- Time will permit us to focus only on venturi meter and pitot- static tube in class
- Common flowmeters are these + rotometer, magnetic, ultrasonic

Miami University

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Description of Venturi

1. Meter constricts flow to narrow sections and then gradually expands again back to pipe diameter
2. Meter measures the pressure drop from pipe to the throat

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How Venturi Works

- Continuity says velocity increases
- Bernoulli says pressure drops
- Designed for minimal losses (no vena contracta). Losses would further increase the amount of pressure drop

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Equations for Venturi

- Losses taken into account with vendor supplying discharge coefficient C
- Text has Eq. 15-3, 4, & 5 incorrect on p. 442 and Eq 15-4 correct on p. 444

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Corrected Equations for Venturi

- To correct, substitute

$$\left(\frac{A_1}{A_2}\right)^2 - 1$$

- For

$$1 - \left(\frac{A_1}{A_2}\right)^2$$

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Venturi Concluded

- Discharge coefficient C is itself a function of the Reynolds number to about Re of 200,000

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Description of Pitot-Static Tube

- Static tube is a hollow tube (closed in front, with holes on side) that sees the pressure of the moving fluid
- Pitot tube is a hollow tube (with opening in front) that sees the pressure at the opening where the fluid has stopped moving

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More Description

- Tubes are concentric(central tube is the pitot) and connected to a differential manometer

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How Pitot-Static Tube Works

- Write Bernoulli from moving fluid to stagnation point, where v is local velocity

$$\frac{P_1}{\gamma} + \frac{v^2}{2g} = \frac{P_s}{\gamma} \quad \text{or v } = \sqrt{\frac{2g(P_s - P_1)}{\gamma}}$$

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Confusing Terms in Pitot-Static Tube Equation

- P_1 called static pressure even though fluid is moving
- P_1/γ called static head even though fluid is moving
- Ps = stagnation or total pressure at point of zero velocity

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Drawbacks with Pitot- Static

- To get average velocity, must take several readings at different points across the cross section of the pipe, and compute average velocity
- This is big drawback, which is why strap-on ultrasonic flowmeter has become so popular

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Guidelines for Mounting Flow Meter

For laminar, Length = ideally 0.06 (Re) D from flow disturbance.

-For Re = 20, L = D.

-For Re = 2300, this is 138D

Difficult to do in pilot plant

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More Guidelines

For turbulent, Length = about 4.4 D (Re) $^{1/6}$

For Re = 4000, L = 18D

For Re = 10^6, L = 44D

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More Guidelines

- Place where no boiling can occur and there's no entrained air.
- Place where your sure pipe is always full; i.e, mount in vertical pipe

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What Goes Wrong with Flowmeters

- Mounting problems previously discussed
- Flow is above range or below accurate range of flowmeter
- Usually no way to calibrate absolutely

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More on What Goes Wrong with Flowmeters

- Doesn't read zero at zero flow because electronics drift, etc
- Instrument people do only partial calibration at one value

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Accuracy of Flowmeters

- In typical chemical or paper plant, most accurate flow known is amount of product.
- Large flows can only be determined within + or – 20%, small flows + or – 10%
- If two flowmeters near the same point along a pipe read almost identical values, assume they are both wrong. Verify with other material balances.

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