ENGR 292 Fluids and Thermodynamics

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Feb.07, 2017

Review of Last Class

Step	Detail	Theory or Reference
Step 1	Pipe System Layout	Pipe, Pump, Valves, Piping routing (pipe length), fittings
Step 2	Pipe Size – Discharge	Recommended Velocity and required Flow rate;
Step 3	Pipe Size – Suction	One standard size larger than Discharge
Step 4	Actual Flow Velocity	Commercially available pipes NPS
Step 5	Reynolds Number	Flow Type: Laminar, Turbulent

Review of Last Class

Step	Detail	Theory or Reference
Step 6	Pipe Material	Based on → Roughness
Step 7	Relative Roughness	Roughness/ID
Step 8	Friction Factor	By Moody Diagram
Step 9	Pipe Length	Based on the Step 1
Step 10	Pipe Friction Head Loss	Darcy's Equation

Review of Last Class

Step	Detail	Theory or Reference
Step 11	Minor Loss	K factor
Step 12	Head added by Pump	General Energy Equation
Step 13	Pump Selection	Pump Head + Pump Flow → Pump Curves
Step 14	Check Suction Design	NPSH

Step 11: Minor Loss

- **K Factors**
  - **Valves**
    - **Gate Valve**
    - **Check Valve**
  - **Elbow**
  - **Discharge**

Step 11: Minor Loss

	Nominal diameter, in								
	Screwed				Flanged				
	½	1	2	4	1	2	4	8	20
Valves (fully open):									
Globe	14	8.2	6.9	5.7	13	8.5	6.0	5.8	5.5
Gate	0.30	0.24	0.16	0.11	0.80	0.35	0.16	0.07	0.03
Swing check	5.1	2.9	2.1	2.0	2.0	2.0	2.0	2.0	2.0
Angle	9.0	4.7	2.0	1.0	4.5	2.4	2.0	2.0	2.0
Elbows:									
45° regular	0.39	0.32	0.30	0.29					
45° long radius					0.21	0.20	0.19	0.16	0.14
90° regular	2.0	1.5	0.95	0.64	0.50	0.39	0.30	0.26	0.21
90° long radius	1.0	0.72	0.41	0.23	0.40	0.30	0.19	0.15	0.10
180° regular	2.0	1.5	0.95	0.64	0.41	0.35	0.30	0.25	0.20
180° long radius					0.40	0.30	0.21	0.15	0.10
Tees:									
Line flow	0.90	0.90	0.90	0.90	0.24	0.19	0.14	0.10	0.07
Branch flow	2.4	1.8	1.4	1.1	1.0	0.80	0.64	0.58	0.41

Step 11: Minor Loss

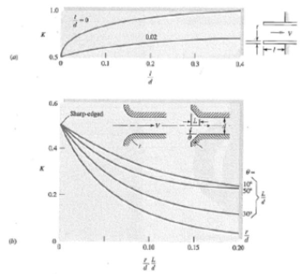

Fig. 6.21 Entrance and exit loss coefficients: (a) reentrant inlets; (b) rounded and beveled inlets. Exit losses are $K = 1.0$ for all shapes of exit (reentrant, sharp, beveled, or rounded). (*From Ref. 37.*)

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Step 12: Head added by Pump

Determine the pump head by using the General Energy Equation:

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} + h_A - h_R - h_L = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

To:

$$h_A = \frac{p_2 - p_1}{\gamma} + z_2 - z_1 + \frac{v_2^2 - v_1^2}{2g} + h_R + h_L$$

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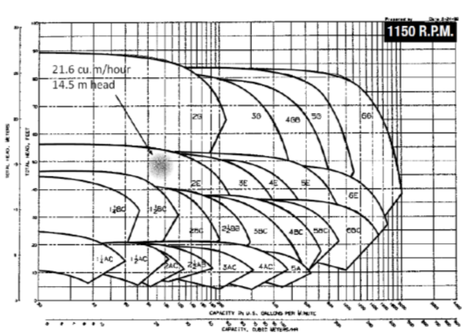
Step 13: Pump Curve



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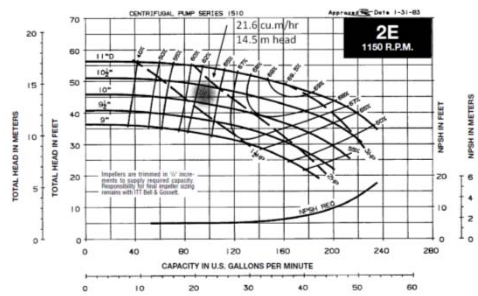
Step 13: Pump Curve



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Step 13: Pump Selection

- ***Pump Spec:***
  - ***Make: B&G***
  - ***Series: 1510***
  - ***Model: 2E***
  - ***RPM: 1150***
  - ***Power: 2 HP***
  - ***Impeller: 10 ½ " ∅***
  - $NPSH_R$***: 5 feet = 1.52 m***

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Step 14: Check the Suction Design

- ***Check the Suction Design:***
  - ***NPSH: Net Positive Suction Head (m)***
  - $NPSH_A$***: Available NPSH at pump's impeller***

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Step 14: Check the Suction Design

- **Check the Suction Design:**

$$NPSH_A = \frac{P_{atm}}{\gamma} - h_e - h_f - \frac{P_v}{\gamma}$$

$\frac{P_{atm}}{\gamma}$: atmospheric pressure or absolute pressure at the fluid surface

h_e : Lift from fluid surface to pump

h_f : Suction line head loss

P_v: Fluid vapor pressure

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Step 14: Check the Suction Design

- **Check the Suction Design:**

$$NPSH_A = \frac{P_{atm}}{\gamma} - h_e - h_f - \frac{P_v}{\gamma}$$

$$= \frac{101.3kPa}{9.81kN/m^3} - 1 - [0.266 + 0.458] - \frac{0.9kPa}{9.81kN/m^3}$$

$$= 10.33 - 1 - 0.724 - 0.0917$$

$$= 8.5\ m$$

This is how much NPSH we have (available)

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Step 14: Check the Suction Design

- **Check the Suction Design:**

The pump needs (requires) NPSH 1.52 m to be happy

$NPSH_R$ =1.52 m

$NPSH_A$ =8.5 m

$$NPSH_A > NPSH_R$$

The pump is happy ☺

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NPSH

- **NPSH: Net Positive Suction Head**
  - $NPSH_A$: NPSH available
  - $NPSH_M$: NPSH margin
  - $NPSH_R$: NPSH required

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NPSH

- **Low pressure at the suction side of a pump may cause the fluid to start boiling with**
  - Reduced efficiency
  - Cavitation
  - Damage

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Bernoulli's Equation

- **Bernoulli's equation**
  - Based on the principle of conservation of energy
  - Restrictions on its use.

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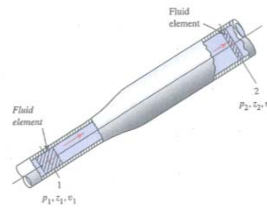
Bernoulli's Equation

- ***Bernoulli's equation***
  - ***Control volume or integral analysis***
  - ***Infinitesimal or differential analysis***
  - ***Experimental study***

Bernoulli's Equation

- ***Fluid elements used in Bernoulli's equation:***



Bernoulli's Equation

- ***Bernoulli's Equation:***

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

Bernoulli's Equation

- ***Restrictions on Bernoulli's Equation***
  - ***It is valid only for incompressible fluids***
  - ***There can be no mechanical devices between two sections of interest***
  - ***There can be no heat transferred into or out of the fluid***
  - ***There can be no energy lost due to friction***

Bernoulli's Equation

- ***In reality no system satisfies all these restriction.***
- ***However, there are many systems for which only a negligible error will result when Bernoulli's equation is used.***

Bernoulli's Equation

- ***Conservation of Energy – Bernoulli's Equation***

- ***As we know:***
  - ***Energy can be neither created or destroyed***
  - ***But it can be transformed from one form into another***

Recommended Velocity

- ***How?***

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General Energy Equation

- ***Nomenclature of Energy Losses and Addition***
  - h_A: ***Energy added to the fluid with a mechanical device such as a pump; this is often referred to as the total head on the pump***
  - h_R : ***Energy removed from the fluid by a mechanical device such as fluid motor***
  - h_L: ***Energy losses from the system due to friction in pipes or minor losses due to valves and fittings.***

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General Energy Equation

- ***General Energy Equation***

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} + h_A - h_R - h_L = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

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Fluid Dynamics

- ***Power Required by Pumps***
  - ***Power added to a fluid by a pump***

$$P_A = h_A \gamma Q$$

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Fluid Dynamics

- ***Mechanical Efficiency of Pumps***

$$e_M = \frac{P_A}{P_1}$$

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Fluid Dynamics

- ***Power Delivered to Fluid Motors***

$$P_R = h_R \gamma Q$$

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Fluid Dynamics

- ***Mechanical Efficiency of Fluid Motors***

$$e_M = \frac{P_O}{P_R}$$

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Fluid Dynamics

- ***Use of Software for Pipe Flow Problems***

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What is next?

- ***Any Questions?***

- ***Next class, we will have a Midterm Review***

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