ENGR 292 Fluids and Thermodynamics

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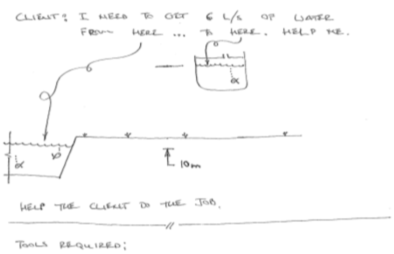
ENGR 292

- ***Fluid Dynamics***
  - ***Start with an Example (a project)***
  - ***Talk about the concepts, principles and equations during the problem-solving***
  - ***You need to read books or other references of fluid dynamics to brush up on your memory to fully understand all the relevant stuffs, such as:***
    - ***Control volume analysis***
    - ***Bernoulli's Equation***
    - ***Navier-Stokes Equation (NS Equation)***
    - ***…***

2

Fluid Dynamics

- ***A Starter Problem for Technologist***



3

Fluid Dynamics

- ***A problem in Client's "language" and "sketch"***
  - ***Given:***
    - ***Fluid: Water***
    - ***Function required: Pool → Tank, Flow Rate: 6 L/s***
    - ***The difference between the initial water levels of Pool and Tank is 10 m.***
    - ***Fishes in both Pool, and Tank, Water is safe for fish.***
  - ***Help me = Design a system?***

4

Design a Water Pumping System

1. Do Rough Layout

- ***Pipe***
- ***Pump***
- ***Valves***

5

Design a Water Pumping System

2. Determine Discharge Pipe Size

- $Q = \mathrm{v}A$
- $A = \frac{\pi D^2}{4}$
- v ***: Select a velocity***

6

Design a Water Pumping System

3. Determine Suction Pipe Size

- ***One standard size larger than the size of discharge pipe***

7

Design a Water Pumping System

4. Calculate Actual Flow Velocities

- ***Discharge:*** $Q = \mathrm{v}A$
- ***Suction:*** $Q = \mathrm{v}A$

8

Design a Water Pumping System

5. Determine Reynolds Number

- ***Discharge:*** $N_R = \frac{\mathrm{v}D\rho}{\mu}$
- ***Suction:*** $N_R = \frac{\mathrm{v}D\rho}{\mu}$

9

Design a Water Pumping System

6. Choose Pipe Material

- ***Discharge:***
- ***Suction:***

Roughness ε

10

Design a Water Pumping System

7. Determine Relative Roughness:

- ***Discharge:*** $\frac{\varepsilon}{D_{Discharge}}$ ***or*** $\frac{D_{Discharge}}{\varepsilon}$
- ***Suction:*** $\frac{\varepsilon}{D_{Suction}}$ ***or*** $\frac{D_{Suction}}{\varepsilon}$

11

Design a Water Pumping System

8. Determine Friction Factor f:

- ***Discharge: Moody Diagram***
- ***Suction: Moody Diagram***

12

Design a Water Pumping System

9. Determine Pipe Length: (from the step 1, piping layout)

- ***Discharge:***
- ***Suction:***

Design a Water Pumping System

10. Calculate Pipe Friction Head Loss, $h_{L\_friction}$

$$h_{L\_friction} = f\frac{L}{D}\frac{v^2}{2g}$$

- ***Discharge:***
- ***Suction:***

Design a Water Pumping System

11. Determine Minor Head Loss, h_L

$$h_{L\_Minor} = \left[\sum K\right]\frac{v^2}{2g}$$

- ***Discharge:***
- ***Suction:***

Design a Water Pumping System

12. Determine Head Added by Pump, h_A

General Energy Equation:

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

$$h_L = h_{L\_friction} + h_{L\_Minor}$$

Design a Water Pumping System

13. Select Pump, Q, h_A

- ***Pump Curves***

Design a Water Pumping System

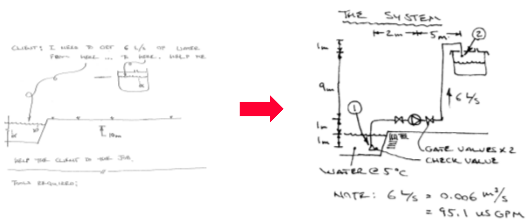
14. Check suction design,

$$NPSH_A > NPSH_R$$

Or Change Design !

Pump and Pipe Example

Rough Layout



19

Pump and Pipe Example

Pipe Size:

- $Q = vA$ → $A = \frac{Q}{v}$
- $A = \frac{\pi D^2}{4}$ → $D = \sqrt{\frac{4A}{\pi}}$
- v **: Recommended**
  - **We choose** $v = 3m/s$ **(Design)**
  - **So** $A = \frac{Q}{v} = \frac{0.006\ m^3/s}{3\ m/s} = 0.002m^2$
  - $\therefore\ D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{(4)(0.002)}{\pi}} \approx 0.050463m = 50.463mm$

20

Pump and Pipe Example

Pipe Size:

- **Choose a close real size**
- **SCH 40 … ID=52.501mm**
- **That is for 2” SCH 40 Pipe**
- $A_{Flow} = 21.648 \times 10^{-4} m^2$

21

Pump and Pipe Example

Suction Line Size:

- **Choose a close real size**
- **SCH 40 … ID=52.501mm**
- **That is for 2” SCH 40 Pipe**
- $A_{Flow} = 21.648 \times 10^{-4} m^2$

22

What is next?

- ❑ **Any Questions?**
- ❑ **Next class, we will continue on this project**

23