CHEG 1810
Spring 2017

MODULE 5 EXERCISE PROBLEM

PROBLEM STATEMENT:
Calculate the size (in horsepower, HP) of a pump required to move water moving at three different average velocities of 5, 10, and 15 feet per second through a 5,000-foot long pipe with a 1-inch inside diameter. Assume that the viscosity of water is 0.01 poise at room temperature and that the pump has an efficiency of 0.70. Create one Mathcad worksheet file for each of the velocities to be tested. Show all your complete solutions.

PROBLEM SOLVING STEPS TO FOLLOW:

[1] Calculate the Reynolds Number or Re using the formula:

$$Re = \frac{D_i V_{avg} \rho}{\mu}$$

where Re = Reynold's number, D_i is the inside diameter of the pipe, V_{avg} is the average velocity of the fluid, ρ (Greek letter rho) is the fluid density, and μ (Greek letter mu) is the fluid viscosity. Re is dimensionless so make sure that the units of the given values cancel out.

[2] Calculate the Fanning Friction Factor *f* using the formula:

$$\frac{1}{f} = 2.5 \ln\left(Re\sqrt{\frac{f}{8}}\right) + 1.75$$

Note: This formula is applicable only if Re > 60000.

[3] Calculate the pressure drop across the pipe, assuming that the pipeline is purely horizontal using Bernoulli's equation for this system:

$$\Delta P = 4f \frac{L}{D_i} \frac{\rho\left(V_{avg}\right)^2}{2}$$

where ΔP is the pressure drop in psi (pounds per square inch) and L is the pipe length. Make sure that your units are consistent.

[4] Solve for the energy per mass quantity required to overcome friction in the pipeline, h_f.

$$h_f = \frac{\Delta P}{\rho}$$

[5] Solve for the mass flow rate of the flowing fluid (water), *w:*

$$w = V_{avg} A_{flow} \rho$$

*A_{flow} is the cross-sectional flow area of the pipe. If you know the inside diameter as given above, how can you calculate this?

[6] Solve for the required pump power, P_p*:*

$$P_p = \frac{h_f w}{\eta}$$

where η (Greek letter eta) is the pump efficiency.