Technical Note

<u>Calculating Pressure Losses in Equipment Handling Non-Newtonian Fluids from Manufactures' Data for Water</u>

Determining the pressure loss that occurs over pipeline components (heat exchangers, strainers, pneumatic vales, etc.) is required to size pumps and evaluate process performance. Flow patterns are complex so pressure drop cannot be predicted from fundamental equations – an empirical approach is needed.

Fortunately, equipment manufactures provide some information describing the pressure loss for their products. Data are usually given for water, and plotted as pressure loss (psi or inches of water) versus volumetric flow rate (gpm). Considering the friction factors for each fluid, one can make an approximation of the pressure loss that occurs with other Newtonian fluids (more or less viscous than water), as well as non-Newtonian fluids.

Assume that the energy loss per unit mass ($\Delta P/\rho$) can be expressed in terms if the friction factor (f) for the connecting pipes, and the equivalent length of the equipment (L_e). Then, the energy loss for the application fluid is

$$\left(\frac{\Delta P}{\rho}\right)_{application\ fluid} = \left(\frac{2 f \bar{u}^2 L_e}{D}\right)_{application\ fluid}$$

and, the equation for water is

$$\left(\frac{\Delta P}{\rho}\right)_{water} = \left(\frac{2 f \bar{u}^2 L_e}{D}\right)_{water}$$

Assuming the velocity, equivalent length, and diameter are the same in each case; and taking the ratio of the above equations yields

$$\frac{\left(\frac{\Delta P}{\rho}\right)_{application\ fluid}}{\left(\frac{\Delta P}{\rho}\right)_{water}} = \frac{f_{application\ fluid}}{f_{water}}$$

Hence, the pressure loss for a non-Newtonian fluid, or a different Newtonian fluid, can easily be estimated using experimental data for water (provided with the equipment) and a friction factor ratio:

$$\left(\frac{\Delta P}{\rho}\right)_{application\ fluid} = \left(\frac{\Delta P}{\rho}\right)_{water} \left(\frac{f_{application\ fluid}}{f_{water}}\right)$$

For more information on this method, feel free to contact Prof. Steffe: steffe@msu.edu, 517-353-4544.

Nomenclature:

D	= diameter, m
f	= Fanning or Darcy friction factor, dimensionless [Note: $f_{Darcy} = 4\ f_{Fanning}$]
L_e	= equivalent length, m
$\bar{u}$	= volumetric average (also called mean) velocity, m s^{-1}
μ	= Newtonian fluid viscosity, Pa s
ΔP	= pressure loss or change in pressure, Pa
ρ	= density, kg m^{-3}