SOFTWARE TOOLS HELP AVOID ENGINEERING ERRORS

Advances in computer technology are providing better tools to simplify the tasks faced by engineers, especially those responsible for designing and managing process lines that handle fluids and gases.

Tools, such as ABZ, Inc.'s *Design Flow Solutions* software, allow quick solutions to fluid flow problems that would have been difficult, time consuming, and error prone by hand. In addition, these software tools eliminate many of the errors common with hand calculations.

Data Collection

The first step in solving a fluid flow problem is to find data for the hardware and the fluid being used. Hardware data includes size and flow resistance and can be provided in different forms (K factor, equivalent length, and Cv are common). This data is found in various textbooks and from hardware manufacturers, and keeping track of multiple sources can be difficult. In comparison, software tools typically include data for common hardware. Software tools also may permit the user to add specialty items to customize the data available in the program.

Required fluid data include density and viscosity (and for gases, molecular weight and specific heat ratio). This information is generally obtained from textbooks or internal company information. This data can be difficult to obtain, particularly for new engineers. Software tools typically include common fluid data.

Darcy Equation

$$h_L = \frac{Kv^2}{2g}$$

Friction Factor

$$\frac{1}{\sqrt{f}} = -2 * \log_{10}\left(\frac{\varepsilon}{3.7D} + \frac{2.51}{R_e\sqrt{f}}\right)$$ For $R_e > 4000$ (Colebrook Equation)

$$f = \frac{64}{R_e}$$ For $R_e <= 4000$ $$R_e = \frac{Dv\rho}{\mu_e}$$

Bernoulli's Equation

$$\frac{dP}{\rho} + \frac{VdV}{g} + dZ = -\frac{fV^2dx}{2gD}$$ Generalized Conservation Equation

$$\frac{P_1 - P_2}{\rho} + \frac{V_1^2 - V_2^2}{2g} + Z_1 - Z_2 = h_L$$ Solved For Liquids

Real Gas Equation

$$PV = ZRT$$ Where $$R = \frac{\Re}{MW}$$

Figure 1

This data must then be used with the proper equations. Equations used can include, for example, the Colebrook equation for friction factor, the real gas equation for fluid density, the Darcy equation for frictional head loss, and Bernoulli's theorem for conservation of energy (figure 1). Knowledge of which equations are needed and should be used is left to the engineer.

Equation Selection

The proper equations must be used in the right sequence to correctly solve a problem. A common error in hand calculations is not applying Bernoulli's theorem to account for energy conversion between static pressure and velocity. This conversion occurs across any change in elevation or size (or change in flow area such as across a tee). When solved properly, static pressure generally increases when flow area increases due to the decrease in velocity. Figure 2 shows energy profiles for a horizontal pipe and enlarger. Static pressure for the pipe decreases because of frictional loss. Static pressure for the enlarger increases due to the decrease in velocity. A similar effect is seen across tees in a flow network where the flow stream divides. A good software tool will automatically apply the proper equations.

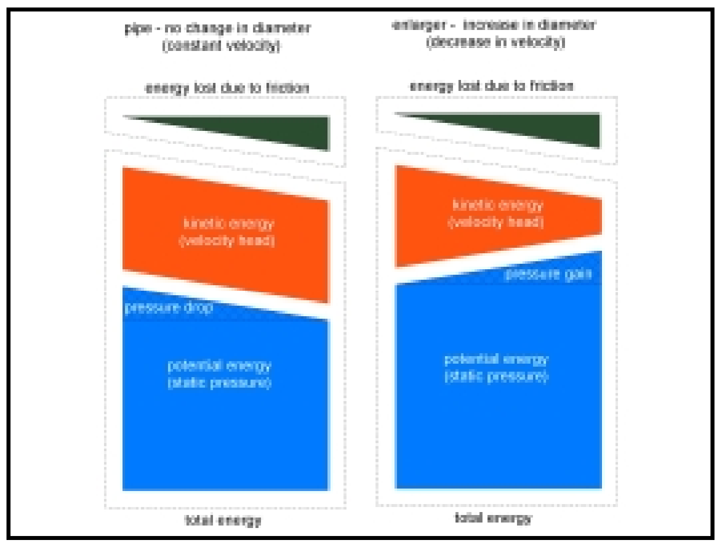

Figure 2

Other equations have subtle requirements or assumptions that are commonly overlooked. For example, hardware resistance information such as K factors are provided or calculated for a specific diameter. K factors for different items in a problem can only be added together if they are based on the same diameter. Otherwise, K factors must be corrected to a common diameter before they are added. A good software tool will correct automatically for size differences.

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A similar issue occurs with hardware resistance in determining the friction factors to be used. The correct friction factor for any given item depends on several things, including the size and type of the item. Fittings, such as valves, almost always use a turbulent friction factor while pipes use a value based on actual fluid velocity. A good software tool will account for these situations automatically and consistently, thus preventing errors.

Complex Calculations

One additional issue with using equations results from using desired data together with known data in an equation. Often engineers confuse what is truly known about a problem and what is desired, and attempt to solve an equation with more information than is mathematically required. This often leads to solutions that don't make sense. A good software tool doesn't allow this error to occur. This can be accomplished in several ways, including warnings by the software.

The engineer's job if further complicated because values must often be converted into different units. This requires another reference for conversion factors, and often introduces more errors as the factors are transcribed incorrectly or not applied consistently and correctly.

Finally, one of the biggest issues with hand calculations is performing these complex calculations correctly. Ensuring that mathematical errors are not made in a calculation is extremely difficult. Even repeated reviews of calculations often do not identify such errors.

Tools such as spreadsheets can be used to reduce errors in calculations. Spreadsheets, however, are generally tailored for very specific problems. The effort to make them useable for a wide variety of problems would be essentially the same as creating a new software package. ▪

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