EZZE PIPE 3.0

TERMINOLOGY

In the EZZE PIPE program there is some terminology used which may not be familiar to you. Definitions and significance of calculated parameters can be found in the references listed below or the tutorial.

TECHNOLOGY

EZZE PIPE is a utility program for doing hydraulic calculations which can be used for the design of water and chemical process piping systems. The calculation of flow rate through pipe is complicated in that the flow rate depends on the friction coefficient for which there are several friction formulas available. This template is oriented toward the Darcy friction factor but provides the option of using the Hazen-Williams equation. Both techniques are accepted in Industry with Hazen-Willliams more common in the design of water systems.

DATA ENTRY TO HAZEN-WILLIAMS AND TO DARCY WEISBACH

The data entry pages for Hazen-Williams (HAZEN-WILLIAMS worksheet) and for Darcy Weisbach (SAMPLEWKSHT) are complicated because of the amount of information contained in them. The user is therefore cautioned to read the instructions for data entry listed below very carefully and to ensure all the data required has been entered.

The data entry worksheets for the two methods are highlighted in red font above.

To make it easier to follow the instructions DarcyWeisbach instructions are in purple font , whereas Hazen-Williams instructions are in blue font.

REFERENCES

MECH 451:LOSSES IN PIPING — Rick Sellens
Queen's University at Kingston (Canada)
http://me.queensu.ca/courses/MECH451/losses.htm

PERRY'S CHEMICAL ENGINEERS' HANDBOOK
Fourth Edition — Perry, Chilton, Kirkpatrick
McGraw Hill

PIPING DESIGN AND ENGINEERING
Sixth Edition — ITT Grinnell Indusrial Piping, Inc.

PRESSURE LOSS CALCULATION METHODS — Arash Dejkam
http://arash.dejkam.com/software/pressure_loss/methods.php

MISCELLANEOUS EQUATIONS — http://docs.bentley.com/en/HMHammer/Hammer-11.65 to 69.html

CRANE TECHNICAL PAPER No. 410

PUMP SYSTEM FORMULAS IN AMERICAN UNITS- — Aquatic Eco-Systems, Inc.

COLEBROOK-WHITE EQUATIONS' — http://www.bossintl.com/forums/

PLUMBING ENGINEER(FIRE PROTECTION
-series of articles 1999 - 2000) — TMB Publishing

SPECIAL NOTE: SU UNITS ARE USED IN THIS TEMPLATE. A CONVERSION UTILITY IS PROVIDED ON THIS PAGE
THE CONVERSION TEMPLATE IS TO THE RIGHT OF THIS TUTORIAL AND IS PROVIDED FOR YOU TO USE
TO CONVERT SI UNITS TO SU FOR USE IN THE PROGRAM AND OF COURSE TO CONVERT SU TO SI
FOR USE IN YOUR REPORTS

THEORY AND USERS GUIDE

DARCY-WEISBACH EQUATION FOR PRESSURE DROP

THE FIRST STEP IS TO CREATE A SKETCH OF THE SYSTEM YOU ARE DESIGNING .

This template contains a 'modular' system for sketching (EZSKETCH page) your piping system.
After completion the sketch can be pasted into either of the program worksheets (HAZEN-WILLIAMS or SAMPLEWKSHT (DARCY-WEISBACH)) if you do not have a sketch or cannot make a sketch to paste of the system you are designing. I ask for your indulgence while I describe the sketching system because I know that you can do much better on the back of a cigarette package. But the main thing is you are laying out your system and there is method to my madness. Each module you paste on your sketch is an ugly block that is easy to count when you tote your fittings for your pressure loss calculations.

BEFORE WE START LETS LOOK AT EZSKETCH
There are two sketches actually on the EZSKETCH sketch pad. The one on the left was used for the demo. operation of the program while the one on the right was just 'playing around' to give you some ideas to use for your sketches. Please note that I tried to place things so that I could use the format-cell-border excel command to draw straight lines to make the sketch look more presentable on the work sheet page. Note the dimensions on the drawing. These are for your static head determination which uses the pump elevation as zero datum and above it is +ve.

The 'SKETCH PAD' doesnot have an extensive module library so in case you need to add a component there are 3 user areas to store your components. All the components in the existing library were created using Paint
If you don't feel creative you can find drafting symbols on the internet to cut and paste into the library'
You just have to ensure they are to 'scale' by shrinking or expanding to suit.

TO 'ERASE' A DRAWING CREATE A NEW WORKSHEET. NEXT CUT AND PASTE THE DRAWING (ONLY) TO THE WORKSHEET YOU CREATED AND DELETE THE WORKSHEET.

To place a module in your sketch - right click it with your mouse in the library and drag it into position on your sketch pad. When you release it click copy it and it can be positioned using the arrow keys on your keyboard.

Once you've completed your sketch you need to do a fitting and straight pipe inventory of the branches in your system. Enter the totals in the branch summaries (note that Branch 3 is the suction line)
The following information is required for the pressure drop calculations. Process Fluid (physical properties), and Pump (pump capacity, pipeline description).

The template (worksheet 'samplewksht)calculates the branch pressure drops using the Darcy Weisbach equation for head loss in pipe. For the calculation of pressure drop you have 18 friction factors to choose from. The friction factor values are determined by the material of construction of the pipe and its condition and are a function of Reynolds number, kinematic viscosity and the pipe diameter. This relationship is automatically changed as changes are made in made in the controlling functions

AFTER YOU CLICK THE AUTO FRICTION FACTOR BUTTON FOR YOUR PIPE CONDITION FRICTION FACTOR THE TEMPLATE FOR THE DARCY WEISBACH CALCULATES THE BRANCH PRESSURE DROPS FOR YOUR SYSTEM AND THE DATA COPIES THE DATA TO A REPORT PAGE (SEE REPORTS BELOW).

The 'AUTO' friction factors offered are 1. Glass or brass copper;2. Concrete good joints; 3. Concrete Rough condition, 4. Seamless steel; 5. Steel enamel coated; 6. Cast Iron; 7. Galvanized; 8. CS; 9. Wood Stave: 10. Asphalted CI.
11. Wrought iron, 12. Brick lined 13.stainless steel 14. PVC
In addition there are 4 generic categories SMOOTH, NEW, AVERAGE plus ROUGH/OLD.

The 'AUTO' feature refers to clicking a button for the appropriate material and/or line condition and the pressure drop calculations are done for that material.

In this template there is no allowance made for mixed line types or sizes.Each size or type can be run separately. should the need arise.

The friction factors are calculated from the pipesystems "e" or roughness height. Yes, you are using mathematics to 'determine' the Darcy-Weisbach factor from the Moody graph. The accuracy of the method is reported to be +/- 1% and was checked using a 'tabulated correlation technique" to confirm its accuracy.

The basic equations used in this template are the following:

$$h_l = f\frac{L}{D}\frac{V^2}{2g}$$

The Darcy-Weisbach equation is now considered the best empirical relation for pipe-flow resistance. In terms of head units gravity.where, h_l is the head loss, f is the friction factor, L is the pipe length, V is the average flow velocity, and g is the

acceleration of In terms of pressure drop, Δp it is,

$$\Delta p = f\frac{L}{D}\frac{\rho V^2}{2}$$

where ρ is the fluid density. The Darcy-Weisbach f is a complex function of the Reynolds Number and relative roughness. The Reynolds number, Re is defined as,

$$Re = \frac{\rho V D}{\mu}$$

where μ is the fluid absolute viscosity, and D is the pipe diameter. The relative pipe roughness is the ratio of the pipe surface

roughness,e to its diameter, D, or e/D.For laminar flow where Re < *2,000,* pipe roughness is not a factor and,

$$f = 64/Re$$

For *hydraulically smooth pipes (e = 0)* such as glass, copper and plastic tubing in turbulent flow, use Blasius equation for *f*

(4,000 < *R* e < 100,000)

NOTE- Most literature gives a range of 2300 to 100,000 , however 2300 to 4000 is in transition zone from laminar to turbulent Blasius is valid for turbulent and not for the transition zone.

$$f = \frac{0.3164}{Re^{0.25}}$$

For rough pipe in turbulent flow you must use the Moody diagram to obtain f. That may require an iterative solution where a flow rate is guessed, f estimated and than a new flow calcuated.

An easier, and almost as accurate procedure as the Moody Diagram is to use the empirical formulas of Swamee and Jain, (J. of Hydraulics Division,. Proc. ASCE, pp 657-664, May 1976).

For academic interest I created generic factors using graphic based equations and found reasonable agreement for my 4 generic (NEW,AVERAGE, SMOOTH and ROUGH) with published results. They are presented for user feedback. This template uses the Swamee and Jain approximation for the other fourteen factors available to the user

$$f = \frac{0.25}{\{\log[(e/3.7D) + (5.74/Re^{0.9})]\}^2} \quad \text{SWAMEE JAIN}$$

(10^-6 < *e/D* < 0.01; 5,000 < *Re* < 3x10^8)

The Colebrook-White equation can be used to iteratively calculate for the Darcy-Weisbach friction Factor:

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{k}{14.8R} + \frac{2.51}{R_e\sqrt{f}}\right)$$

The following approximation is used in this template to solve the Colebrook-White equation. As noted above it has been found to be accurate within 1% without the need to go through the iterative solving process. Another approximation technique was also used and although unproven and not as accurate , when combined with external dataconfirmed the validity of the following equation

$$f = 1.325/[\ln(e/(3.7D) + 5.74/Re^{0.9})]^2$$

The Darcy-Weisbach equation is widely used in the chemical process industry and is the virtual standard for doing pipe pressure drop calculations. Inspite of its accuracy and wide acceptance it has not been widely accepted nor used for water distribution systems. The Hazen-Willliams formula, is the method most commonly used for pressure drop calculations in American fire sprinkler systems, water distribution systems and irrigation Systems.

The following is a brief discussion of Hazen-Williams and its application to water distribution systems.

To the right of these notes is a utility to calculate kinematic viscosity of water.

HAZEN-WILLIAMS EQUATION

V = 0.849 C R^0.63 S^0.54 SI   V= 1.318 C R^0.63 S^0.54 SU

Pd = $\dfrac{4.52 \quad Q^{1.85}}{C^{1.85} \quad d^{4.87}}$ HAZEN-WILLIAMS EQUATION

Hazen Williams equation (Mays, 1999; Streeter et al., 1998; Viessman and Hammer, 1993)

where k=0.85 for meter and seconds units or 1.318 for feet and seconds units:

$$H = L\left[\frac{V}{kC}\left(\frac{4}{D}\right)^{0.63}\right]^{1/0.54} \qquad V = \frac{Q}{A} \qquad A = \frac{\pi}{4}D^2$$

This is the prime equation used in this template and the HAZEN-WILLIAMS worksheet.

On this worksheet you can paste your sketch , do your fitting and pipe inventory enter your pipe pump and liquid properties and your branch Pdrops are automatically calculated (DON'T FORGET TO ENTER YOUR BRANCH HEADS)

On the worksheet there is a 'Quick' Calculator which is independent of the calculation of your branch pressure drops noted above.It is provided for you to 'experiment with the impact of changing parameters in your design without changing your original calculations

WHY USE TWO METHODS

As mentioned previously, both methods are used in industry and there are proponents for one method over the other. In my research for this template I have found that each method has limitations and if care is exercised in their use either can provide an accurate result. But, both still require some experience and engineering judgement in the selection of friction factor / coefficients for existing systems. Your very poor pipe could be my average condition, etc, So inspite of Graphs, and iterative solutions etc. there is still some 'room for error". For this reason alone, I think it is good engineering practise to use both methods in your calculations using one to check the other

REPORTS

There are two report pages - Hazen-Williams report and DarcyWeisbach report. Each report page is set up to copy the results of your calculations .PLEASE DO NOT CHANGE CELLS ON THESE TWO PAGES. They are linked to results on their respective calculation pages. if you wish to create your own report page please cut and paste from these pages using the copy link command where pertinent.

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