Program evaluates pressure drop for single phase fluids

Fortran 77 computer program calculates pressure loss through piping systems with fittings for single phase fluids

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A FORTRAN 77 PROGRAM has been developed that calculates pressure losses through pipe with fittings for single phase fluids. Previously published programs have been mainly for use in card programmable calculators or in a BASIC language with limited versatilities[1,2,3]. The program is written to calculate pressure drop of single phase incompressible fluids at isothermal condition when flowrate and system characteristics are given. For compressible fluids (gas and vapor lines where pressure losses are small relative to the line pressure), reasonable accuracy can often be predicted providing the following conditions are met:

The average gas density of flow is used.

i.e. $\rho = (\rho_1 + \rho_2)/2$

The pressure drop is less than or equal to 40% of the upstream pressure.

i.e. $(P_1 - P_2) \leq 0.4P_1$

This is because energy losses due to acceleration and density variations can be neglected up to this limit. In cases where the pressure drop is less than 10% of the upstream pressure, an average value of ρ is not required and either the downstream or upstream density can be used. The program, however, does not account for pressure losses in longer pipelines involving compressible fluids where the total pressure loss is greater than 40% of the upstream pressure. In such complex cases, methods for solving the pressure losses in the lines are described by Sandler and Luckievicz[4] and Crane Co. Ltd.[5]. Alternatively, the line can be divided into segments so that the pressure loss in each segment is less than 40% of the upstream pressure, taking the density variation in each segment.

Program features. The program is interactive with the user (i.e. user friendly) and produces a report quality output. It requires either the mass flowrate or volumetric rate of the fluid being considered. Calculations are accurate for both laminar or turbulent regimes and the program uses the Colebrook equation[6] to determine the Darcy friction factor, f_D. It also incorporates changes in pipe sizes due to sudden enlargement or contraction. The program includes the two-K method developed by Hooper[7,8] to determine the excess head loss in a pipe fitting.

TABLE 1—Velocity head factors of pipe fittings

			Fitting type	K_1	K_∞
Elbows	90°		Standard (R/D = 1), screwed	800	0.40
			Standard (R/D = 1), flanged/welded	800	0.25
			Long-radius (R/D = 1.5), all types	800	0.20
		Mitered elbows (R/D = 1.5)	1 weld (90° angle)	1,000	1.15
			2 weld (45° angles)	800	0.35
			3 weld (30° angles)	800	0.30
			4 weld (22½° angles)	800	0.27
			5 weld (18° angles)	800	0.25
	45°		Standard (R/D = 1), all types	500	0.20
			Long-radius (R/D = 1.5), all types	500	0.15
			Mitered, 1 weld, 45° angle	500	0.25
			Mitered, 2 weld, 22½° angles	500	0.15
	180°		Standard (R/D = 1), screwed	1,000	0.60
			Standard (R/D = 1), flanged/welded	1,000	0.35
			Long radius (R/D = 1.5) all types	1,000	0.30
Tees	Used as elbow		Standard, screwed	500	0.70
			Long-radius, screwed	800	0.40
			Standard, flanged or welded	800	0.80
			Stub-in-type branch	1,000	1.00
	Run-through tee		Screwed	200	0.10
			Flanged or welded	150	0.50
			Stub-in-type branch	100	0.00
Valves	Gate, ball, plug		Full line size, β = 1.0	300	0.10
			Reduced trim, β = 0.9	500	0.15
			Reduced trim, β = 0.8	1,000	0.25
	Globe, standard			1,500	4.00
	Globe, angle or Y-type			1,000	2.00
	Diaphragm, dam-type			1,000	2.00
	Butterfly			800	0.25
	Check		Lift	2,000	10.00
			Swing	1,500	1.50
			Tilting-disk	1,000	0.50

Note: Use R/D = 1.5 values for R/D = 5 pipe bends, 45° to 180°. Use appropriate tee values for flow through crosses.

Changes in pipe sections due to enlargement and contraction. The frictional losses caused by a sudden contraction (entrance) or enlargement (discharge) are included in the design of any piping system and are determined by the following expressions.

For a sudden contraction, the resistance coefficient or velocity head can be expressed as:

$$K = 0.5\ \{1 - (d/D)^2\} \qquad (1)$$

Alternatively, for a sudden enlargement

$$K = \{1 - (d/D)^2\}^2 \qquad (2)$$

where d = smaller pipe diameter
D = larger pipe diameter

The Two-K method. The two-K method used in the program is accurate for either low or high Reynolds number, N_{Re}. This method is more favorable than the conventional