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Estimation polypropylene elbow losses

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Abstract

Normally the values of losses in plastic pipe and fitting is small in most cases was neglected, the paper was estimate the coefficient for Polypropylene elbow losses by using experimental model consist of 18 elbows and it was K=1.77, also the paper describes the methodology can be estimate all values of minor losses.

Keywords: Index Terms; Plastic pipes; Pressure drop; Minor losses

1 Introduction

The transporting liquid in pipes, energy loss due to friction between pipe wall and liquid molecules and also within liquid due to its viscous effects[1] . Polymers are a large class of materials consisting of small molecules called monomers that can be linked together to form long chains[2]. The polymer can generally classify to Thermoplastics material that can easily reshaped and recycled if it is expanded to temperature change such as polyethylene (PE), polypropylene (PP). Thermosets material its chain that can be connected to each other with cross links so that the material cannot be softened again by the application of heat. If excess heat is applied to these materials they will char and degrade such as epoxy and unsaturated polyesters[3] . Elastomers its chains are rubbery in elastomers because they are above their glass transition at room temperature it can be cross linked called vulcanization, cross linking makes elastomers reversibly stretchable for small deformations such as natural rubber (poly-isoprene), poly-butadiene[4]. The Galvanized pipes was replaced by plastic pipes made from (PVC, PE. PP, PS) in different applications such as in water pipeline, irrigate, and venting systems[5].Plastic pipes made from Random Polypropylene(PPR) pipes has large advantages like Long life time, Low pressure losses, nontoxic and great welding ability[6].

Minor head energy losses in pipelines occur at fittings such as Tees, Elbows, and Bends, sudden Expansion and contraction, junctions etc. are connected in pipeline. And major occur at along of pipe.

The fluid minor losses equation is:

$$h_{min} = \left(\sum_{i=1}^{n} k\right) \frac{V^2}{2g} \quad \ldots\ldots 1$$

The fluid major losses equation is:

$$h_{maj} = f\left(\frac{L}{d}\right) \frac{V^2}{2g} \ldots\ldots 2$$

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The fluid total losses equation is:

$$H_T = h_{minor} + h_{maj} = \left(\sum_{i=1}^{n} k + f\frac{L}{d}\right)\frac{V^2}{2g} - - - - - - - - - - 3$$

Bernoulli equation

$$\frac{\Delta P}{\rho g} + \Delta Z + \frac{\Delta V^2}{2g} = H_T - - - - - - - - - - - - 4$$

Bernoulli equation at constant diameter ($\Delta V^2 = 0$)with horizontal level ($\Delta z = 0$) and neglected major losses becomes:

$$\frac{\Delta P}{\rho g} = h_{minor} = \left(\sum_{i=1}^{n} k\right)\frac{V^2}{2g} - - - - - - 5$$

Where: $h_m(m)$=head minor losses, $h_m(m)$=head major losses, n=number of fitting (elbows), V(m/s) =average fluid velocity, g=gravity acceleration=9.81m, k=fitting coefficient, L(m)=pipe length, $H_T(m)$ =tatal losses, f=friction factor, $\Delta P(pa)$=pressure drop, $\rho(\frac{kg}{m^3})$=fluid dencity, ΔZ = elevation difference. [6]

2 Material and methods

PPR fitting model is based on selected nominal diameter 0.5inch (internal diameter=1.27 cm, area is 0.000127 m^2) PPR pipe, 18 elbows with nominal diameter 0.5inch also, and valve were constructed horizontally shown in Figure (1) it was used to estimate the minor losses coefficient (k). The experiment was done at different flow rate time to fall 3 litter centenar by the valve position, the values of pressure at the two ends were monitored in the pressure gauges. Water was used in the experiments at isothermal condition and take $\rho = 1000\frac{kg}{m^3}, = 9.81\frac{m^2}{s}$.

Figure 1 The elbows model

3 Results and discussion

Table (1) shown the experimental and calculation results of elbows fluid model, in figure 2 the linear relationship between minor head losses and velocity head was 31.779 for summation of eighteen elbows coefficients then for one k= 31.779/18= 1.77, these values was high but it is considered the two-end welding of the elbow. Figure (3) it obvious that relation of pressure drop and flow rate was power raise 2.

Table 1 Elbows model experimental and calculations

No	Time (s)	$Q(m3/s) = \frac{volume}{time}$	V(m/s) $= \frac{Q}{area}$	Velocity head $\frac{V^2}{2g}(m)$	P1 (psi)	P2 (psi)	P1 (pa)	P2 (pa)	Pressure drop ΔP (pa)	helbows(m) $= \frac{\Delta P}{\rho g}$	K $= \frac{h_{elbows}}{velocity\ head}$
1	49.8	6.024E-05	0.476	0.011538002	17.5	17	123000.3404	119486.0449	3514.295439	0.358236028	31.04835804
2	36.4	8.242E-05	0.651	0.021596658	16	15	112457.4541	105428.8632	7028.590878	0.716472057	33.17513626
3	30	1.000E-04	0.790	0.031794119	15.2	14	106834.5813	98400.27229	8434.309054	0.859766468	27.04168214
4	26.8	1.119E-04	0.884	0.039840036	14.2	12	99805.99047	84343.09054	15462.89993	1.576238525	39.56418436
5	22.4	1.339E-04	1.058	0.057028674	12.7	10	89263.10415	70285.90878	18977.19537	1.934474554	33.92108607
6	21	1.429E-04	1.128	0.064885958	12.3	9	86451.6678	63257.3179	23194.3499	2.364357788	36.43866668
7	19.1	1.571E-04	1.241	0.078437289	11.5	7.8	80828.7951	54823.00885	26005.78625	2.650946611	33.79701984
8	18.7	1.604E-04	1.267	0.081828784	10.5	7	73800.20422	49200.13615	24600.06807	2.507652199	30.64511148
9	17.6	1.705E-04	1.346	0.092377025	9.5	6	66771.61334	42171.54527	24600.06807	2.507652199	27.14584269

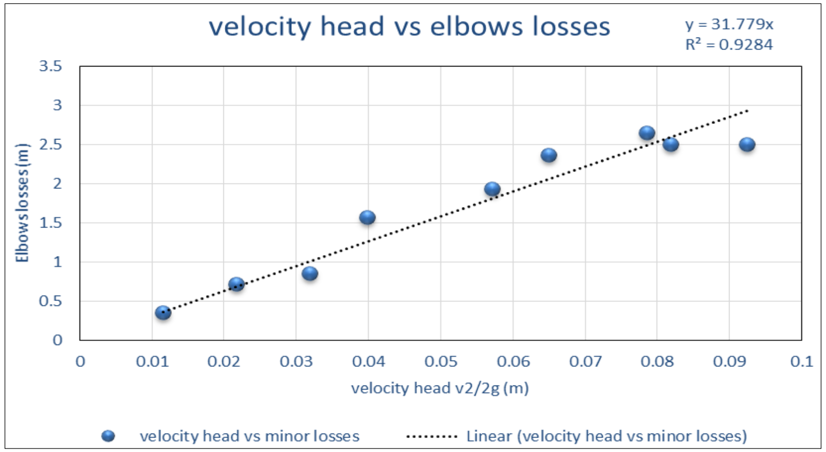

Figure 2 Relation velocity head and minor losses

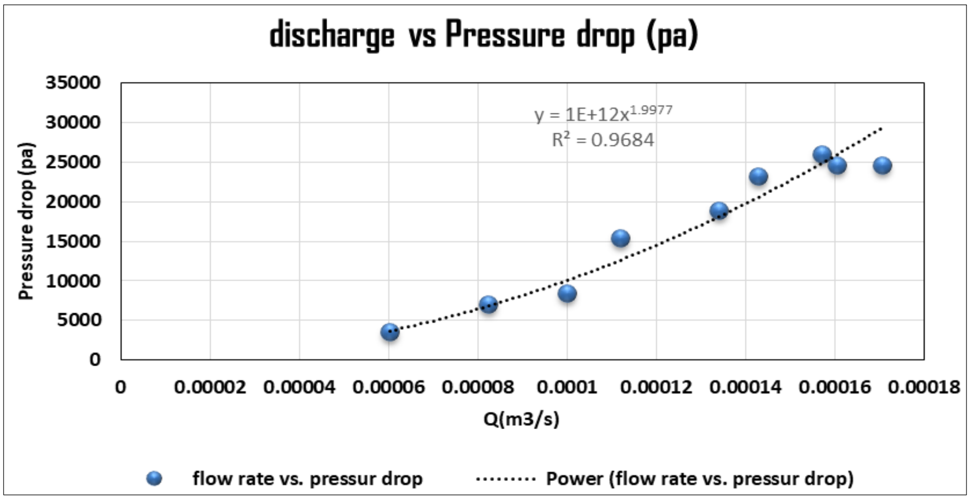

Figure 3 Relation between flow rate and pressure drop

4 Conclusion

The energy losses of a real fluid flow depended on different factors such as friction, connections, and diameter, the good welding in PPR fitting lead to small coefficients and verse versa. The model was a simple resulted that the all fitting coefficients of PPR cannot be neglected in fluid calculation and design fluid network. Different kinds of fittings designed or other kinds of plastic pipes like PVC, HDPE can be studied practically.

Compliance with ethical standards

Disclosure of conflict of interest

Three authors are involved in however no conflicts of interest.

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