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Experiment Number (1)

Losses in Piping System

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Abstract

One of the most common problems in fluid mechanics is the estimation of pressure loss. It is the objective of this experiment to enable pressure loss measurements to be made on several small bore pipe circuit components such as pipe bends valves and sudden changes in area of flow (expansion and contraction), There are essentially two separate hydraulic circuits one painted dark blue which were calculated a major losses from it, and the other painted light blue which were calculated minor losses from it , but having common inlet and outlets. A hydraulic bench is used to circulate and measure water. The pressure change across each of the component is measured by pressurized piezometer tubes. Were obtained the values of loss Coefficient for the gate valve and globe valve when it is fully opened and compared with theoretical, were founded that the major loss is due to the friction, and it is larger than minor losses.

main results

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Results of dark blue circuit:

Table 1 : Data sheet for dark blue circuit (Gate valve)

p (bar)	p(mh2o)	flow rate (l/s)	flow rate (m^3/s)	1,2	3,4	5,6
0.1	1.019744289	0.197	0.000197	260	159	316
0.15	1.529616433	0.182	0.000182	226	139	272
0.2	2.039488578	0.164	0.000164	184	115	224
0.25	2.549360722	0.143	0.000143	148	93	177
0.3	3.059232867	0.131	0.000131	124	77	146
0.35	3.569105011	0.102	0.000102	80	51	98
0.4	4.078977156	0.073	0.000073	44	28	52
0.45	4.5888493	0.036	0.000036	14	10	16
0.5	5.098721445	0	0	1	1	2

Table 2 : a) Parameters for standard-bore straight pipe (nominally 13.6 mm bore copper)

p(mh2o)	flow rate (l/s)	flow rate (m^3/s)	3,4(mm)	v (m/s)	Re
1.019744	0.197	0.000197	159	1.356809	18324.45
1.529616	0.182	0.000182	139	1.253499	16929.18
2.039489	0.164	0.000164	115	1.129526	15254.87
2.549361	0.143	0.000143	93	0.984892	13301.5
3.059233	0.131	0.000131	77	0.902244	12185.29
3.569105	0.102	0.000102	51	0.70251	9487.784
4.078977	0.073	0.000073	28	0.502777	6790.277

Table 3: b) Parameters for standard-bore straight pipe (nominally 13.6 mm bore copper)

f exp	$\frac{v^2}{2g}$	k	log(Q)	log(h34)
0.02716	0.093829	1.694567	-3.70553	2.201397
0.027703	0.080085	1.735665	-3.73993	2.143015
0.028434	0.065027	1.768496	-3.78516	2.060698
0.029425	0.04944	1.881069	-3.84466	1.968483
0.030077	0.04149	1.855847	-3.88273	1.886491
0.032018	0.025154	2.027514	-3.9914	1.70757
0.034811	0.012884	2.173233	-4.13668	1.447158

K value (theoretical)=1.7735

K value (experimental)= 1.876627

Percentage of error =5.8148%

Table 4 : a) Parameters for standard 90 elbow (13.6 mm radius)

P (mH2O)	flow rate Q (l/s)	flow rate Q (m^3/s)	3,4 (mmH2O)	1,2 (mmH2O)	1,2 (mH2O)
1.019744	0.197	0.000197	159	260	0.26
1.529616	0.182	0.000182	139	226	0.226
2.039489	0.164	0.000164	115	184	0.184
2.549361	0.143	0.000143	93	148	0.148
3.059233	0.131	0.000131	77	124	0.124
3.569105	0.102	0.000102	51	80	0.08
4.078977	0.073	0.000073	28	44	0.044

Table 5 : b) Parameters for standard 90 elbow (13.6 mm radius)

v (m/s)	Re	hm	k	log(Q)	log(hm)
1.356809	18324.45	0.101	1.076423	-3.70553	-0.99568
1.253499	16929.18	0.087	1.086352	-3.73993	-1.06048
1.129526	15254.87	0.069	1.061098	-3.78516	-1.16115
0.984892	13301.5	0.055	1.11246	-3.84466	-1.25964
0.902244	12185.29	0.047	1.13279	-3.88273	-1.3279
0.70251	9487.784	0.029	1.1529	-3.9914	-1.5376
0.502777	6790.277	0.016	1.241847	-4.13668	-1.79588

K value (theoretical)=1.01846

K value (experimental)= 1.12341

Percentage of error =10.30477%

Table 6 : a) Parameters for 90-degree miter bend

P (mH2O)	flow rate Q (l/s)	flow rate Q (m^3/s)	3,4 (mmH2O)	5,6 (mmH2O)	5,6 (mH2O)
1.019744	0.197	0.000197	159	316	0.316
1.529616	0.182	0.000182	139	272	0.272
2.039489	0.164	0.000164	115	224	0.224
2.549361	0.143	0.000143	93	177	0.177
3.059233	0.131	0.000131	77	146	0.146
3.569105	0.102	0.000102	51	98	0.098
4.078977	0.073	0.000073	28	52	0.052

Table 7 : b) Parameters for 90-degree miter bend

v(m/s)	Re	hm	k	log(Q)	log(hm)
1.356809	18324.45	0.157	1.673251	-3.70553	-0.8041
1.253499	16929.18	0.133	1.660744	-3.73993	-0.87615
1.129526	15254.87	0.109	1.676227	-3.78516	-0.96257
0.984892	13301.5	0.084	1.69903	-3.84466	-1.07572
0.902244	12185.29	0.069	1.663031	-3.88273	-1.16115
0.70251	9487.784	0.047	1.868493	-3.9914	-1.3279
0.502777	6790.277	0.024	1.862771	-4.13668	-1.61979

K value (theoretical)=1.740513168

K value (experimental)= 1.729078

Percentage of error =0.656999%

Figures

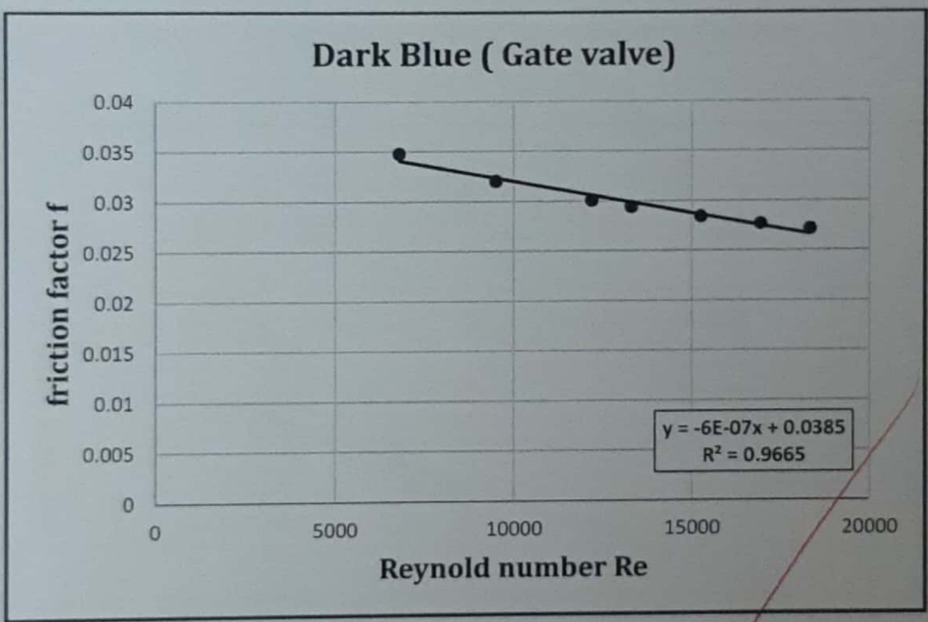

Figure1 : Friction factor against Reynold number

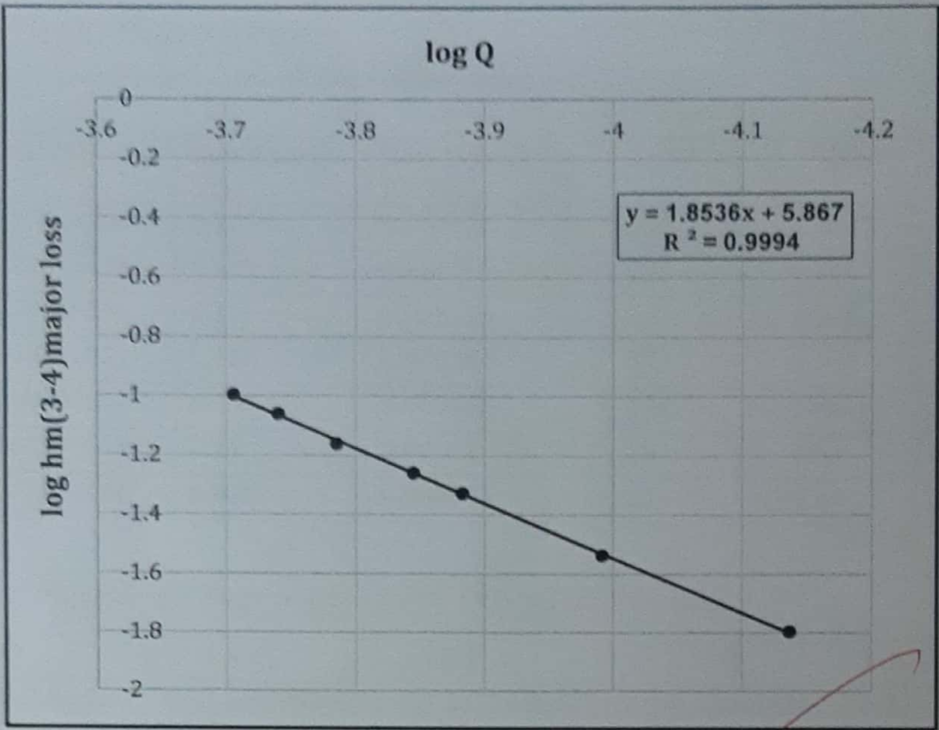

Figure 2 : log head loss against log volumetric flow rate

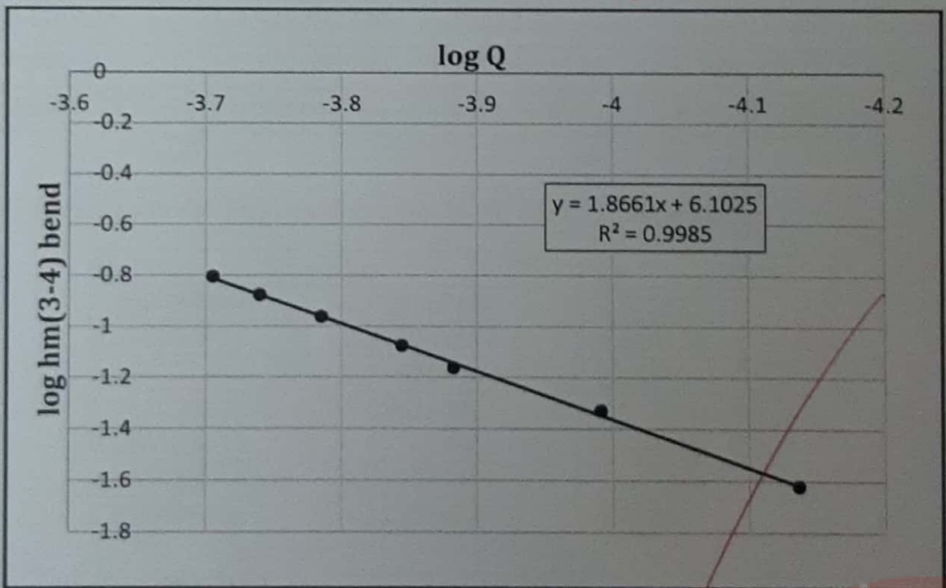

Figure 3 : : Log head loss due to the bend against log volumetric flow rate

Results of light blue circuit

Table 8 : Data sheet for light blue circuit (Globe valve)

p(bar)	p(mH2O)	flow rate Q (l/s)	flow rate Q (m^3/s)	11,12	13,14	15,16
0.1	1.019744289	0.225	0.000225	275	214	302
0.15	1.529616433	0.197	0.000197	213	164	232
0.2	2.039488578	0.175	0.000175	177	136	192
0.25	2.549360722	0.156	0.000156	143	110	154
0.3	3.059232867	0.135	0.000135	114	86	122
0.35	3.569105011	0.11	0.00011	78	58	82
0.4	4.078977156	0.075	0.000075	42	29	44

Table 9 : a) Parameters for large radius smooth 90 bend (150mm radius)

hL	Q	V	Re	v^2/2g	f (Blasius)
214	0.000225	1.549820382	20720.33577	0.122423202	0.026338309
164	0.000197	1.356953846	18141.8051	0.093849324	0.027228076
136	0.000175	1.205415853	16115.81671	0.07405848	0.028046198
110	0.000156	1.074542132	14366.09947	0.058850193	0.028863724
86	0.000135	0.929892229	12432.20146	0.044072353	0.029926097
58	0.00011	0.757689965	10129.94193	0.029260657	0.031498172
29	0.000075	0.516606794	6906.778591	0.013602578	0.034663164

Table 10 : b) Parameters for large radius smooth 90 bend (150mm radius)

hf	hb	kb
0.050739904	0.163260096	1.333572
0.030815996	0.133184004	1.419126
0.020771696	0.115228304	1.55591
0.013739698	0.096260302	1.635684
0.008340633	0.077659367	1.762088
0.003930806	0.054069194	1.847846
0.001005476	0.027994524	2.058031

K value (theoretical)=1.781503

K value (experimental)= 1.658894

Percentage of error =6.882334748%

Table 11 : a) Parameters for medium radius smooth 90 bend (100mm radius)

hL	Q	V	Re	/2gv^2	f (blasuis
275	0.000225	1.548415605	20920.56374	0.12220137	0.026275061
213	0.000197	1.355723885	18317.11581	0.093679269	0.027162692
177	0.000175	1.204323248	16271.54958	0.073924286	0.02797885
143	0.000156	1.073568153	14504.92419	0.058743557	0.028794412
114	0.000135	0.929049363	12552.33825	0.043992493	0.029854233
78	0.00011	0.757003185	10227.83116	0.029207636	0.031422533
42	0.000075	0.516138535	6973.521247	0.01357793	0.034579925

Table 12 : b) Parameters for medium radius smooth 90 bend (100mm radius)

hf	Hb	Kb
0.064899275	0.210100725	1.719299
0.03983669	0.17316331	1.84847
0.026907763	0.150092237	2.030351
0.017778365	0.125221635	2.131666
0.011004662	0.102995338	2.341203
0.005261621	0.072738379	2.490389
0.00144942	0.04055058	2.986507

K value (theoretical)=2.087782

K value (experimental)= 2.221126

Percentage of error =6.386873%

Table 13 : a) Parameters for medium radius smooth 90 bend (50mm radius)

hL	Q	V	Re	/2gv^2	f (blasuis
302	0.000225	1.56955414	20851.83382	0.125560663	0.026296686
232	0.000197	1.374231847	18256.93895	0.096254494	0.027185047
192	0.000175	1.220764331	16218.09297	0.07595645	0.028001877
154	0.000156	1.088224204	14457.27145	0.060358406	0.02881811
122	0.000135	0.941732484	12511.10029	0.045201839	0.029878804
82	0.00011	0.76733758	10194.22987	0.030010548	0.031448394
44	0.000075	0.523184713	6950.611275	0.013951185	0.034608385

Table 14 : b) Parameters for medium radius smooth 90 bend (50mm radius)

hf	hb	kb
0.073789281	0.228210719	1.817534
0.044923213	0.187076787	1.943564
0.030219324	0.161780676	2.129914
0.019822375	0.134177625	2.223015
0.012193008	0.109806992	2.429259
0.005726879	0.076273121	2.541544
0.001572088	0.042427912	3.041169

K value (theoretical)=2.640528

K value (experimental)= 2.303714

Percentage of error =12.74523%

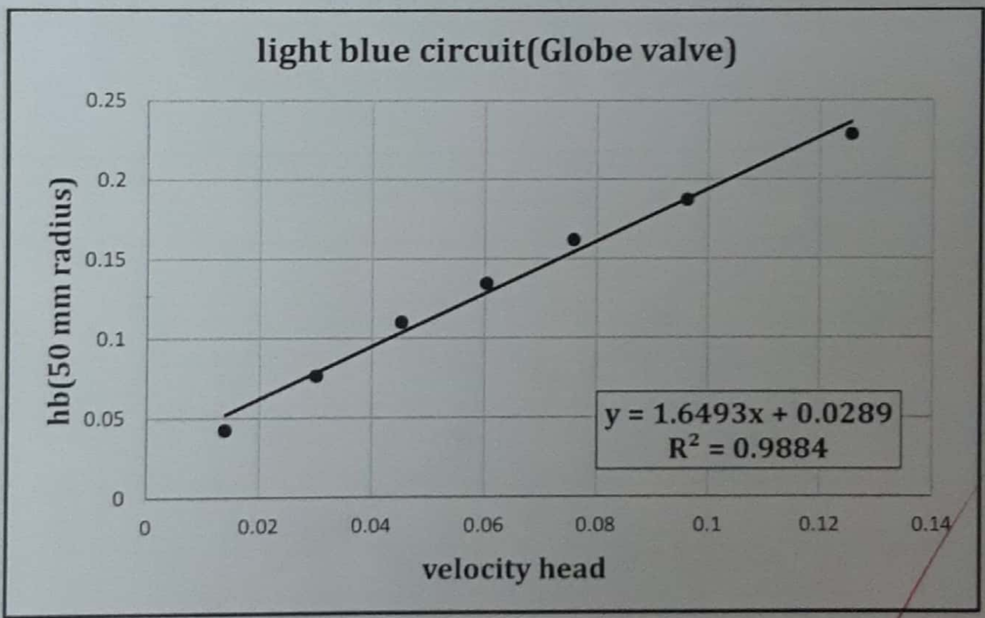

Figure 4 : Hb against v^2/2g in small radius smooth 90 bend 15-16 (50mm radius)

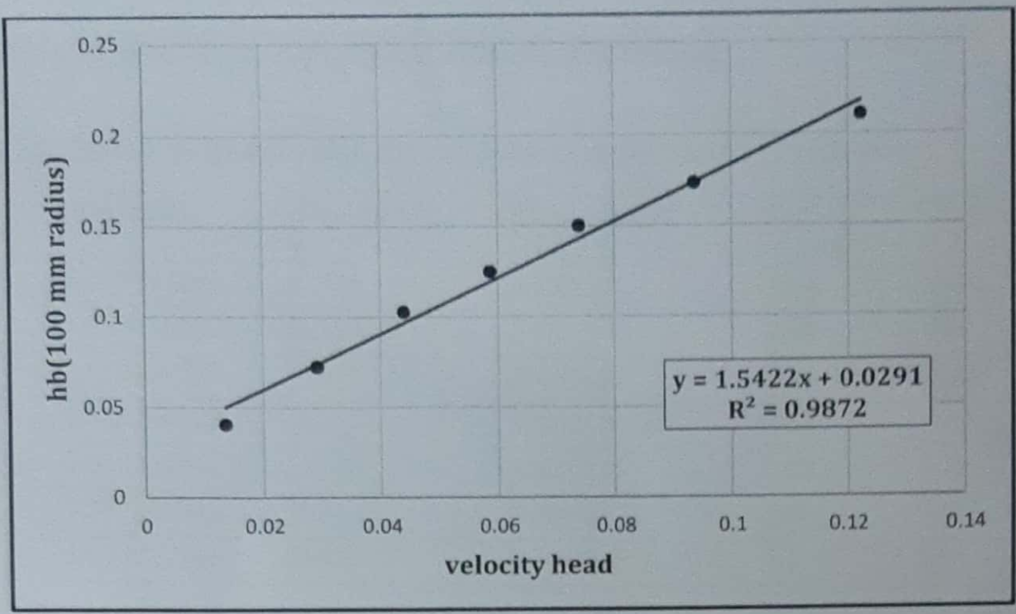

Figure 5 : : hb against v^2/2g in small radius smooth 90 bend 11-12 (100mm radius)

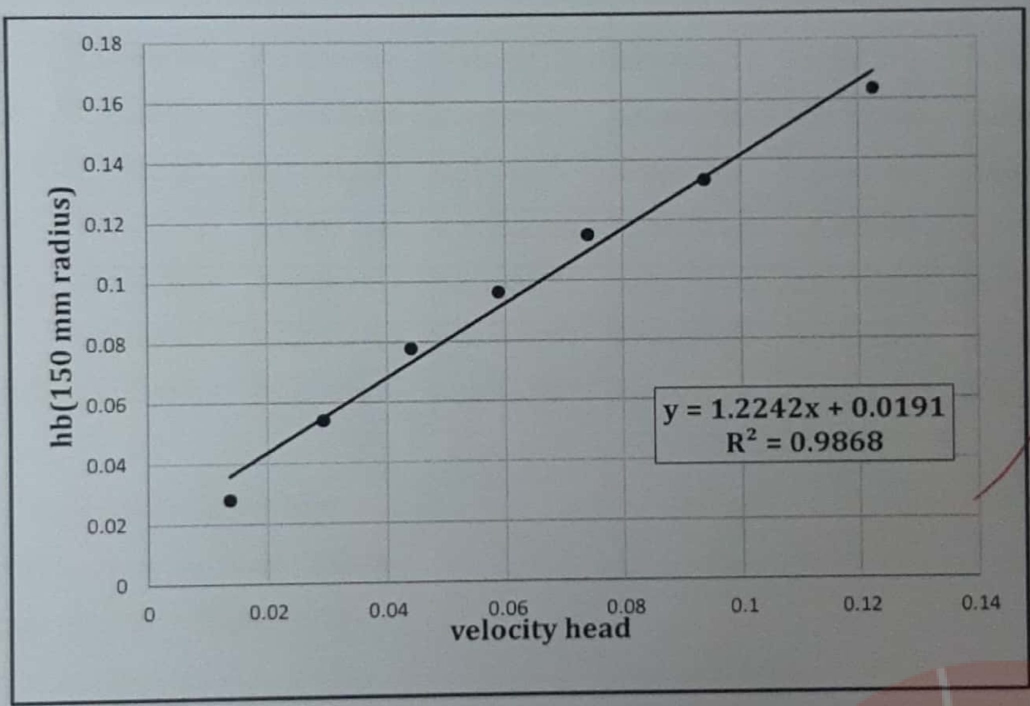

Figure 6 : hb against v^2/2g in small radius smooth 90 bend 13-14 (150mm radius)

Results of Sudden expansion and contraction

Table 15 : Raw data for light blue circuit (sudden expansion and contraction)

p(bar)	p(mH2O)	flow rate Q (l/s)	flow rate Q (m^3/s)	7,8	9,10
0.1	1.019744289	0.225	0.000225	-34	196
0.15	1.529616433	0.197	0.000197	-26	147
0.2	2.039488578	0.175	0.000175	-21	120
0.25	2.549360722	0.156	0.000156	-15	96
0.3	3.059232867	0.135	0.000135	-13	76
0.35	3.569105011	0.11	0.00011	-9	49
0.4	4.078977156	0.075	0.000075	-4	26

Table 16 : Parameters for sudden expansion in light blue circuit (13 .6mm to 26.2mm)

h78	flow rate (m^3/s)	v1	$\frac{v1^2}{2g}$	v2	$\frac{v2^2}{2g}$	Hl	K
-34	0.000225	1.549655081	0.122397088	0.417551722	0.008886312	0.079510776	0.649613299
-26	0.000197	1.356809116	0.093829306	0.36558973	0.006812225	0.061017081	0.650298757
-21	0.000175	1.205287285	0.074042683	0.32476245	0.00537567	0.047667013	0.643777493
-15	0.000156	1.074427523	0.05883764	0.289502527	0.004271749	0.039565891	0.672458841
-13	0.000135	0.929793049	0.044062952	0.250531033	0.003199072	0.027863879	0.632365249
-9	0.00011	0.757609151	0.029254415	0.204136397	0.002123938	0.018130477	0.619751815
-4	0.000075	0.516551694	0.013599676	0.139183907	0.000987368	0.008612308	0.633273041

K value (theoretical)= 0.53370598

K value (experimental)= 0.643076928

Percentage of error = 20.4927342%

Table 17: Parameters for sudden contraction in light blue circuit (26.2mm to 13 .6mm)

h 910	flow rate Q (m^3/s)	v1	$\frac{v1^2}{2g}$	v2	$\frac{v2^2}{2g}$	Hl	k
196	0.000225	0.417551722	0.008886312	1.549655081	0.122397088	0.082489224	0.673947599
147	0.000197	0.36558973	0.006812225	1.356809116	0.093829306	0.059982919	0.639277023
120	0.000175	0.32476245	0.00537567	1.205287285	0.074042683	0.051332987	0.693289129
96	0.000156	0.289502527	0.004271749	1.074427523	0.05883764	0.041434109	0.704210917
76	0.000135	0.250531033	0.003199072	0.929793049	0.044062952	0.035136121	0.797407326
49	0.00011	0.204136397	0.002123938	0.757609151	0.029254415	0.021869523	0.747563162
26	0.000075	0.139183907	0.000987368	0.516551694	0.013599676	0.013387692	0.984412501

K value (theoretical)= 0.53370598

K value (experimental)= 0.748586808

Percentage of error =40.2620237%

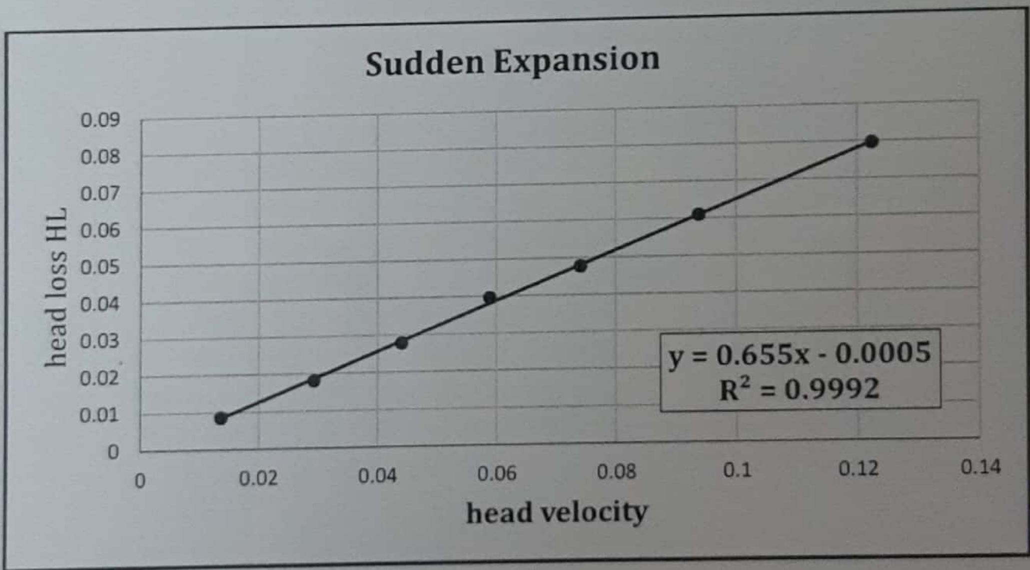

Figure 7 : Head loss vs. standard bore velocity for expansion

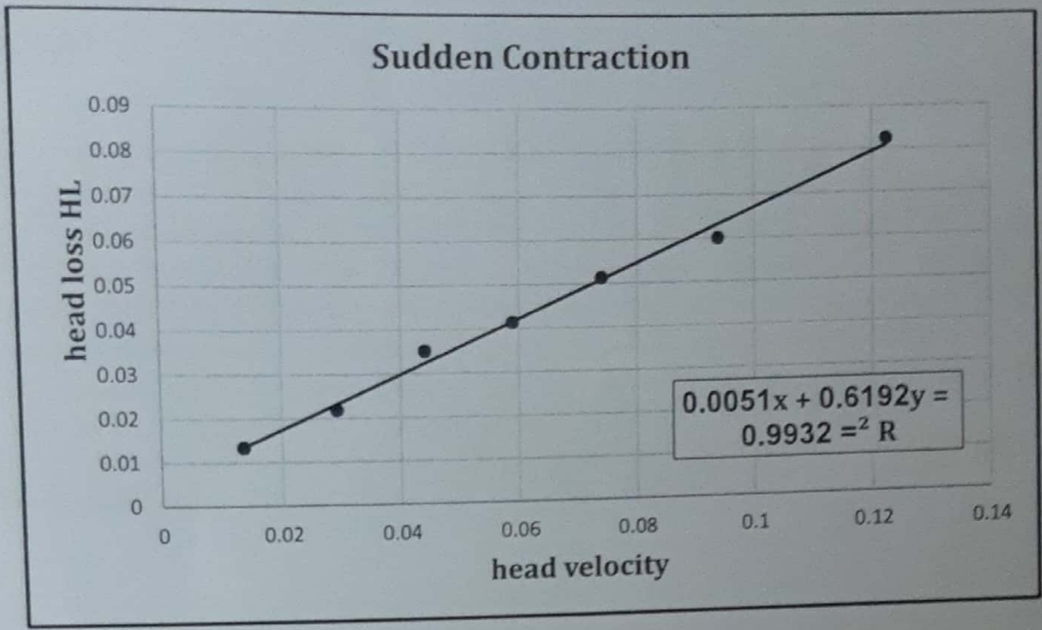

Figure 8 : : Head loss vs. standard bore velocity for contraction

Discussion

Data collected from the piping system. The globe valve section resulted in a pressure drop and the friction factor is greater than the gate tube section, as expected, graph 1 shows that in general with the increase of Reynolds number, the friction in the long tube decreases, and graph 2 shows the friction factor decreases at high speed. The sudden expansion and contraction of the piping system has two speeds: the effects of inlet and outlet pressure difference and head loss, there are many common sources that can lead to errors in the experiment. These sources include inaccuracies in the pressure transducer and flowmeter. Moreover, before the water reaching pressure taps in pipe sections, they incur a slight loss due to passage through one of the fittings. In addition, manufacturing defects, such as the diameter of the tube and the length between them Pressure faucets can be attributed to the fault. There was also a leak at globe valve

not enough

Conclusions

the values for friction that we obtained for the long pipe are almost consistent with the values in the literature (Moody's Chart). We learned through this experiment that there is a head loss in each pipe due to internal friction of the pipes. the gate valve better than globe valve for low losses in piping system, head loss of sudden expansion and contraction Higher than other losses in the system

References

1) Chemical engineering laboratory "1" (0915361); University of Jordan; faculty of engineering and Technology; Department of Chemical engineering.

2) Noel de nevers, (1991), Fluid Mechanics for Chemical Engineers. third edition, McGraw-Hill, (pp. 164-202).

Appendices

❖ For dark blue circuit:

1) Volumetric flow rate:

$$Q = \frac{0.197\ L}{s} \times \frac{m^3}{1000L} = 0.000197$$

2) Area:

$$A = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times (0.0136)^2 = 0.00014519\ m^2$$

3) Flow velocity:

$$V = \frac{Q}{\frac{\pi}{4} d^2} = 1.3912\ m\backslash s$$

4) Reynolds number:

$$Re = \frac{\rho\, v\, d}{\mu} = \frac{998.02 \times 1.3912 \times 0.0136}{1.005 \times 10^{-3}} = 18324.45$$

5) Friction factor:

$$f = \frac{2dgh_f}{L\, v^2} = 0.02716$$

❖ For light blue circuit and globe valve (row data):

1) Pressure gage

1 bar = 10.19744 m water

(0.1) × (10.19744) =1.019744 m water

2) Volumetric flow rate in m^3/s

0.225/1000 = 0.000225 m^3/s

3) Medium radius smooth 90 bend radius =100 mm, diameter equal:

$$\frac{radius}{7.35} = \frac{100 \times 10^{-3}}{7.35} = 0.013605\ m$$

4) Area:

$$A = \frac{\pi}{4} d^2 = \frac{\pi}{4} 0.013605^2 = 1.4538 \times 10^{-4}\ m^2$$

5) Piezometer in mm water (L):

=275 mm H_2o

6) Velocity (m/s)

$$V = \frac{Q}{Area} = \frac{0.00025}{1.4538\times10^{-4}} = 1.54841 \text{ m/s}$$

7) Reynolds number

$$Re = \frac{v\,\rho\,d}{\mu} = \frac{1.54841 \times 998.02 \times 0.013605}{1.005^{-3}} = 20920.563$$

8) $\frac{v^2}{2g}$

$$\frac{v^2}{2g} = \frac{1.54841^2}{2\times9.81} = 0.12220137$$

9) Friction factor from Blasius equation

$$F = \frac{0.136}{Re^{0.25}} = \frac{0.136}{(20920.563)^{0.25}} = 0.02627506$$

10) H_f

$$H_f = \frac{f\,l\,v^2}{2gd} = \frac{0.02627516 \times (1.54841)^2 \times 275\times10^{-3}}{2\times9.81\times0.013605} = 0.06489928$$

11) H_b

$$H_b = H_l - H_f = 0.275 - 0.06489928 = 0.21010072$$

❖ For Sudden expansion:

1) **Area**

$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} 0.0136_1^2 = 0.00015\ m^2$

$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} 0.0262_1^2 = 0.0005389\ m^2$

2) **Volumetric flow rate**

$Q = 0.225/1000 = 0.000225\ m^3/s$

3) **Velocity**

$V_1 = \frac{Q}{A_1} = 1.5497\ m/s$

$V_2 = \frac{Q}{A_2} = 0.41755\ m/s$

4) **$V^2 / 2g$**

$\frac{V_1^2}{2g} = \frac{1.5497^2}{2*9.81} = 0.1223971$

$\frac{V_2^2}{2g} = \frac{0.41755^2}{2*9.81} = 0.008886312$

5) **H_L**

$H_L = \text{measured value} + \frac{V_1^2 - V_2^2}{2g}$

$H_L = 0.079511$

6) **K**

$K = \frac{H_L}{V_1^2/2g} = 0.64961$

❖ For Sudden contraction:

7) **Area** (**1 for small diameter & 2 for large diameter**)

$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} 0.0136_1^2 = 0.00015\ m^2$

$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} 0.0262_1^2 = 0.0005389\ m^2$

8) **Volumetric flow rate**

$Q = 0.225/1000 = 0.000225\ m^3/s$

9) **Velocity**

$V_1 = \frac{Q}{A_1} = 1.5497\ m/s$

$V_2 = \frac{Q}{A_2} = 0.41755\ m/s$

10) $V^2 / 2g$

$\frac{V_1^2}{2g} = \frac{1.5497^2}{2*9.81} = 0.1223971$

$\frac{V_2^2}{2g} = \frac{0.41755^2}{2*9.81} = 0.008886312$

11) H_L

$H_L = \text{measured value} + \frac{V_1^2 - V_2^2}{2g}$

$H_L = 0.082489224$

12) **K**

$K = \frac{H_L}{V_1^2/_{2g}} = 0.67395$