90/100

The University of Jordan

School of Engineering

Chemical Engineering Department

Chemical Engineering Laboratory (1) 0915361

Experiment Number (1)

Losses in piping system

Type of the report : short report

Instructor:prof. Ahmad Abu Yaghy

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Name	Id Number
Laila Alameri	
Noor Ghassan	
Saja Alqaisi	
Sara Albanna	

Abstract

In this experiment We used two separate circuits to find the pressure major and minor losses across various components of a flow rate, such as pipes and valves, and compared the theoretical friction factor with that founded in the real experiment, The parts include two separate circuits; one painted dark blue, one painted light blue. Each circuit has several pipe system components. Both circuits are supplied with water from the same hydraulic bench. A gate valve controls the flow in the dark blue circuit. A globe valve controls the flow in the light blue circuit. The valves are both downstream of the pipe work to reduce the chance of turbulence from the valves affecting the pipe work readings. We used the piezometer tubes to measure pressure changes across the pipe work components. Our main results; we found that the gate valve is more efficient than globe valve due to the structure, we found that the major loss is due to the friction, and it is larger than minor losses.

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Result

Result of dark blue circuit:

Table (1): Raw data for dark blue circuit

pressure gauge (bar)	pressure gauge (m water)	flow rate (L /s)	flow rate (m^3 /s)	Δh (3-4) straight line(mm)	Δh (1-2) standard 90° elbow (mm)	Δh (5-6) 90° mitre (mm)
0.1	1.033	0.196	1.960E-04	150	245	302
0.15	1.550	0.189	1.890E-04	138	218	276
0.2	2.067	0.164	1.640E-04	110	176	220
0.25	2.583	0.15	1.500E-04	95	150	188
0.3	3.100	0.129	1.290E-04	72	116	140
0.35	3.617	0.107	1.070E-04	53	84	102
0.4	4.133	0.08	8.000E-05	32	50	64
0.45	4.650	0.044	4.400E-05	7	10	14

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

pressure gauge (bar)	pressure gauge (m water)	flow rate (L /s)	flow rate (m^3/s)	$\Delta h_{(3-4)}$ straight line(mm)	flow velocity (m/s)	Re number	f factor experimental	f factor theoretical
0.1	1.033	0.196	1.960E-04	150	1.350	21501	0.024	0.026
0.15	1.550	0.189	1.890E-04	138	1.302	20733	0.024	0.026
0.2	2.067	0.164	1.640E-04	110	1.130	17990	0.026	0.027
0.25	2.583	0.15	1.500E-04	95	1.033	16455	0.026	0.028
0.3	3.100	0.129	1.290E-04	72	0.888	14151	0.027	0.029
0.35	3.617	0.107	1.070E-04	53	0.737	11738	0.029	0.030
0.4	4.133	0.08	8.000E-05	32	0.551	8776	0.031	0.033
0.45	4.650	0.044	4.400E-05	7	0.303	4827	0.023	0.038

Table (2): b) parameters for standard -bore straight pipe (nominally 13.6 mm bore copper)

$V^2/2g$ (m)	K value Loss coefficient (theoretical)	Log (flow rate)	Log ($\Delta h_{(3-4)}$) Major loss
0.0911	1.646	-3.708	-0.824
0.0847	1.629	-3.724	-0.860
0.0638	1.724	-3.785	-0.959
0.0534	1.780	-3.824	-1.022
0.0395	1.824	-3.889	-1.143
0.0272	1.952	-3.971	-1.276
0.0152	2.108	-4.097	-1.495
0.0046	1.524	-4.357	-2.155

- Average K value (theoretical) = 1.7735
- K value (experimental) = 1.7139
- Percentage of error =3.4%

Figures:

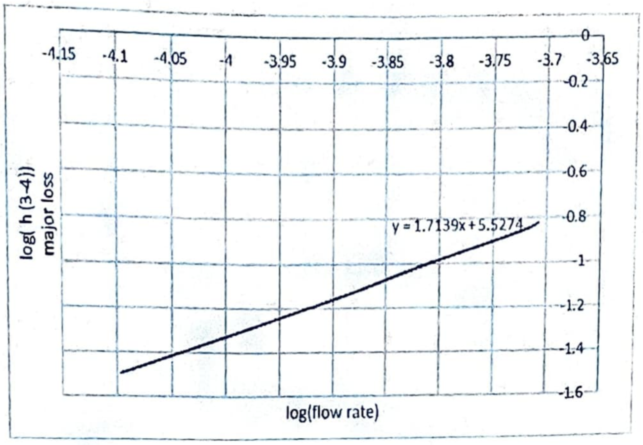

Figure (1): log major head vs. log volumetric flow rate

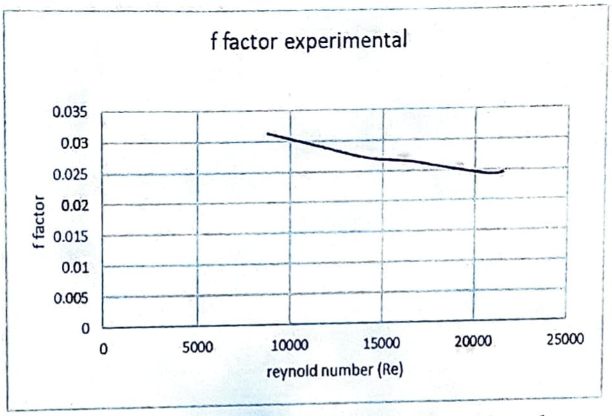

Figure (2): experimental friction factor vs. Reynold number

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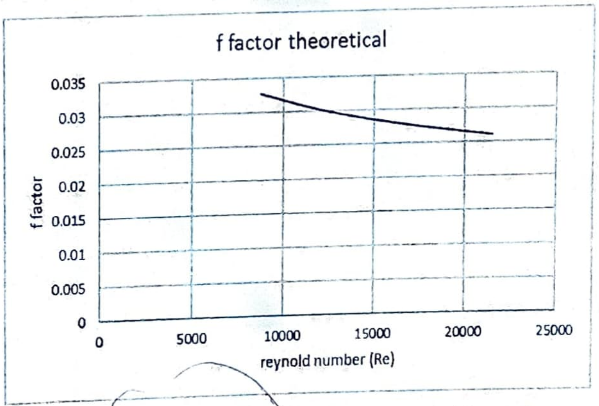


Figure (3) : theoretical friction factor vs. Reynold number

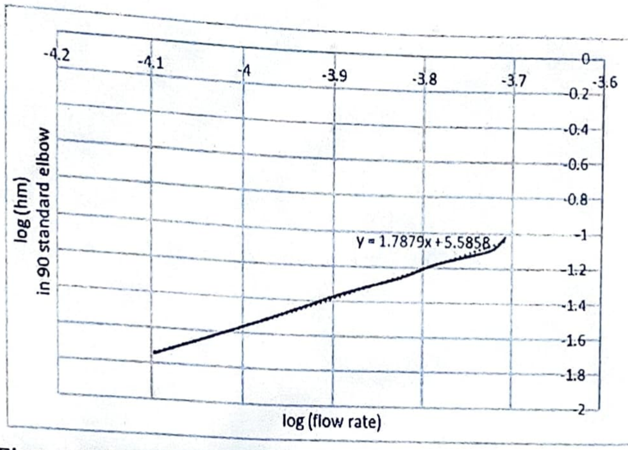
Table (3): a) parameters for standard 90 elbow (13.6 mm radius)

pressure gauge bar	pressure gauge (m water)	flow rate (L /s)	flow rate (m^3/s)	Δh (3-4) straight line(mm)	$\Delta h_{(1-2)}$ standard 90 elbow (mm H_2O)	$\Delta h_{(1-2)}$ standard 90 elbow (m H_2O)	flow velocity (m/s)	Re	$h_m = \Delta h_{(1-2)} - \Delta h_{(3-4)}$ (m H_2O)
0.1	1.033	0.196	1.960E-04	150	245	0.245	1.350	21501	0.095
0.15	1.550	0.189	1.890E-04	138	218	0.218	1.302	20733	0.08
0.2	2.067	0.164	1.640E-04	110	176	0.176	1.130	17990	0.066
0.25	2.583	0.15	1.500E-04	95	150	0.15	1.033	16455	0.055
0.3	3.100	0.129	1.290E-04	72	116	0.116	0.888	14151	0.044
0.35	3.617	0.107	1.070E-04	53	84	0.084	0.737	11738	0.031
0.4	4.133	0.08	8.000E-05	32	50	0.05	0.551	8776	0.018
0.45	4.650	0.044	4.400E-05	7	10	0.01	0.303	4827	0.003

Table (3): b) parameters for standard 90 elbow (13.6 mm radius)

K value (theoretical)	Log (flow rate)	Log(h_m) in standard 90 elbow
1.043	-3.708	-1.022
0.944	-3.724	-1.097
1.035	-3.785	-1.180
1.031	-3.824	-1.260
1.115	-3.889	-1.357
1.142	-3.971	-1.509
1.186	-4.097	-1.745
0.653	-4.357	-2.523

- Average K value (theoretical) = 1.01846
- K value (experimental) = 1.7879
- Percentage of error = 43%



Figure(4) :log minor head loss in standard elbow vs. log flow rate

Table (4):a) parameters for 90-degree miter bend

pressure gauge bar	pressure gauge (m water)	flow rate (L /s)	flow rate (m3/s)	Δh (3-4) straight line(mm)	Δh (5-6) 90 miter (mm H_2O)	Δh (5-6) 90 miter (m H_2O)	flow velocity (m/s)	Re	h_m=Δh (5-6) -Δh (3-4) (m H_2o)
0.1	1.033	0.196	1.960E-04	150	302	0.302	1.350	21501	0.152
0.15	1.550	0.189	1.890E-04	138	276	0.276	1.302	20733	0.138
0.2	2.067	0.164	1.640E-04	110	220	0.22	1.130	17990	0.11
0.25	2.583	0.15	1.500E-04	95	188	0.188	1.033	16455	0.093
0.3	3.100	0.129	1.290E-04	72	140	0.14	0.888	14151	0.068
0.35	3.617	0.107	1.070E-04	53	102	0.102	0.737	11738	0.049
0.4	4.133	0.08	8.000E-05	32	64	0.064	0.551	8776	0.032
0.45	4.650	0.044	4.400E-05	7	14	0.014	0.303	4827	0.007

Table (4):b) parameters for 90-degree miter bend

K value (Theoretical)	Log (flow rate)	Log(hm) in 90 miter
1.668	-3.708	-0.818
1.629	-3.724	-0.860
1.724	-3.785	-0.959
1.743	-3.824	-1.032
1.723	-3.889	-1.167
1.804	-3.971	-1.310
2.108	-4.097	-1.495
1.524	-4.357	-2.155

- Average K value (theoretical) = 1.740513168
- K value (experimental)= 1.7584
- Percentage of error = 1%

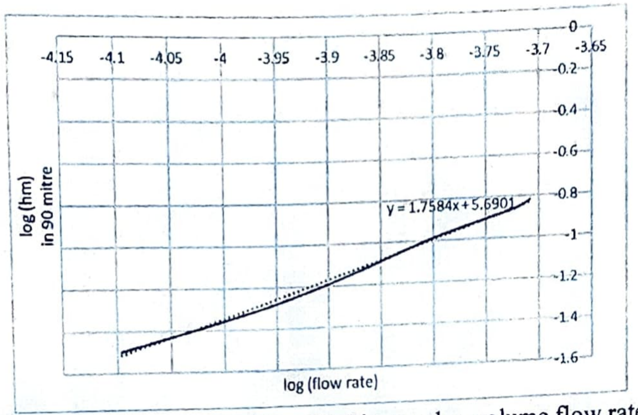


Figure (5):log minor head loss 90 miter vs. log volume flow rate

Table (5): Raw data for light blue circuit –bends

pressure gauge bar	pressure gauge m water	flow rate L/s	volumetric flow rate m^3/s	delta H (mm water)		
				11--12	13-14	15-16
0.1	1.020	0.212	0.000212	218	180	270
0.15	1.530	0.193	0.000193	185	152	226
0.2	2.039	0.173	0.000173	153	127	186
0.25	2.549	0.159	0.000159	132	108	158
0.3	3.059	0.132	0.000132	43	75	112
0.35	3.569	0.11	0.00011	69	54	80
0.4	4.079	0.068	0.000068	32	22	38
0.45	4.589	0	0	6	2	6

Table (6): Parameters for medium radius smooth 90 bend (100mm radius)

hL in mm 11-12	volumetric flow rate in m^3/s	velocity(m/s)	Re	v^2/2g	f from Blasius equation	hf	hB	KB
218	0.000212	1.458	170775	0.108	0.0155	0.0271	0.1908	2.011
185	0.000193	1.328	155469	0.090	0.0159	0.0195	0.1655	2.060
153	0.000173	1.190	139359	0.072	0.0164	0.0133	0.1397	2.120
132	0.000159	1.094	128081	0.061	0.0167	0.0099	0.1220	2.165
43	0.000132	0.908	106331	0.042	0.0175	0.0023	0.0407	1.023
69	0.00011	0.757	88609	0.029	0.0183	0.0027	0.0662	2.365
32	0.000068	0.468	54777	0.011	0.0207	0.0005	0.0314	2.870
6	0	0	0	0				

K experiment: 2.2826

K theoretical: 2.087782

Percentage of error =9.3%

Table (7): Parameters for large radius smooth 90 bend (150mm radius)

hL in mm 13-14	volumetric flow rate m^3/s	velocity(m/s)	Re	$v^2/2g$	f (Blasius equation)	hf	hB	kb
180	0.000212	1.460	170930	0.109	0.0155	0.0224	0.158	1.658
152	0.000193	1.329	155611	0.090	0.0159	0.0161	0.136	1.689
127	0.000173	1.191	139485	0.072	0.0164	0.0111	0.116	1.757
108	0.000159	1.095	128197	0.061	0.0167	0.0081	0.100	1.768
75	0.000132	0.909	106428	0.042	0.0175	0.0041	0.071	1.782
54	0.000110	0.757	88690	0.029	0.0183	0.0021	0.052	1.847
22	0.000068	0.468	54827	0.011	0.0207	0.0004	0.022	1.969
2	0	0	0	0				

K experiment: 1.8639

K theoretical: 1.781503

Percentage of error =4.6%

Table (8): Parameters for small radius smooth 90 bend (50mm radius)

hL in mm 15-16	volumetric flow rate in m^3/s	velocity(m/s)	Re	$v^2/2g$	f from Blasius equation	hf	hB	KB
270	0.000212	1.478	173106	0.1113	0.0155	0.0344	0.2356	2.425
226	0.000193	1.346	157592	0.0923	0.0159	0.0244	0.2016	2.449
186	0.000173	1.206	141261	0.0742	0.0163	0.0166	0.1694	2.508
158	0.000159	1.109	129829	0.0626	0.0166	0.0122	0.1458	2.522
112	0.000132	0.920	107783	0.0432	0.0174	0.0062	0.1058	2.594
80	0.000110	0.767	89819	0.0210	0.0183	0.0032	0.0768	2.668
38	0.000068	0.474	55525	0.0115	0.0206	0.0007	0.0373	3.317
6	0	0	0	0				

K experiment: 2.694

K theoretical: 2.640528

Percentage of error =2.02%

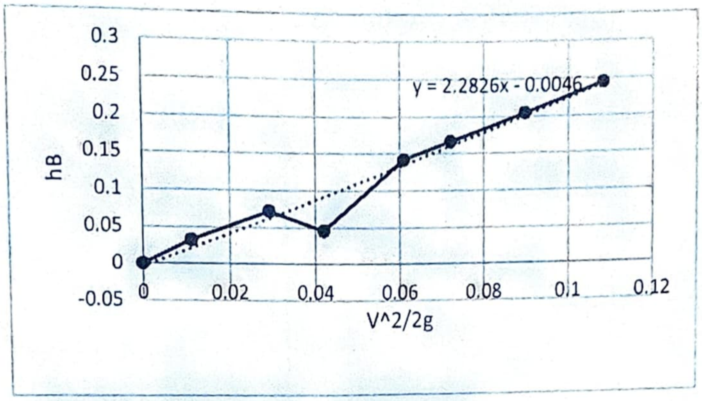


Figure (6): hB against $v^2/2g$ in medium radius smooth 90 bend 11-12 (100mm radius)

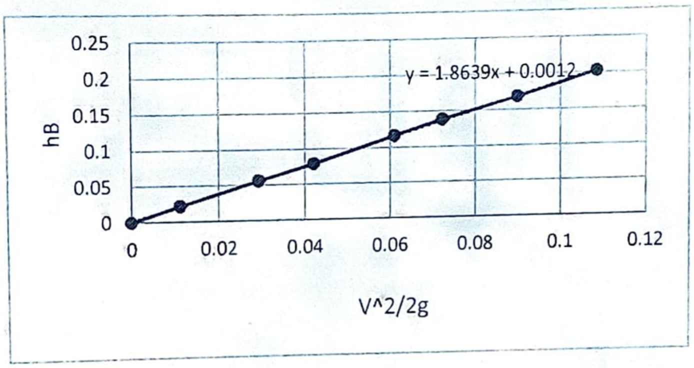


Figure (7): hB against $v^2/2g$ in large radius smooth 90 bend 13-14 (150mm radius)

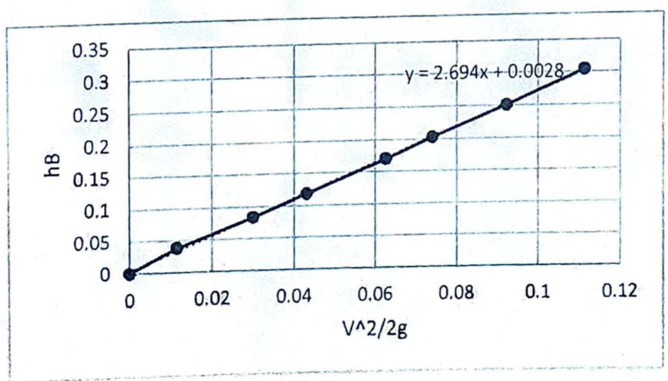


Figure (8): hB against v^2/2g in small radius smooth 90 bend 15-16 (50mm radius)

Table(9) :raw data for light blue circuit -sudden expansion and contraction

Pressure gauge(bar)	Pressure gauge(m water)	Volumetric Flow rate(L/s)	Volumetric flow rate(m^3/s)	Light Blue circuit Piezometer tube heights (mm water)			
				7-8 (expansion)	Δh(7-8)	9-10 (contraction)	Δh(9-10)
0.1	1.020	0.212	2.12E-04	540-590	-50	564-390	174
0.15	1.530	0.193	1.93E-04	548-572	-24	566-420	146
0.2	2.040	0.173	1.73E-04	552-574	-22	568-450	118
0.25	2.549	0.159	1.59E-04	558-574	-16	568-470	98
0.3	3.059	0.132	1.32E-04	564-576	-12	570-506	64
0.35	3.569	0.11	1.10E-04	568-576	-8	572-526	46
0.4	4.079	0.068	6.80E-05	576-580	-4	573-558	15
0.45	4.589	0	0.00E+00	582-582	0	582-580	2

Table (10):Parameters for sudden expansion in light blue circuit (13.6mm to 26.2mm)

Δh(mm) (9-10) (measured)	Area (m^2) on standard bore pipe (13.6mm)	flow velocity (m/s)(V1)	$V1^2/2g$	Area (m^2) on Large bore pipe (26.2mm)	flow velocity(m/s) (V2)	$V2^2/2g$	h_L (m water)	K theoretical
-50	2.12E-04	1.45E-04	1.459	0.109	5.39E-04	0.393	7.88E-03	5.07E-02
-24	1.93E-04	1.45E-04	1.329	0.090	5.39E-04	0.358	6.53E-03	5.94E-02
-22	1.73E-04	1.45E-04	1.191	0.072	5.39E-04	0.321	5.25E-03	4.50E-02
-16	1.59E-04	1.45E-04	1.095	0.061	5.39E-04	0.295	4.43E-03	4.06E-02
-12	1.52E-04	1.45E-04	1.046	0.056	5.39E-04	0.282	4.05E-03	3.98E-02
-8	1.10E-04	1.45E-04	0.757	0.029	5.39E-04	0.204	2.12E-03	1.91E-02
-4	6.80E-05	1.45E-04	0.468	0.011	5.39E-04	0.126	8.11E-04	6.36E-03
0	0.00E+00	1.45E-04	0.000	0.000	5.39E-04	0.000	0.00E+00	0.00E+00

- k experimental=0.5456
- k theoretical= 6.22E-01
- percentage error=12.22%

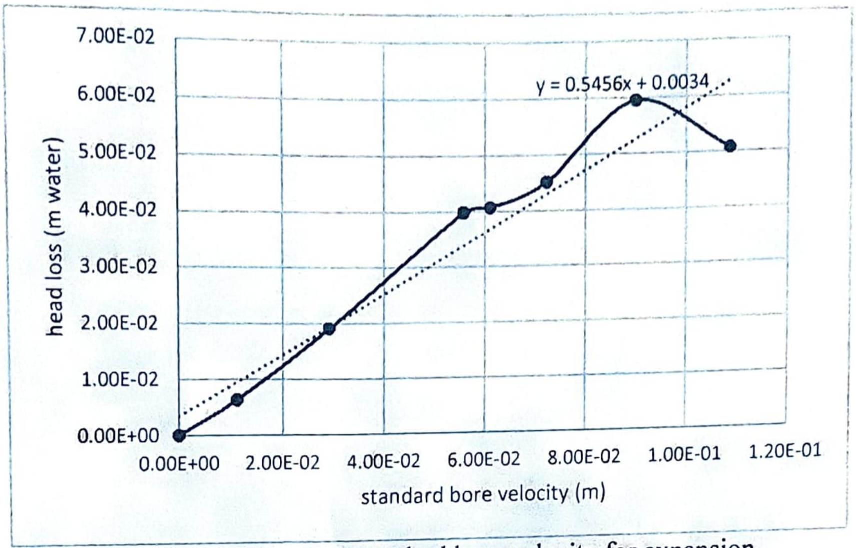


figure (9):head loss vs. standard bore velocity for expansion

Table(11) :Parameters for sudden contraction in light blue circuit (26.2mm to 13.6mm)

Δh (9-10) (measured)	Area (m2) on Large bore pipe (26.2mm)	flow velocity (m/s) (V1)	$V1^2/2g$	Area (m^2) on standard bore pipe (13.6mm)	flow velocity (m/s) (V2)	$V2^2/2g$	h_L	K theoretical
174	2.12E-04	5.39E-04	0.393	7.88E-03	1.45E-04	1.459	0.109	0.073
146	1.93E-04	5.39E-04	0.358	6.53E-03	1.45E-04	1.329	0.090	0.063
118	1.73E-04	5.39E-04	0.321	5.25E-03	1.45E-04	1.191	0.072	0.051
98	1.59E-04	5.39E-04	0.295	4.43E-03	1.45E-04	1.095	0.061	0.041
64	1.52E-04	5.39E-04	0.282	4.05E-03	1.45E-04	1.046	0.056	0.012
46	1.10E-04	5.39E-04	0.204	2.12E-03	1.45E-04	0.757	0.029	0.019
15	6.80E-05	5.39E-04	0.126	8.11E-04	1.45E-04	0.468	0.011	0.005
2	0.00E+00	5.39E-04	0.000	0.00E+00	1.45E-04	0.000	0.000	0.002

- k experimental= 0.6839
- k theoretical= 5.76E-01
- percentage error=18.63%

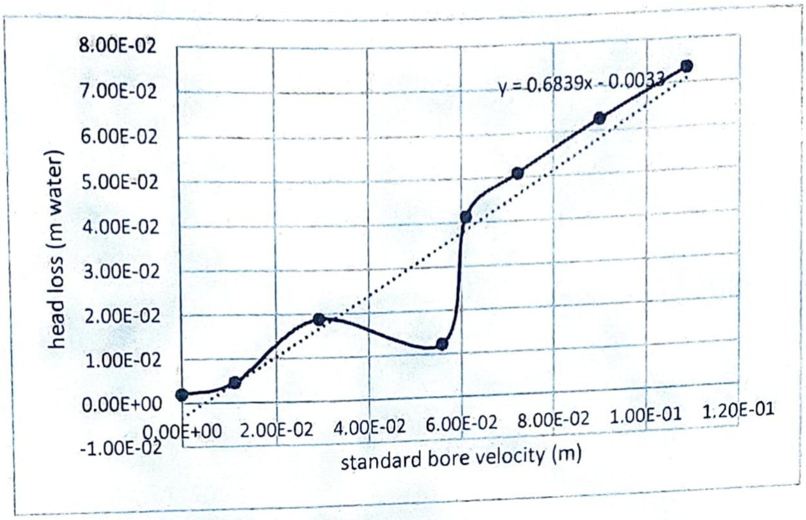


Figure (10) :head loss vs. standard bore velocity for contraction

optional rough pipe H16p

Table (12): parameters for optional rough pipe H16p

piezometer (mm h2o)	piezometer (mmh2o)	volumetric flow L/s	volumetric flow m^3/s	velocity m/s	Re	f average
44	0.044	0.444	0.000444	1.566	36627	0.053
42	0.042	0.429	0.000429	1.513	35390	0.054
38	0.038	0.414	0.000414	1.460	34152	0.055
34	0.034	0.39	0.00039	1.376	32173	0.056
32	0.032	0.375	0.000375	1.323	30935	0.057

kinematic viscosity: 8.53878E-07

cross sectional area:0.000283529

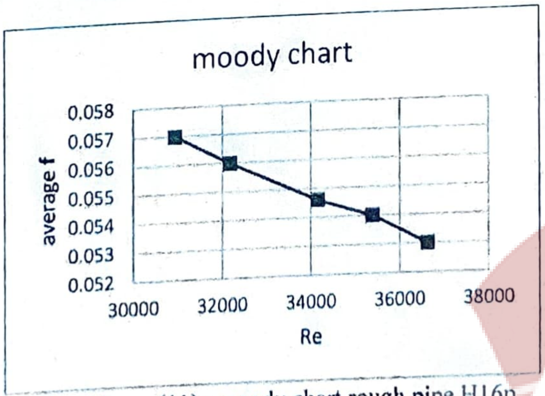


Figure (11) : moody chart rough pipe H16p

Discussion

Finally, we get the following results [the gate value better than globe value for a low loss piping system, the loss coefficient decreases as the flow rate increases, the radius of curvature with head loss coefficient].

In the laws of natural state if you want something you have to pay for it , if you want to move something there will be resistance .

As seen in figure (1) as the flow rate increase the head loss increase because the flow rate increase with pressure .

the friction factor decrease as shown in figure (2) , when velocity of liquid increase Reynolds number increase leading to decrease in the friction factor , so we can say friction factor decrease at high velocities.

The fitting such as elbow and valve have a value of k . in this experiment the value of k for gate and globe valve are calculated and compared with actual k values as shown in the results ,the tabulated value for 90 elbow and 90 miter are (1.01 ,1.74) while experimental values are (1.78 ,1.758).

Sudden expansion and contraction in piping system have two velocities : inlet and outlet effects the pressure difference and head loss .

Conclusion:

- the radius of curvature of a pipe has increased relation with load loss coefficient.
- the loss coefficient decreases as the flow rate increases..
- the gate valve better than globe valve for a low loss piping system
- friction loss in 90 miter higher than 90 elbow.
- head loss of sudden expansion Higher than sudden contraction .
- globe valve have higher values of K when changing fluids which make gate valve a choice for less loss piping system (dark blue), also have very little fluid flow resistance in fully open and have small Δp.

References

Manual Chemical engineering Laboratory (1),faculty of engineering and-technology, department of chemical engineering, the university of Jordan,8/8/2022.

Appendix

Sample of calculations:

Taking the first row for each table:

At Pressure gauge=0.1 bar

- **For sudden expansion from table (10):**

1. Pressure gauge(m water):

$P = 0.1 * \frac{10.333}{1.01325} = 1.0197\ m\ water.$

2. Volumetric flow rate (m^3/s) :

$Q\ (m^3/s) = 0.212/1000 = 0.212 * 10^{-3}\ m^3/s.$

3.Head difference (mm):

$\Delta h(7-8) = 540 - 590 = -50\ mm.$

4. Area (m^2) on standard bore pipe (13.6mm):

$A = \frac{\pi}{4}\ d^2 = \frac{\pi}{4}\ (13.6 * 10^{-3})^2 = 1.453 * 10^{-4}\ m^2.$

5.Flow velocity (m/s)(V1):

$$V = \frac{Q}{A} = \frac{0.212 * 10^{-3}\ m^3/s}{1.453 * 10^{-4}\ m^2} = 1.46\ m/s.$$

6.velocity head for standard bore pipe:

$$= \frac{V1^2}{2g} = \frac{1.46^{\ 2}}{2*9.81} = 0.1086\ m.$$

7. Area (m^2) on larger bore pipe (26.2mm):

$A = \frac{\pi}{4}\ d^2 = \frac{\pi}{4}\ (26.2 * 10^{-3})^2 = 5.39 * 10^{-4}\ m^2.$

8.Flow velocity (m/s)(V2):

$$V = \frac{Q}{A} = \frac{0.212 * 10^{-3}\ m^3/s}{5.39 * 10^{-4}\ m^2} = 0.393\ m/s.$$

9.velocity head for larger bore pipe:

$$= \frac{V2^2}{2g} = \frac{0.393^{\ 2}}{2*9.81} = 7.87 * 10^{-3}\ m.$$

10.total head loss for enlargement:

h_L= measured quantity + $\frac{V1^2-V2^2}{2g}$ $=-50*10^{-3}\,m+(1.086*10^{-1}\ m-7.87*10^{-3}\ m)$

=0.0507 m water

- **For sudden contraction from table (12):**

1. Pressure gauge(m water):

$P = 0.1 * \frac{10.333}{1.01325} = 1.0197\ m\ water.$

2. Volumetric flow rate (m^3/s) :

$Q\ (m^3/s) = 0.212/1000 = 0.212 * 10^{-3}\ m^3/s.$

3.Head difference (mm):

$\Delta h(9-10) = 564 - 390 = 174\ mm.$

4. Area (m^2) on larger bore pipe (26.2mm):

$A = \frac{\pi}{4}\,d^2 = \frac{\pi}{4}\,(26.2*10^{-3})^2 = 5.39*10^{-4}\ m^2.$

5.Flow velocity (m/s)(V1):

$$V = \frac{Q}{A} = \frac{0.212 * 10^{-3}\ m^3/s}{5.39 * 10^{-4}\ m^2} = 0.393\ m/s.$$

6.velocity head for standard bore pipe:

$$= \frac{V1^2}{2g} = \frac{.393^2}{2*9.81} = 7.87 * 10^{-3}\ m$$

7. Area (m^2) on standard bore pipe (13.6mm):

$A = \frac{\pi}{4}\,d^2 = \frac{\pi}{4}\,(13.6*10^{-3})^2 = 1.453*10^{-4}\ m^2.$

8.Flow velocity (m/s)(V2):

$$V = \frac{Q}{A} = \frac{0.212 * 10^{-3}\ m^3/s}{1.453 * 10^{-4}\ m^2} = 1.46\ m/s.$$

9.velocity head for larger bore pipe:

$$= \frac{V2^2}{2g} = \frac{1.46^2}{2*9.81} = 0.1086\ m.$$

10.total head loss for enlargement:

h_L= measured quantity + $\frac{V1^2 - V2^2}{2g}$ =$174 * 10^{-3}\, m + (7.87 * 10^{-3}\ m - 1.086 * 10^{-1}\ m)$=0.0733 m water

- **For dark blue circuit:**

1.volumetric floe rate

(Q) =$\frac{0.196\ L}{s} \times \frac{m^3}{1000\ L}$ =0.00196 $\frac{m^3}{s}$.

2.Area

A=$\frac{\pi}{4} d^2 = \frac{\pi}{4} \times (13.6 \times 10^{-3})^2$ =1.452 ×$10^{-4} m^2$.

3.flow velocity

V =$\frac{Q}{\frac{\pi}{4} d^2}$ =1.35 $\frac{m}{s}$.

4.Reynold number

Re= $\frac{\rho D V}{\mu} = \frac{996.512 \times 13.6 \times 10^{-3} \times 1.35}{0.8509 \times 10^{-3}}$ =21502.

5.friction factor

f=$\frac{h_f 2dg}{L v^2}$ =0.0245.

6.to calculate minor head loss in standard 90°ellbow

h_m=Δh $_{(1-2)}$ $- h_f$(major loss (3-4)+Δk (=o in bent pipe)

=245-150=95 mm H_2O.

- **for light blue circuit and globe valve (row data)**

1.pressure gage in bar =0.15 in m water

=(0.15)×(10.197) =1.0197.

2.volumetric flow rate in L/sec =0.212×10^{-3} ,in m^3 /sec

=0.212×10^{-3} in (11-12) .

3.(medium radius smooth90 bend radius =100mm) ,Diameter

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

4.area

$A=\frac{\pi}{4}d^2=\frac{\pi}{4}\times(0.013605)^2=1.4538\times10^{-4}m^2.$

5. piezometer in mm water =504-286=218 mm H_2O

6.velocity in m/sec =

$$\text{velocity}=\frac{Q}{Area}=\frac{0.212\times10^{-3}\text{m}^3/\text{sec}}{1.4538\times10^{-4}\text{m}^2}.$$

7.Reynold number

$$Re=\frac{\rho DV}{\mu}=\frac{996.512\times0.013605\times1.458}{0.8509\times10^{-3}}=23230.58141.$$

8. $\frac{v^2}{2g}=\frac{1.458^2}{2\times9.81}=0.108378.$

9.f (from blasius equation)

$$f=\frac{0.316}{Re^{0.25}}=\frac{0.316}{170774.592^{0.25}}=0.015447.$$

9. $f=\frac{h_f 2dg}{Lv^2}$

$$\rightarrow h_f=\frac{flv^2}{2dg}=\frac{0.015547\times218\times10^{-3}\times0.1083776}{13.5351351\times10^{-3}}=0.2713.$$

10. $h_B=h_L-h_f=0.02713-218\times10^{-3}=-0.19087.$

- **rough pipe**

1.kinamatic viscosity $=\frac{\text{dynamic viscosity}}{\text{fluid density}}=\frac{\mu}{\rho}=\frac{0.850\times10^{-3}}{996.512}=8.53878\times10^{-7}.$

2.piezometer mm H_2O=108-64=44 mm H_2O in m H_2O =44×10^{-3}m H_2O .

3.volumetric flow rate in L/sec =0.444 in m^3 /sec =0.444×10^{-3}.

4.area

$A=\frac{\pi}{4}d^2=\frac{\pi}{4}\times(19\times10^{-3})^2=0.000283529\ m^2=2.835\times10^{-4}m^2.$

5.velocity

$$V=\frac{Q}{Area}=\frac{0.444\times10^{-3}m^3/\text{sec}}{2.835\times10^{-4}m^2}.$$

6.Reynold number

$$Re=\frac{\rho DV}{\mu}=\frac{996.512\times19\times10^{-3}\times1.5659}{0.8509\times10^{-3}}=36627.29.$$

Losses in Pipes Experiment Data Sheet

Dark Blue Circuit and Gate Valve:

(0.225)??

major

Pressure Gauge (bar)	Pressure Gauge (m water)	Flow rate (L/s) (volumetric) or kg/s (gravimetric)	Volume Flow rate ($m^3.s^{-1}$)	Dark Blue circuit piezometer tube heights (mm water)		
				1-2	(3-4)	5-6
0.1	1.0333	0.196	$0.196 * 10^{3}$	710 - 465	725 - 578	1030 - 728
0.15	1.54995	0.189	$0.189 * 10^{-3}$	710 - 492	728 - 590	1024 - 748
0.2	2.0666	0.164	$0.164 * 10^{-3}$	718 - 542	726 - 606	1020 - 800
0.25	2.58325	0.150	$0.150 * 10^{-3}$	720 - 570	725 - 630	1016 - 828
0.3	3.0999	0.129	$0.129 * 10^{-3}$	724 - 608	724 - 652	1010 - 870
0.35	3.61655	0.107	$0.107 * 10^{-3}$	726 - 642	724 - 671	1008 - 906
0.4	4.1332	0.080	$0.080 * 10^{-3}$	728 - 678	724 - 692	1006 - 942
0.45	4.64985	0.044	$0.044 * 10^{-3}$	730 - 720	725 - 718	1000 - 986
0.5						
Water Temperature: 27°C						

Light Blue Circuit and Globe Valve:

Dia = 13.6D

Pressure Gauge (bar)	Pressure Gauge (m water)	Flow rate (L/s) (volumetric) or kg/s (gravimetric)	Volume Flow rate ($m^3.s^{-1}$)	Light Blue circuit piezometer tube heights (mm water)					
				7-8	8-9	9-10	11-12	(13-14)	15-16
0.1	1.0197	0.212	0.212×10^{-3}	540 - 590		564 - 390	504 - 286	534 - 354	618 - 342
0.15	1.52955	0.193	0.193×10^{-3}	548 - 572		566 - 420	513 - 328	548 - 396	616 - 390
0.2	2.0394	0.173	0.173×10^{-3}	552 - 574		568 - 450	521 - 368	559 - 432	614 - 428
0.25	2.54925	0.159	0.159×10^{-3}	558 - 574		558 - 470	526 - 394	564 - 456	610 - 452
0.3	3.0591	0.132	0.132×10^{-3}	564 - 576		570 - 506	533 - 490	573 - 498	606 - 494
0.35	3.56895	0.116	0.110×10^{-3}	568 - 576		572 - 626	527 - 468	578 - 524	602 - 522
0.4	4.0788	0.068	0.068×10^{-3}	576 - 580		573 - 658	543 - 511	586 - 564	600 - 562
0.45	4.58865	0	0	580 - 580		582 - 580	548 - 542	592 - 590	598 - 592
0.5									
Water Temperature: 27°C									

Instructor signature and Date: [signature] 1/8/2022

- Subtract h_F from your actual piezometer readings h_L to get the loss due to the bend h_B .
- Create a chart of hB against $V^2/2g$ and find its gradient.
- Compare your **average** K_B values with the theoretical values.

For Light Blue Circuit – Sudden Expansion and Contraction:

For each flow rate:

- Calculate the flow velocities in the standard bore and larger bore sections of pipe, and the velocity head.
- Convert piezometers readings (actual head loss) into meters of water.
- Calculate the total head loss for the contraction and enlargement.
- Create a chart of head loss (vertical axis) against the standard bore velocity head $V^2/2g$.
- Find the gradient of your actual results to find the K value and compare with the theoretical one.

Experiments with Optional Rough pipe (H16p):

Objectives:

To measure the pressure losses along a roughened pipe at different flow rates and compare results with those predicted by Moody and Nikuradse.

Procedure:

Piezometer (mm water)	Piezometer (m water) hL	Volume Flow rate (m³.s⁻¹) Q $\frac{L}{sec}$	Velocity (m.s⁻¹) V	Reynolds Number	Actual f
108 – 64	0.044	0.0144 × 10⁻³	1.566	3.6627 × 10⁴	
110 – 68	0.042	0.429 × 10⁻³	1.513	35384.879	
114 = 76	0.038	0.414 × 10⁻³	1.460	34152.471	
120 – 86	0.034	0.390 × 10⁻³	1.376	32172.618	
124 – 92	0.032	0.375 × 10⁻³	1.323	30935.209	

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