DESIGN AND ANALYSIS OF TEST-RIG FOR MULTIPLE VALVE TESTING

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Abstract

Valves are used to control the flow, divert the flow or stop the flow. In many industries like the Beverage, Food and Dairy, Cosmetic, Pharmaceutical and Biotech. Hence, valves need to be tested thoroughly for proper functioning. The machines used for testing the valves are called test-rig. There are different test-rigs available in the market to test different types of valves. If a company manufactures five to six types of valves, it needs five to six type of test-rigs to test them.Itwouldbecomeverycostly.Hencethisstudyaimstoreducethetestingcost.

The below study is an attempt to design and analyze a test-rig for multiple valve testing. In the present study, test-rig was designed to test different types of valves. The proposed setup was designed and developed in such a way that valves with different diameters can be tested in one setup. Valves are having the range of 1” to 8” diameter. The developed test-rig was designed to find out pressure drop of valve. The modeling of test-rig has been carried out. A further, analytical calculation of losses was carried out at every section of test-rig. The optimum setup with lowest pressure drop was selected after CFDanalysis.

Keywords-Valve automation, Valve technology, Fluid mechanics, Mechanical, Advance Engineering, System analysis, Technology, Process engineering, Thermodynamics, Designing, Modeling, Analytical calculations

1 INTRODUCTION

1.1 INTRODUCTION OFVALVES:

- Definition: -

A valve is a device for isolating or regulating the flow rate of gases, liquids and slurries through pipework and launder systems.

- Mode of Operation:-

The force required to operate a valve can be carried out either manually (by hand) or mechanically. Mechanical attachments (actuators) to a valve are usually either electrically or pneumatically operated. The actuators can be controlled manually (i.e. a technician pushing a button/switch) or by the plant controlsystem.

2 LITERATURE REVIEW

2.1 OVERVIEW:

This chapter includes different literatures, documents, research papers, etc. related to valves, valves test benches, computational fluid dynamics and valve sizing that has been studied and referred in order to carry out our project in the right direction.

2.2 LITERATURES:

1. B.V.Hubbali, Dr.V.B.Sondur, Investigation Into Causes of Pressure Relief Valve Failure:-

   The purpose of data collected by testing is intended to support the alternative path to determine service life of relief valves following their removal from system prior to their replacement or disposal.

2. Herbert Addition, The Pump Users' Handbook:-

   We were able to understand the characteristics and performance of pump which would provide the desired flow rates of fluid in test-rig piping network and also the recommended pump to use for test-rig setup.

3. Alan O'Donovan, Ronan Grimes, Pressure Drop Analysis of Steam Condensation in Air-Cooled Circular Tube Bundles:-

   The pressure drop characteristics were, therefore, analyzed over a vapor Reynolds's number range of 1890-5150 and liquid Reynolds's number range of 25-95. Results indicate that the major pressure drop through the tube bundle was relatively small, in range of 130-250 Pa.

3 METHODOLOGY

3.1 OVERVIEW:

This chapter deals with the objectives need to be fulfilled by the project and the methodology that was carried out during the span of the project.

3.2 METHODOLOGY:

1
- Designing of proposed setups for valvetest-rig.

2
- Analytical calculations of losses at each sectionof Test-rig.

3
- Modeling of designed setups in Creo Parametricfor CFDanalysis.

4
- CFD analysis of piping network in ANSYSFluent.

5
- Figuringoutmostoptimumsetupwithminimum Losses.

6
- Creation of C program and excel sheet that provides the direct calculated values of losses accordingto Input parameters.

4 PROPOSED SETUPS FORTEST-RIG

4.1 TECHNICALSPECIFICATIONS

- Material:
  - Housing : AISI 316L
  - Bonnet : AISI 316L
  - Stem : AISI 316L
  - Othernon-Contactparts : AISI 304L
- FDASeals:
  - Diaphragm : PTFE
  - O-ring : PTFE
- TemperatureRange:
  - WorkingTemperatureRange : 77 to 104 °F (25 to 40°C)
- SurfaceFinish:
  - Inside : Ra ≤ 0.8µm
  - Outside : Brightfinish
- Connection PipeDiameter:
  - Inlet : 1 to 8inches
  - Outlet : 1 to 8inches

4.2 SETUP 1.1SKETCH:

- Firstly, a rough sketch of the set-up was conceptualized and it was further worked on to give the followingsetups.
- This setup aims to enable the testing of valves ranging from 1" to 4" diameters with help of appropriate reducers and expanders at both end. The equivalent pipe diameter is 2.5"here.

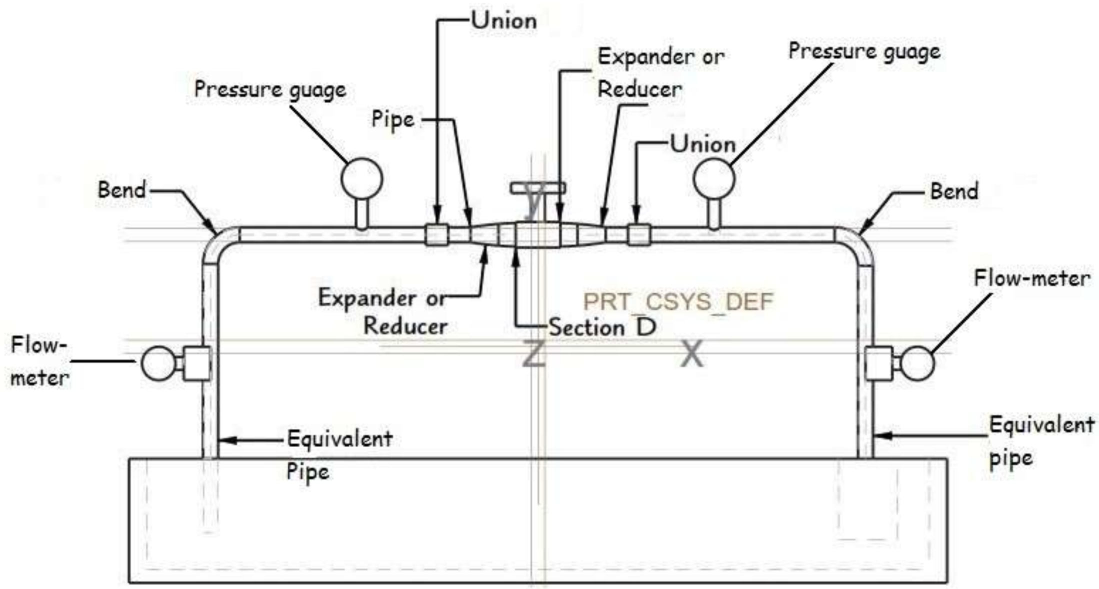


Figure 4.1 Setup 1.1 Sketch

- For testing of 1" and 2" diameter valves, we can use reducer at left end and then expander at right end as equivalent pipe is 2.5"diameter.
- For testing of 3" and 4" diameter valves, we can use expander at left end and reducer at right end.
- Pressure gauges and flow meters are attaches as shown infigure.

4.3 Setup 1.1Model:

After the rough sketch of the test-rig, its model was developed using software which is given as below.

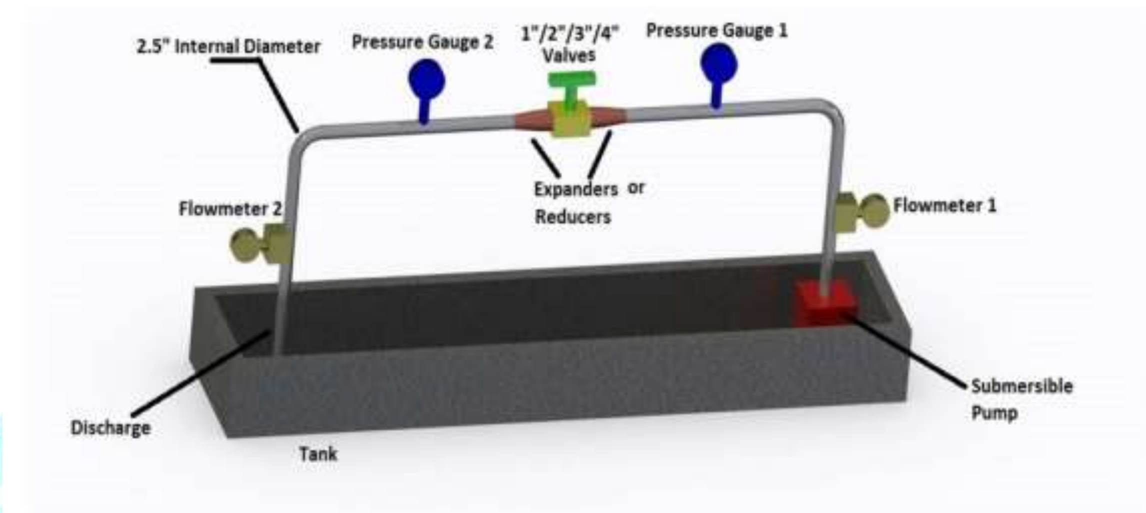


Figure 4.2 Setup 1.1 Model

The valves can be changed and tested as explained using the above figure.

- At first the setup would be ran without the valve and the overall pressure drop would bemeasured.
- Then after attaching the valve the pressure drop would bemeasured.
- The difference would give the pressure drop of thevalve.

4.4 SETUP 1.2MODEL:

- This setup aims to enable the testing of valves ranging from 5” to 8” diameters with help of appropriate reducers and expanders at both end. The equivalent pipe diameter is 6.5”here.

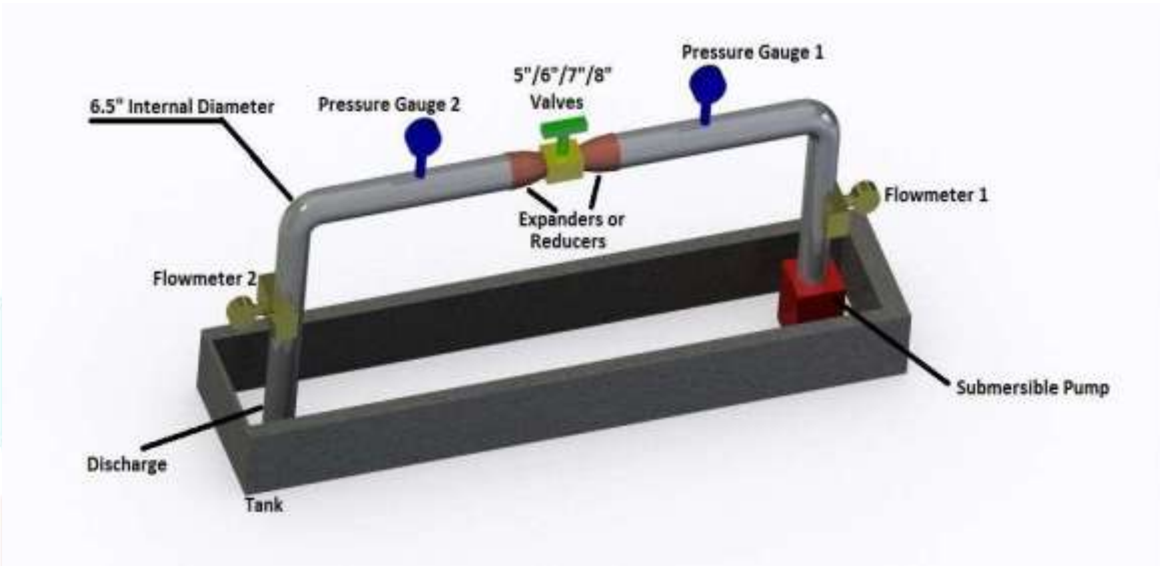


Figure 4.3 Setup 1.2 Model

- For testing of 5” and 6” diameter valves, we can use reducer at left end and then expander at right end as equivalent pipe is 6.5”diameter.

- For testing of 7” and 8” diameter valves, we can use expander at left end and reducer at right end.

- Pressure gauges and flow meters are attaches as shown infigure.

- The submersible pump is used in bothsetups.

4.5 SETUP 2.1MODEL:

- This setup, as shown in the figure below, is designed to test valves with diameter ranging from 1” to4”.
- Here as we can see there is no need of expander or reducer at the inlet or outlet of the valve.
- The expander or reducer are attached at the end of the division line or pipe where the flow divides in four other pipes as shownbelow

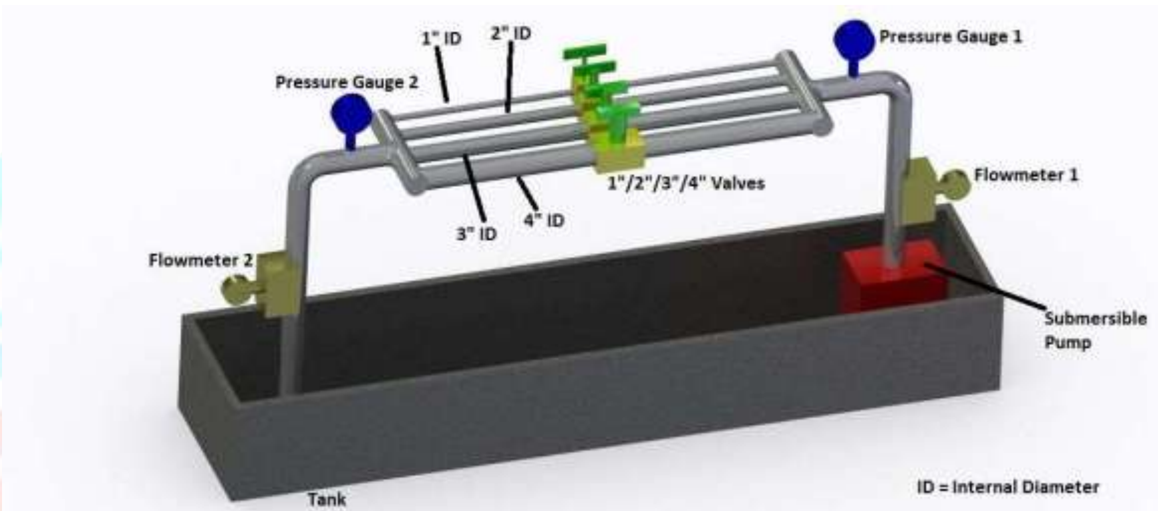


Figure 4.4 Setup 2.1 Model

- The remaining things i.e. pressure gauges, flow-meters, and pump remains the same as the first setup.

4.6 SETUP 2.2MODEL:

- This setup, as shown in the figure below, is designed to test valves with diameter ranging from 5” to8”.
- Here as we can see there is no need of expander or reducer at the inlet or outlet of the valve.
- The expander or reducer are attached at the end of the division line or pipe where the flow divides in four other pipes as shownbelow

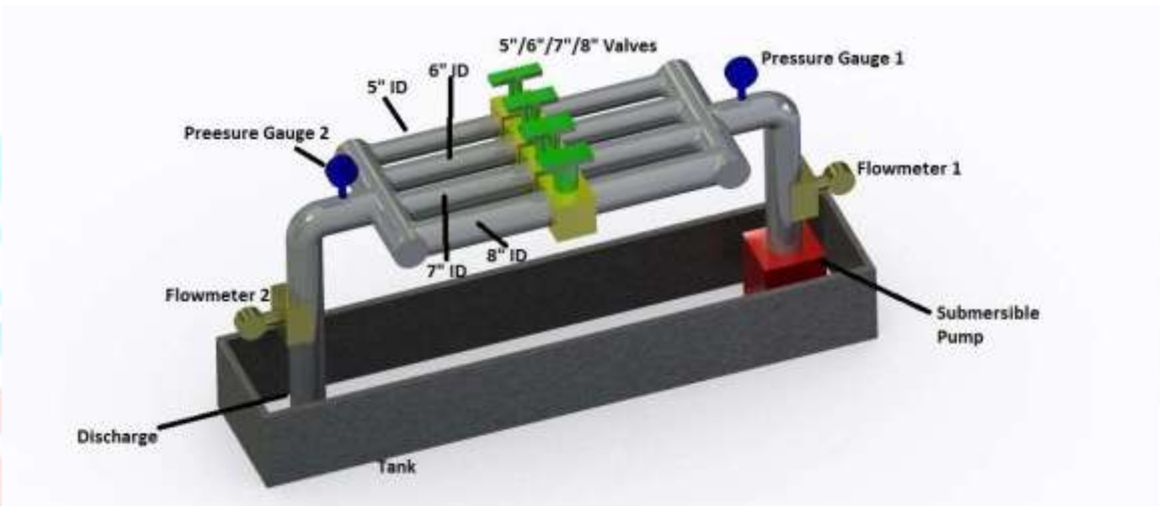


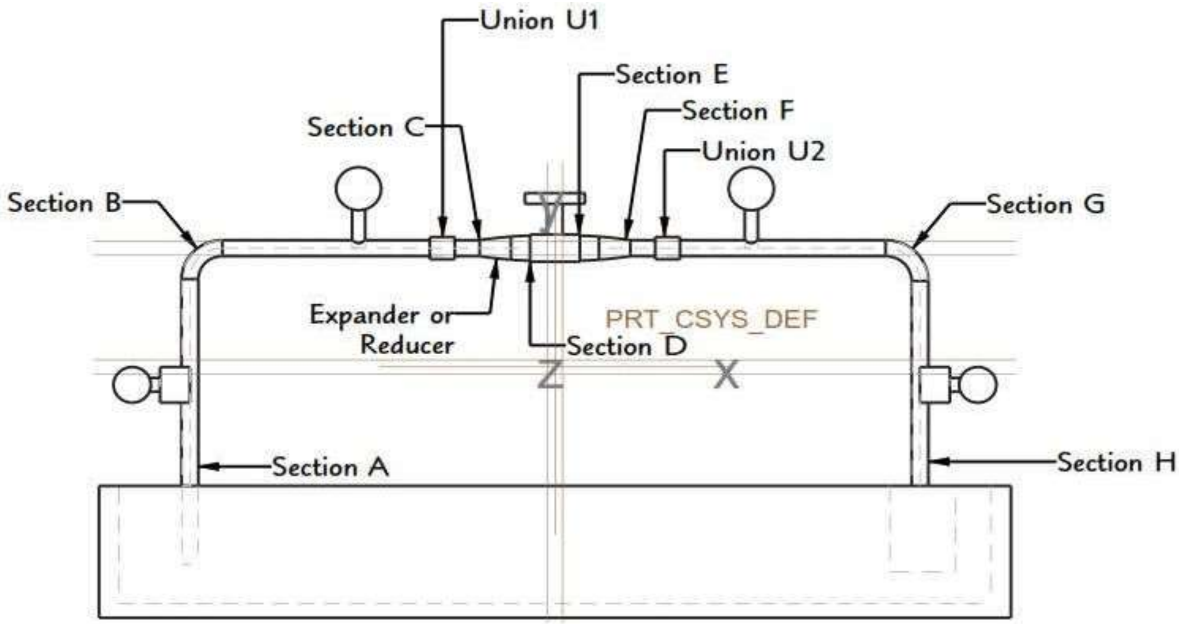
Figure 4.5 Setup 2.2 Model

- The remaining things i.e. pressure gauges, flow-meters, and pump remains the same as the first setup.

5 ANALYTICALCALCULATION

5.1 DESIGNEDSETUP:

- Wehavecalculatedvariouslosseswhichoccurateachsectionofsetupshowninfigure below.



AB = GH = 1 m
BC = FG = 0.5 m
C = DE = F =0.1 m

Figure 5.1 Diagram of Setup Design

- We have calculated the losses for three flow rate values(Gallons perMinute)

1. 100 GPM = 0.006309 m^3/s
2. 500 GPM = 0.031545 m^3/s
3. 1000 GPM = 0.06309 m^3/s

6 RESULTS OF ANALYTICAL CALCULATIONS

6.1 CALCULATED LOSSES FOR 100 GPM FLOW RATE (SETUP 1.1 AND 1.2)

6.1.1 Setup 1.1 with 100 GPM (0.006309 m^3/s) Flow Rate (Table6.1.1)

Setup	1" Setup	2" Setup	3" Setup	4" Setup
AB (Friction Loss)	0.05203344	0.05203344	0.05203344	0.05203344
B (Bend Loss)	0.15327477	0.15327477	0.15327477	0.15327477
BU1 (Friction Loss)	0.168884801	0.168884801	0.168884801	0.168884801
U1(Union Loss)	0.174088145	0.174088145	0.174088145	0.174088145
U1C(Friction Loss)	0.179291489	0.179291489	0.179291489	0.179291489
CD(Expand/Reduce Loss)	3.145346077	0.364669899	0.188396071	0.185197318
DE(friction loss)	3.653485135	0.380548899	0.190487178	0.185693547
EF(Expand/Reduce Loss)	9.226923841	0.4445297	0.266418176	0.261624544
FU2(friction loss)	9.232127185	0.449733	0.27162152	0.266827888
U2(Union Loss)	9.237330529	0.454936344	0.276824864	0.272031232
U2G(Friction Loss)	9.252940561	0.470546376	0.292434896	0.287641264
G(Bend Loss)	9.354181891	0.571787706	0.393676226	0.388882594
GH(Friction Loss)	9.40621533	0.623821146	0.445709665	0.440916034

All values are in meters

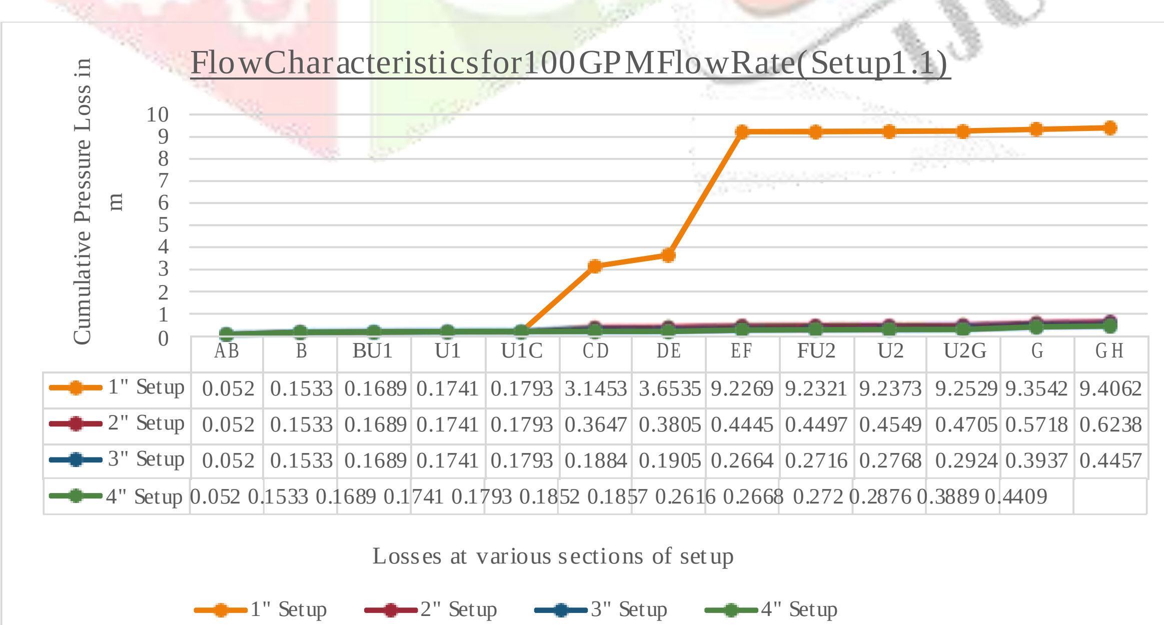


Figure 6.1.1 Graph of Setup 1.1 with 100 GPM Flow Rate Results

6.1.2 Setup 1.2 with 100 GPM (0.006309 m3/s) Flow Rate (Table6.1.2)

Setup	5" Setup	6" Setup	7" Setup	8" Setup
AB (Friction Loss)	0.020008303	0.020008303	0.020008303	0.020008303
B (Bend Loss)	0.121249633	0.121249633	0.121249633	0.121249633
BU1 (Friction Loss)	0.124625081	0.124625081	0.124625081	0.124625081
U1(Union Loss)	0.125750231	0.125750231	0.125750231	0.125750231
U1C(Friction Loss)	0.126875381	0.126875381	0.126875381	0.126875381
CD(Expand/Reduce Loss)	0.131621068	0.129164003	0.126959351	0.127118452
DE(friction loss)	0.131827547	0.129246982	0.126997743	0.127138143
EF(Expand/Reduce Loss)	0.13393428	0.129675979	0.12865934	0.12879974
FU2(friction loss)	0.135059429	0.130801129	0.129784489	0.12992489
U2(Union Loss)	0.136184579	0.131926278	0.130909639	0.13105004
U2G(Friction Loss)	0.139560027	0.135301727	0.134285087	0.134425488
G(Bend Loss)	0.240801357	0.236543057	0.235526417	0.235666818
GH(Friction Loss)	0.26080966	0.25655136	0.25553472	0.255675121

All values are in meters

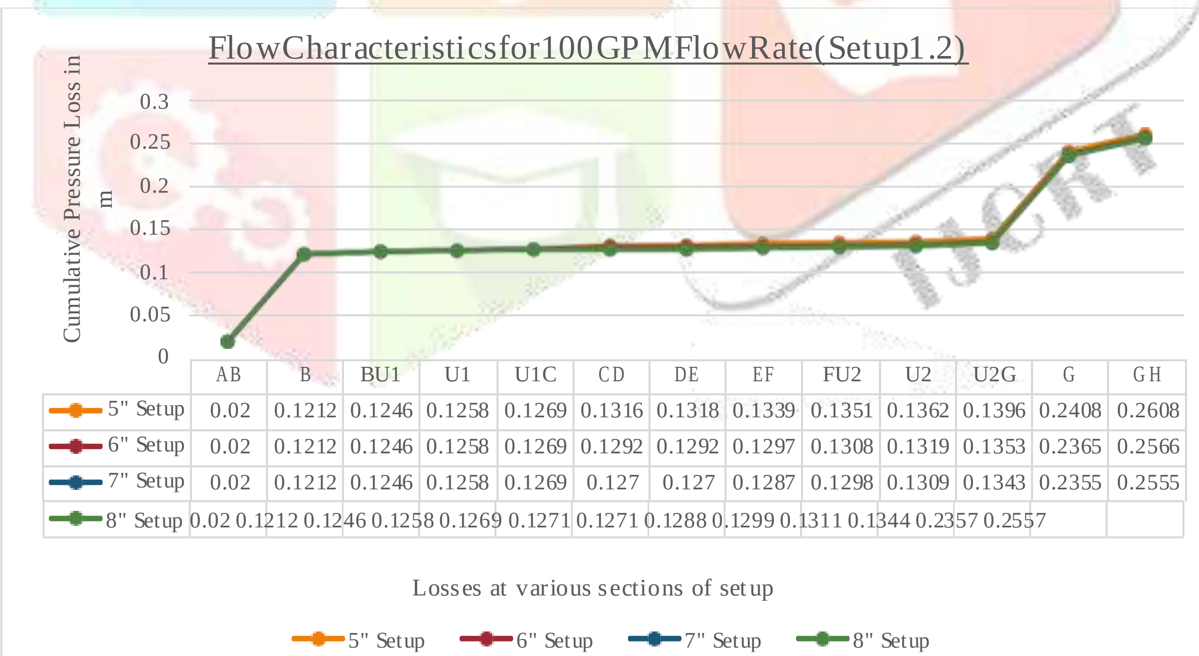


Figure 6.1.2 Graph of Setup 1.2 with 100 GPM Flow Rate Results

6.2 Calculated Losses for 500 GPM Flow Rate (Setup 1.1 and 1.2)

6.2.1 Setup 1.1 with 500 GPM (0.031545 m^3/s) Flow Rate (Table6.2.1)

Setup	1" Setup	2" Setup	3" Setup	4" Setup
AB (Friction Loss)	0.869921457	0.869921457	0.869921457	0.869921457
B (Bend Loss)	3.400954705	3.400954705	3.400954705	3.400954705
BU1 (Friction Loss)	3.661931142	3.661931142	3.661931142	3.661931142
U1(Union Loss)	3.748923288	3.748923288	3.748923288	3.748923288
U1C(Friction Loss)	3.835915433	3.835915433	3.835915433	3.835915433
CD(Expand/Reduce Loss)	77.98728011	4.021293843	3.845020015	3.841821253
DE(friction loss)	86.48260684	4.031913003	3.846418415	3.842153102
EF(Expand/Reduce Loss)	225.8185744	4.095893803	5.744693351	5.740428038
FU2(friction loss)	225.9055666	4.182885949	5.831685497	5.827420184
U2(Union Loss)	225.9925587	4.269878095	5.918677643	5.91441233
U2G(Friction Loss)	226.2535352	4.530854532	6.17965408	6.175388767
G(Bend Loss)	228.7845684	7.06188778	8.710687328	8.706422015
GH(Friction Loss)	229.6544899	7.931809237	9.580608785	9.576343472

All values are in meters

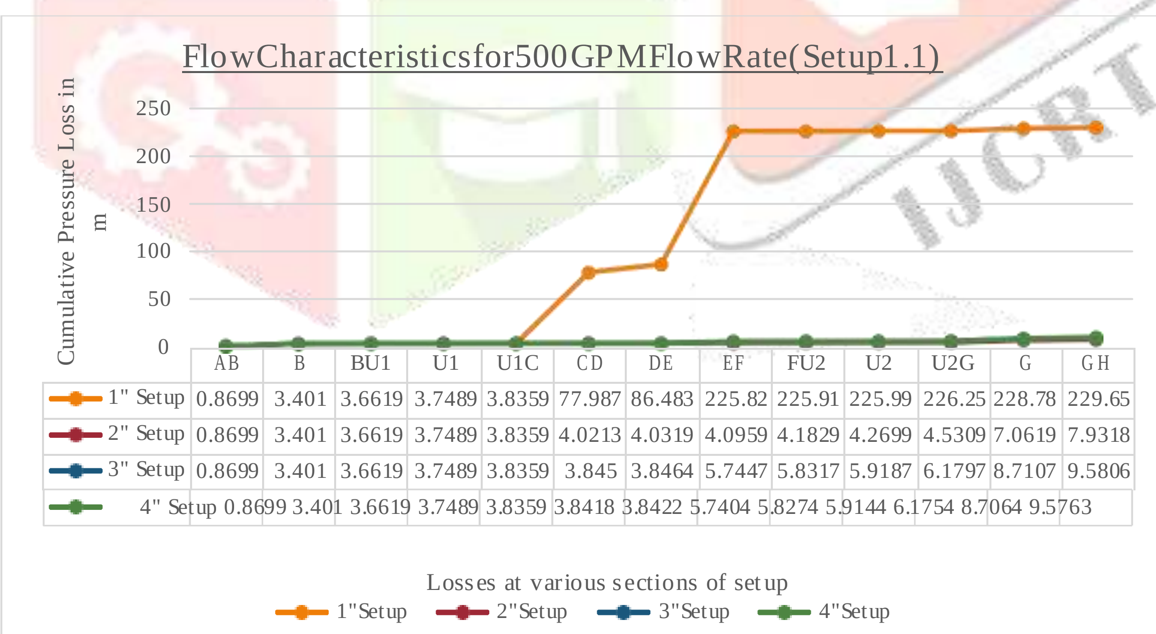


Figure 6.2.1 Graph of Setup 1.1 with 500 GPM Flow Rate Results

6.2.2 Setup 1.2 with 500 GPM (0.031545 m^3/s) Flow Rate (Table6.2.2)

Setup	5" Setup	6" Setup	7" Setup	8" Setup
AB (Friction Loss)	0.334508965	0.334508965	0.334508965	0.334508965
B (Bend Loss)	2.865542213	2.865542213	2.865542213	2.865542213
BU1 (Friction Loss)	2.965894902	2.965894902	2.965894902	2.965894902
U1(Union Loss)	2.999345798	2.999345798	2.999345798	2.999345798
U1C(Friction Loss)	3.032796695	3.032796695	3.032796695	3.032796695
CD(Expand/Reduce Loss)	3.037542385	3.035085317	3.034895957	3.038873479
DE(friction loss)	3.037680465	3.035140808	3.034921631	3.038886647
EF(Expand/Reduce Loss)	3.039787195	3.035569805	3.076461557	3.080426573
FU2(friction loss)	3.073238091	3.069020702	3.109912453	3.11387747
U2(Union Loss)	3.106688988	3.102471598	3.14336335	3.147328366
U2G(Friction Loss)	3.207041677	3.202824288	3.243716039	3.247681056
G(Bend Loss)	5.738074925	5.733857536	5.774749287	5.778714303
GH(Friction Loss)	6.07258389	6.0683665	6.109258252	6.113223268

All values are in meters

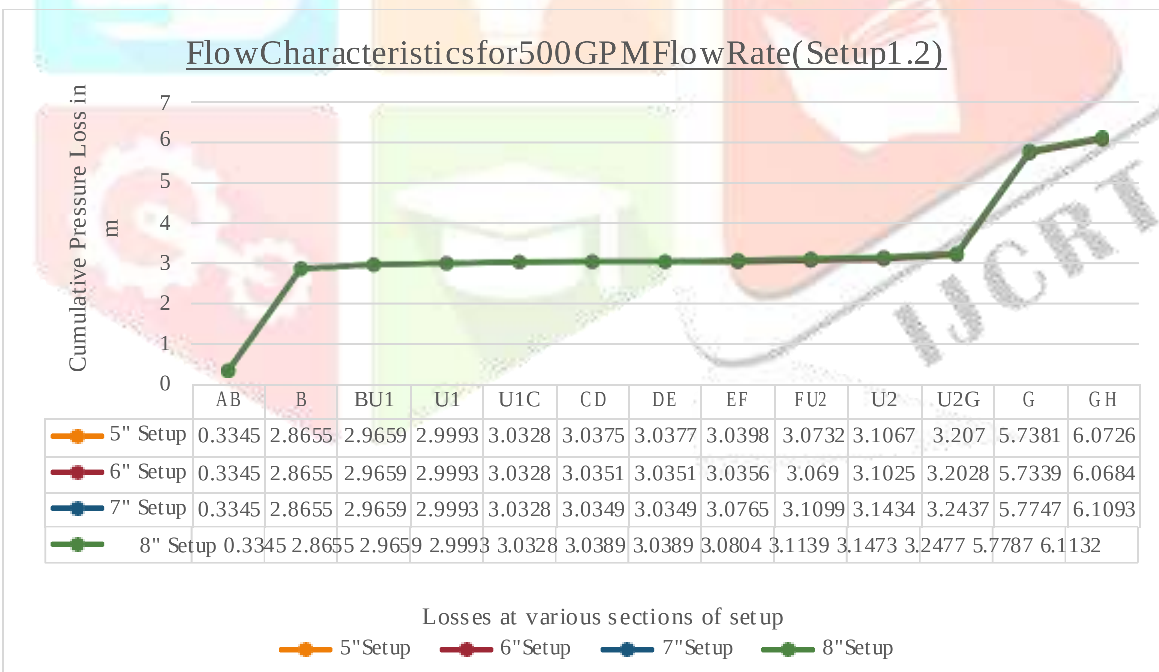


Figure 6.2.2 Graph of Setup 1.2 with 500 GPM Flow Rate Results

6.3 CALCULATEDLOSSESFOR1000GPMFLOWRATE(SETUP1.1AND1.2)

6.3.1 Setup 1.1 with 1000 GPM (0.06309 m3/s) Flow Rate (Table6.3.1)

Setup	1" Setup	2" Setup	3" Setup	4" Setup
AB (Friction Loss)	2.926055339	2.926055339	2.926055339	2.926055339
B (Bend Loss)	13.05018833	13.05018833	13.05018833	13.05018833
BU1 (Friction Loss)	13.92800493	13.92800493	13.92800493	13.92800493
U1(Union Loss)	14.22061047	14.22061047	14.22061047	14.22061047
U1C(Friction Loss)	14.513216	14.513216	14.513216	14.513216
CD(Expand/Reduce Loss)	311.1186747	14.69859441	14.52232058	14.51912183
DE(friction loss)	339.6934339	14.70752402	14.5234965	14.51940088
EF(Expand/Reduce Loss)	897.0373045	14.77150483	22.11659624	22.11250062
FU2(friction loss)	897.32991	15.06411036	22.40920178	22.40510616
U2(Union Loss)	897.6225155	15.35671589	22.70180731	22.69771169
U2G(Friction Loss)	898.5003321	16.23453249	23.57962391	23.57552829
G(Bend Loss)	908.6244651	26.35866549	33.7037569	33.69966128
GH(Friction Loss)	911.5505205	29.28472082	36.62981224	36.62571662

All values are in meters

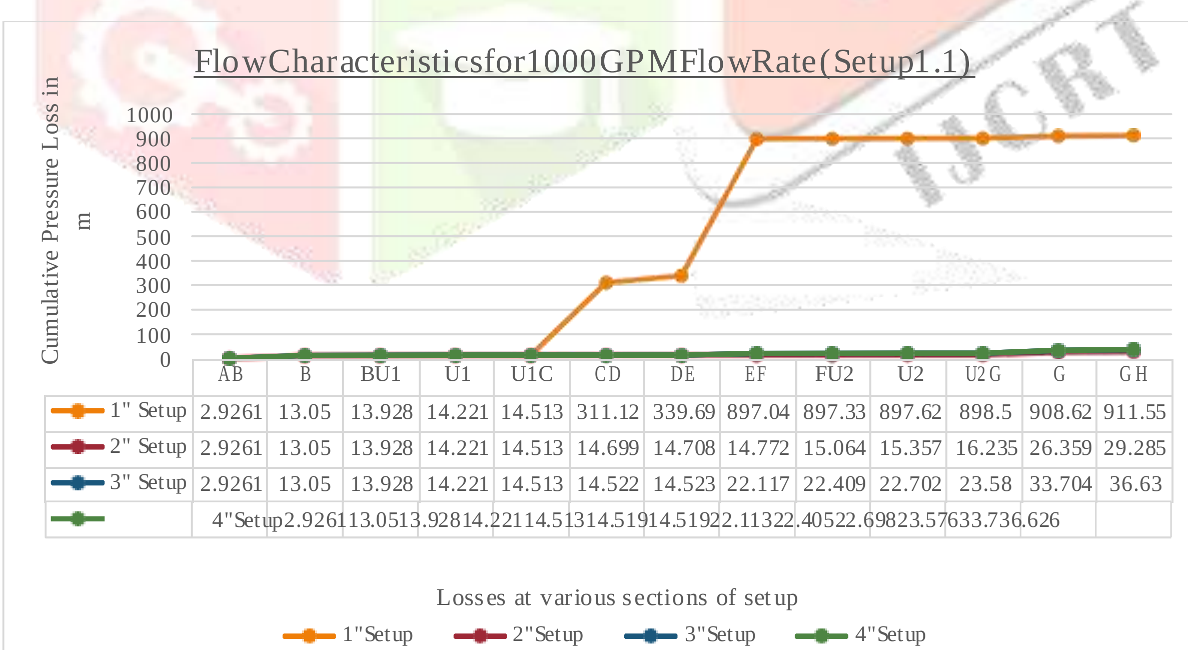


Figure 6.3.1 Graph of Setup 1.1 with 1000 GPM Flow Rate Results

6.3.2 Setup 1.2 with 1000 GPM (0.06309 m^3/s) Flow Rate (Table6.3.2)

Setup	5" Setup	6" Setup	7" Setup	8" Setup
AB (Friction Loss)	1.125149557	1.125149557	1.125149557	1.125149557
B (Bend Loss)	11.24928255	11.24928255	11.24928255	11.24928255
BU1 (Friction Loss)	11.58682742	11.58682742	11.58682742	11.58682742
U1(Union Loss)	11.69934237	11.69934237	11.69934237	11.69934237
U1C(Friction Loss)	11.81185733	11.81185733	11.81185733	11.81185733
CD(Expand/Reduce Loss)	11.81660301	11.81414595	11.82025437	11.83616446
DE(friction loss)	11.81671913	11.81419261	11.82027596	11.83617554
EF(Expand/Reduce Loss)	11.81882586	11.81462161	11.98643567	12.00233524
FU2(friction loss)	11.93134081	11.92713656	12.09895062	12.1148502
U2(Union Loss)	12.04385577	12.03965152	12.21146558	12.22736515
U2G(Friction Loss)	12.38140064	12.37719639	12.54901045	12.56491002
G(Bend Loss)	22.50553363	22.50132938	22.67314344	22.68904301
GH(Friction Loss)	23.63068319	23.62647894	23.798293	23.81419257

All values are in meters

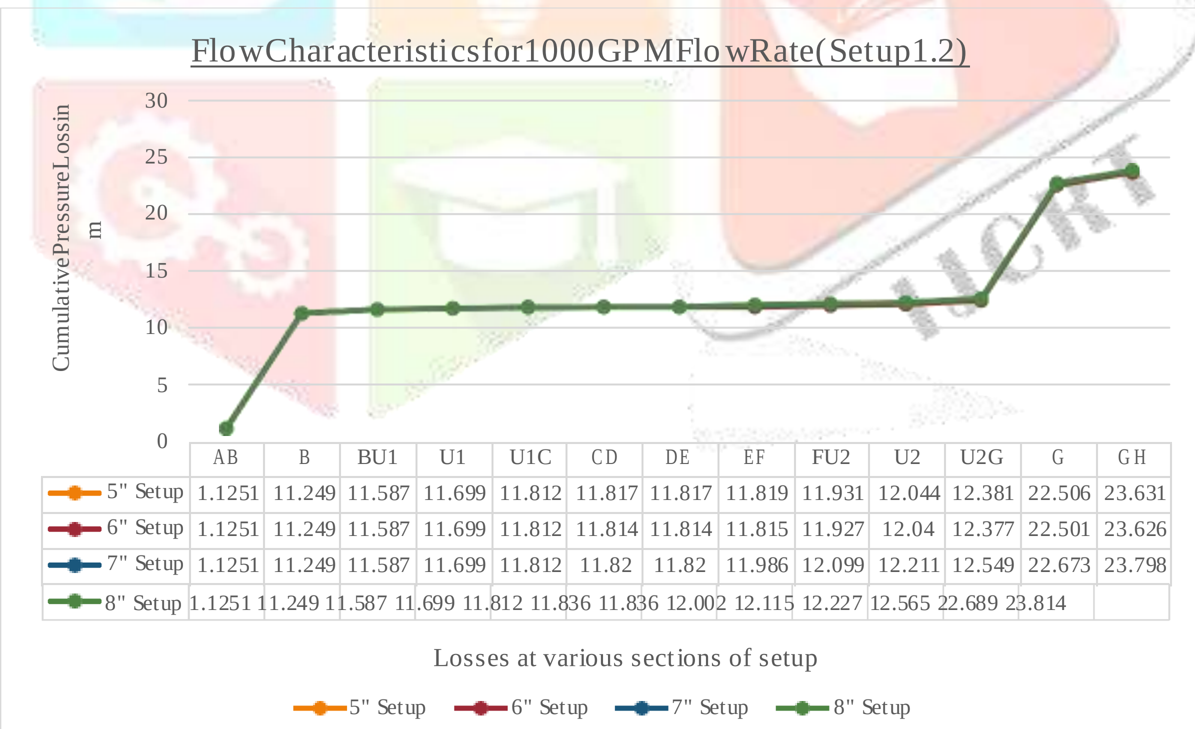


Figure 6.3.2 Graph of Setup 1.2 with 1000 GPM Flow Rate Result

6.4 SETUP HAVING COMBINE TESTING OF FOUR VALVES (SETUP 2.1 & SETUP 2.1)

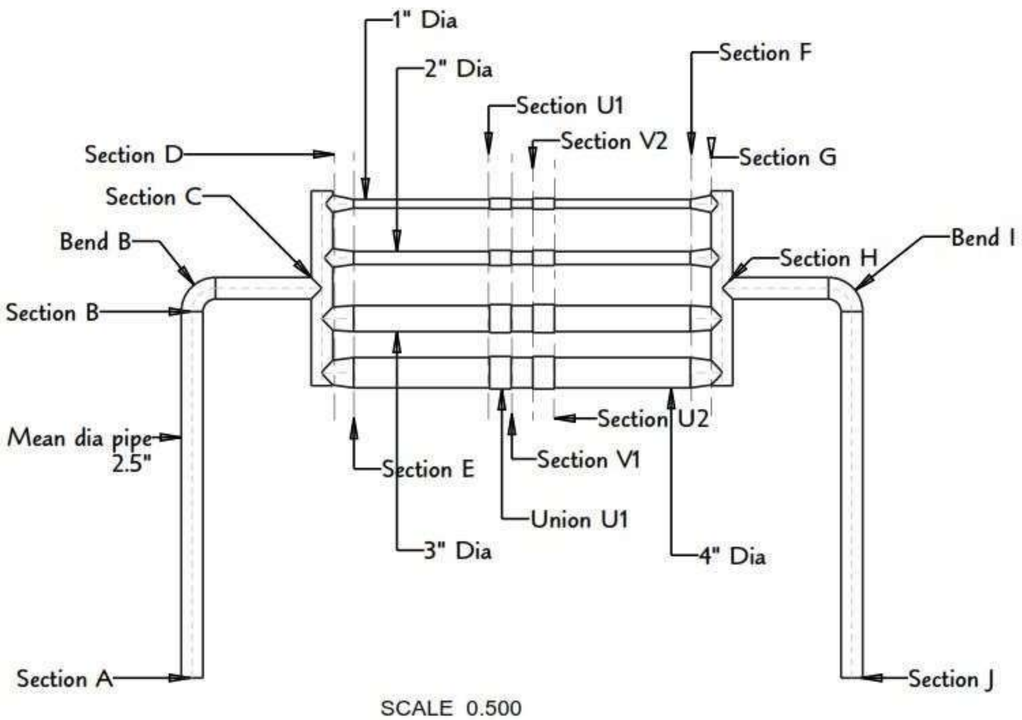


Figure 6.4 Setup 2.1 Sketch

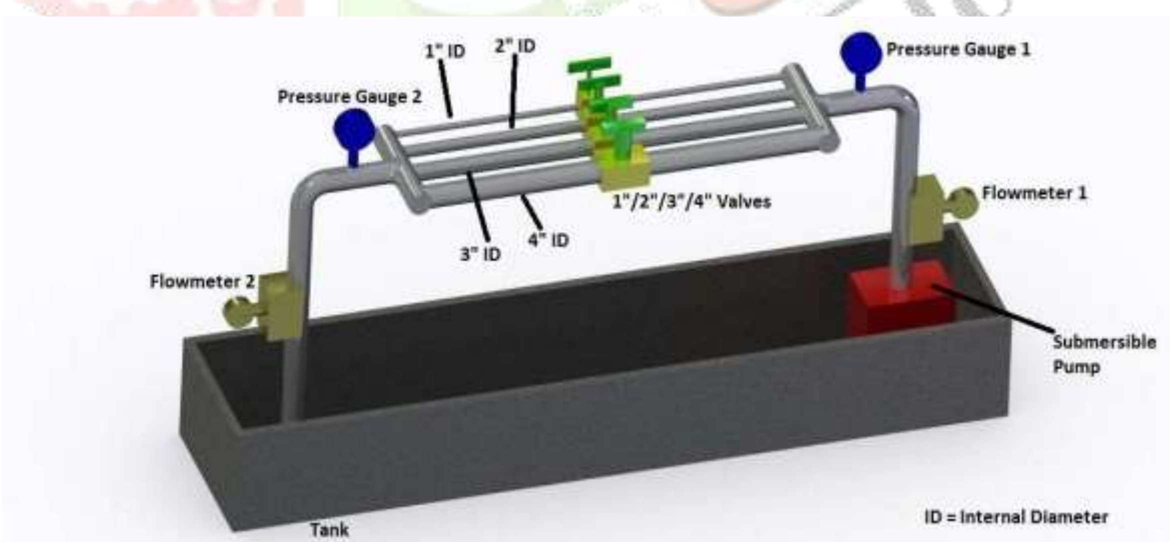


Figure 6.4 Setup 2.1 Model

6.4.1 Setup 1 with 100 GPM (0.006309 m3/s) Flow Rate (Table6.4.1)

Setup	1.1	1.2	1.3	1.4
AB	0.05203344	0.05203344	0.015610032	0.015610032
B	0.10124133	0.10124133	0.10124133	0.10124133
BC	0.015610032	0.015610032	0.005203344	0.005203344
C	0.10124133	0.10124133	0.10124133	0.10124133
CD	0.005203344	0.005203344	0.005203344	0.005203344
D	0.10124133	0.10124133	0.10124133	0.10124133
DE	3.480170716	0.21751067	0.00911682	0.01147300
EU1	2.540695294	0.079396728	0.002091107	0.002481148
U1V1	0.508139059	0.015879346	0.002091107	0.00049623
V1V2	0.508139059	0.015879346	0.002091107	0.00049623
V2U2	0.508139059	0.015879346	0.002091107	0.00049623
U2F	2.540695294	0.079396728	0.002091107	0.002481148
FG	5.580928311	0.064066779	0.08909237	0.08909237
G	0.10124133	0.10124133	0.10124133	0.10124133
GH	0.005203344	0.005203344	0.005203344	0.005203344
H	0.10124133	0.10124133	0.10124133	0.10124133
HI	0.015610032	0.015610032	0.015610032	0.015610032
I	0.10124133	0.10124133	0.10124133	0.10124133
IJ	0.05203344	0.05203344	0.05203344	0.05203344
Total Losses	16.4200484	1.241150552	0.814976238	0.813327874

All values are in meters

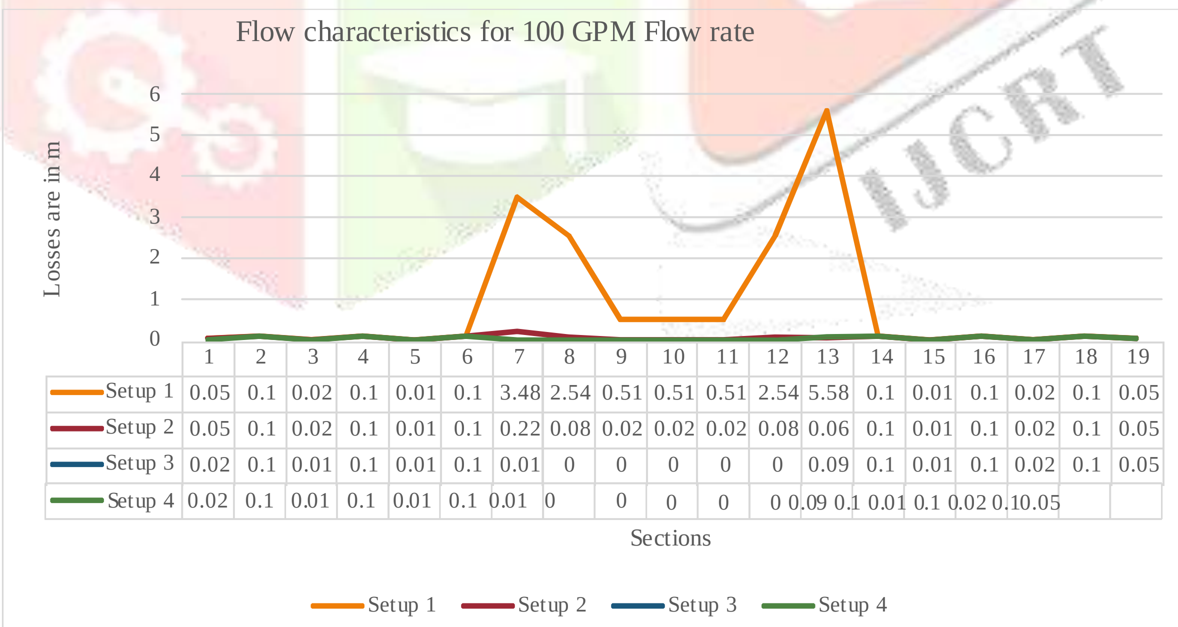


Figure 6.4.1 Graph of Setup 2.1 with 100 GPM Flow Rate Results

6.4.2 Setup 2 with 100 GPM (0.006309 m3/s) Flow Rate (Table6.4.2)

Setup	2.1	2.2	2.3	2.4
AB	0.000556108	0.000556108	0.000166832	0.000166832
B	0.002215463	0.002215463	0.002215463	0.002215463
BC	0.000166832	0.000166832	0.000144588	0.000144588
C	0.002215463	0.002215463	0.002215463	0.002215463
CD	0.000144588	0.000144588	0.000144588	0.000144588
D	0.002215463	0.002215463	0.002215463	0.002215463
DE	3.480170716	0.002685317	0.00007209	0.000223021
EU1	3.226234419	0.000414896	3.83916E-05	9.84569E-05
U1V1	0.645246884	8.29793E-05	3.83916E-05	1.96914E-05
V1V2	0.645246884	8.29793E-05	3.83916E-05	1.96914E-05
V2U2	0.645246884	8.29793E-05	3.83916E-05	1.96914E-05
U2F	3.226234419	0.000414896	3.83916E-05	9.84569E-05
FG	7.539496623	0.000133552	0.001949607	0.001949607
G	0.002215463	0.002215463	0.002215463	0.002215463
GH	0.000144588	0.000144588	0.000144588	0.000144588
H	0.002215463	0.002215463	0.002215463	0.002215463
HI	0.000166832	0.000166832	0.000166832	0.000166832
I	0.002215463	0.002215463	0.002215463	0.002215463
IJ	0.000556108	0.000556108	0.000556108	0.000556108
	19.42290466	0.018925433	0.016829966	0.01704493

All values are in meters

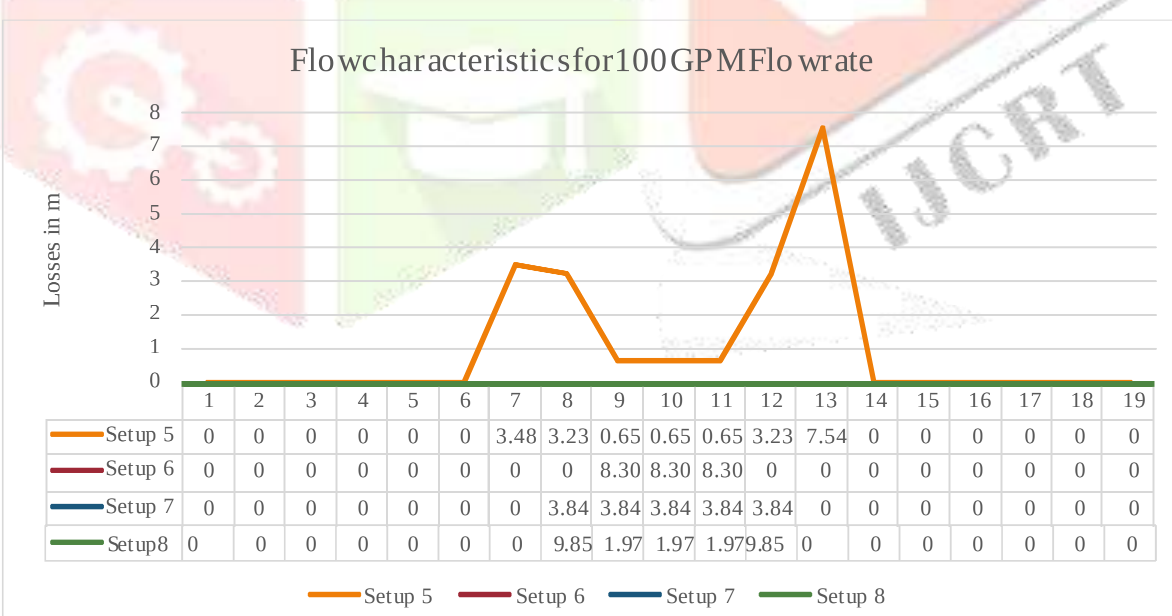


Figure 6.4.2 Graph of Setup 2.2 with 100 GPM Flow Rate Results

6.5 OVERALLPRESSURELOSSESFORSETUP1.1FORALLFLOWRATES(TABLE 6.5.1)

Flow rate/Setups	1" Setup	2" Setup	3" Setup	4" Setup
100 GPM	9.40621533	0.623821537	0.445709665	0.440916034
500 GPM	229.6544899	7.931809237	9.580608785	9.576343472
1000 GPM	911.5505205	29.28472082	36.62981224	36.62571662

All values are in meters

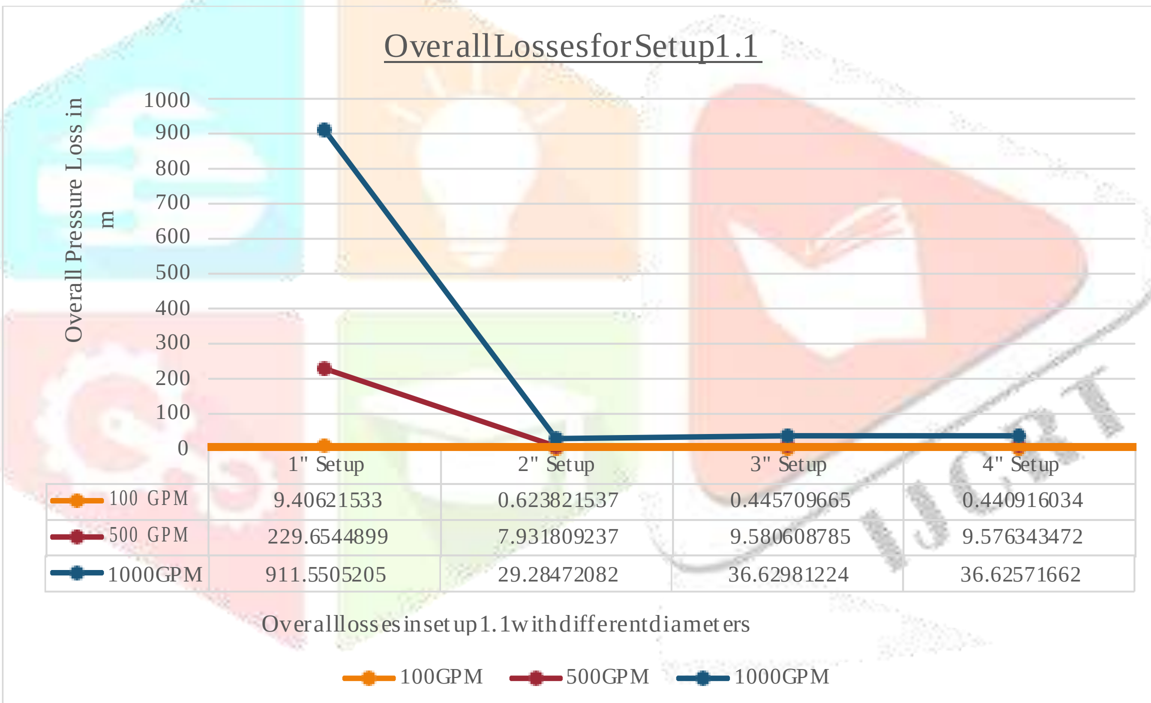


Figure 6.5.1 Graph of Setup 1.1 with overall loss

- Overall losses for setup 1.1 with 1” diameter valve is highest for all flow rates and losses for 1000 GPM is sohigh.
- Also the losses are considerably higher with 500 GPM flow rate in setup1.1.

6.6 OVERALL PRESSURE LOSSES FOR SETUP 1.2 FOR ALL FLOW RATES (TABLE 6.6.1)

Flow rate	5" Setup	6" Setup	7" Setup	8" Setup
100 GPM	0.26080966	0.25655136	0.25553472	0.255675121
500 GPM	6.07258389	6.0683665	6.109258252	6.113223268
1000 GPM	23.63068319	23.62647894	23.798293	23.81419257

All values are in meters

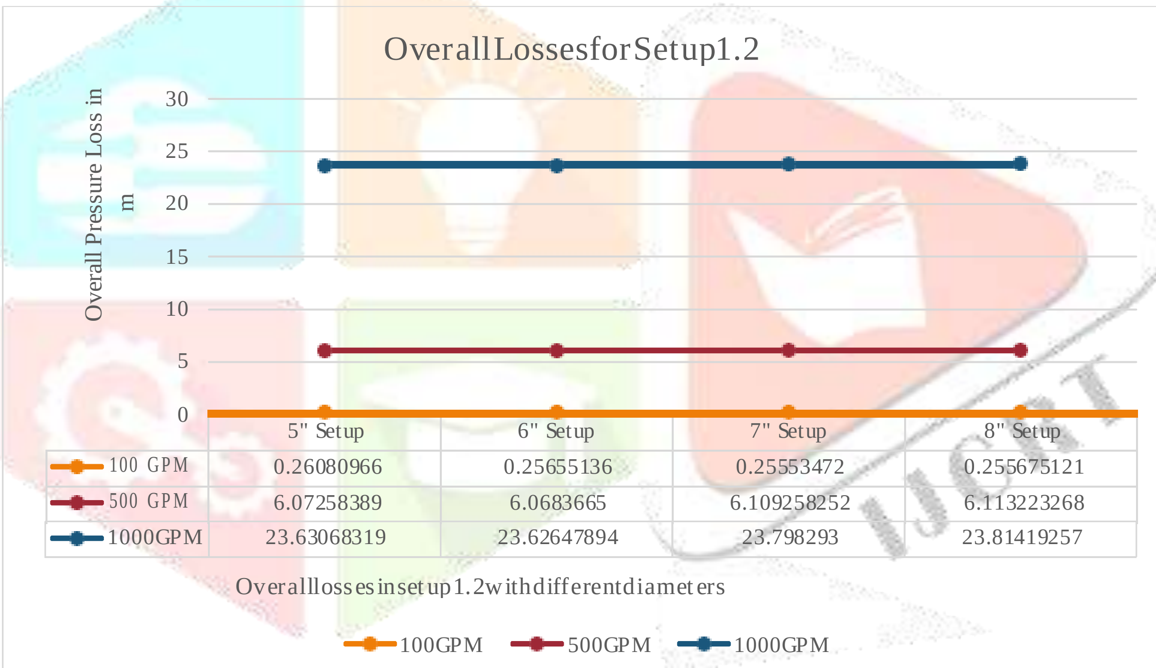


Figure 6.6.1 Graph of Setup 1.2 with overall loss

6.7 COMPARISONOFINDIVIDUALPIPESETUP(SETUP1)ANDFOURCOMBINE PIPE SETUP (SETUP2)

	Individual setup			
Flow rate/Setups	1" Setup	2" Setup	3" Setup	4" Setup
100 GPM	9.40621533	0.623821537	0.445709665	0.440916034
500 GPM	229.6544899	7.931809237	9.580608785	9.576343472
1000 GPM	911.5505205	29.28472082	36.62981224	36.62571662
	Combine setup			
100 GPM	16.4200484	1.241150552	0.814976238	0.813327874
500 GPM	354.5887027	18.04160607	19.08246837	19.08214655
1000 GPM	1346.519525	69.3354153	75.22853652	75.22864078

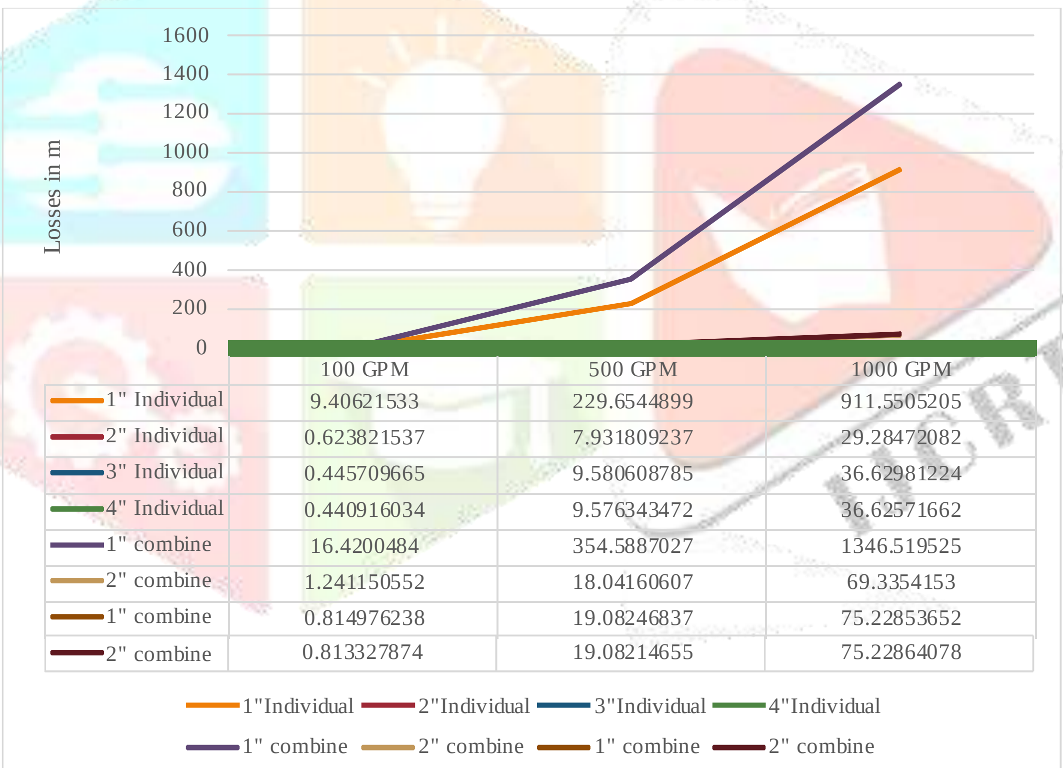


Figure 6.5.3: - Comparison between Setup 1 and Setup 2

- Herewithflowratesof100GPM,500GPMand1000GPM,theoveralllossesinsetup 1.2 with different diameters have similar pattern on graph apart from the change in value of losses which is lowest for 100 GPM flow rate and highest for 1000 GPM flow rate.

7 CFD SIMULATIONRESULTS

- Wehavesimulatedtheresultsforsetup1.1and1.2becausesetup2.1and 2.2 have considerably higher losses than setup 1.1 and 1.2 and hence their simulation is not required as they aren't recommended to use.

7.1 SIMULATIONMETHODOLOGY

- The first step in Simulation is to import a SATfile.
- After importing the geometry, we have to develop the mesh in which we have to give the inlet and outlet of the setup.
- Next comes the setup. In this we have to give all the input parameters like material of fluid, inlet velocity,etc.
- Then comes solution in which we have to give the number of iterations we wantandfurtherinitializethecalculationandfinallycalculatetheresults.
- Finally we have to get the final report, images and charts or graphs that we need.

7.2 MESHING:-

In order to analyze fluid flows, flow domains are split into smaller subdomains which made up of geometric primitives like hexahedral and tetrahedral in 3D and quadrilaterals and triangles in 2D. The subdomains are often called elements or cells, and the collection of all elements or cells is called a mesh orgrid.

The process of obtaining an appropriate mesh (or grid) is termed mesh generation (or grid generation), and has long been considered a bottleneck in the analysis process due to the lack of a fully automatic mesh generation procedure.

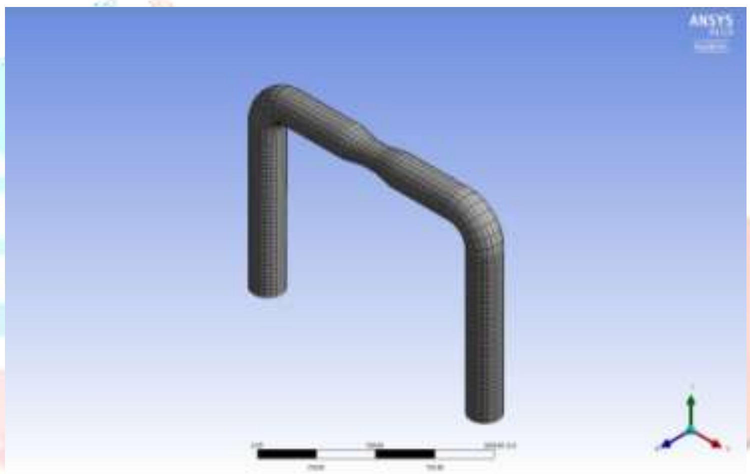


Figure 7.2.2 Meshing of Setup 1.

7.2.1 Mesh Specifications (Table 7.1)

Use Advanced Size Function	On: Curvature
Relevance Center	Coarse
Smoothing	Medium
Curvature Normal Angle	Default (18.0 °)
Min Size	Default (1.33260 m)
Max Size	Default (170.570 m)
Growth Rate	Default (1.20)
Minimum Edge Length	19.9490 m
Nodes	19062
Elements	15488

7.3 SIMULATION PARAMETERS

In CFD analysis, following criteria is considered for simulation:

3.6.1 Model Specifications:

- SimulationType : 3 – D, Steady
- SolverType : Pressure based
- GradientType : Green – Gauss Node based
- ViscousModel : Standard k – epsilon (2 – equations)

3.6.2 FluidSpecifications:

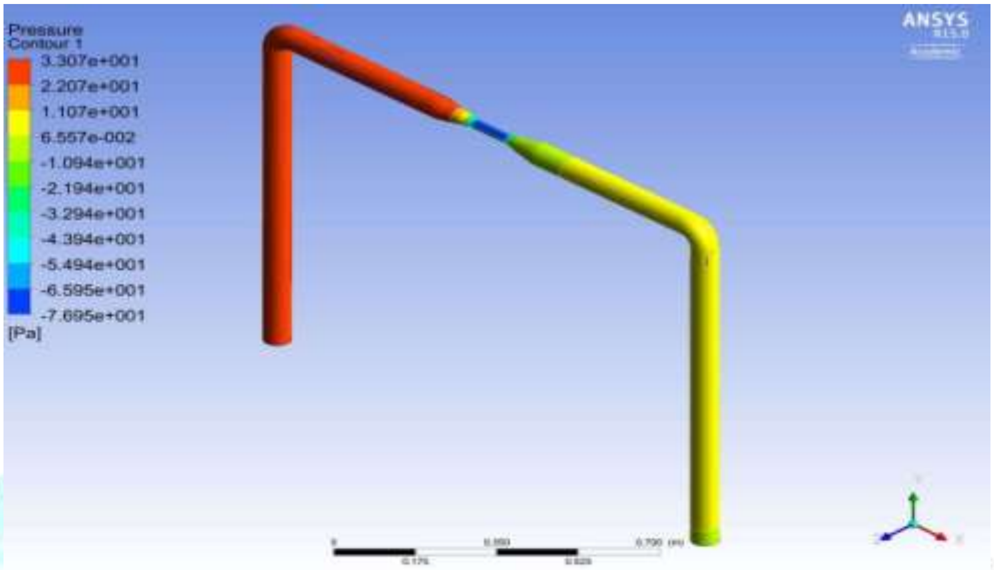
- Type : Water (Liquid)
- Density : 1000 Kg / m^3
- Sp.Heat(C_p) : 4.187 KJ / kg K
- DynamicViscosity : 0.0009 Kg / m s
- ThermalConductivity : 0.6 w / m K

3.6.3 Operating ParametersSpecifications:

- OperatingPressure : 14.50PSI
- OperatingTemperature : 303 K (30ºC)

7.4 For Valve Size1”

o Pressure Contour: -



Figures 7.1 Pressure Contour

- The above figure shows us the pressure contour on the wall of thepipe.
- As we can see that due to the high pressure in the pump, the fluid exerts high pressure on the inlet part right up to the reducer. Hence this part is shown reddish-orange.
- Then at the reducer the pressure decreases suddenly and it again increases after getting out of thevalve.
- Hence the pressure from the expander at the outlet of the valve to the outlet of the pipe is increased but it is less than that of the inlet section. This can beeasily seen from thegraph.

o Velocity Streamline: -

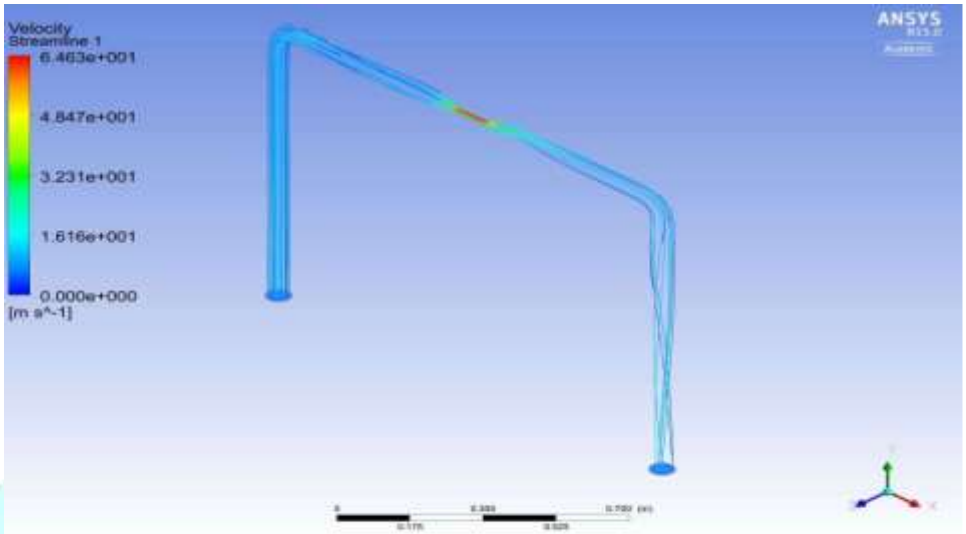


Figure: 7.1.1 Velocity Streamline

- Velocity at the inlet of the pipe is given as boundary condition and equal to 2 m/s.
- As we can see from the figure above that the velocity is almost constant in the inlet part up to thereducer.
- Then due to sudden decrease of cross sectional area, the velocity increases. In this case the reducer acts as a nozzle. Hence the velocity in the valve is maximum.
- Thisisshownbyreddish-orangestreamlinesinthebelowfigureofvelocity streamline.

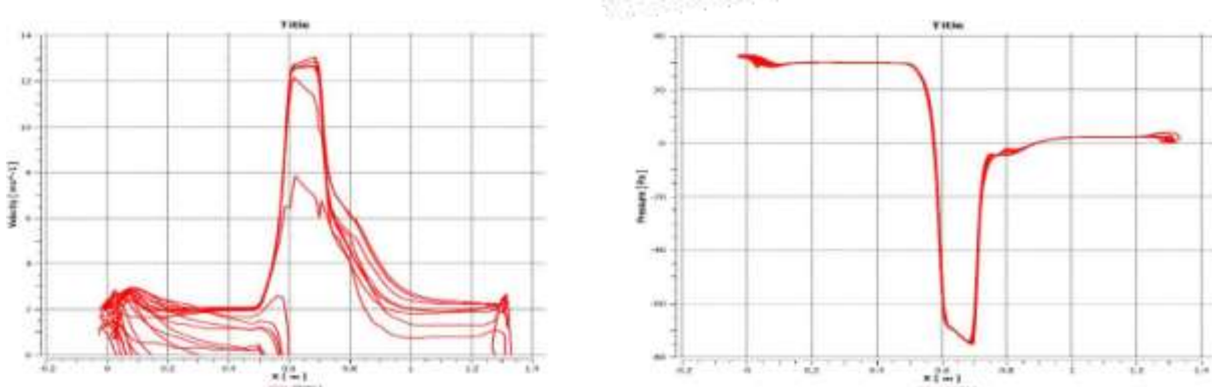


Figure 7.2: Simulated graph of Velocity and pressure

7.5 PRESSURECONTOURIMAGESFOROTHERSETUPS

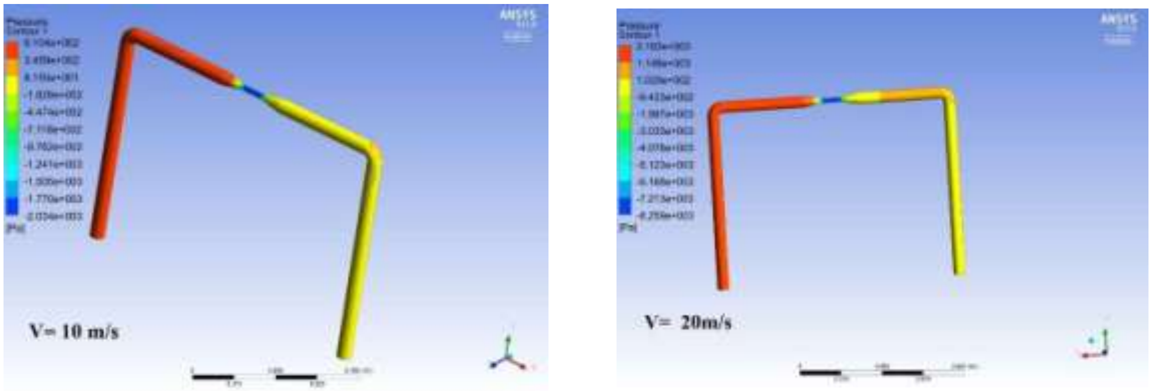


Figure 7.4.1 Pressure contour 1” Setup

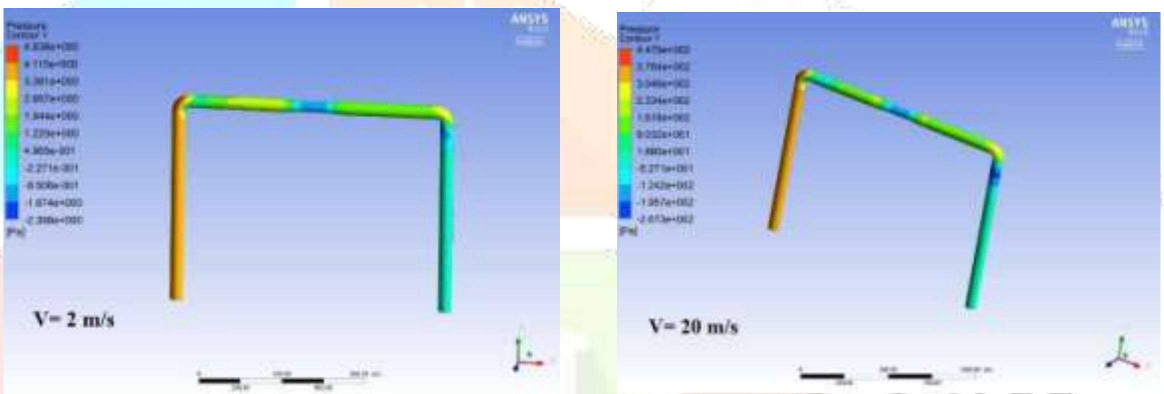


Figure 7.4.2 Pressure contour 2” Setup

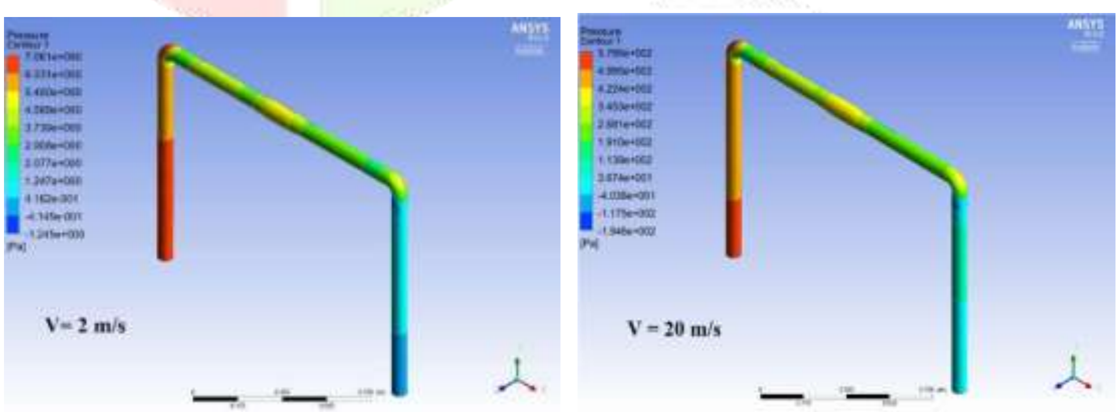


Figure 7.4.3 Pressure contour 3” Setup

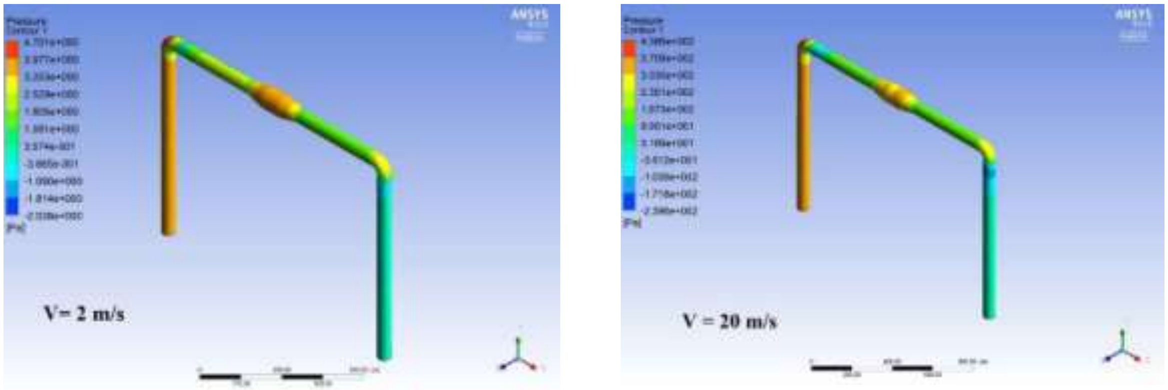


Figure 7.4.4 Pressure contour 4” Setup

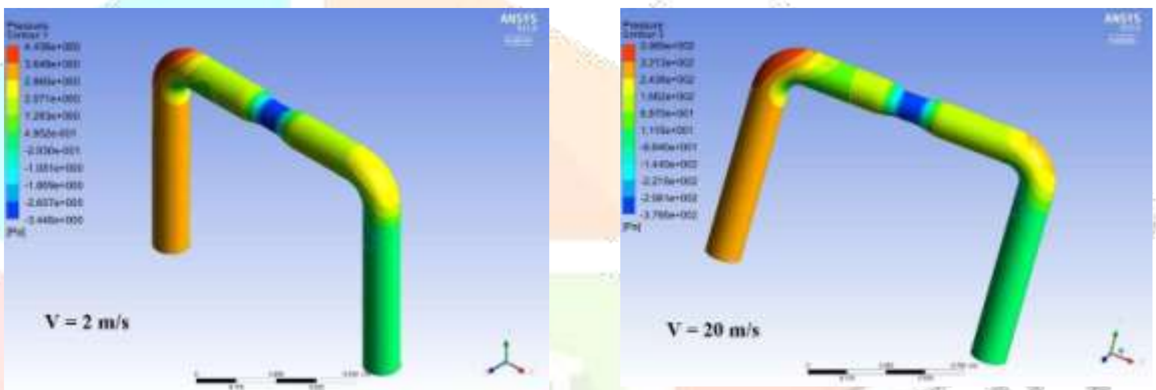


Figure 7.4.5 Pressure contour 5” Setup

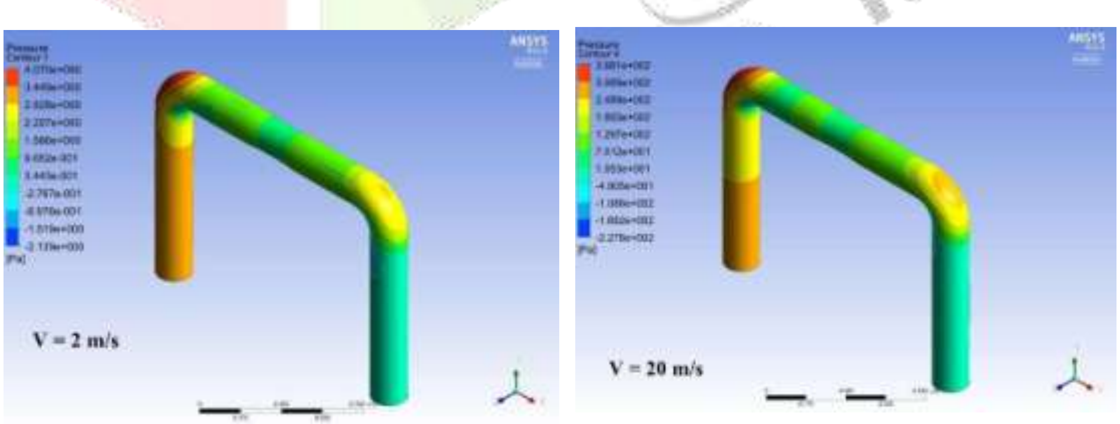


Figure 7.4.6 Pressure contour 6” Setup

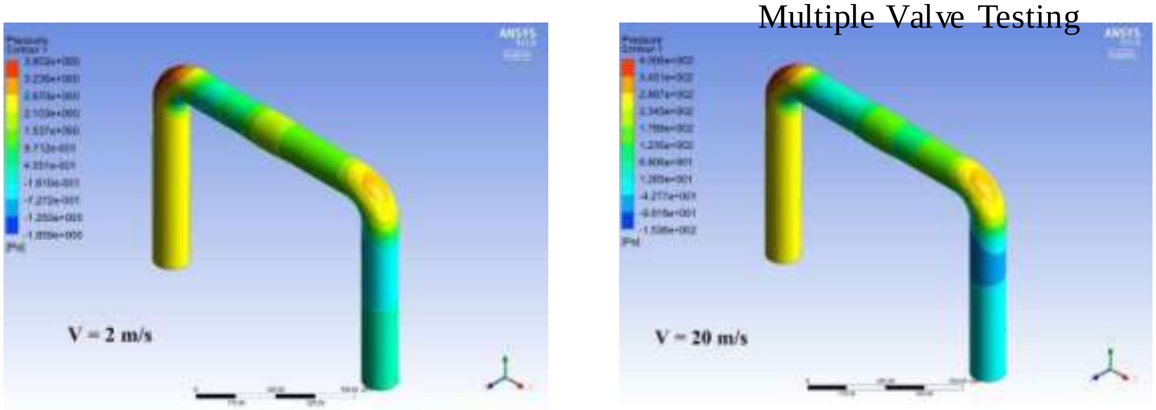


Figure 7.4.7 Pressure contour 7” Setup

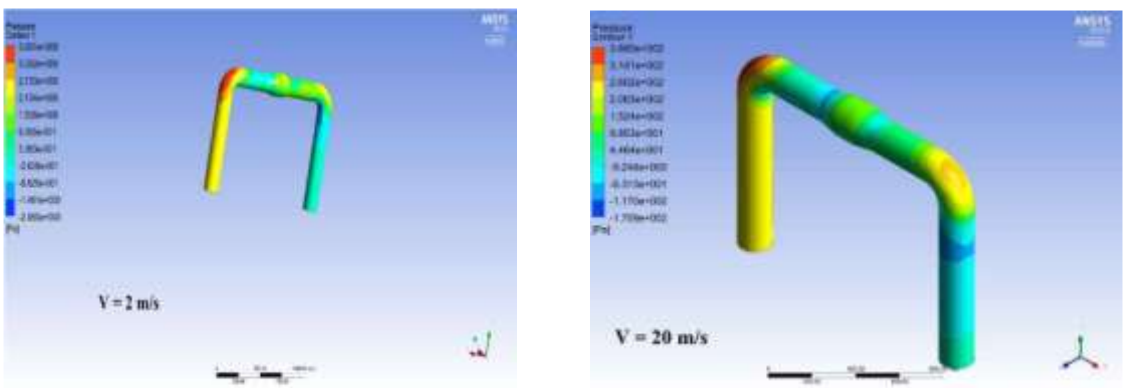


Figure 7.4.8 Pressure contour 8” Setup

8 COMPARISON

8.1Comparisonbetweenanalyticalandsimulatedvaluesfor100GPM

Setup	1.1		1.2		1.3		1.4	
	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated
AB	0.05203344	0.03307	0.05203344	0.03307	0.05203344	0.03307	0.05203344	0.03307
B	0.10124133	0.21367	0.10124133	0.21367	0.10124133	0.21367	0.10124133	0.21367
BU1	0.015610032	0.03145	0.015610032	0.03145	0.015610032	0.03145	0.015610032	0.03145
U1	0.005203344	0.003307	0.005203344	0.003307	0.005203344	0.003307	0.005203344	0.003307
U1C	0.005203344	0.003307	0.005203344	0.003307	0.005203344	0.003307	0.005203344	0.003307
CD	3.480170716	2.20715	0.21751067	0.2271	0.009104582	0.007061	0.011457608	0.01081
DE	0.508139059	1.094	0.015879346	0.122	0.002091107	0.004569	0.00049623	0.0003253
EF	5.573438706	4.394	0.063980801	0.04965	0.042965071	0.003739	0.013594417	0.01805
FU2	0.005203344	0.003307	0.005203344	0.005203344	0.005203344	0.003307	0.005203344	0.005203344
U2	0.005203344	0.003307	0.005203344	0.005203344	0.005203344	0.003307	0.005203344	0.005203344
U2G	0.015610032	0.03145	0.015610032	0.015610032	0.015610032	0.03145	0.015610032	0.015610032
G	0.10124133	0.21367	0.10124133	0.10124133	0.10124133	0.21367	0.10124133	0.10124133
GH	0.05203344	0.03307	0.05203344	0.05203344	0.05203344	0.03307	0.05203344	0.05203344
Total loss	9.920331459	8.264758	0.655953795	0.862845489	0.412743738	0.584977	0.384131233	0.493280789

Table 8.1.1 Comparison between analytical and simulated values for 100 GPM for setup 1

Setup	2.1		2.2		2.3		2.4	
	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated
AB	0.020012861	0.02071	0.020012861	0.02071	0.020012861	0.02071	0.020012861	0.02071
B	0.10124133	0.1283	0.10124133	0.1283	0.10124133	0.1283	0.10124133	0.1283
BU1	0.015610032	0.01078	0.015610032	0.01078	0.015610032	0.01078	0.015610032	0.01078
U1	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.00444
U1C	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.00444
CD	0.005568273	0.004952	0.002685317	0.002657	8.40E-05	8.05E-05	0.000511058	0.00059
DE	0.000206479	0.000293	8.30E-05	8.11E-05	3.84E-05	3.88E-05	1.97E-05	1.54E-05
EF	0.002106733	0.0020789	0.000133372	0.0001283	0.001449467	0.001443	0.001661597	0.00146
FU2	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.00444
U2	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.004436	0.005203344	0.00444
U2G	0.015610032	0.01078	0.015610032	0.01078	0.015610032	0.01078	0.015610032	0.01078
G	0.10124133	0.1283	0.10124133	0.1283	0.10124133	0.1283	0.10124133	0.1283
GH	0.020012861	0.02071	0.020012861	0.02071	0.020012861	0.02071	0.020012861	0.02071
Total loss	0.302423307	0.3446479	0.297443491	0.340190359	0.296113651	0.338886313	0.296734168	0.33939

Table 8.1.3 Comparison between analytical and simulated values for 100 GPM for setup 2

8.2Comparisonbetweenanalyticalandsimulatedvaluesfor500GPM

Setup	1.1		1.2		1.3		1.4	
	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated
AB	0.0093	0.00976	0.0093	0.00976	0.0093	0.00976	0.0093	0.00976
B	0.05539	0.05104	0.05539	0.05104	0.05539	0.05104	0.05539	0.05104
BU1	0.00279	0.00203	0.00279	0.00203	0.00279	0.00203	0.00279	0.00203
U1	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224
U1C	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224
CD	87.0043	81.5001	0.06713	0.06081	0.00156	0.00142	0.00557	0.00591
DE	10.7876	9.7692	0.00139	0.00184	0.00064	0.00073	0.00033	0.00032
EF	188.234	177.013	0.00333	0.0034	0.03624	0.03378	0.02124	0.02477
FU2	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224
U2	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224	0.00242	0.00224
U2G	0.00279	0.00203	0.00279	0.00203	0.00279	0.00203	0.00279	0.00203
G	0.05539	0.05104	0.05539	0.05104	0.05539	0.05104	0.05539	0.05104
GH	0.0093	0.00976	0.0093	0.00976	0.0093	0.00976	0.0093	0.00976
Total loss	286.171	268.416	0.21647	0.20069	0.18305	0.17057	0.17175	0.16564

Table 8.2.1 Comparison between analytical and simulated values for 500 GPM for setup 1

Setup	2.1		2.2		2.3		2.4	
	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated
AB	0.0093	0.00922	0.0093	0.00922	0.0093	0.00922	0.0093	0.00922
B	0.05539	0.05031	0.05539	0.05031	0.05539	0.05031	0.05539	0.05031
BU1	0.00279	0.00245	0.00279	0.00245	0.00279	0.00245	0.00279	0.00245
U1	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092
U1C	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092
CD	0.13921	0.14437	0.06713	0.06429	0.0021	0.00263	0.01278	0.01338
DE	0.00345	0.00339	0.00139	0.00111	0.00064	0.00067	0.00033	0.00031
EF	0.05267	0.05392	0.00333	0.00342	0.03624	0.03598	0.04154	0.04502
FU2	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092
U2	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092	0.00093	0.00092
U2G	0.00279	0.00245	0.00279	0.00245	0.00279	0.00245	0.00279	0.00245
G	0.05539	0.05031	0.05539	0.05031	0.05539	0.05031	0.05539	0.05031
GH	0.0093	0.00922	0.0093	0.00922	0.0093	0.00922	0.0093	0.00922
Total loss	0.33399	0.32933	0.21052	0.19647	0.17764	0.16693	0.19331	0.18636

Table 8.2.3 Comparison between analytical and simulated values for 500 GPM for setup 2

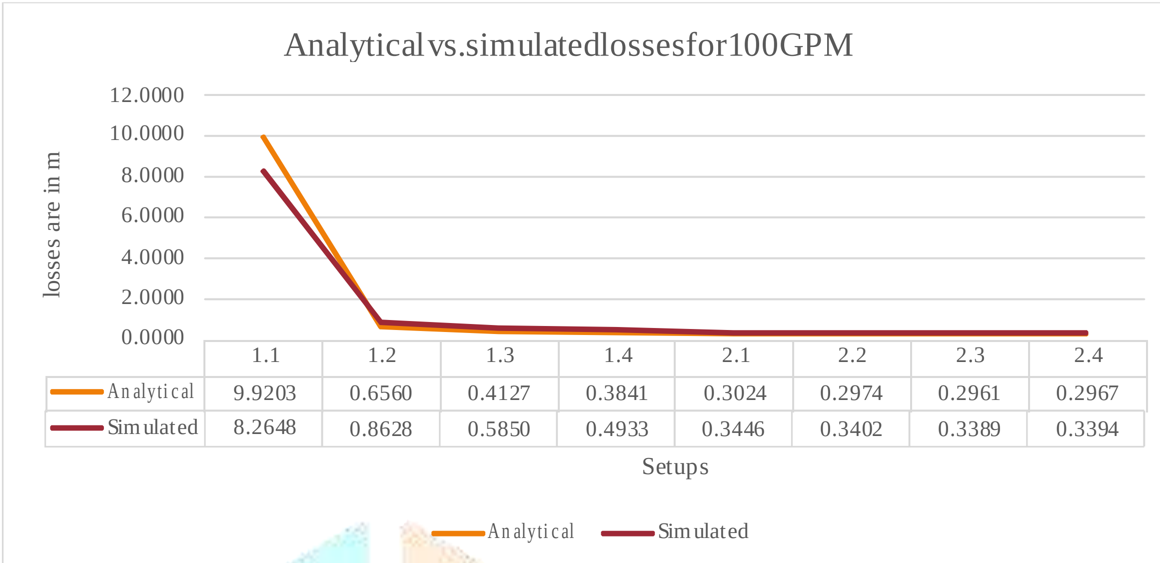
8.3Comparisonbetweenanalyticalandsimulatedvaluesfor1000GPM

Setup	1.1		1.2		1.3		1.4	
	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated
AB	0.03127	0.03033	0.03127	0.03033	0.03127	0.03033	0.03127	0.03033
B	0.22155	0.2193	0.22155	0.2193	0.22155	0.2193	0.22155	0.2193
BU1	0.00938	0.00942	0.00938	0.00942	0.00938	0.00942	0.00938	0.00942
U1	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826
U1C	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826
CD	348.017	342.33	0.26853	0.26734	0.00624	0.00677	0.02227	0.02396
DE	36.2849	30.3303	0.00467	0.00448	0.00216	0.00202	0.00111	0.00104
EF	752.938	721.332	0.01334	0.01245	0.14495	0.19101	0.08497	0.08595
FU2	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826
U2	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826	0.00813	0.00826
U2G	0.00938	0.00942	0.00938	0.00942	0.00938	0.00942	0.00938	0.00942
G	0.22155	0.2193	0.22155	0.2193	0.22155	0.2193	0.22155	0.2193
GH	0.03127	0.03033	0.03127	0.03033	0.03127	0.03033	0.03127	0.03033
Total loss	1137.8	1094.54	0.84346	0.83542	0.71027	0.75094	0.66527	0.6621

Table 8.3.1 Comparison between analytical and simulated values for 1000 GPM setup 1

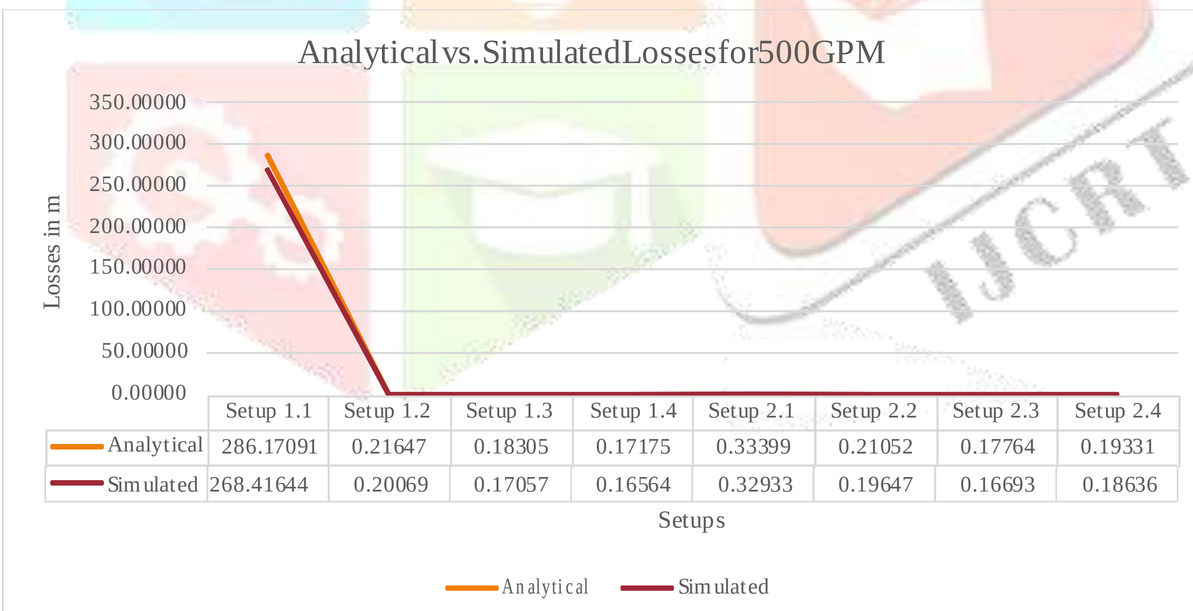
Setup	2.1		2.2		2.3		2.4	
	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated
AB	0.03127	0.03214	0.03127	0.03214	0.03127	0.03214	0.03127	0.03214
B	0.22155	0.2215	0.22155	0.2215	0.22155	0.2215	0.22155	0.2215
BU1	0.00938	0.00987	0.00938	0.00987	0.00938	0.00987	0.00938	0.00987
U1	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329
U1C	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329
CD	0.55683	0.56478	0.26853	0.2278	0.0084	0.00882	0.05111	0.05464
DE	0.01161	0.01441	0.00467	0.00491	0.00216	0.00234	0.00111	0.00117
EF	0.21067	0.2216	0.01334	0.01297	0.14495	0.1536	0.16616	0.1509
FU2	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329
U2	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329	0.00313	0.00329
U2G	0.00938	0.00987	0.00938	0.00987	0.00938	0.00987	0.00938	0.00987
G	0.22155	0.2215	0.22155	0.2215	0.22155	0.2215	0.22155	0.2215
GH	0.03127	0.03214	0.03127	0.03214	0.03127	0.03214	0.03127	0.03214
Total loss	1.31602	1.34097	0.82344	0.78586	0.69241	0.70495	0.75528	0.74689

Table 8.3.3 Comparison between analytical and simulated values for 1000 GPM setup 2



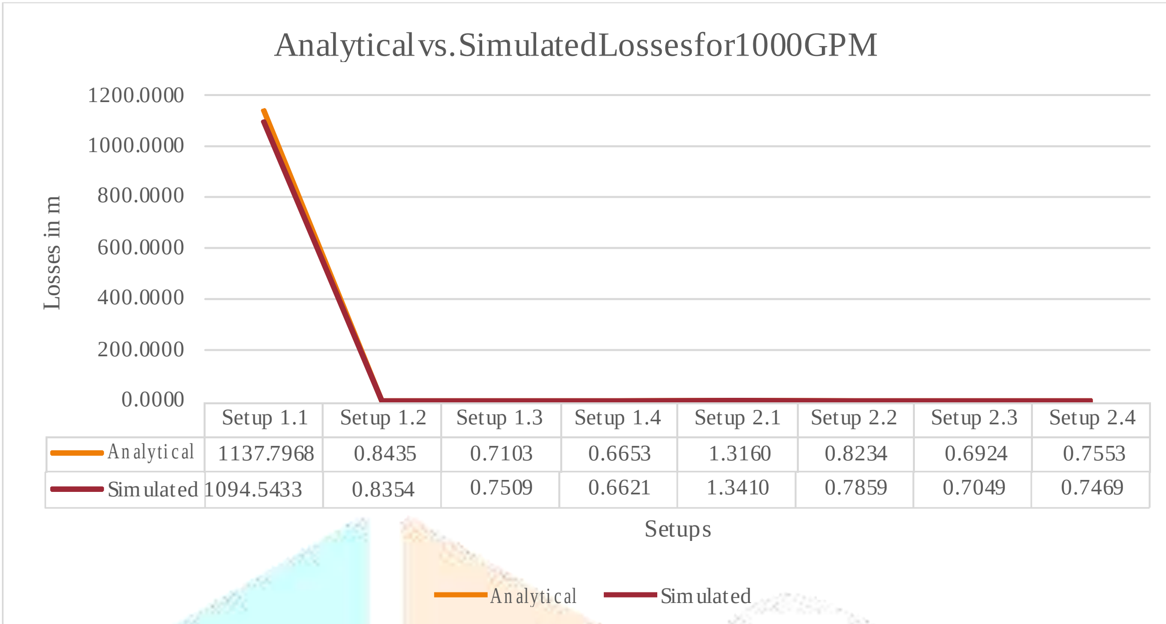
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4
Analytical	9.9203	0.6560	0.4127	0.3841	0.3024	0.2974	0.2961	0.2967
Simulated	8.2648	0.8628	0.5850	0.4933	0.3446	0.3402	0.3389	0.3394

Figure 8.1 Graph of Analytical vs.simulated losses for 100 GPM



	Setup 1.1	Setup 1.2	Setup 1.3	Setup 1.4	Setup 2.1	Setup 2.2	Setup 2.3	Setup 2.4
Analytical	286.17091	0.21647	0.18305	0.17175	0.33399	0.21052	0.17764	0.19331
Simulated	268.41644	0.20069	0.17057	0.16564	0.32933	0.19647	0.16693	0.18636

Figure 8.1 Graph of Analytical vs.simulated losses for 500 GPM



	Setup 1.1	Setup 1.2	Setup 1.3	Setup 1.4	Setup 2.1	Setup 2.2	Setup 2.3	Setup 2.4
Analytical	1137.7968	0.8435	0.7103	0.6653	1.3160	0.8234	0.6924	0.7553
Simulated	1094.5433	0.8354	0.7509	0.6621	1.3410	0.7859	0.7049	0.7469

Figure 8.1 Graph of Analytical vs.simulated losses for 1000 GPM

- As the graph of analytical and simulated overall losses follows the same trend for analytically calculated losses as well as for simulated losses and hence we can comment that both values for all setups are approximately similar

9 CPROGRAMINPUTS AND OUTPUT OF CPROGRAM

- The image below shows the output of C program which shows section wise losses along with overall total loss of the setup when input followingparameters.
- Diameter of valve ininch
- Equivalent diameter of pipe ininch
- Flowrate inGPM
- Density of fluid
- Kinematic viscosity offluid

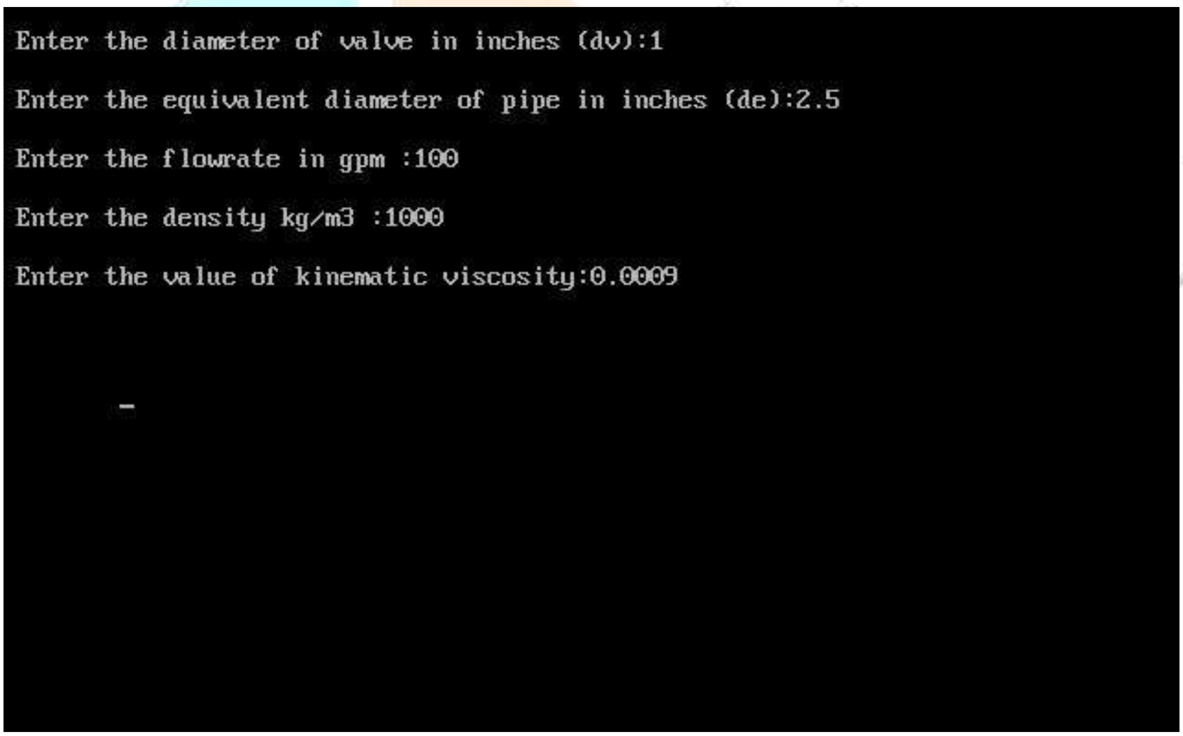


Figure 9.1: Input of C program

- Here as we enter the values for these parameters, the following output is obtained

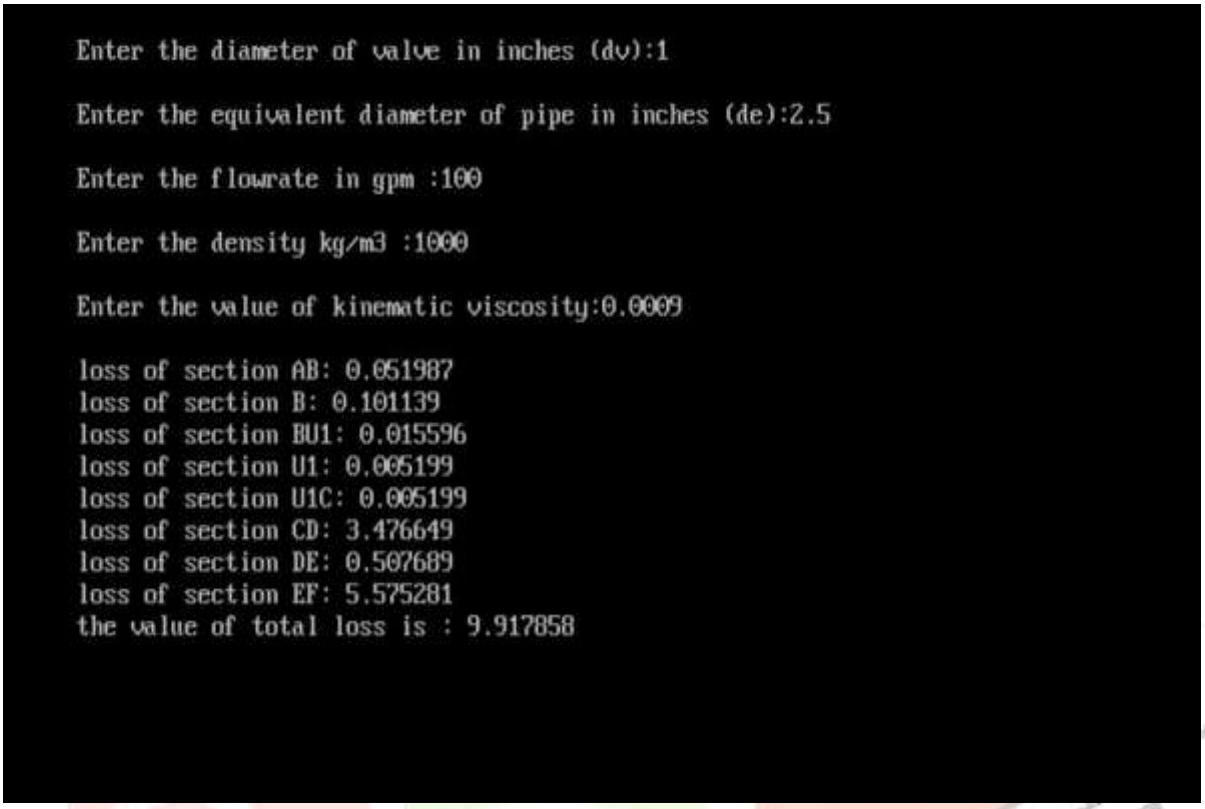


Figure 9.1: Output of C program

- As we can see the output is showing the values of losses at each sections and this way we can calculate sectional losses for various setups and various parameters.
- This way we can introduce flexibility with inputparameters.
- This program would help the company to obtain losses for their need specific test rigs with differentparameters.

10 APPENDIX

- The interactive excel sheet is made which contains various input parameters and section wise as well as overall losses for test rigsetups.
- If we change any of the input parameters in that sheet, the losses will alsochange accordingly.
- So, changing the parameters according to need will give the section wise and overall losses for particularsetup.
- Input parameters included hereare

1. Pipe diameter ininches
2. Flow rate inGPM
3. Density in Kg/m^3
4. Kinematic ViscosityNs/m^2
5. Equivalent pipe diameter ininches

- As we write the input parameters, we get the result table of various losses at various sections as shown in screen on excelsheet.
- All values of losses are inmeter.

11 CONCLUSION

Valve test rigs cannot be readily available in market for company specific valves. Rather it has to be designed and developed according to the need of company and according to the valves to be tested on test rig. Valve test rig being the essential part of the valve manufactures, thus it has to be designed properly to assure accurate testing of valves.

After determining the calculation results and plotting the graphs shown above, it has been observed that 1” valve diameter on setup 1 will have high losses with all three flow rates because we are using equivalent pipe of diameter 2.5” and sudden contraction or expansion between 1” and 2.5” diameters results into high pressure losses.

Among the three flow rates, the minimum losses occurs with the flow rate of 100 GPM (0.006309 m^3/s) in all setups with valve diameters from 1” to 8”.

The overall losses in Setup 2.1 and 2.2 with four pipes are higher than the setup 1.1 and 1.2 because of the more number of bends in setup 2.1 and 2.2.

Also the simulated and analytical results are almost same.

An interactive excel sheet has been created which allows us to calculate losses with desired flow rate.

Also a C program is created which gives overall as well as section wise losses with given input parameters.

12 FUTURESCOPE

- Due to the time constraints, we cannot develop the valve test rig setup and validate practical results with simulated and analyticalresults.
- In future, the new setups can be designed and tested with varying equivalentpipe diameters and different flowrates.
- Development and validation of same can be carriedout.

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