EVALUATION OF HYDRAULIC RESISTANCE IN FLUID TRANSPORTATION THROUGH PIPE NETWORK

[1]Sachin Kumar,[2]Er. Rahul Malik
[1] M.Tech (CAD) Student, [2]Head of Department (Mechanical Engineering)
[1]Mechanical Engineering Department,
[1]PM College of Engineering, Sonipat, Haryana, India

Abstract— The aim of this study is to evaluate the fluid properties at various cross-sections of pipe network, head loss and Frictional loss coefficient occurred due to fluid flow passing through pipe network having different cross-sections. Also, Assimilation of pipe sizes used to find minimum pressure losses in straight pipe. In this study we have compared our results with different diameters of pipelines to obtain optimum pipe diameter for minimum head loss.

Index Terms— Frictional loss, Head loss, Pressure losses.

I. INTRODUCTION (HEADING 1)

The term *Pipe, duct* and *conduit* are usually used interchangeably for flow sections. In general, flow sections of circular cross-section are referred to as pipes (especially when the fluid is a liquid) and flow sections of circular cross-section as ducts (especially when the fluid is a gas). Small diameter pipes are usually referred to as tubes. Piping system in a chemical plant is comparable to the vanes and arteries through which fluids, vapors, slurries, solids etc. flow under various conditions, as imposed by the process design of the plant piping network is subjected to almost all severest conditions of the plant such as high temperature, pressure, flow and combination of these. In addition to the above, corrosion, erosion, toxic conditions and radioactivity add to more problems and difficulties in piping design. With the process conditions becoming more and more severe by the advancement in process development, a continuous effort is required to be carried on simultaneously to cope up with the demands of process. This makes the job of piping engineer more complex and responsible. The first pipes were short and basic, to get oil from drill holes to nearby tanks or refineries. The rapid increase in demand for a useful product, in the early case kerosene, led to more wells and a greater need for transportation of the products to markets. In the 1860s as the pipeline business grew, quality control of pipe manufacturing became a reality and the quality and type of metal for pipes improved from wrought iron to steel. Technology continues to make better pipes of better steel, find better ways to install pipe in the ground, and continually analyze its condition once it is in the ground. At the same time, pipeline safety regulations have become more complete, driven by better understanding of materials available and better techniques to operate and maintain pipelines. They continue to play a major role in the petroleum industry providing safe, reliable and economical transportation. As the need for more energy increases and population growth continues to get further away from supply centers, pipelines are needed to continue to bring energy to you.

II. LITERATURE SURVEY

Graber (1982, 2006) gave an explanation of the flow that flows in symmetric expansion is asymmetric. He proposed a predictive method which satisfies the experimental results. Graber extended it theoretically to analyze it further. Asymmetric flow outlines may occur in symmetric expansions in which main flow diverts and attaches to one side wall of expansion. Resulting adverse effect include increasing the vortices at pump inlet insufficient operation of screens. **G. Zhou (1995)** developed mathematical model (depth average mathematical model) and undertake testing this model in canal with sudden expansion. He analyzed that the flow lines, flow rate and vortex formed on both side are identical. **Souhar and Aloui (2000)** represented an experimental study of recalculating flow downstream of a sudden expansion. An observation of this study shows that the RMS and average quantities of the axial velocity and pressure are asymmetric of flow behind sudden expansion in 2 Dimensional cases. **P. Oliveira et.al (2002)** presented an experimental study of turbulent flow through plane sudden expansion. Results not only shows that the flow to be strongly asymmetric, but also integration of average axial velocity profiles exposed considerable departure from 2 Dimensionality along with center plane of sudden expansion. **Sneharnoy Majumder et al. (2010)** gave a numerical analysis of turbulent fluid flow by RANS method through axis-y metric sudden expansion. Observation of this study shows that the recirculation bubbles are generated. The sizes of recirculation bubbles are generated. The size of recirculation bubbles increases with increase in expansion ratio. While initially the reattachment length increases with increase in Reynolds number. Also strength of recirculation bubble increases with expansion ratio at constant Reynolds number. **S.K.M.Pasha et al. (2013)** Under title comparison of flow analysis of a sudden and gradual change of pipe diameter using fluent software. The researchers use analytical approach to analyze the regime of pipe a section are mostly prone to damage and tries to analyze behavior of flow across different geometries. Results are related to pressure and velocity counters across pipeline in which water is act as a working medium on sudden expansion are large at enlarge area of pipe begins also expansion creates more severe eddies in flow than contraction. In sudden contraction at pointy of contraction vane contracta's are formed. Pressure drop increases with higher incoming velocities, results in increase in mass flow rate. This point is more prone for pipe damage. Therefore to increase the life of pipe network the corners of expansion and contraction should be rounded to minimize losses in pipes. **Sachin Kumar et al. (2017)** Under title *Assimilation of Hydraulic Resistance through Pipe Network*. The researchers use analytical approach to analyze the hydraulic losses across various cross-sections of pipeline. the flow characteristics are investigated for various cross-sections of pipelines. The study has been provided detailed numerical results for various cross-sections of pipes. The major observations made related to pressure head and velocity in the process flow through these pipes.

III. DETAILED PROCEDURE

In present section hydraulic resistance of pipeline for all four cases is obtained by using experimental approach. List of equipments used to conduct experiments is listed below:-

(a) Pipelines made of galvanized iron having 1.5m each with four different cross-sectional areas having diameters of 0.0127, 0.01905, 0.0254 and 0.03175 m.

(b) Four isolating valves fitted in Pipelines having diameters of 0.0127, 0.01905, 0.0254 and 0.03175 m.

(c) Eight isolating valves fitted in branch pipe (hoses) at inlet and outlet of sections of pipelines used to isolate pipelines with Piezometer.

(d) Pump having discharge capacity of $0.0003727 m^3/s$, used to supply water to all sections of pipelines.

(e) Water Tank having adequate volume of water, which is open to atmosphere, pump takes suction from water tank and discharge goes back to the same water tank.

Figure 1: Experimental Setup

Setup consists of four pipelines of 1.5 m of length having different cross-sections connected in parallel. Left limb and right limb of Piezometer, which is small diameter hose along with isolating valves used to measure the hydraulic head of water, having a common header. Inlet of Pipelines is connected with left limb and outlet of pipelines with right limb of Piezometer with the help of small diameter hose into the header. Each pipeline has isolating valve to isolate flow across pipe section. Suction and Discharge tank which is open to atmosphere. A centrifugal pump having discharge capacity of $0.0003727 m^3/s$ is fitted at the outlet of water tank which is used to supply water in all four sections of pipelines.

Step by step operating procedure is explained below:-

Step 1:- Fill water tank with water of adequate volume so the pump should not dry run. Close.

Step 2:- Open isolating valve in line of pipeline having different diameters also open isolating valves connected with hoses so that water can go into left and right limb of Piezometer.

Step 3:-Start the motor so that pump can discharge water at specified flow rate through pipe sections.

Step 4:- Read the initial readings from left and right limb of Piezometer. Keep running he setup for few minutes to read the final readings from left and right limb of Piezometer. Now these readings can be used to determine hydraulic resistance across pipe line. Differential head Δh can be obtained by subtracting hydraulic head of water at outlet section of pipeline from hydraulic head of water at inlet section of pipeline.

Step 5:- Determine the velocity of flow across pipeline by using the formula mentioned below:-

$$V = \sqrt{2gh} \quad (1)$$

Where, h can be obtained by using relation

$$h = \Delta h\left(\frac{Sm}{Sw} - 1\right) \quad (2)$$

Where Sm is specific gravity of mercury = 13.6

Sw is specific gravity of water = 1

Putting the value of h in equation (1) to obtain valve of velocity of flow inside pipe line

Step 6:- Determination of Hydraulic Resistance in terms of head loss

Hydraulic Resistance can be formulated as

$$h_L = f\,\frac{L\ V^2}{2Dg} \quad (3)$$

Where f is Drachy – Weishbach friction factor can be used from observation table used in theoretical method

IV. Results and Conclusion

Initial data and Assumptions Let us consider Fresh water is flowing through a straight pipe having four different cross-sectional areas viz. 0.0127m, 0.01905m, 0.0254m, 0.03175m of length 1.5 m, is made up of Galvanized iron. The Flow rate across pipelines is 'Q' is 0.04333m3/s. Further consider water is at 25^0C

Major Observations are shown in Table 1:

TABLE I
OBSERVATION TABLE

	Diameter, m	**Velocity of flow inside pipe, m/s**	**Hydraulic Resistance of pipeline, meters of water column**
Case 1	0.0127	3.1446	**2.46378**
Case 2	0.01905	1.9256	**0.5566**
Case 3	0.0254	1.1118	**0.13228**
Case 4	0.03175	0.86118	**0.062053**

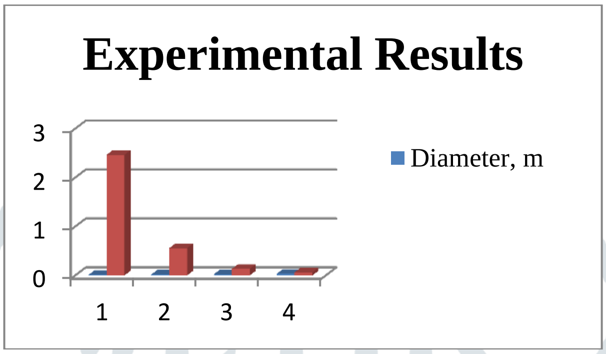

Figure 2: Graphical Representation of Experimental Result

In the present work, the flow characteristics are investigated for various cross-sections of pipelines. The study has been provided detailed numerical results for various cross-sections of pipes. The major observations made related to pressure head and velocity in the process flow through these pipes. From result tabulated above it is observed that the pressure drop or hydraulic resistance, velocity inside the pipeline is higher as the diameter of pipeline decreases. Also Drachy – Weishbach friction factor decreases as diameter of pipeline increases. Also the material selection is critical for obtaining the lesser value of Hydraulic Resistance. Therefore, it can be concluded that pipe size taken in case 4 for a specified flow rate is considered more suitable.

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