Assimilation of Hydraulic Resistance through Pipe Network

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***Abstract* — The aim of this study is to analyze the flow properties at various cross-sections of pipelines, Frictional loss coefficient and head loss occurred due to flow passing through various cross-sections of pipe and to study feasibility of pipe sizes used to find minimum head loss 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* — Straight Pipe, Head Loss, Frictional loss Coefficient.**

I. INTRODUCTION

About two decades ago, in India, the design of piping systems for Petrochemicals, Refineries, and Fertilizers Plants, in depth, magnitude and complexities were not fully developed. Now we are self sufficient in the field of piping technology. Piping system in a Power plant is comparable to the vanes and arteries through which Steam, fluids, vapors etc. flow under different conditions, as obligatory by the process design of the plant piping network is subjected to all different conditions of the plant such as high pressure, temperature, flow and combination of these. Also, erosion, corrosion, radioactivity and toxic conditions add to more difficulties in piping network design. With the process conditions becoming difficult by the improvement in process development, a uninterrupted effort is required to be carried on simultaneously to compensate with the requirement of process. This makes the job of piping engineer more responsible and complex.

While iron pipe for other uses in the U.S. dates back to the 1830s, the use of pipe for oil transportation started soon after the drilling of the first commercial oil well in 1859 by "Colonel" Edwin Drake in Titusville, Pennsylvania. 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. Early transport by teamster wagon, wooden pipes, and rail rapidly led to the development of better and longer pipes and pipelines. 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. From the early days of wooden trenches and wooden barrels, the pipeline industry has grown and employed the latest technology in pipeline operations and maintenance. Today, the industry uses sophisticated controls and computer systems, advanced pipe materials, and corrosion prevention techniques.

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.

III. DETAILED PROCEDURE

When fluid flows in a pipe, the fluid experiences some resistances Losses can occur in many forms. Commonly, losses are determined in terms of head loss. in fluid dynamics, head is determine as difference in elevation between two points in a column of fluid and resulting pressure of fluid at lower point. One can say head is lost if energy of the fluid flow is decreases due to turbulence. Head loss can be classified into two forms namely major losses and minor losses.

Major losses generally include the pressure drop and head loss. A quantity of interest in the analysis of pipe flow is the pressure drop since it is directly related to power requirements of pump or fan to maintain the flow requirement.

For Laminar Flow the pressure drop can be calculated by using equation given below

$$\Delta p = \frac{32\mu LV}{D^2} \quad (1)$$

For all types of fully developed internal flows (circular or non circular pipes, laminar or turbulent flow, horizontal or inclined pipes, smooth or rough surface) pressure loss can be calculated by using equation below

$$\Delta P_L = f\,\frac{L\,\rho\,V^2}{2D} \quad (2)$$

Where, $\rho\,V^2/2$ is the dynamic pressure and f is **Drachy Friction factor**, also called **Drachy – Weishbach friction factor**.

$$f = \frac{8\,\tau}{\rho\,V^2} \quad (3)$$

For circular pipe laminar flow

$$f = \frac{64}{Re} \quad (4)$$

The head loss, is the additional height that the fluid needs to be raised by a pump in order to overcome the frictional losses in pipes, can be formulated as

$$h_L = \frac{\Delta P_L}{\rho g} \quad (5)$$

In a piping system fluid passes through various fittings, valves, bends, elbows, tees, inlets, exits, expansions and contractions in addition to straight section of piping. These components disturb the smoothness of fluid and causes additional losses because of separation of flow. In a typical system these losses are minor as compared to head loss in straight section of pipeline i.e major losses. These losses due to components are called minor losses. The head loss due to completely open valve may be negligible but a partially open valve may have largest head loss in the system. The flow through valves and fittings is very complicated and is generally not possible to analysis theoretically. Therefore minor losses are determined experimentally by manufacturer of components.

IV. RESULT AND DISCUSSIONS

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 0.04333 m^3/s. Further consider water is at 25^0C.

Table 1 Observation Table

Parameter	Symbol	Units	Case 1	Case 2	Case 3	Case 4
Flow Rate	Q	m^3/s	0.0003727	0.0003727	0.0003727	0.0003727
Length of Pipeline	L	m	1.5	1.5	1.5	1.5
Pipe Diameter	D	m	0.0127	0.01905	0.0254	0.03175
Cross-sectional Area of Pipe	A	m^2	0.00012661	0.000285	0.0005065	0.000791
Velocity of Flow in Pipe	V	m/s	2.9436237	1.308277	0.7359059	0.4709798
Water Temperature	T	^0C	25	25	25	25
Specific Weight of Water at 25 ^{0}C	ρ	kg/m^3	1000	1000	1000	1000
Dynamic Viscosity of water at 25 ^{0}C	μ	kg/(m s)	0.00089	0.00089	0.00089	0.00089
Reynolds number	Re		42004.518	28003.012	21002.259	16801.807

Parameter	Symbol	Units	Case 1	Case 2	Case 3	Case 4
Absolute Roughness Coefficient of Galvanized Iron	ε	m	0.15	0.15	0.15	0.15
Roughness Characteristic	ε/D		0.01181102	0.0078740	0.0059055	0.00472441
Drachy – Weishbach friction factor	*f*		0.0413892	0.0373721	0.0355538	0.0347477
Hydraulic Resistance of pipeline	H	m WC	2.15893792	0.2567109	0.0579548	0.01856005

V. CONCLUSION

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. 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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