EXPERIMENT-1

PRESSURE LOSS IN PIPING SYSTEMS

Introduction

A typical piping system involves pipes of different diameters connected to each other by various fittings or elbows to direct the fluid, valves to control the flow rate, and pumps to pressurize the fluid. Piping systems involve changes in direction without a change in diameter, and such flow sections are called bends or elbows. The losses during changes of direction can be minimized by making the turn easy on the fluid by using circular arcs (like 90° elbow) instead of sharp turns (like the miter bends). Sudden or gradual expansion or contraction sections are also involved to accommodate changes in flow rates or properties such as density and velocity. Valves are commonly used to control the flow rates by simply altering the head loss until the desired flow rate is achieved.

Main factors that affect the energy losses in pipes are quality of flow in pipe, material types of pipe, geometric dimensions of pipe (diameter, length and cross sectional shape of pipe) and geometric factors which cause changing direction of flow in pipe. Reynolds number determine types of flow that are laminar, transition or turbulent. These losses can change with velocity distribution in straight pipe based on types of flow and are known as continuous loss of head.

Other the most important energy losses in pipe flows take place in elements which restrict the flow like change of pipe section, tank inlet or outlet, pipe connections, changing the direction of flow in elbow-shape pipe, bifurcation of flow and valves. These types of losses are local losses and loss coefficient specified in experimental studies.

The particular attention is paid to friction, which is directly related to the pressure drop and head loss during flow through pipes and ducts. The pressure drop is then used to determine the pumping power requirement.

The pressure drop in the piping system is sum of the major and minor losses. Major losses include the friction losses occurred in the piping surfaces, which is affected by material surface roughness (ε).

Major Loss:

$$h_P = f\frac{L}{D}\frac{V^2}{2g}$$

where, h_p is major friction loss, J/kh; f is fanning friction factor and is a function of Re number and surface roughness. Moody chart or empirical equations are used to determine the fanning frinction factor.

The fluid in a typical piping system passes through varios fittings, valves, bends, elbows, tees, inlets, exits, enlargements and contraction in addition to the pipes. These components interrupt the smooth flow of the fluid and cause additional losses because of the flow separation and mixing they induce. These losses are minor compared to the major losses and are called minor losses:

$$h_L = K_c \frac{V^2}{2g}$$

K_c is expressed as loss coefficient. Loss coefficients K_c vary with the pipe diameter, the surface roughness, the Reynolds number, and the details of the design.

Bernoulli equation:

$$\frac{P_1}{\rho_1 g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho_2 g} + \frac{V_2^2}{2g} + z_2 + h_f$$

Objective

The aim of this study is to analysis energy losses occurring during flowing of incompressible fluid through straight pipe and several fitting elements (valves, elbows, sudden contraction and sudden enlargement etc.) with using the pressure difference and investigate the change of pressure losses depending fluid velocity, experimentally and theoretically.

Test System and Experimental Procedure

Test System

System consists of 6 different flow line could be opened and closed separately. These parts are equipped with several pipe sections and fittings. Pressure differences are determined in inlet and outlet of selected fitting element via 2 manometers. There are flowmeter (0-2000 L/h), 90-45° elbow, “T” connection, ball valve, disk valve, gate valve, ball valve with drain, silt trap, swing check valve, spring check valve, counter, pressure regulator, “U” connection (return connection), corner radiator valve, 86 cm 20 mm (12.5 mm inner diameter), 25 mm (16 mm inner diameter) and 32 mm (20 mm inner diameter) PPRC (Polypropilene Random Copolymer) pipe in flow line (Figure 1).

Experimental Procedure

Fitting elements take place on varied locations in different flow line of setup. Flow must be provided to line where elements located for measuring the pressure losses. This treatment is implemented with opening-closing the inlet-outlet valves of lines. While the main inlet-outlet valves and inlet-outlet valves of line which is given flow, the other all valves must be closed.

Open position of valves is the valve arm parallel with pipe and close position is valve arm perpendicular to pipe.

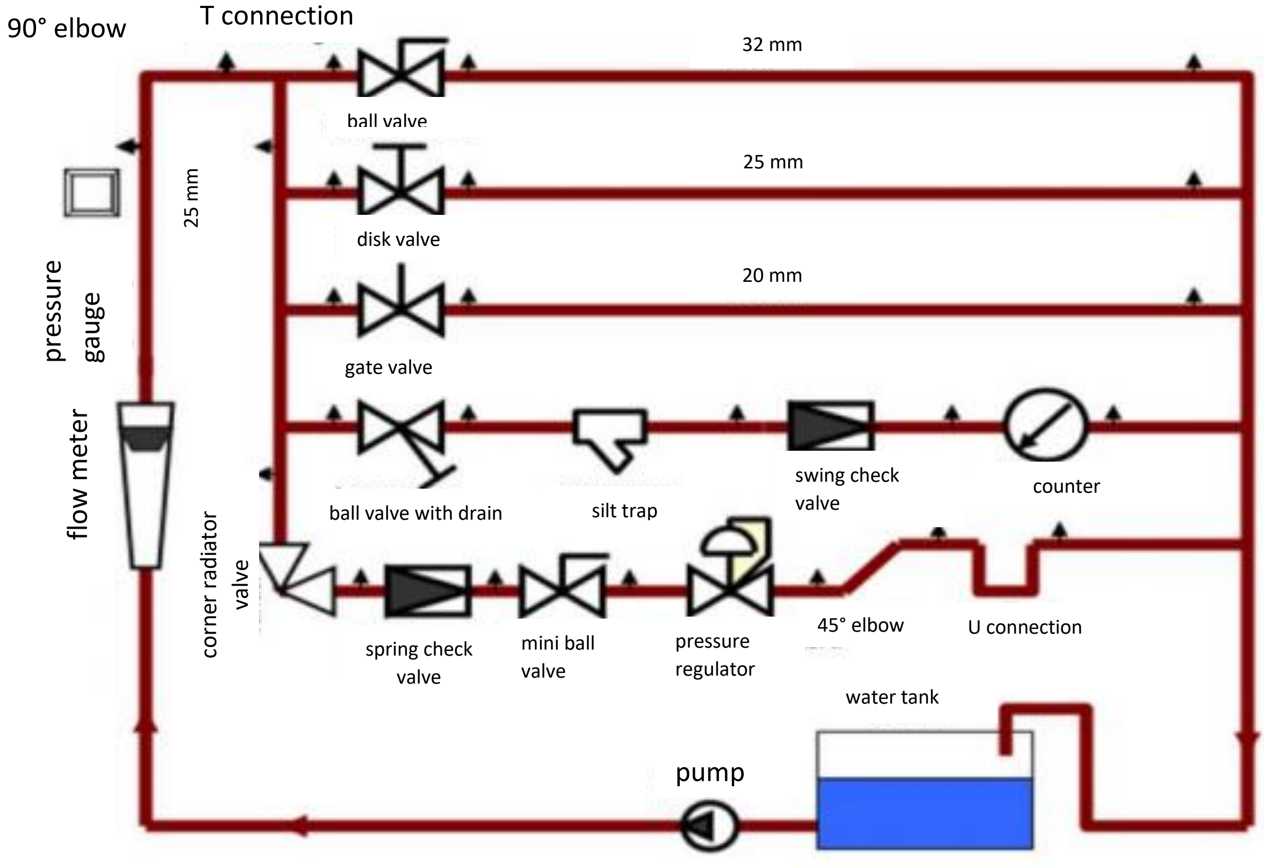

Figure 1. Test system of pressure loss in pipes.

1) Firstly pump is activated with opening the valve of pipe line to be worked on.
2) Flow velocity in line is arranged to determinated value with controlling of the relevant valve.
3) Inlet valve of line is opened with specifing the line of element to be analysed on and connecting the manometer on inlet-outlet pressure measuring points of element.
4) Pressure difference (ΔP) between two end where the manometer is connected is read from device screen.
5) ΔP values is repeated in 2 different flow rate and for at least 3 elements and results are recorded to the data paper.
6) For ending the experiment, the pump firstly is closed, then inlet valves of all lines are closed. The inlet valve of store equipment is completely left opened.

Calculations

1) Calculate the average flow rate (V) and Reynolds number (Re) of water for 2 different flow.

2) Draw the graphic of Reynolds number for straight pipe against friction coefficient (f) calculated with using pressure difference.
3) Compare theoric pressure differences calculated from friction coefficents (f) determined through Moody diagram with experimental pressure differences in graphic.
4) Find the values of local loss coefficient (K_c) for every fitting elements (valve, elbow) from literature and compare them with calculated values (K_c) with using measured pressure losses in experiment.
5) Draw graphic for change of experimental pressure losses for every fitting elements depending fluid velocity.
6) Compare ΔP values calculated with using loss coefficients (K_c) found from literature in Bernoulli equation with ΔP values observed in experiment for every fitting elements.
7) Determine the equivalent lengths of fitting elements.
8) Discuss the interventions can be done for reducing the pressure losses in store equipment.

References

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