Original Research Paper
Volume - 15 | Issue - 11 | November - 2025 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar
Engineering

FRICTION LOSSES IN PIPES

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ABSTRACT Pipe friction losses play a critical role in pump sizing, pressure regulation, and the reliability of hydraulic and power systems. Reducing these losses directly improves energy efficiency and operational performance. This study aims to quantify and analyze pipe friction losses in a recirculation test loop, focusing on the relationship between flow regime, Reynolds number, and pressure loss. Differential pressure transducers, volumetric flow meters, and viscosity corrections were used to measure velocity profiles, calculate Reynolds numbers, and determine friction coefficients using the Darcy-Weisbach formula. The results confirm the expected decrease in the friction coefficient with increasing Reynolds number across the tested range, consistent with a transition to turbulent flow without full roughness control. The pressure loss per unit length increased approximately with the square of the velocity, while the hydraulic gradient decreased with increasing Reynolds number, indicating improved momentum transfer efficiency at higher flow rates. The data trends in both datasets are consistent internally, with friction coefficient values ranging from 0.049 at lower Re values to 0.038 at higher Re values, and the pressure loss coefficients exhibit similar measurement behavior. These results provide validated empirical benchmarks for piping system design, enabling more accurate pump and pipeline sizing and supporting energy-efficient valve and diameter selections. Future studies should extend this analysis to include different pipe roughness classes and complex fittings to further improve predictive correlations.

KEYWORDS : Pipe friction, Darcy-Weisbach, pressure loss, Reynolds number, hydraulic gradient, experimental hydraulics.

INTRODUCTION

Friction losses in pipes are a crucial consideration in various engineering applications, such as plumbing systems, HVAC (Heating, Ventilation, and Air Conditioning), and fluid transportation networks. When a fluid flows through a pipe, it experiences resistance due to the frictional forces acting between the fluid and the pipe wall. This resistance leads to a loss of energy, often expressed in terms of pressure drop or head loss along the length of the pipe.

Several factors influence friction losses in pipes, including the roughness of the pipe surface, the velocity of the fluid, the viscosity of the fluid, and the diameter and length of the pipe. Engineers use empirical equations, such as the Darcy-Weisbach equation or the Hazen-Williams equation, to estimate friction losses and design efficient piping systems.

OBJECTIVE

The objective in minimizing friction losses in pipes is to reduce the energy required to transport fluids through the system. By minimizing friction losses, you can improve the overall efficiency of the system, reduce energy consumption, and lower operating costs. This can be achieved by using smooth pipes, reducing flow velocity, maintaining proper pipe diameter, and ensuring proper fluid properties.

THEORY

The theory of friction loss in tubers is based on the resistance experienced by the flow of fluids across the tubers due to friction between the fluids and the inner walls in the tubers. This friction results in a loss of energy in the form of calories, resulting in a decrease in pressure and fluid velocity along the tube. The theory of frictional losses describes moderately healthy cases such as Darcy-Weisbach injury or Hazen-Williams injury, which allows pressure losses to be calculated by using different parameters such as cam diameter and wall density. Flow speed and fluid supply. The energy loss in a pipe can be determined by applying the energy equation to a section of a straight pipe with a uniform cross section:

$$\frac{p_{in}}{\gamma}+\frac{v2_{in}}{2g}+z_{in}=\frac{p_{out}}{\gamma}+\frac{v2_{out}}{2g}+z_{out}+h1$$

If the pipe is horizontal: $z_{in}=z_{out}$

Since vin = vout

$$h1=\frac{(pout-pin)}{\gamma}$$

The pressure difference (P_{out}-P_{in}) between two points in the pipe is due to the frictional resistance, and the head loss h_L is directly proportional to the pressure difference.

The head loss due to friction can be calculated from the Darcy-Weisbach equation:

$$h1=f\frac{Lv^2}{D2g}$$

where:
h_L: head loss due to flow
f: Darcy-Weisbach coefficient
L: pipe length
D: pipe diameter
v: average velocity
g:gravitationalacceleration.

Figure 1: Minor Losses Apparatus With hydraulic bench

For laminar flow, the Darcy-Weisbach coefficient (or friction factor f) is only a function of the Reynolds number (Re) and is independent of the surface roughness of the pipe, i.e.:

$$f=\frac{64}{Re} \quad \text{(Hagen – Poiseuille equation)}$$

For turbulent flow in a smooth pipe, a well-known curve fit to the Moody diagram is given by:

$$f=0.316Re^{-0.25} \quad \text{(Blasius equation)}$$

Reynolds number is given by:

$$Re = \frac{\rho v D}{\mu} = \frac{vD}{\nu}$$

The average velocity, v, is calculated from the volumetric flow rate (Q) as:

$$v = \frac{Q}{\frac{\pi D2}{4}}$$

Length of test pipe = 36 cm

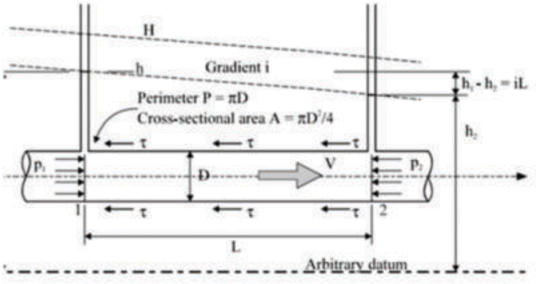


Figure2: Schematic drawing of the energy-loss in pipe

CALCULATIONS AND RESULTS

D_1=7mm

D_2=10mm

$A_1 = 5.5\times10^{-3} m^2$

$A_2 = 7.9\times10^{-3} m^2$

T=24°C

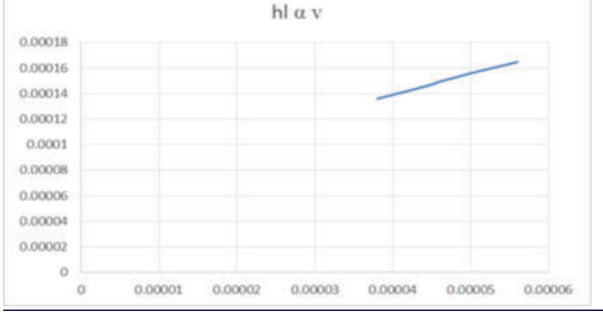
$\rho = 997.3 Kg/m^3$

$\mu = 0.913\times 10^{-3} N.s/m^2$

Table1:						
Vm^3	0.000620	0.000680	0.000780	0.000860	0.000980	0.001060
t_s	18	19	21	23	25	26
Qm3/s	0.0000344	0.0000366	0.0000377	0.0000374	0.0000399	0.000041
Vm/s	0.0062	0.0065	0.0067	0.0068	0.0071	0.0075
h_1	0.40	0.397	0.392	0.387	0.38	0.375
h_2	0.355	0.349	0.34	0.332	0.32	0.31
Δh	-0.045	-0.048	-0.052	-0.055	-0.06	-0.065
hloss	0.045	0.048	0.052	0.055	0.06	0.065
Re	47.4	49.7	51.2	52	54.2	57.3
f	1.35	1.28	1.25	1.23	1.18	1.12
h1	0.000136	0.0001418	0.0001471	0.0001491	0.000156	0.000165
log Re	1.68	1.7	1.71	1.72	1.73	1.76
log f	0.13	0.11	0.097	0.09	0.072	0.049
v^2	0.000038	0.000042	0.000045	0.000046	0.00005	0.000056

Re < 2000

Laminar Flow



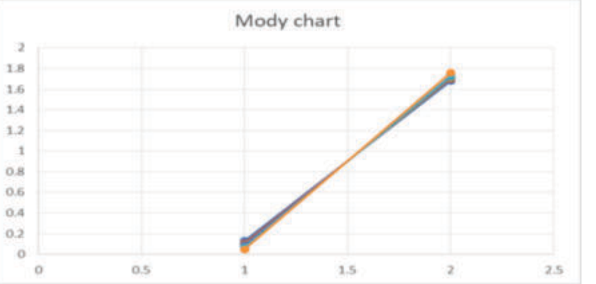
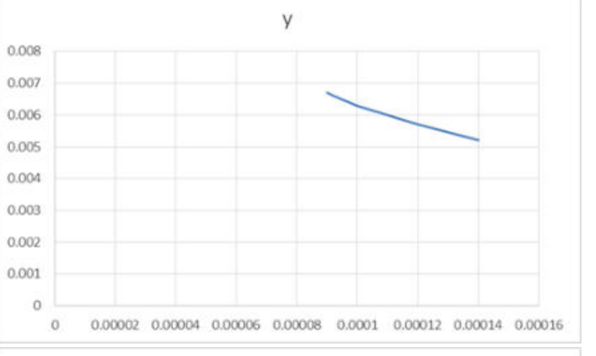
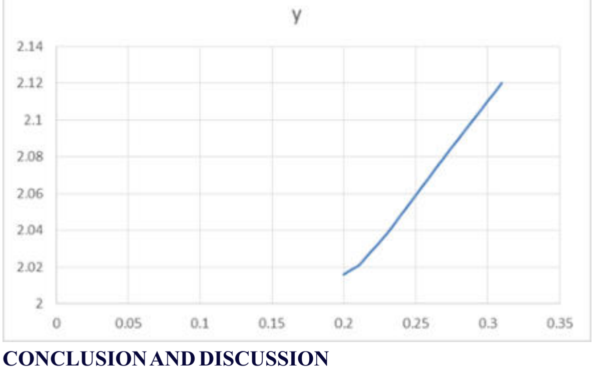


Table2:						
V_m^3	0.000600	0.000840	0.001060	0.001000	0.001080	0.001200
t_s	8	11	13	11	11.5	12
Qm3/s	0.000075	0.000076	0.000082	0.011	0.012	0.0013
Vm/s	0.0095	0.0096	0.01	0.0068	0.0071	0.0075
h_1	0.39	0.384	0.375	0.36	0.355	0.345
h_2	0.345	0.332	0.318	0.294	0.278	0.265
Δh	-0.045	-0.052	-0.057	-0.066	-0.077	-0.08
hloss	0.045	0.052	0.057	0.066	0.077	0.08
Re	103.8	104.9	109.2	120.2	131.1	14.2
f	0.617	0.610	0.586	0.532	0.488	4.507
h_1	0.0067	0.0066	0.0063	0.0057	0.0052	0.048
log Re	2.016	2.021	2.038	2.08	2.12	1.15
log f	0.20	0.21	0.23	0.27	0.31	0.65
V^2	0.00009	0.000092	0.0001	0.00012	0.00014	0.0000017





CONCLUSION AND DISCUSSION

For all charts, there are some errors and marginal differences in values that cause fexp to differ from ftheo. These errors may be caused by a bubble inside the tube which can cause a large difference in the measurement, and also by the flow rate of the water source changing inconsistently during the experiment.

In the discussion of friction loss in tubers, it is important to consider the appropriate selection of tuber material, tuber diameter, tuber strength, flow velocity, and fluid viscosity. Moreover, it is important to take into account the specific operating conditions and apply relevant procedures to calculate and reduce losses in an effective manner. Understanding these concepts is key to ensuring optimal and efficient design of tuber systems. In conclusion, friction losses in tubers are an important factor to consider in the design and operation of fluid conveying systems. Reducing these losses can improve energy efficiency, reduce operating costs, and improve overall system performance.

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