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Effect of Reynolds Number and Temperature on Water Heater Loss Coefficient

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Abstract

The heater's loss coefficient determines the pressure drop as fluid flows through it. Accurate estimation of the heater's loss coefficient is essential for optimizing thermal system performance. A higher heater loss coefficient indicates greater resistance to flow, which can reduce system performance. To determine the effect of Reynolds Number and temperature on water heater loss coefficient, an experimental apparatus was designed and fabricated to measure pressure differences and flow rates across a water heater system. Tests were conducted under two conditions: constant temperature and different volumetric flow rate; and different temperature and constant volumetric flow rate. The experimental findings demonstrate that the heater's loss coefficient is directly proportional to the Reynolds number. This relationship suggests that the flow regime and velocity play a dominant role in determining the heater's hydraulic resistance. In contrast, variations in fluid temperature had no measurable effect on the loss coefficient. This suggests that changes in temperature within the tested range do not significantly influence the fluid's interaction with the heater geometry. This outcome highlights the dominance of flow dynamics over thermal influences in determining hydraulic resistance. These findings provide a valuable basis for optimizing heater design and improving efficiency in thermal fluid systems.

1. Introduction

Fluid flow describes the movement of liquids and gases driven by pressure differences. In engineering applications, understanding fluid flow is essential for designing efficient systems such as water supply networks, pipelines, and HVAC systems. The behavior of fluids is influenced significantly by viscosity, which introduces internal friction within the fluid. This friction affects flow characteristics, particularly near boundaries and surfaces, thereby reducing overall efficiency. Fluid flow can be categorized into two forms: laminar and turbulent. Laminar flow is a flow where it travels smoothly through transitional flow, while turbulent flow is a disorganized or mixed motion. The Reynolds number is a dimensionless parameter that helps predict the type of flow based on factors such as velocity, fluid viscosity, and the pipe diameter. A thorough understanding of these fluid mechanics principles enables engineers to calculate pressure drops, optimize velocities, and ensure the safe and efficient operation of fluid systems [1]. Loss coefficient K_L is a dimensionless parameter used in fluid mechanics to determine the energy loss caused by various components within a system, such as bending, valves, fittings, and internal geometries of equipment [2].

Water heaters play a vital role in delivering hot water across a wide range of environments, including residential, commercial, and industrial facilities. Water heaters are available in two types: tankless (instantaneous) and storage units. Tankless water heaters heat water only when needed, providing a continuous supply without a storage tank. In contrast, storage-type water heaters store pre-heated water in a tank, ensuring immediate access whenever required. Both systems function by transferring heat from various energy sources such as electricity, natural gas, or solar power, making them versatile and adaptable to different energy preferences and needs. These devices are essential for maintaining comfort, hygiene, and operational efficiency in daily activities and industrial processes. Their reliable performance ensures a steady supply of hot water for various applications [3].

The main objective of this project is to determine the effects of Reynolds number and temperature on the water heater loss coefficient through a comprehensive experimental study. Therefore, examining the effects of Reynolds number and temperature helps better understand their influence on the water heater's performance. Furthermore, this project focuses precisely on determining the loss coefficients of the Panasonic water heater model DH-3RP1. This experiment was carried out based on two different scenarios. Scenario one is about constant temperature and different flow rate, and scenario two is about constant flow rate and different temperature.

2. Methodology

The study develops a procedural flowchart to illustrate the chronological order of tasks in the project. The operational framework is fully shown in this image, which makes it clear how each stage will advance the project in the future. This is to ensure the proper execution of a project requires maintaining efficiency and coordinating each operation with its goals. Firstly, a literature review was written for the thesis to create a guideline. Besides that, an experiment was designed and a pilot test was conducted to refine the design before finalizing it. If the pilot doesn't yield a logical result, the experiment must be redesigned. Once the pilot test is confirmed, full data collection and analysis will be carried out for a further set of data, followed by discussion and conclusion for the overall thesis. Figure 1 displays a schematic illustration of the process.

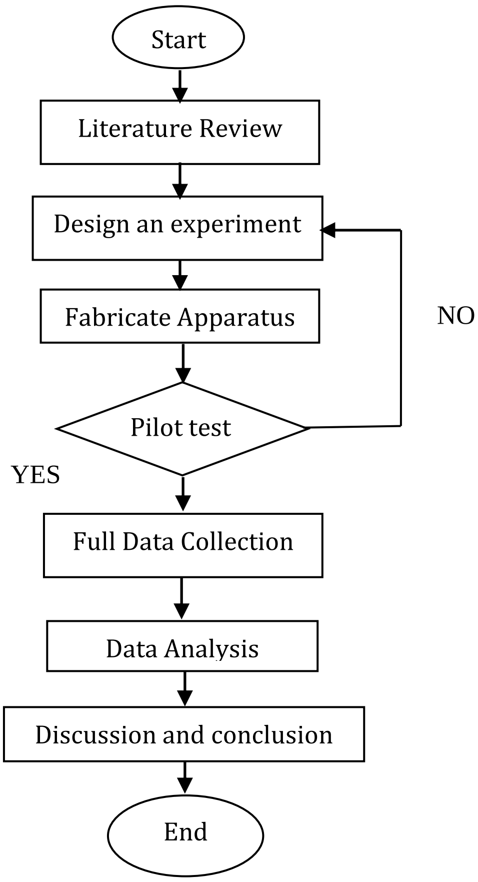

Fig 1: Flowchart diagram

Relevant facts and data are examined based on the subject. It has a wide range of books, magazines, articles, and research papers. This is done to determine the criteria needed for this experiment and to identify the best strategy to accomplish the project's aims. The process and experimental design are developed using all relevant information, and they are compared with previous studies. At this time, all procedures for experiments and boundary conditions have been established to ensure precise, suitable experimental outcomes. The equipment was created, containing every component needed for the experiment.

The design phase begins with sketching on paper, then is later transferred into SolidWorks software to illustrate the design and facilitate fabrication of the apparatus. The structure of the experimental design was referred from past research [4]. This sketch was later converted into a physical apparatus, and the related equipment and tools were bought at a nearby hardware store.

After fabrication, a comprehensive pilot test was conducted on the newly assembled piping systems, using a hydraulic bench to supply the required fluid. During the testing phase, the fluid was allowed to flow through the entire system, passing critical components such as the elbow joint, water heater, manometer, and pressure gauge. Throughout this process, precise pressure readings were carefully recorded at various points, and height differences within the setup were measured to gather essential initial data. Close attention was paid to the system's behavior, with careful observation to detect any signs of leaks or irregularities. Ensuring the absence of leaks was essential to prevent energy loss and to confirm the system's integrity and efficiency.

Following the pilot test, a full data collection was carried out to obtain raw data. The raw data extracted from the apparatus consisted primarily of temperature, inlet and outlet water heater pressures, time to reach a 9 litre volume of water, water volume, and the height difference between the two points. This study consists of 36 data points for constant-temperature, different flow-rate situations, and 135 data points for different temperatures, constant flow rate. Later, after completing the entire raw data collection, a data analysis was carried out to calculate the loss coefficient and Reynolds number of the water heater for both situations. The variables were determined by referring to Equations 1 and 2 below. Equation 1 shows the equation to calculate the Reynolds number, while Equation 2 shows the equation for calculating the water heater's loss coefficient. In addition, a scatter plot was created to illustrate the Reynolds number against loss coefficient for constant-temperature conditions and different flow rates, and the temperature against loss coefficient for different temperature conditions.

$$Re = \frac{\rho v D}{\mu} \tag{1}$$

$$h_L = K_L \frac{V^2}{2g} \tag{2}$$

Finally, a discussion of the findings and results throughout this project has been conducted. Furthermore, a conclusion was stated for the overall study, based on the summary and findings, to demonstrate that this thesis is supported by past research, along with recommendations for improvement and for future studies.

3. Results and Discussion

3.1 Designed and Fabricated Apparatus

The general structure of this design, shown in Figure 2, is the design of the experiment for this project. This design was inspired by past research. The efficiency of this design was verified and supported by previous research [4]. It was verified based on past research, as they had successfully collected raw data using the same hydraulic bench. The difference was only in using the water heater and the pressure gauge.

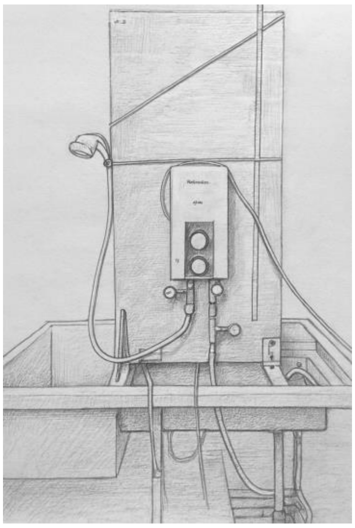

Fig. 2 *Design of the experiment*

3.2 Pilot Test

Since the experimental apparatus was newly developed, a pilot test was conducted to obtain preliminary data for each experimental condition. The objective was to determine the Reynolds number and loss coefficient of the water heater. Initially, pressure measurements were attempted using a manometer; however, this method proved unsuitable because the operating pressure exceeded 1 bar, corresponding to a liquid column height exceeding 10 m. Consequently, a pressure gauge was employed to measure the pressure difference. For the first experimental scenario, the test was carried out at a constant temperature of 25 °C while varying the flow rate. The pressures at points 1 and 2 were recorded using the pressure gauge as the valve opening was adjusted from maximum to minimum flow rate. The density and dynamic viscosity of water at 25 °C were taken as 997 kg/m^3 and 8.91×10^{-4} Pa·s, respectively. Figure 3 illustrates the relationship between the loss coefficient and Reynolds number for the water heater, showing a trend consistent with the fundamental behaviour reported in [5].

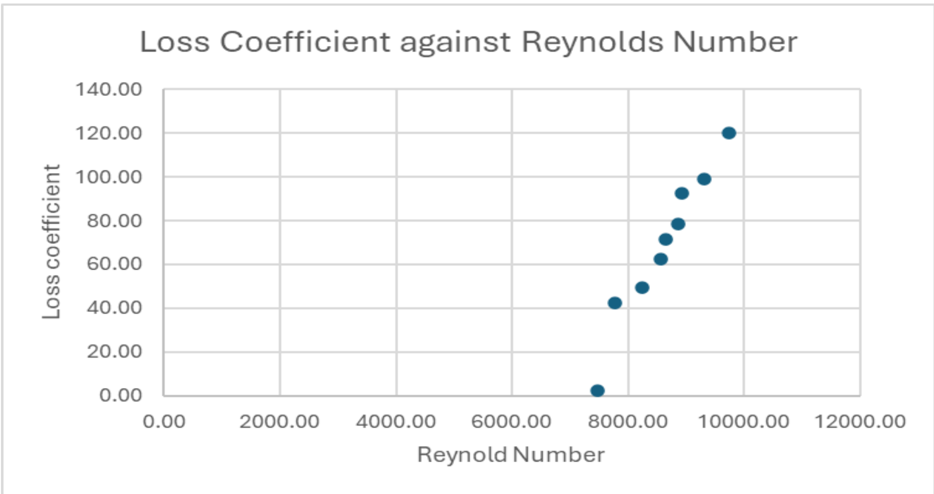

Fig. 3 *Graph of Loss coefficient against Reynolds number for situation one*

Figure 4 illustrates the graph for scenario two, with different temperatures and a constant flow rate. In this scenario, the density of water varies with temperature, as does its dynamic viscosity, while the flow rate remains constant. All these related property table data were retrieved from the book by Cengel, Y.A., and Cimbala, J.M. [6].

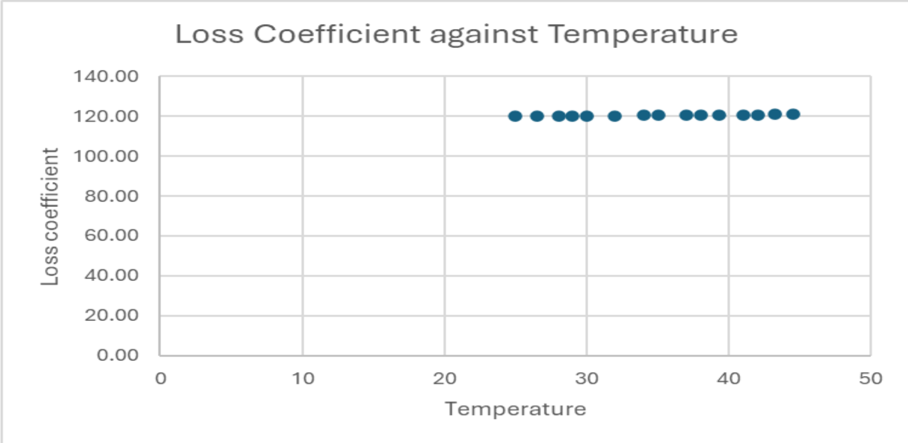

Fig. 4 *Graph of Loss Coefficient against Temperature for scenario two*

Additionally, the graph in Figure 4 shows that it is constant for scenario 2. This graph is acceptable in terms of pattern, too, because it is inversely proportional or nearly constant compared with previous research by [7]. The calculation steps are basically the same for both scenarios and will be continued for all 171 data. The converted data will be produced in further data analysis for better understanding.

3.3 Data Analysis

The raw data collected during full data collection will be illustrated in this data analysis. All the data analyzed has been attached in Appendix A. Therefore, Tables 1-4 show the data analysis for scenario one: constant temperature, different flow rate. Besides that, tables 5 to 13 show the analysis done for scenario two, with a different temperature and a constant flow rate. This data analysis consists of finding the temperature and pressure at points 1 and 2, the time taken to fill 8 litres of water, the volume to be filled in that time, the volumetric flow rate, the velocity at point 1, the Reynolds number, and the Loss coefficient.

A scatter plot visually exhibits how the Reynolds number (R_e) correlates with the loss coefficient (K_L) at a constant temperature. By analyzing data points across different flow rates, the graph highlights the relationship between flow characteristics and energy losses, providing valuable insights into fluid dynamics behavior under different conditions. Figures 5 and 6 show the graph of Loss Coefficient against Reynolds number for scenario one and Loss Coefficient against temperature for scenario two from the experiment.

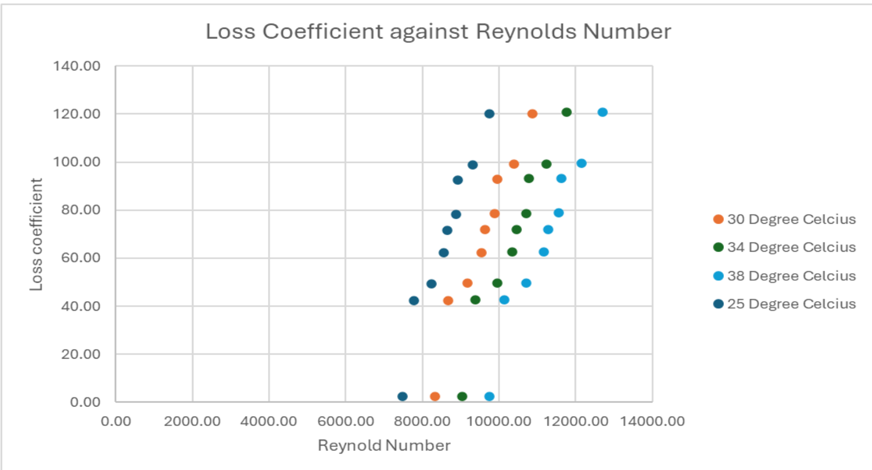

Fig. 5 *Graph of Loss coefficient against Reynolds number for scenario one*

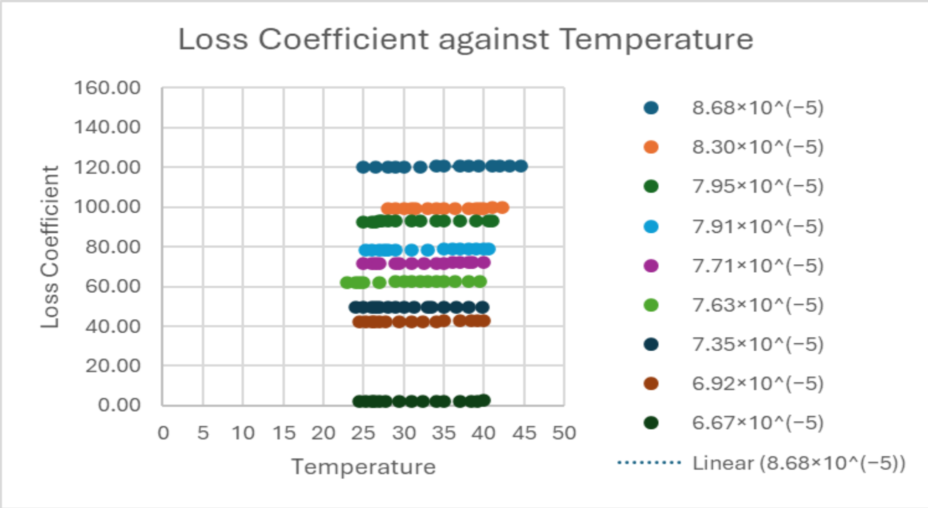

Fig. 6 *Graph of Loss coefficient against temperature for scenario two*

3.4 Discussion

In findings, basically, this water heater pressure can be measured using a pressure gauge and a manometer. Even though manometers may provide an accurate reading compared to a pressure gauge, they are more time-consuming and yield readings almost identical to those of a pressure gauge. To improve the efficiency of pressure reading, a pressure gauge was used. Moreover, a manometer wasn't suitable for this experiment, as the inlet and outlet pressures were typically more than 1 bar, requiring a manometer hose of more than 10 meters. Therefore, a manometer is suitable for low-pressure measurements but less suitable for high-pressure measurements, because the higher the pressure, the longer the hose must be extended for the manometer method.

Secondly, as we see, the volumetric flow rate is fundamentally proportional to pressure. According to Bolij, M., & Kailas, N [1], the observed decrease in pressure drop at lower volumetric flow rates can be explained by the principles of fluid energy. When the flow rate (Q) decreases, the fluid's average velocity decreases; therefore, the pressure drops, which directly affects the pressure loss within the system. This relationship is clearly illustrated by the Darcy–Weisbach equation, which indicates that pressure drop is proportional to the square of the flow velocity. Specifically, as velocity reduces, the energy loss due to friction within the pipe decreases significantly [1]. Furthermore, there were some implications during the pressure difference measurement, as the pressure gauge fluctuated during high flow rate. The pressure reading was taken as an average based on the guidance to reduce random errors and improve reproducibility [8].

The experiment reveals a clear positive correlation between the Loss Coefficient and Reynolds number, showing that as the Reynolds number increases from 7477 to 12703, water losses within the system tend to rise. This trend shows that higher turbulence levels lead to greater pressure drops, which can affect overall system efficiency. These observations align with established fluid mechanics principles, as referenced in the book, underscoring the role of flow characteristics in energy loss prediction [9]. Furthermore, the findings are consistent with prior research, which observed similar patterns when testing water at varying temperatures in a 25 mm diameter pipe, reinforcing Reynolds number as a reliable indicator of pressure losses [5].

In addition, the scatter plot, which illustrates the Loss coefficient against temperature, presents a more scattered distribution with a linear trend. The loss coefficient values vary widely across the temperature range, indicating that temperature does not create loss in the system due to a constant pattern in the graph in the range of 23℃ till 44.5℃. Furthermore, its influence may be indirect, acting through changes in fluid properties such as viscosity or density, or through interactions with other variables, such as flow velocity. This situation and pattern align with Wu, Y's [7] past research, in which she tested different water temperatures in a straight pipe with a diameter of 0.02m. Comparison of the analyses between the two research indicates that head loss is proportional to the loss coefficient; therefore, the scatter plot of temperature against the loss coefficient tallies.

4.0 Conclusion

In summary, the project objective was successfully achieved by determining the relationships between the Loss coefficient and Reynolds number, and between the loss coefficient and temperature. Therefore, the findings show that the Loss coefficient is proportional to the Reynolds number and constant with respect to temperature. Besides that, this result shows that, in scenario one, when the Reynolds number increases, the Loss coefficient also increases. Well, in scenario two, when the temperature value increases drastically, the Loss coefficient remains constant, meaning there is no effect on the system due to temperature.

Furthermore, pressure tapping can be classified into two ways: low-pressure and high-pressure. Therefore, if the system creates low pressure, a manometer will provide a more accurate reading than a pressure gauge. If the system creates high pressure, it is suitable for obtaining a wide range of data.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Vairavan Manikandan A/L Vairavan Nachiappan, Ahmad Fu'ad Idris, Mohd Azwir Azlan;* ***data collection:*** *Vairavan Manikandan A/L Vairavan Nachiappan;* ***analysis and interpretation of results:*** *Vairavan Manikandan A/L Vairavan Nachiappan, Ahmad Fu'ad Idris;* ***draft manuscript preparation:*** *Vairavan Manikandan A/L Vairavan Nachiappan, Ahmad Fu'ad Idris, Mohd Azwir Azlan. All authors reviewed the results and approved the final version of the manuscript.*

Appendix A: Data analysis

Table 1: Data analysis for the temperature of 25℃

Temperature, T (°C)	Pressure 1 P_1 (Pa)	Pressure 2 P_2 (Pa)	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Reynolds Number, Re	Loss Coefficient, K_L
25	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	9741.00	120.08
25	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	9309.48	98.95
25	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	8919.89	92.70
25	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	8867.01	78.38
25	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	8651.57	71.61
25	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	8555.07	62.22
25	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	8240.05	49.33
25	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	7765.82	42.38
25	60000	58000	0.008	120	6.67×10^{-5}	0.53	7477.84	2.41

Table 2: Data analysis for the temperature of 30℃

Temperature, T (°C)	Pressure 1 P_1 (Pa)	Pressure 2 P_2 (Pa)	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Reynolds Number, Re	Loss Coefficient, K_L
30	115000	85000	0.008	92.07	8.69×10^{-5}	0.69	10871.22	120.07
30	105000	82000	0.008	96.45	8.29×10^{-5}	0.65	10377.54	99.18
30	98000	78000	0.008	100.69	7.95×10^{-5}	0.63	9940.54	92.97
30	92000	75000	0.008	101.3	7.90×10^{-5}	0.62	9880.69	78.63
30	88000	73000	0.008	103.81	7.71×10^{-5}	0.61	9641.78	71.82
30	83000	70000	0.008	105	7.62×10^{-5}	0.60	9532.51	62.42
30	75000	65000	0.008	109.03	7.34×10^{-5}	0.58	9180.17	49.52
30	68000	60000	0.008	115.59	6.92×10^{-5}	0.55	8659.17	42.47
30	60000	58000	0.008	120.14	6.66×10^{-5}	0.53	8331.23	2.43

Table 3: Data analysis for the temperature of 34℃

Temperature, T (°C)	Pressure 1 P_1 (Pa)	Pressure 2 P_2 (Pa)	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Reynolds Number, Re	Loss Coefficient, K_L
34	115000	85000	0.008	92.22	8.67×10^{-5}	0.68	11755.32	120.68
34	105000	82000	0.008	96.42	8.30×10^{-5}	0.65	11243.26	99.29
34	98000	78000	0.008	100.65	7.95×10^{-5}	0.63	10770.74	93.06
34	92000	75000	0.008	101.27	7.90×10^{-5}	0.62	10704.80	78.72
34	88000	73000	0.008	103.78	7.71×10^{-5}	0.61	10445.90	71.91
34	83000	70000	0.008	104.95	7.62×10^{-5}	0.60	10329.45	62.48
34	75000	65000	0.008	109	7.34×10^{-5}	0.58	9945.65	49.59
34	68000	60000	0.008	115.57	6.92×10^{-5}	0.55	9380.25	42.54
34	60000	58000	0.008	120.1	6.66×10^{-5}	0.53	9026.44	2.45

Table 4: Data analysis for the temperature of 38℃

Temperature, T (℃)	Pressure 1 P_1 (Pa)	Pressure 2 P_2 (Pa)	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Reynolds Number, Re	Loss Coefficient, K_L
38	115000	85000	0.008	92.2	8.68×10^{-5}	0.69	12703.28	120.88
38	105000	82000	0.008	96.48	8.29×10^{-5}	0.66	12139.75	99.46
38	98000	78000	0.008	100.87	7.93×10^{-5}	0.63	11611.41	93.23
38	92000	75000	0.008	101.33	7.89×10^{-5}	0.62	11558.70	78.86
38	88000	73000	0.008	103.84	7.70×10^{-5}	0.61	11279.30	72.04
38	83000	70000	0.008	105	7.62×10^{-5}	0.60	11154.69	62.59
38	75000	65000	0.008	109.5	7.31×10^{-5}	0.58	10696.28	49.70
38	68000	60000	0.008	115.62	6.92×10^{-5}	0.55	10130.11	42.62
38	60000	58000	0.008	120.19	6.66×10^{-5}	0.53	9744.93	2.48

Table 5: Data analysis for the volumetric flow rate of $8.68 \times 10^{-5}\ m^3/s$

Temperature, T (℃)	Pressure 1 P_1 (Pa)	Pressure 2 P_2 (Pa)	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
25	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.876	120.08
26.5	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.876	120.12
28	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.877	120.15
29	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.878	120.18
30	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.879	120.21
32	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.881	120.31
34	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.884	120.41
35	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.885	120.46
37	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.887	120.56
38	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.888	120.61
39.3	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.890	120.67
41	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.892	120.76
42	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.893	120.81
43.2	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.895	120.88
44.5	115000	85000	0.008	92.12	8.68×10^{-5}	0.69	2.896	120.94

Table 6: Data analysis for the volumetric flow rate of $8.30 \times 10^{-5}\ m^3/s$

Temperature, T (℃)	Pressure 1 P_1 (Pa)	Pressure 2 P_2 (Pa)	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
28	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.166	99.01
29	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.166	99.04
30	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.167	99.06
31	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.168	99.10
31.5	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.168	99.12
33	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.170	99.19
34	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.170	99.23
35	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.171	99.27
36.3	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.173	99.33
38	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.174	99.40
39	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.175	99.44
39.5	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.176	99.46
40	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.176	99.48
41	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.177	99.52
42.2	105000	82000	0.008	96.39	8.30×10^{-5}	0.66	2.178	99.58

Table 7: Data analysis for the volumetric flow rate of $7.95 \times 10^{-5}\ m^3/s$

Temperature, T (℃)	Pressure 1 P_1 (Pa)	Pressure 2 P_2 (Pa)	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
25	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.861	92.70
26	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.862	92.72
26.5	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.862	92.73
27	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.862	92.74
27.3	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.862	92.75
28	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.863	92.76
29	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.863	92.78
31	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.864	92.84
32	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.865	92.88
34	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.867	92.97
35	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.868	93.01
37	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.869	93.09
39	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.871	93.16
40.5	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.872	93.22
41	98000	78000	0.008	100.6	7.95×10^{-5}	0.63	1.872	93.24

Table 8: Data analysis for the volumetric flow rate of $7.91 \times 10^{-5}\ m^3/s$

Temperature, T (°C)	Pressure 1 $P_1\ (Pa)$	Pressure 2 $P_2\ (Pa)$	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
25.3	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.555	78.38
26	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.556	78.40
27	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.556	78.41
27.5	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.556	78.42
28	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.556	78.43
29	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.557	78.45
31	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.558	78.50
33	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.559	78.57
35	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.561	78.64
36	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.561	78.68
37	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.562	78.71
38	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.563	78.74
39	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.563	78.78
40	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.564	78.81
40.5	92000	75000	0.008	101.2	7.91×10^{-5}	0.62	1.564	78.83

Table 9: Data analysis for the volumetric flow rate of $7.71 \times 10^{-5}\ m^3/s$

Temperature, T (°C)	Pressure 1 $P_1\ (Pa)$	Pressure 2 $P_2\ (Pa)$	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
25	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.353	71.61
26	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.353	71.63
26.5	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.353	71.64
27	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.353	71.65
29	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.354	71.68
29.5	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.353	71.64
31	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.355	71.73
32.5	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.356	71.78
34	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.357	71.83
35	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.357	71.86
36	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.358	71.89
37	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.359	71.92
38	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.359	71.95
38.5	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.360	71.97
40	88000	73000	0.008	103.72	7.71×10^{-5}	0.61	1.360	72.01

Table 10: Data analysis for the volumetric flow rate of $7.63 \times 10^{-5}\ m^3/s$

Temperature, T (°C)	Pressure 1 $P_1\ (Pa)$	Pressure 2 $P_2\ (Pa)$	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
23	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.149	62.19
24	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.149	62.20
24.5	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.149	62.21
25	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.149	62.22
27	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.150	62.25
29	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.150	62.28
30	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.151	62.29
31	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.151	62.32
32	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.152	62.35
33	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.152	62.38
34	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.153	62.41
35	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.153	62.43
36.4	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.154	62.47
38	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.155	62.52
39.5	83000	70000	0.008	104.89	7.63×10^{-5}	0.60	1.156	62.56

Table 11: Data analysis for the volumetric flow rate of $7.35 \times 10^{-5}\ m^3/s$

Temperature, T (°C)	Pressure 1 $P_1\ (Pa)$	Pressure 2 $P_2\ (Pa)$	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
24	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.845	49.32
25	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.845	49.33
26	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.846	49.35
26.5	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.846	49.35
27	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.846	49.36
28	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.846	49.37
29	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.846	49.38
30	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.846	49.39
31.3	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.847	49.43
33	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.848	49.47
33.4	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.848	49.48
35	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.848	49.51
36.5	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.849	49.55
38	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.850	49.58
39.7	75000	65000	0.008	108.9	7.35×10^{-5}	0.58	0.850	49.62

Table 12: Data analysis for the volumetric flow rate of $6.92 \times 10^{-5}\ m^3/s$

Temperature, T (°C)	Pressure 1 $P_1\ (Pa)$	Pressure 2 $P_2\ (Pa)$	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
24.5	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.645	42.38
25.3	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.645	42.38
26	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.645	42.39
26.3	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.645	42.39
27	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.645	42.40
27.8	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.646	42.41
29.5	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.646	42.43
31	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.646	42.46
32.3	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.647	42.48
34	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.647	42.52
35	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.648	42.54
37	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.648	42.58
38.4	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.649	42.61
39.2	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.649	42.63
40	68000	60000	0.008	115.55	6.92×10^{-5}	0.55	0.649	42.65

Table 13: Raw data for the volumetric flow rate of $6.67 \times 10^{-5}\ m^3/s$

Temperature, T (°C)	Pressure 1 $P_1\ (Pa)$	Pressure 2 $P_2\ (Pa)$	Volume, ∇ (m^3)	Time, t (s)	Flowrate, Q (m^3/s)	Velocity 1, V_1 (m/s)	Head Loss, h_L	Loss Coefficient, K_L
24	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03396	2.406
25	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03400	2.409
25.5	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03402	2.410
26	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03404	2.412
26.5	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03406	2.413
27.3	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03409	2.416
28.2	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03413	2.418
29.4	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03418	2.422
31.2	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03430	2.430
33	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03445	2.441
34	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03453	2.447
35.2	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03463	2.454
37	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03477	2.464
38.4	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03488	2.472
39.3	60000	58000	0.008	115.55	6.67×10^{-5}	0.53	0.03495	2.477

References

[1] Kailas, B.N. (2024). Flow Through Pipes: An Analytical Study. *International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal*, *4*(1), https://ijarsct.co.in/Oct4i1.html

[2] Ntengwe, F. W., Chikwa, M., & Witika, L. K. (2015). Evaluation of friction losses in pipes and fittings of process engineering plants. International Journal of Scientific and Technology Research, 4(10), 330-336. https://www.ijstr.org/final-print/oct2015/Evaluation-Of-Friction-Losses-In-Pipes-And-Fittings-Of-Process-Engineering-Plants.pdf

[3] Hohne, P. A., Kusakana, K., & Numbi, B. P. (2019). A review of water heating technologies: An application to the South African context. Energy Reports, 5, 1-19. https://doi.org/10.1016/j.egyr.2018.10.013

[4] Suhaimi, M. S., & Idris, A. F. A. (2023). The Effect of Reynolds Number on 90° PVC Elbow Minor Loss Coefficient. Research Progress in Mechanical and Manufacturing Engineering, 4(2), 204-210. https://publisher.uthm.edu.my/periodicals/index.php/rpmme/article/view/13545

[5] Jamil, R., & Mujeebu, M. A. (2018). Empirical Relation between Hazen-Williams and Darcy-Weisbach Equations for Cold and Hot Water Flow in Plastic Pipes. Water Journal, 10. https://doi.org/10.14294/WATER.2019.1

[6] Çengel, Y. A., & Cimbala, J. M. (2018). *Fluid Mechanics Fundamentals and Applications, Fourth Edition*. McGraw Hill

[7] Wu, Y. (2023). A quantitative analysis on the influence of temperature on head loss along PVC pipe and the choice of pipe diameter. *Journal of Physics: Conference Series*, *2634*(1). https://doi.org/10.1088/1742-6596/2634/1/012004

[8] Stavros Tavoularis, J. N. (2024). Fluid Mechanical Apparatus and Experimental Practices. In *Measurement in Fluid Mechanics* (pp. 296–344). Cambridge University Press. https://doi.org/10.1017/9781009343657.010

[9] Frank M. White. (2011). FLUID MECHANICS. In *Fundamentals of Fluid Mechanics (Seventh Edition), McGraw-Hill*.