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ORIGINAL RESEARCH PAPER

Engineering

FLOW THROUGH VENTURIMETER

KEY WORDS:

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ABSTRACT

This experiment focuses on fluid flow measurement using a Venturi meter, emphasizing its application in determining flow rates accurately across industrial systems. The Venturi meter operates by channeling fluid through a constricted section, creating a measurable pressure drop as velocity increases at the throat. Key objectives of the experiment are to derive the discharge coefficient (Cd) from empirical data and to analyze the relationship between Reynolds number and Cd , providing insight into the performance of the Venturi meter under varying flow conditions. The setup includes a closed-loop water system with a Venturi meter, orifice plate, and rotameter, each equipped with pressure taps for measuring differentials across the devices. Using Bernoulli's equation, theoretical flow rates are calculated and compared to actual measurements obtained by catch-tank and stopwatch methods, which serve as the control standard. Additionally, energy losses incurred across pipeline components, including elbows and rapid expansions, are assessed, illustrating how different devices impact fluid dynamics. This experiment reinforces fundamental fluid mechanics concepts and demonstrates how Venturi meters enable precise flow measurement in industrial settings, underscoring the importance of calibration and measurement accuracy. The results validate the reliability of the Venturi meter and deepen understanding of practical flow measurement technologies essential in engineering applications.

INTRODUCTION

A Venturi meter is a tube with a constricted throat that increases velocity and decreases the pressure. Venturi meter is used for measuring the flow rate of both compressible and incompressible fluids in pipeline.

For example, the Venturi meter is found in the wastewater treatment plant , Flow measurement is an important topic in the study of fluid dynamics. It must be made in chemical plants, refineries, power plants, and any other place where the quality of the product or performance of the plant depends on having a precise flow rate.

Flow measurements also enter into our everyday lives in the metering of water and natural gas into our homes and gasoline into our cars. There are many instruments used in flow measurements. In this experiment, we are going to use the following devices:

1) Venturi.
2) Orifice plate
3) Rotameter.

There are many different meters used to measure fluid flow: the turbine-type flow meter, the rotameter, the orifice meter, and the venturi meter are only a few.

Each meter works by its ability to alter a certain physical property of the flowing fluid and then allows this alteration to be measured. The measured alteration is then related to the flow. The subject of this experiment is to analyze the features of certain meters.

Objective

The main objectives of this experiment is to obtain the coefficient of discharge from experimental data by utilizing venturi meter and, also the relationship between Reynolds number and the coefficient of discharge.

This Experiment Aims To:

1- Familiarize students with some common devices and methods used in measuring flow rate.
2- Each flow measurement device will be compared to the standard method of using the catch-tank and stopwatch to measure the flow rate.
3- Determine the energy loss incurred by each of these devices.
4- Determine the energy loss arising in a rapid enlargement and a 900 elbow.

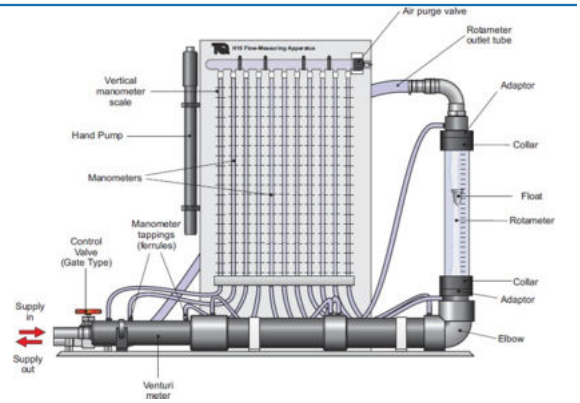


Figure 1: Flow Measurement Apparatus

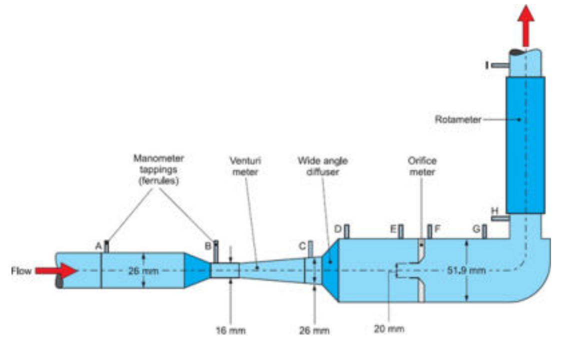


Figure 2: Explanatory diagram of the flow measurement apparatus

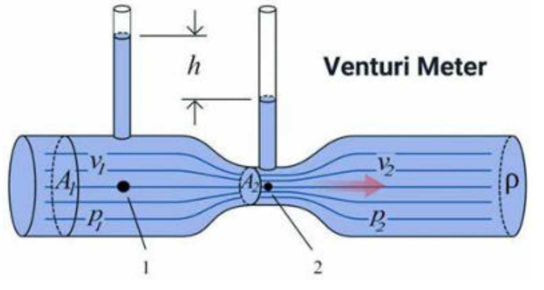


Figure 3: Explanatory diagram of the flow measurement apparatus

Theory Of Experiment:

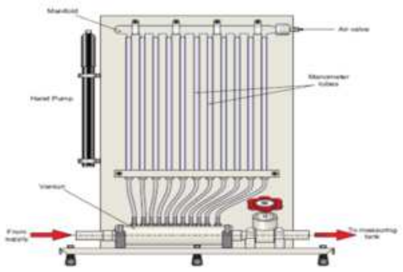


Figure 4: Schematic Diagram of Venturimeter

The flow measurement apparatus consists of a water loop as shown above figure. The supple line is connected to a gravimetric hydraulic bench. The flow rate controlled by a gate valve located at the discharge side of the hydraulics bench. A venturi meter, wide-angled diffuser, orifice meter and rotameter are arranged in series. Pressure taps across each device are connected to vertical manometer tubes located on a panel at the rear of the apparatus. The discharge from the apparatus is returned to the hydraulics bench .

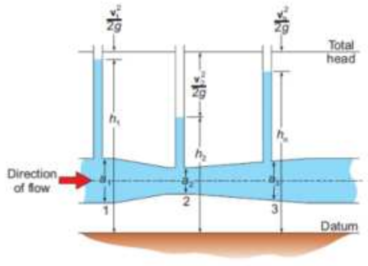


Figure 5: An incompressible fluid flowing along a convergent-divergent pipe

The Materials That Will Be Used In This Experiment Are:

- Venturi Meter1
- Water Supply
- Flow meter
- Stop watch
- Calculator

- **The Equations:**

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+Z_2 \quad (1)$$

Use of the continuity Equation $Q = A_1V_1 = A_2V_2$, equation (1) becomes

Qact = V/t

$$\frac{P_1-P_2}{\gamma}+Z_1-Z_2=\frac{V_2^2}{2g}\left[1-\left(\frac{A_2}{A_1}\right)^2\right] \quad (2)$$

$$V_2=\frac{1}{\sqrt{1-\left(\frac{A_2}{A_1}\right)^2}}\sqrt{2g\left(\frac{P-P_2}{\gamma}+(Z_1-Z_2)\right)} \quad (3)$$

Theoritical

$$Q_{theo}=A_2V_2=\frac{A_2}{\sqrt{1-\left(\frac{A_2}{A_1}\right)^2}}\sqrt{2g\left(\frac{P_1-P_2}{\gamma}+(Z_1-Z_2)\right)} \quad (4)$$

The term $\frac{P_1-P_2}{\gamma}+(Z_1-Z_2)$ represents the difference in piezometric head (Δh) between the two sections 1 and 2. The above expression for V_2 is obtained based on the assumption of one-dimensipnal frictionless flow. Hence the theoritical flow can be expressed as

Qtheo = $$Q=\frac{C_dA_2}{\sqrt{1-\beta^4}}\sqrt{2g\Delta h}=\left[\frac{C_dA_2}{\sqrt{1-\beta^4}}\sqrt{2g}\right]\sqrt{\Delta h}$$

Equipment Description:

The flow through venturimeter is a piece of equipment used in fluid mechanics experiments to measure the flow rate of a fluid. It consists of a converging section followed by a throat and then a diverging section. The converging section causes the fluid to accelerate, which creates a pressure drop at the throat. This pressure drop is measured using pressure sensors, and the flow rate is calculated using the Bernoulli equation. The venturimeter is commonly used in industrial and laboratory settings to accurately measure the flow of liquids and gases.

Tools:

1. **Venturi Tube:** The main component of the venturimeter, which is a tapered tube that narrows in the middle and widens at both ends.
2. **Manometer:** A device used to measure the pressure difference between the narrow and wide sections of the venturi tube.
3. **Flow Meter:** A device used to measure the flow rate of fluid passing through the venturimeter.
4. **Stopwatch:** Used to measure the time it takes for a certain volume of fluid to pass through the venturimeter, which is used to calculate the flow rate.
5. **Measuring Cylinder:** Used to collect and measure the volume of fluid passing through the venturimeter.
6. **Pressure Gauge:** Used to measure the pressure at different points along the venturi tube.
7. **Thermometer:** Used to measure the temperature of the fluid passing through the venturimeter, as this can affect its density and therefore its flow rate.

Steps To Make The Experiment:

1. Gather the necessary materials: venturi meter, tubing, flow meter, and a source of fluid (e.g. water).
2. Set up the venturi meter by connecting it to the tubing and ensuring that it is securely in place.
3. Connect the flow meter to the tubing on either side of the venturi meter to measure the flow rate.
4. Adjust the flow of fluid through the venturi meter by adjusting the source of fluid or any valves in the system.
5. Measure and record the pressure difference between the narrow and wide sections of the venturi meter using a pressure gauge.
6. Measure and record the flow rate using the flow meter.
7. Repeat steps 4-6 multiple times at different flow rates to gather a range of data.
8. Analyze the data collected to determine how changes in flow rate affect pressure difference and calculate any other relevant parameters such as velocity or discharge coefficient.
9. Draw conclusions based on your analysis and compare your results with theoretical predictions or other experimental data if available.
10. Clean up and properly store all equipment after completing the experiment.

Calculations And Results :

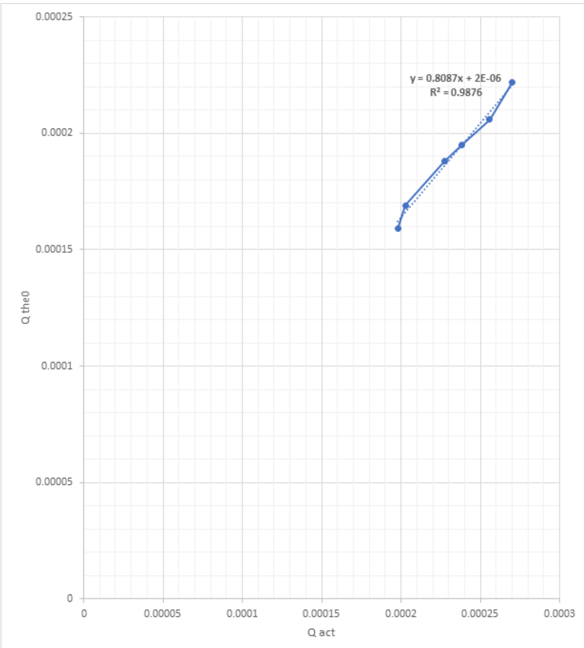
1. Calculate Q_{act} by using equation (Q_{act}=Vol/time).
2. Calculate the cross sectional area of upstream section (A1) and throat section (A2) by using equation (Area=(□/4)d^2).
3. Calculate the differential between reading (h1-h2).
4. Calculate the theoretical discharge ($Q_{theortical}$) by using equation (1).
5. Calculate C_d by using equation (2).
6. Calculate the average of the discharge coefficient by collecting the calculated runs and dividing it on the readings number.
7. Plot the relationship between the actual flow rate (Q_{act}) versus the root square of (h1-h^2) 1/2 and finding the slope from linear equation for graph then calculate C_d .

Table1: All Calculations

Run	V (m^3)	t (sec)	h1 (m)	h2 (m)	h3 (m)	H (m)	Qact (m^3/sec)	Qtheo	Cd	R

1	0.01	50.5	0.509	0.31	0.455	0.199	0.00019802	0.000159	1.245408	72.86432
2	0.01	49.3	0.49	0.265	0.435	0.225	0.00020284	0.000169	1.200235	75.55556
3	0.01	44	0.482	0.205	0.418	0.277	0.000227273	0.000188	1.208897	76.89531
4	0.01	42	0.474	0.177	0.406	0.297	0.000238095	0.000195	1.221001	77.10438
5	0.01	39.1	0.46	0.128	0.388	0.332	0.000255754	0.000206	1.241527	78.31325
6	0.01	37	0.452	0.065	0.365	0.387	0.00027027	0.000222	1.217434	77.51938

Shape (1)



DISCUSSION:

The experiment flow through a venturi meter is an important topic in fluid mechanics and is often conducted in laboratory settings to study the principles of fluid flow and pressure measurement.

The venturi meter is a device used to measure the flow rate of fluid in a closed conduit. It consists of a converging section, throat, and diverging section. As the fluid flows through the venturi meter, the velocity increases in the converging section, reaches its maximum at the throat, and then decreases in the diverging section. This change in velocity causes a corresponding change in pressure, which can be measured using pressure taps located before and after the throat.

During the experiment, students typically set up a closed loop water flow system with a pump, venturi meter, pressure gauges, and control valves. The flow rate is controlled using the control valve while pressure readings are taken at different points along the venturi meter. By measuring these pressures and knowing the geometry of the venturi meter, students can calculate the flow rate using Bernoulli's equation or other relevant equations.

The experiment allows students to observe how changes in flow rate affect pressure differentials across the venturi meter. They can also compare their experimental results with theoretical calculations to understand any discrepancies and sources of error.

Additionally, this experiment provides valuable insights into practical applications of fluid mechanics such as measuring flow rates in pipelines or determining pressure drops across various components in industrial systems.

In conclusion, conducting an experiment on flow through a venturi meter provides students with hands-on experience in fluid mechanics principles and helps them understand how this technology is used for practical engineering applications. It also allows them to develop skills in data collection, analysis, and interpretation which are essential for future engineering work.

CONCLUSION:

In conclusion, the experiment on flow through a venturi meter provided valuable insights into the principles of fluid mechanics and the application of Bernoulli's equation. The data collected and analyzed demonstrated the relationship between fluid velocity and pressure, as well as the accuracy of the venturi meter in measuring flow rates. The experiment also highlighted the importance of careful calibration and accurate measurements in obtaining reliable results. Overall, this experiment was successful in deepening our understanding of fluid flow and the functioning of venturi meters in practical applications.

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