Variation of Static and Dynamic head at Different Discharge using Venturimeter

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Abstract— In this study, tests were performed to determine the effects of Variation of Discharge on Static Head, Dynamic Head as well as total head at different diameter of Venturimeter. The results showed by Venturi meters validate Bernoulli’s Principle.

Keywords— Venturimeter, Static head, Dynamic head, Total Head, Bernoulli’s Theorem.

I. INTRODUCTION
The use of venturimeter as flow-measuring devices is a part of traditional hydraulics. It is differential pressure producing device, which can be inserted into a pipeline of any shape and size and orientation of conduit. The flow through venturimeter results into a pressure difference between the inlet and the throat. This pressure difference is used to compute the flow rates. As Venturimeter do not have moving parts, there is no wear and tear. Considerable theoretical and experimental studies have been published to describe mathematical models of Venturimeter The study of multiphase flow through contraction devices is described for example by Murdock (1962) [1], Smith and Leang (1975) [2], Chisholm (1977) [3], Lin (1982) [4], de Leeuw (1994) [5] and Steven (2002) [6]. All of these correlations depend either on the mass flow quality, x or empirical constants. Online measurement of mass flow quality x is rather difficult and not practical in multiphase flow applications. [7] Discusses Performance characteristics of eccentric Venturimeter. [8] Compares coefficient of discharge with standard and non-standard converging angle. [9] Study flow of wet gas through venturimeter. [10] evaluate the performance of venturimeter

II. STUDY AREA
The Experiment was performed using Venturimeter in Fluid Mechanics Lab., King Khalid University. The experiment was performed at temperature 20°C. The Equipment Employed for performing the job are F1-10 Hydraulics Bench which allows us to measure flow by timed volume collection and F1-15 Bernoulli’s Apparatus test equipment. A stopwatch for timing the flow measurement.

III. THEORY
The research work is based on Bernoulli equation which represents the conservation of mechanical energy for a steady, incompressible, frictionless flow

\[ p_1/\gamma + v_1^2/2g + z_1 = p_2/\gamma + v_2^2/2g + z_2 \]  

(1)

Where:

\[ p = \text{static pressure detected at a side hole}, \]
\[ v = \text{fluid velocity, and} \]
\[ z = \text{vertical elevation of the fluid}. \]

In present case \( z_1 = z_2 \) as the tube is horizontal tube. so equation 1 reduces to

\[ p_1/\gamma + v_1^2/2g = p_2/\gamma + v_2^2/2g \]

(2)

With the Armfield F1-15 apparatus, the static pressure head \( p \), is measured using a manometer directly from a side hole pressure tapping. The manometer actually measures the static pressure head \( h \), in metres which is related to \( p \) using the relationship \( h = p/\gamma \). The velocity related portion of the total pressure head is called the dynamic pressure head. The velocity of the flow is measured by measuring the volume of the flow, \( V \), over a time period, \( t \). This gives the rate of volume flow as \( Q \) which in turn gives the velocity of flow through a defined area, \( A \).

It is a noteworthy point that in the venturi meter the fluid is accelerated through a converging cone of angle 15-21° and the pressure difference between the upstream side of the cone and the throat is measured and provides the signal for the rate of flow. The fluid slows down in a cone with smaller angle (5-7°) where most of the kinetic energy is converted back to pressure energy. Because of the cone and the gradual reduction in the area there is no “vena contracta”. The flow area is at minimum at the throat.

IV. ANALYSIS FOR VENTURI
The flow through the Venturi can be regulated using the valves on the hydraulic bench and the apparatus itself. Set up the apparatus initially so that the variation in pressure between the entrance and neck is as large as possible; this will occur when the flow-rate is largest. It may be necessary to adjust the overall water level in the tubes by using the bike pump to increase the pressure in the chamber above the tubes.

Record the pressure heads at the entrance and neck of the Venturimeter. Obtain the flow rate by using the hydraulic bench. Gradually reducing the flow-rate, repeat the measurements for a total of at least 5 different flow rates.

V. EXPERIMENTAL SETUP
The test section is an accurately machined clear acrylic duct of varying circular cross section.

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Pressurisation of the manometers is facilitated by removing the hand pump from its storage location at the rear of the manometer board and connecting its flexible coupling to the inlet valve on the manometer manifold. In use, the apparatus is mounted on a base board which is stood on the work surface of the bench. This base board has feet which may be adjusted to level the apparatus. A level glass is provided as part of the base. The inlet pipe terminates in a female coupling which may be connected directly to the bench supply.

![Venturimeter showing various tapping position](image)

**Fig. 1 Venturimeter showing various tapping position**

### TABLE I

<table>
<thead>
<tr>
<th>Tapping Position</th>
<th>Manometer Legend</th>
<th>Diameter (mm)</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>h₁</td>
<td>25</td>
<td>490.9 x 10⁻⁶</td>
</tr>
<tr>
<td>B</td>
<td>h₂</td>
<td>13.9</td>
<td>151.7 x 10⁻⁶</td>
</tr>
<tr>
<td>C</td>
<td>h₃</td>
<td>11.8</td>
<td>109.4 x 10⁻⁶</td>
</tr>
<tr>
<td>D</td>
<td>h₄</td>
<td>10.7</td>
<td>89.9 x 10⁻⁶</td>
</tr>
<tr>
<td>E</td>
<td>h₅</td>
<td>10</td>
<td>78.5 x 10⁻⁶</td>
</tr>
<tr>
<td>F</td>
<td>h₆</td>
<td>25</td>
<td>490.9 x 10⁻⁶</td>
</tr>
</tbody>
</table>

### VI. RESULTS AND DISCUSSIONS

Measurements have been made with Venturi meter at six different position having different cross section. The results are presented in fig 2 to 6. The measurements have been made at varying discharge. Five discharge reading in increasing order have been taken which are as follows: Q₁ = 3.02 x 10⁻⁵ m³/s, Q₂ = 7.64 x 10⁻⁵ m³/s, Q₃ = 9.7 x 10⁻⁵ m³/s, Q₄ = 12.5 x 10⁻⁵ m³/s, Q₅ = 12.9 x 10⁻⁵ m³/s. As we go on increasing discharge the static head, dynamic head as well as total head varies at each section. The effect of varying discharge is effective as cross section moves on converging towards throat. The plotted graph reveals the fact that at converging section the static head at each section decreases abruptly. While dynamic head increases abruptly. The nature of total head is somehow similar to static but the nature here is not abrupt.

![Graph showing static, dynamic and total head](image)

**Fig. 2 Measurement at Q₁ = 3.02 x 10⁻⁵ m³/s**

![Graph showing static, dynamic and total head](image)

**Fig. 3 Measurement at Q₂ = 7.64 x 10⁻⁵ m³/s**

![Graph showing static, dynamic and total head](image)

**Fig. 4 Measurement at Q₃ = 9.7 x 10⁻⁵ m³/s**
Fig. 5 Measurement at $Q=12.5 \times 10^{-5} \text{m}^3/\text{s}$

Fig. 6 Measurement at $Q=12.9 \times 10^{-5} \text{m}^3/\text{s}$

VII. CONCLUSION

Experiment was conducted on a Venturi flow meter over a range of flow with the objective of obtaining data on static head, dynamic head and total head as well under laminar flow conditions. The experiment on the venturi meter has revealed its suitability for flow measuring application in water. The main conclusions of the study are as follows:

- As we go on increasing discharge the Total head at each tapping position will increase.
- The static head at converging section shows decreasing trend while dynamic head shows increasing trend. The reason behind this nature is that as cross section of converging section decreases velocity will increase thereby increasing dynamic head. As velocity will increase the pressure will decrease as a result static head will decrease.
- The result validate Bernoulli's theorem.

ACKNOWLEDGEMENT

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REFERENCES