New Technique for measurement of Discharge in Open channel flow

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Abstract- *Using the traditional technique for measuring discharge in open channel flow a new technique of discharge measurement is being developed by calibration of venturiflume to facilitate discharge measurement, which will lead the work in efficient way and achieving economy and accuracy. The methodology which is being refined through preparing actual model and proposed model, by using the experimental observations analysing them and preparing graphical output.*

Keywords- Discharge measurement, Innovative Venturi flume, Open channel. Venturiflume.

I. INTRODUCTION

The evolving circumstances under which irrigation districts operate include growing demands for more accurate knowledge and accountability of flow throughout the conveyance network, along with increased needs for timely awareness when unexpected flow conditions are present. For open channel conveyance systems, critical-flow structures (flumes or weirs) offer the simplicity of a direct correlation between upstream water level and a corresponding discharge. Unfortunately, at many locations where flow measurement is desired there may be insufficient space available for operation of a critical-flow measurement structure under all flow conditions that may occur.

The use of flumes in measuring open-channel flow began shortly after the turn of the century. Flumes have a limited but important use in such measurement. As with any other type of artificial control, such as weirs, flumes are built in streams whose channel characteristics are such that the natural stage-discharge relation is subject to shifting or is insensitive. Flumes are also built in small flashy streams where current meter discharge measurements are impracticable because of the rapidity of changes in stage, and where the difficulty of anticipating stream rises makes it improbable that a stream gages will arrive at the site during high-water periods. Flumes commonly utilize a contraction in channel width and a drop or a steepening of bed slope to produce critical or subcritical flow in the throat (contracted section) of the flume. The relation between depth measured at some standard cross section and discharge is thus a function only of the configuration of the flume and the relation can therefore be determined prior to installation.

II. TRADITIONAL VENTURI FLUME

The traditional venture flume used in current irrigation projects to measure the discharge in open channel flow.

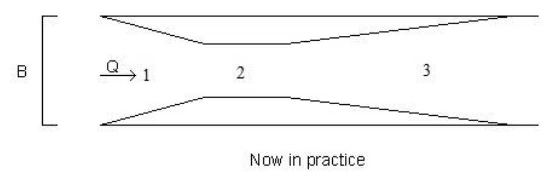


Fig 1.Traditional Venturi Flume.

Where,

1- Convergent ,
2- Throat,
3- Divergent,

Angle of convergent = 21°,

Angle of divergent = 7.6°,

Width of throat = (Width of convergent/2)

Length of throat = (Width of convergent/2)

III. DESIGN OF VENTURI FLUME

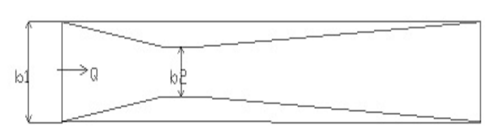


Fig 2. Venturi flume with dimensions

$Q= KC\sqrt{h}$

Where,

$$C=\frac{a_1 a_2\sqrt{2g}}{\sqrt{(a_1^2-a_2^2)}}$$

$$h = y_1 - y_2$$

$$a_1 = b_1 y_1, \qquad a_2 = b_2 y_2$$

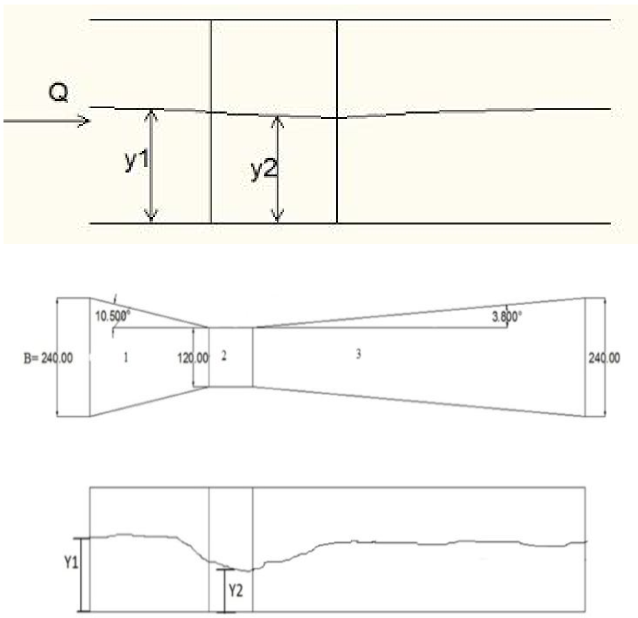


Fig3.Side view of flume with flow from left to right with height difference (y1-y2).

Photo 1: Traditional Venturiflume Prototype model.

IV. EXPERIMENTAL OBSERVATIONS FOR TRADITIONAL VENTURIFLUME

The following table shows the experimental results for traditional venturi flume which is obtained from prototype model. Results show the satisfactory coefficient for discharge of Venturi flume.

Table I. Experimental results for Traditional venturi flume.

Sr. No.	y_1	y_2	t	Q	a_1	a_2	K
1	9.5	7.6	3.2	0.004688	2.128	0.7904	0.9018
2	9.4	7.7	3.1	0.004839	2.1056	0.8008	0.9676
3	9.8	7.7	2.9	0.005172	2.1952	0.8008	0.9369
4	9.8	7.8	3	0.005	2.1952	0.8112	0.9143
5	7.8	5.7	3.9	0.003846	1.74	0.592	0.9518

V. INNOVATIVE VENTURI FLUME

In proposed Venturi flume the size of flume is reduced in scale with respect to traditional flume which will lead the work in efficient way and achieving economy and accuracy. For design purpose i reduced the traditional flume to 1/4th of its actual size.

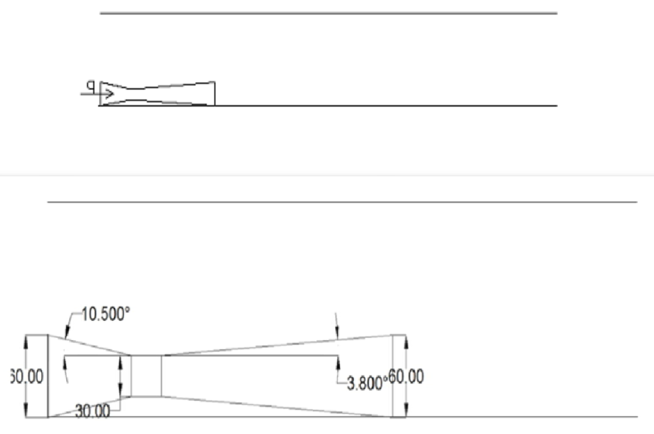


Fig 4. Proposed Design of Venturi Flume.

Equation of the proposed venturi flume

$$Q = K'C\sqrt{h} \text{ ………………..}$$

$$Q = K'\frac{a'_1 a'_2\sqrt{2g}}{\sqrt{a'^2_1 - a'^2_2}}\sqrt{y'_1 - y'_2} \text{ ………}$$

Where,

$$C = \frac{a'_1 a'_2\sqrt{2g}}{\sqrt{a'^2_1 - a'^2_2}} \text{ ……………. ()}$$

$$a'_1 = b'_1 y'_1 \qquad a'_2 = b'_2 y'_2 \text{………….... ()}$$

Photo 2- Innovative venturiflume prototype model

Fig.4 shows the proposed venturi flume for full cross section of canal. For proposed model the angles and height should be same as traditional flume, only width and length of the flume should be reduced to 1/4th with respect to traditional flume.

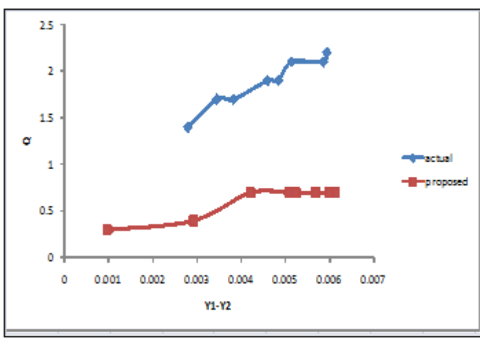
From my experiment I was expecting that some relation between traditional venturi flume and proposed venturi flume will be come which will helpful for irrigation department to discharge measurement of open channel flow.

VI. EXPERIMENTAL OBSERVATIONS FOR INNOVATIVE VENTURIFLUME

From these equations I found out the coefficient of discharge for venture flume. The following table shows the experimental results for proposed venturi flume which is obtained from proposed prototype model.

Table II. Experimental results for Proposed venturi flume

	Y_1	Y_2	t	Q	a_1	a_2	K
1	6.2	5.7	5.3	0.00283	0.372	0.171	0.046929
2	8	7.1	3.6	0.004167	0.48	0.213	0.041718
3	8.9	8	2.9	0.005172	0.534	0.24	0.045816
4	9.5	8.4	2.5	0.006	0.57	0.252	0.04597
5	9.7	8.9	2.5	0.006	0.582	0.267	0.0504
6	9.9	9	2.4	0.00625	0.594	0.27	0.049067



Actual		Proposed	
Q	(y1-y2)	Q	(y1-y2)
0.0028	1.4	0.0061	0.8
0.00345	1.7	0.006	0.7
0.00383	1.7	0.0058	0.6
0.00524	1.5	0.0057	0.7
0.00469	1.8	0.0052	0.7
0.0046	1.9	0.0051	0.7
0.00484	1.9	0.0042	0.7
0.00521	1.8	0.0029	0.4
0.00542	1.8	0.001	0.3
0.00595	2.2	0.0018	0.3
0.00514	2.1	0.0035	0.6
0.00586	2.1	0.0047	0.5
0.00556	2.2		

Graph I. Comparison between traditional and proposed venture flume
{Q vs (y_1-y_2)}

VI. DISADVANTAGES OF TRADITIONAL VENTURI FLUME

- High pressure drop.
- Cost of construction is high.
- Difficult to measure depth of water.
- Because of small cross section at throat, it erodes surface of canal.

VIII. ADVANTAGES OF INNOVATIVE VENTURI FLUME

- Low pressure drop.
- Economical.
- Easy to measure depths of waters i.e.
- High efficiency

IX. APPLICATION

- Irrigation canal.

X. CONCLUSION

For innovative venturi flume conclusion is that we found relation between traditional venturi flume and proposed venturi flume, which will lead the work in efficient way and achieving economy and accuracy.

1) A new miniature venture flume was developed for discharge measurement in Open channel flow using traditional venturi flume.
2) Actual venturi flume was calibrated and proposed miniature venturi flume was tested by experiments in laboratory.
3) From the study it is concluded that the proposed model is valid for design discharge of 0.005 m3/sec and 2.5<B/y1<3.5 with coefficient of discharge 4.00
4) Economy was achieved due to reduced dimensions of new venturi flume.
5) The equations obtained are

$y = -67.857x2 + 2.4507x - 0.017$…………….. (5.1)

$R^2 = 0.9675$……………………………………………(5.2)

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NOTATIONS

Q = Discharge in m3/sec
q = Partial discharge for proposed flume in m3/sec
K= Coefficient of discharge
a_1 = Area of convergent in m^2
a_2 = Area of throat in m^2
b_1= Width of convergent in m.
b_2= Width of throat in m.
k = Coefficient of discharge.
a_1'= Area of convergent in m^2 .
a_2'= Area of throat in m^2 .
b_1' = Width of convergent in m.
$b_{2'}$= Width of throat in m.

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