Minor Loss Coefficient Estimation by Venturimeter Experiment Fitted in a Pipe System

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Abstract- **The calibration of venturimeter pipe system periodically to be done to avoid the major and minor losses in the running condition. This paper work, based on the minor losses experiment conducted on venturimeter setup in the fluid mechanics & hydraulic machinery laboratory the values are taken accordingly and the calculations are performed. The minor loss coefficient associated with a venturimeter fitted with a pipe system is estimated. It is observed that the loss coefficient varies inversely with the increase in the Reynold's number and when it is compared with the Actual discharge the loss coefficient decreases with the increase of Actual discharge.**

Index terms- **Loss coefficient, fluid mechanics & hydraulic machinery, Venturimeter, Reynold's number, Actual discharge**

I.INTRODUCTION

The flow in the pipes undergo different losses such as major Losses and minor losses are to be checked properly in order to maintain the required energy for the flow and the major loss or frictional loss is due to viscous effects in the pipes and minor losses are due to the additional components such as valves, bends and pipe geometry such as expansion and contraction in pipes. Venturimeter is widely used device to measure the discharge through the pipe. A venturimeter is a converging-Diverging nozzle of circular cross section. The principle of venturimeter is when a fluid flows through the venturimeter, it accelerates the convergent section and decelerates in the divergent section, resulting in a drop in the static pressure followed by a pressure recovery in the flow direction. Then by measuring the difference in the pressures at an axial station upstream of the convergent section and at the throat, the volumetric flow rate can be estimated the working of venturimeter is based on the principle of Bernoulli's equation.

Bernoulli's Statement: It states that in a steady, ideal flow of an incompressible fluid, the total energy at any point of the fluid is constant. The total energy consists of pressure energy, kinetic energy and potential energy or datum energy. Mathematically,

It is necessary to quantify the minor losses and design the energy requirement accordingly so that sustainability of the system can be ensured. Generally, the minor losses are expressed in the function of velocity head. To determine the minor loss due to fitting of venturimeter, the loss coefficient has to be estimated maintaining the Integrity of the Specifications.

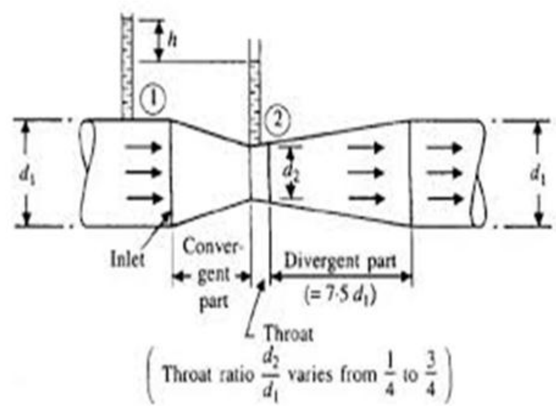

Figure.1.Venturimeter

Farsirotou in the year 2014 conducted experimental studies to estimate the minor losses associated with a Reynold's number indicated that for Reynold's number between 2000 to 5000, the non-dimensional number head loss (which is essentially the loss coefficient) decreased after which it remains constant within the statistical error. The present paper is focused on minor loss estimation with the venturimeter.

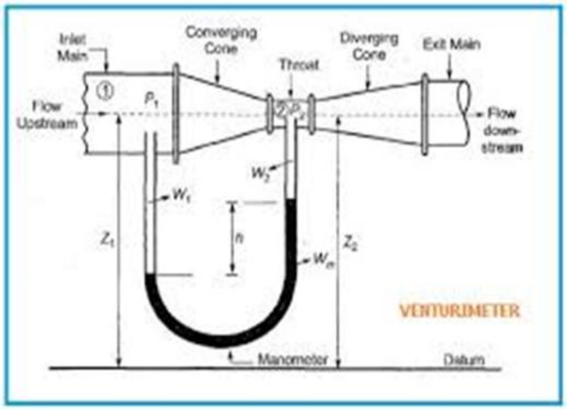

Figure.2.Venturimeter with manometer

The velocity is estimated by measuring the discharge in the collecting tank of area 'A' for 'R' cm rise in the water level at time t. The velocity of flow, V, through the pipe is calculated by dividing the actual discharge Q_{act} in the pipe with the area 'A' of the pipe.

Q_{act} is given by

$$Q_{act} = \frac{AR}{T}$$

The head loss in the divergent section is assumed to be same as that obtained in the convergent section for a given discharge. Major losses are neglected as the length of pipe is more so only minor losses are considered .The total head loss (h_L) is obtained as the sum of head loss in convergent and divergent sections. Loss coefficient (K_v) is then calculated from the following equation.

$$K_V = \frac{2g \times h_L}{V^2}$$

Various graphs are plotted between the Reynold's number and K_V and explainn the variations.

II CALCULATIONS

Consider,

Diameter of the throat = 15mm

Diameter of the pipe = 25mm

Area of the throat $= \frac{\pi r^2}{2} = 1.7671\times10^{-4}$ m^2

Area of the pipe $= \frac{\pi r^2}{2} = 4.9087\times10^{-4}$ m^2

δh =0.7308 m of water

't' time in seconds for rise of head

R rise in head in cm

V volume of water

g = 9.81m/sec^2

$Q_{act} = \frac{AR}{T} = 6.25\times10^{-4}$ m^3/sec

$Q_{the} = \frac{A_1 \times A_2\sqrt{2g\delta h}}{\sqrt{A_2^2} - \sqrt{A_1^2}}$

$= 6.69\times10^{-4}$ m^3/sec

Coefficient of discharge = Q_{act} / Q_{the}

C_d = 0.934

C_d is the coefficient of discharge for venturimeter and its value is always less then 1.

For C_d =0.03

Loss coefficient (K_v)

$$K_V = \frac{2g \times h_L}{V^2}$$

V =Q_{act}/A

= 1.27m/sec

$h_L = \delta h(1-C_d^2) = 0.098$

K_V = 1.19

Reynold's number = $\frac{vD}{\mu}$

D=Diameter of the pipe

V = velocity

μ = kinematic viscosity of water at 34^0 C

=0.801×10^{-6} m^2 / sec

Reynold's number = $\frac{vD}{\mu}$ =39,687

Similar way for all the readings are taken and calculated and tabulated in below tables.

III. RESULTS AND DISCUSSION

The venturimeter experiment is performed and by varying the gate opening (water flow) 14 readings were taken which involved the measurement of mass flow rate, differential pressure and coefficient of discharge (Qa ,Qt and Cd) are also calculated. As expected, two Cd values are choosen from different combinations of discharge and pressure head differences. The readings corresponding to Cd values of 0.93 and 0.98 are collected together and plotted as graphs between the discharge and the pressure head . Reynolds number ranges from 10,000 to 60,000.

TABLE 1: DISCHARGE VARIATION WITH MANOMETRIC HEAD

S.NO	LOSS COEFFICIENT		
	δH	t	Q_{act}
1.	0.730	20	6.25×10^{-4}
2	1.486	14	8.92×10^{-4}
3	1.403	23	5.43×10^{-4}
4	1.466	15	8.33×10^{-4}
5	1.265	14	8.98×10^{-4}
6	1.304	18	6.94×10^{-4}
7	0.842	21	5.95×10^{-4}
8	0.784	19	6.58×10^{-4}
9	0.831	18	6.94×10^{-4}
10	0.792	19	6.57×10^{-4}
11	0.843	18	7.02×10^{-4}
12	0.176	34	3.47×10^{-4}
13	0.621	20	6.25×10^{-4}
14	0.547	23	5.43×10^{-4}

Figure.3.Venturimeter Experiment

TABLE 2:VETURI LOSS COEFFICIENT & REYNOLDS NUMBER

S.NO	VETURI LOSS COEFFICIENT	
	R_e	K_v
1	39687	1.19
2	56803	1.18
3	34332	3.06
4	53125	1.34
5	57187	0.72
6	44007	1.73
7	37812	1.52
8	41822	1.15
9	44062	0.31
10	41875	0.34
11	44375	0.32
12	24375	0.22
13	39681	0.29
14	34332	0.35

GRAPHS

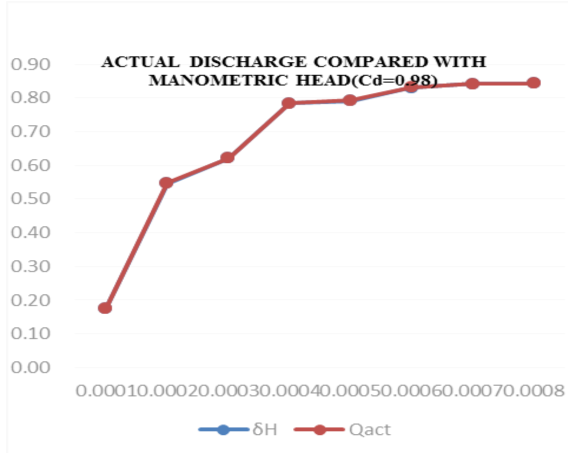

Figure 4.ACTUAL DISCHARGE COMPARED WITH MANOMETRIC HEAD(Cd=0.98

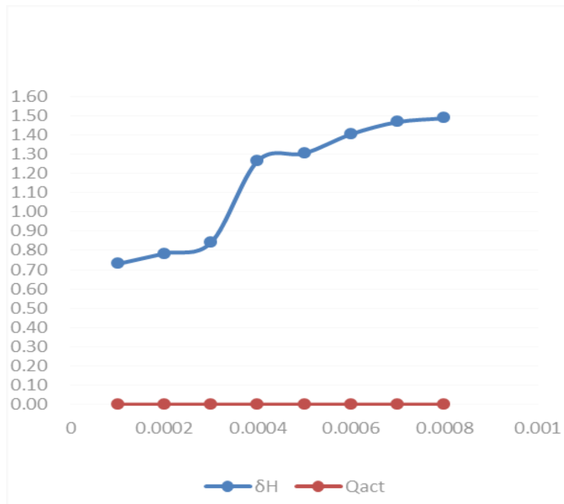

Figure 5.ACTUAL DISCHARGE COMPARED WITH MANOMETRIC HEAD(Cd=0.93)

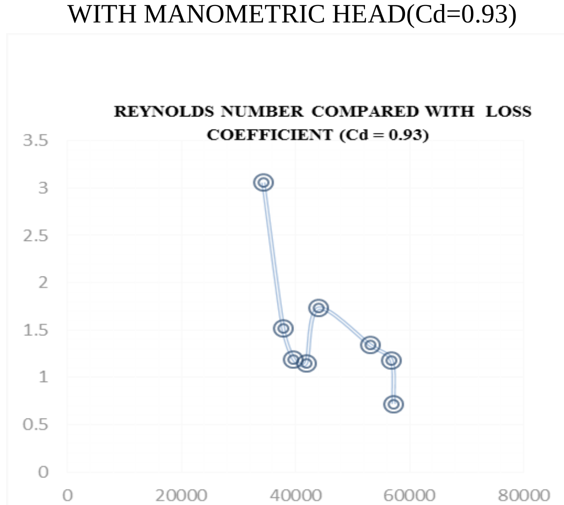

Figure 6.REYNOLDS NUMBER COMPARED WITH LOSS COEFFICIENT (Cd = 0.93)

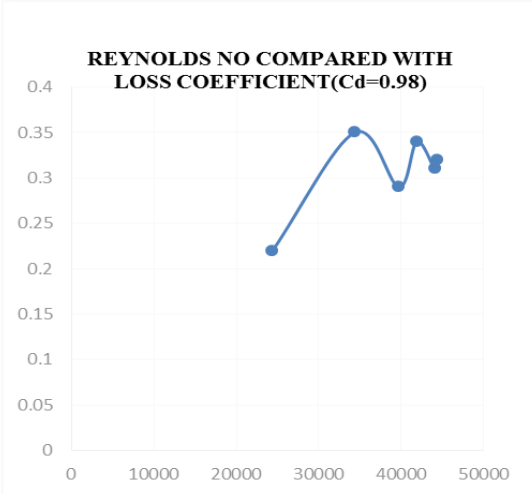

Figure7.REYNOLDS NO COMPARED WITH LOSS COEFFICIENT (Cd=0.98)

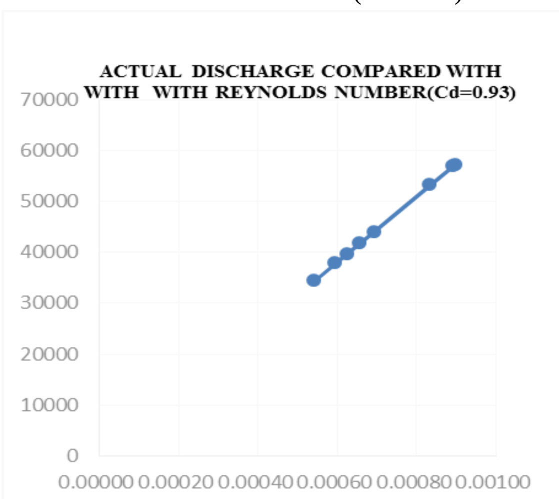

Figure 8.ACTUAL DISCHARGE COMPARED WITH REYNOLDS NUMBER (Cd=0.93)

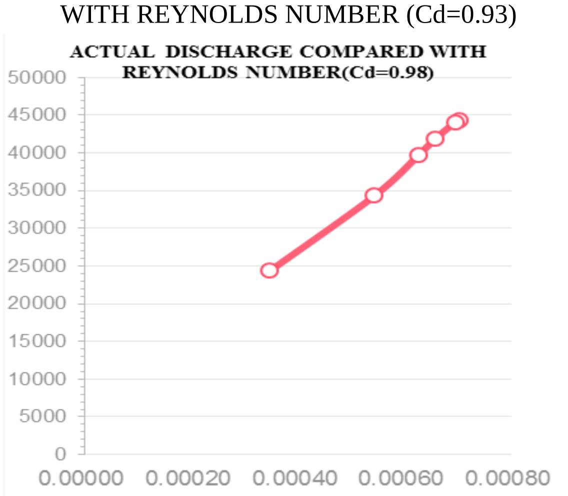

Figure 9 ACTUAL DISCHARGE COMPARED WITH REYNOLDS NUMBER (Cd=0.98)

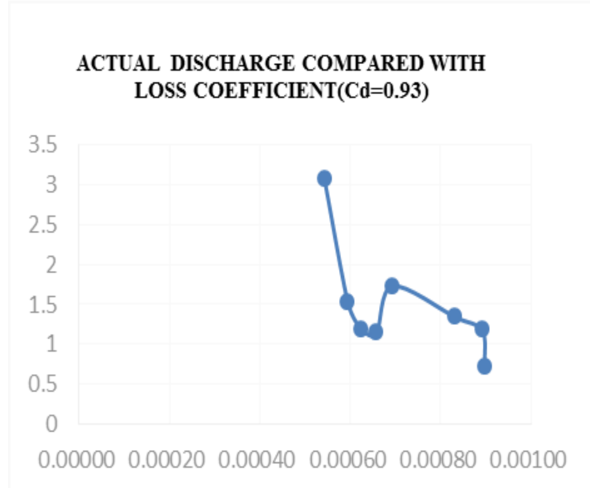

Figure 10 ACTUAL DISCHARGE COMPARED WITH LOSS COEFFICIENT (Cd=0.93)

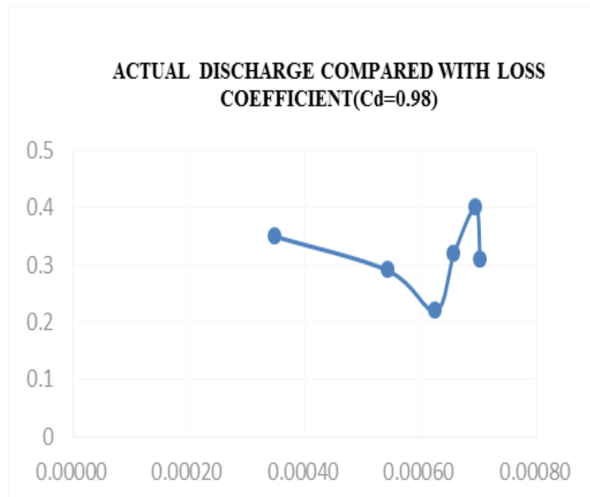

Figure 11.ACTUAL DISCHARGE COMPARED WITH LOSS COEFFICIENT (Cd=0.98)

Where Re is the Reynold’s number and it is observed that the loss coefficient value for the venturimeter is not a constant value and It is varied with the discharge such that when the discharge value Increased the Reynold’s number also increased and the loss coefficient is decreased. It is noted that the assumption of the same head loss in the divergent part of the pipe will have some error to

IV. CONCLUSION

The venturimeter in the pipe setup will exhibit some error in the form of minor losses. The loss coefficient with respect to this minor loss is determined and it is decreased with the increase in the discharge and Reynold’s number. It can be suggested that any pipe fitted with venturimeter must be regularly calibrated for loss coefficient so that accurate results while performing the experiment can be obtained .The method adopted in this paper is an approximately random method involving with some assumptions such as pressure variation from the throat of venturimeter to the downstream of pipe. More elaborately the experimentation studies can be done for accuracy by considering the venturimeter coefficient of discharge values from 0.93 to 0.98. To estimate orifice loss coefficient this method of approach can be used.

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