Impact of Viscosity Variation, and Flow Rate on Coefficient of Discharge in Venturimeter Utilizing Taguchi Methodology

Manoj Modi, Swati D. Chougaonkar, V. Patil, Prachi Kaneherkar, Namrata Chandel, Jayant Awasthi, Kartik Pawar

Abstract: Most of the industries are concerned with flow measurement and accurate measurement of fluid is important to obtain specific proportion as per process requirement. Generally Venturimeter (VM) is utilized in enterprises due to notable highlights offered by it. VM works on the principle of pressure difference i.e. Bernoulli’s principle. By varying cross sectional area of flow, it creates pressure difference along its length which is used to calculate theoretical discharge. Head loss in VM is less as compared to other flow measuring apparatus. Because of its specific geometry eddies formation is avoided causing less head loss. The coefficient of discharge ($C_d$) is an important parameter always referred in case of flow measuring devices. For VM it varies from 0.95 to 0.99. Tests have been performed in accordance to Taguchi L9-O/A on cast iron pipe to examine the impact of variations of viscosity, and rates of flow on the $C_d$.

Keywords: Viscosity, flow rate, VM, and Coefficient of Discharge, etc.

I. INTRODUCTION

Venturimeter (VM) is an apparatus utilized for estimating the fluid flow rate in a pipe. The working concept of VM is by decreasing the C/S area of the fluid-flow of entry, the variation in pressure is made and the estimation of pressure variation empowers us to calculate the release from the pipe. The VM comprises 3 primary components viz. Throat, Converging and Diverging part. Klochko et al. [1] investigated the execution of a VM in fluid-gas stream within the diffuse gases for drop in pressure. Bansode et al. [2] investigated the variability in pressure over the VM utilizing C-FD examination and authenticated the outcomes by experimental test. San et al. [3] examined the impacts of angles of C-D on $C_d$ and over-perusing in W-gas stream estimation.

This work reported about the D-angles have critical impact on over-perusing while C-angles have compelling impact on $C_d$. Wang et al. [4] used C-FD system to investigate the correlation between various factors of VM and suction limit of VI and interpret the various outcomes. Vijay et al. [5] differentiated 4 unique VM Models to investigate about the various input factors and outcomes utilizing C-FD technique. Fig. 1 displays the schematic diagram of venturimeter.

![Fig. 1 Schematic diagram of Venturimeter](image)

II. METHODS TO CALCULATE COEFFICIENT OF DISCHARGE

Adjust the discharge and percentage mixing of glycerin in water and record the difference in pressure ‘$h$’ to compute the theoretical-discharge $Q_{th}$, and evaluate the actual-discharge $Q_{act}$.

The actual-discharge and theoretical discharge are calculated by the equation 1, and 2 respectively.

$$Q_{act} = \frac{\text{Volume of fluid}}{\text{time}}$$  \hspace{1cm} (1)

$$Q_{act} = \frac{A_1 \times A_2 \sqrt{2gh}}{\sqrt{(A_2^2 - A_1^2)}}$$  \hspace{1cm} (2)

The coefficient of discharge is calculated by equation 3.

$$C_d = \frac{Q_{act}}{Q_{th}}$$  \hspace{1cm} (3)

Where,

$A_1$ – diameter of pipe;

$A_2$ – diameter of throat;

$g$ = acceleration due to gravity; and

$h$ – difference in pressure head among inlet and the throat.
III. EXPERIMENTAL PROCEDURE WITH FRICTION SET-UP

One set of nine experiments were conducted in accordance to L9 orthogonal-array on VM set-up. Similarly, various types of Taguchi based O-A has been applied by the various researchers for planning and conduction of experiments in their research works [6-11]. The photographic picture of this frame-up is shown in Fig. 2.

Experiments have been conducted with cast iron pipe to examine the impact of variations of viscosity, and rates of flow on coefficient of discharge in VM set-up. Modi et al. [12, 13, 14] applied Taguchi method in conventional machining procedure for modeling and analyzing the process factors. The level and value of factors associated with these experimental tests are shown in Table 1.

Table 1 Level and value of factors in friction factor determination experiments

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycerin (%)</td>
<td>Kg/litre</td>
<td>0 (0%)</td>
<td>2 (50%)</td>
<td>4 (100%)</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>litre/sec</td>
<td>0.250</td>
<td>0.375</td>
<td>0.500</td>
</tr>
</tbody>
</table>

The L9 orthogonal array, experimental plan and outputs for friction factor are portrayed in Table 2.

Table 2 L9 orthogonal array, experimental plan and outputs for friction factor

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Mixing of Glycerin</th>
<th>Flow Rate (litre/sec)</th>
<th>Coefficient of Discharge (Cd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0.250</td>
<td>0.711</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0.375</td>
<td>0.753</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.500</td>
<td>0.812</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>0.250</td>
<td>0.681</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>0.375</td>
<td>0.729</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>0.500</td>
<td>0.763</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>0.250</td>
<td>0.665</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>0.375</td>
<td>0.698</td>
</tr>
<tr>
<td>9</td>
<td>100</td>
<td>0.500</td>
<td>0.741</td>
</tr>
</tbody>
</table>

IV. RESULTS

The results obtained show that coefficient of discharge can be mathematically modeled and can be displayed by the Figs. 3, 4, and 5 by MINITAB 17 software.
V. CONCLUSIONS

The below mentioned outcomes can be drawn dependent on the interpretations from the Figures 3, 4, and 5.

1. The maximum coefficient of discharge is obtained with pure water, followed by 2 liter of glycerin mixed with water, and for 4 liter of glycerin mixed with water produced the minimum coefficient of discharge in this experimental work.

2. The coefficient of discharge is minimum at minimum flow rate, followed by medium flow rate, and maximum flow rate produced the maximum coefficient of discharge.

REFERENCES


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