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General correlations of the effect of orifice shapes on coefficient of discharge

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ABSTRACT

Orifices are widely used as flowmeters in industries, automobiles and other mechanical equipment's. Significant research has been done in this field but is still in potential area of research. This paper experimentally determines the effect of orifice shapes on the coefficient of discharge. Eight different orifice shapes namely circular, semi-circular, rectangular, elliptical, square, triangular, hexagonal and star shapes are tested in a standard experimental setup under different heads to determine the average coefficient of discharge. Based on the experimental result a correlation is developed connecting coefficient of discharge as a function of the non-dimensional shape coefficient

Keywords: Orifice Shapes, Coefficient of Discharge, Orifice Meter

I. INTRODUCTION

Determining the quantity of fluid passed through the pipe, duct or an open channel we measure the flow (To obtain the specific proportions as per the process requirements there is a need of accurate measurement of fluid) To get maximum efficiency it is important to maintain definite flow rate. Venturi meter, Orifice meter, Rotameter, pitot tube, Flow nozzles etc. are the main flow measuring instruments.

Least co-efficient of discharge is obtained in orifice meter, hence we choose it for the experimental study. Orifice meter id the equipment used. Eight shapes of orifice plates are used they are; circular, semi-circular, squared, rectangular, triangular, elliptical, hexagonal, & star shaped. In the experimental study we are calculating co-efficient of discharge from these shapes of plates. Taking the average 'cd' from different heads. For this actual discharge & Theoretical discharge of the orifice meter is calculated. By meaning their ratio we are getting the co-efficient of discharge. Here the shape factor is considered as ratio of area of pipe A1 to the area of orifice A2. Finally, from the experiment we get the correlation of orifice shapes on the orifice plate.

II. METHODS AND MATERIAL

The Bernoulli's principle is used to measure flow rate. When the velocity increases the pressure decreases and vice versa. An orifice is a thin plate with a hole in the Centre and placed inside pipe where the fluid flows. When the fluid flows through the pipe with certain velocity and pressure it forced to converge to go through the small hole. The point of maximum convergence occurs shortly downstream of physical orifice, at the so-called venacontracta. As it flows the velocity and pressure changes. The mass flow can be calculated by measuring difference in fluid pressure between the normal pipe section and the venacontracta.

The theoretical discharge for an orifice is given by equation

$$Q_{th}=A_1A_2\sqrt{2gH}/(\sqrt{(A_1^2-A_2^2)})$$

A_1= Area of pipe

A_2= Area at orifice

H = Head causing flow

g = Acceleration due to gravity

The actual discharge is given by

$$Qa = \frac{Ax}{t}$$

A = area of the collecting tank

x = 5cm rise of collecting tank

t = time for 5 cm rise if water in the collecting tank

$$C_d = \frac{Qa}{Qth}$$

The experimental setup used to measure the coefficient of discharge of an orifice is shown below

Figure 1: Experimental setup

Figure 2 : Shapes of orifices

III. RESULTS AND DISCUSSION

By conducting this experiment coefficient of discharge of orifices having various shapes are observed. The experiment is conducted by varying the pressures, a set of experimental data is tabulated. With this data coefficient of discharge (C_d) vs head causing flow (H) is plotted.

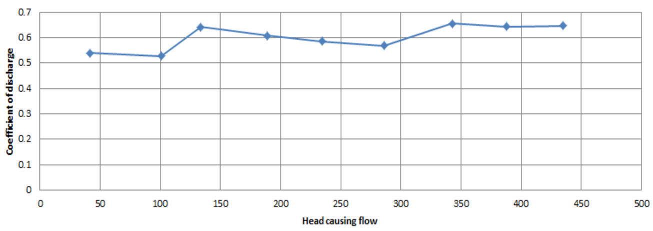

Figure 3: Circle

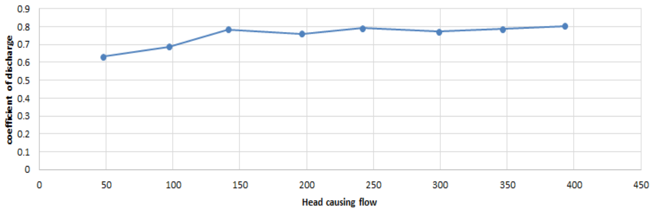

Figure 4: Ellipse

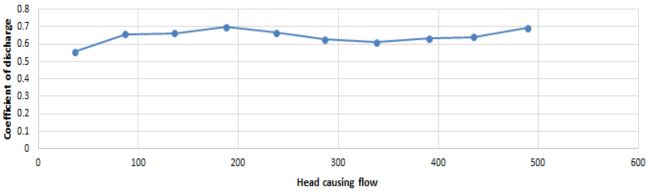

Figure 5: Hexagon

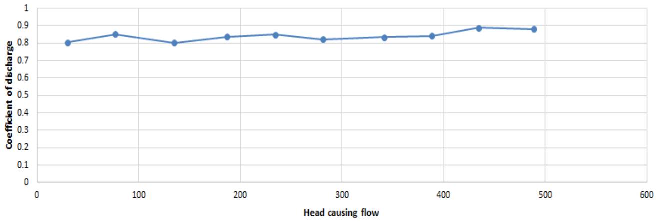

Figure 6: Rectangle

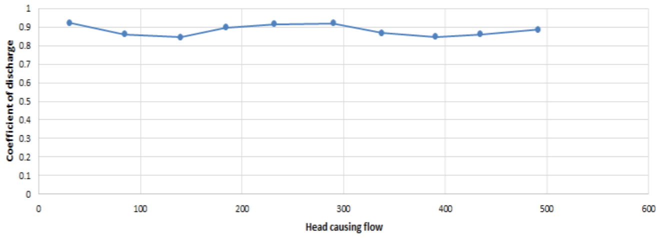

Figure 7: Semicircle

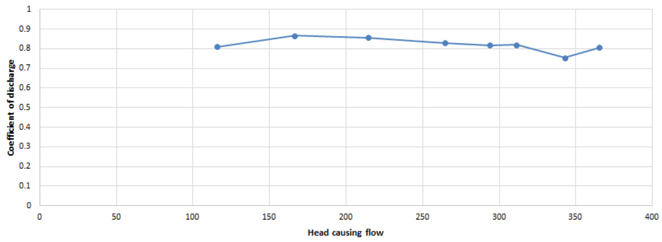

Figure 8: Square

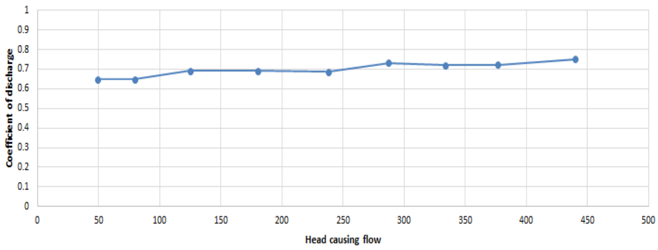

Figure 9: Star

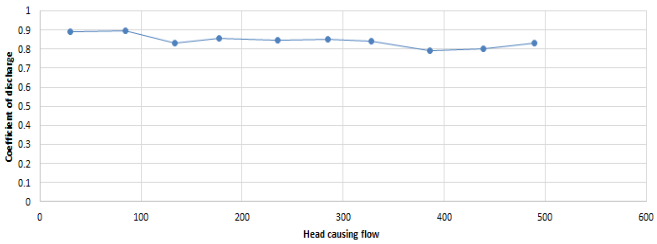

Figure 10: Triangle

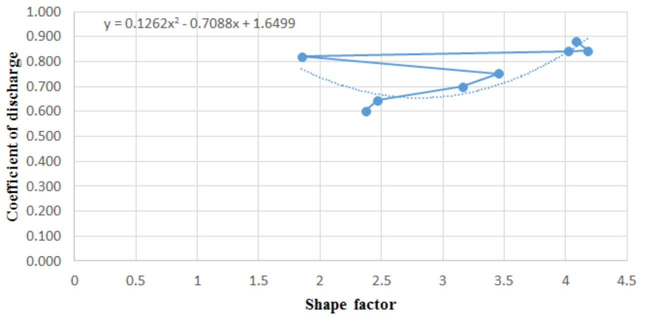

Figure 11 : Correlation

sl no	shapes of orifice	Area of orifice A_2 (cm^2)	Shape factor (A_1/A_2)	Avg. c_d
1	circle	1.32	2.37	0.602
2	hexagon	1.27	2.47	0.644
3	star	0.9926	3.16	0.699
4	ellipse	0.91	3.45	0.753
5	square	1.69	1.85	0.820
6	rectangle	0.78	4.02	0.842
7	triangle	0.6525	4.18	0.843
8	semicircle	0.769	4.08	0.882
	A_1 = AREA OF PIPE d= 2cm ($3.14cm^2$)			
	A_2 = AREA OF ORIFICE (cm^2)			

Fig 12 : Shape factor

From this study we correlate the equation for finding coefficient of discharge of orifices having various shapes. The equation for coefficient of discharge is

$$C_d= 0.1262(A_1/A_2)^2-0.7088(A_1/A_2)+1.6499$$

IV. CONCLUSION

The average coefficient of discharge for different orifice shapes where experimentally found out. The coefficient of discharge is found to vary with the ratio of pipe area to orifice area . A general correlation is found for the coefficient of discharge based up on the area ratio

V. REFERENCES

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