Study on the Small Type Orifice Meter Made of Plastic Materials

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ABSTRUCT

On the purpose of measuring the flow of fluids, the small type of orifice meter were made by plastic materials, and sufficient data were obtained to be able to apply for the field of measuring small amount of fluids in laboratory work.

The orifice meter which made by plastic materials provide the following relationship between the velocity through the orifice V (cc/min) and difference in head dH, as the equation (1).

$$dH=AV^2+BV \tag{1}$$

where,

$$A=\frac{1}{450\,T^2C_0^2GD^4} \tag{2}$$

$$B=\frac{32L}{15\,TGD^4}\times\frac{M}{P} \tag{3}$$

on the equation (1), the term of AV^2 is a main factor which depend on difference in head and it will be a rate determing factor for dH. Also BV is a sub-term which come from pressure loss in the orifice hole.

The equation (1) may ploted on linear relation between (dH/V) and V, therefor there are no dificulties to determine the values of A and B.

This small type orifice meter which made by plastic materials will be able to apply for the laboratory work with very high accuracy.

1. INTRODUCTION.

Necessity of measuring small amount of fluid is raising on our research work, then the small type of orifice meter were made by plastic materials, because there are no such kinds of orifice meter with handy and considerable high accuarancy.

This orifice meter, the small type of, should not be influenced either by viscosity and temperature of the fluid which have to be measured.

For this puorpose two of basic way of thinking were taken for this study:

(1) Orifice meter would be made by new materials and with new conception.

(2) In general, the following equation is widely used to express the differences in head through the orifice meter:

$$v=(T/4)D^2C(2G\cdot dH)^{1/2} \tag{4}$$

then,

$$dH=\frac{8v^2}{T^2C^2D^4G}=f(v^2) \qquad (5)$$

and

$$Q=AC(2G\cdot dH)^{1/2} \qquad (6)$$

after we examined these equations, the new equations were introdused.

2. SMALL TYPES OF ORIFICE METER.

The constand C is not a constant number on the equation (4), (5) and (6). The following datas clearly show the differences of constant C on these equations.

Table 1 Differences of constant C on the equation (4), (5) and (6).

Temp.	A	dH	Q (cm³/sec)	C
24.0°C	A_1	20.1	2.4	0.62
	A_2	17.2	6.79	0.43
	A_3	13.9	10.75	0.41
24.0°C	A_1	16.6	2.07	0.60
	A_2	13.0	5.45	0.44
	A_3	7.4	8.00	0.42
24.0°C	A_1	15.4	2.11	0.65
	A_2	13.0	5.33	0.47
	A_3	9.9	8.24	0.36
24.0°C	A_1	21.8	2.53	0.66
	A_2	19.5	7.0	0.49
	A_3	13.4	10.6	0.41
24.0°C	A_1	10.0	1.84	0.69
	A_2	9.7	6.0	0.60
	A_3	5.1	7.2	0.45

On this Table 1, A_1, A_2, and A_3 mean the hole area of the orifice meter. The area in cm² of the orifice studied are:

$$A_1=1.9\times10^{-2}\ (\text{cm}^2) \qquad (7)$$

$$A_2=7.2\times10^{-2}\ (\text{cm}^2) \qquad (8)$$

$$A_3=1.6\times10^{-2}\ (\text{cm}^2) \qquad (9)$$

also the relationship between dH (cm) and Q (cm³/sec) are explained and illustrated as nearly parallel lines on the log-log paper. (Fig. 1)

On a section paper, even though these are liner-relationship, they do not come together at the zero point, especially the relation between $(dH)^{1/2}$ and V (cc/min). (Fig. 2)
Because of the constand C is a very complicated function of type of hole, Reynolds number (DuP/M) and so on. Constant number C never come out as a constant, particularly at the zero point.

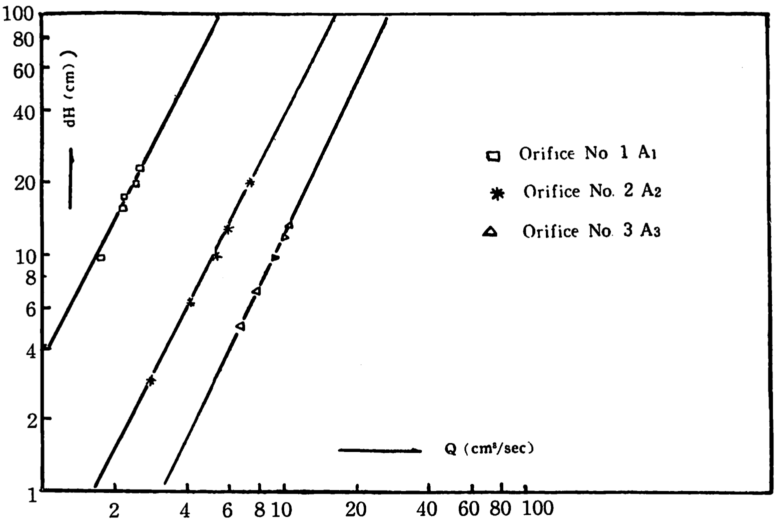

Fig. 1 Illustration for the relationship between dH (cm) and Q (cm³/sec) on the log-log paper.

To keep clear of this results, orifice plate shuld be very thin enough avoid influences of viscosity, Reynold numbers and temperature.
Naturaly, it is not so easy to make a very tiny hole in the orifice plate, but this is a key to obtaine high accuracy datas, because of small orifice meter it self, is a kind of cappilary tube, the hole of the orifice meter should make very small diameter as possible as we can.

On this small type of orifice meter is regarded as a cappilary tube which length L and diameter is D, therefor the equation of this cappilary tube may be introdused from Haugen-Poiseuilles' equation; the pressure diference in head is shown as,

$$dH_1 = \frac{128\,MLv}{TGPD^4} = bv \qquad (10)$$

Also there is another head loss which depend upon as a jet form of the orifice and fluid liquid or gas.
then the head loss which come from a jet type stream of the orifice meter may be written as the following equation,

$$dH_0 = \frac{8v^2}{T^2C_0^2GD^4} = av^2 \qquad (11)$$

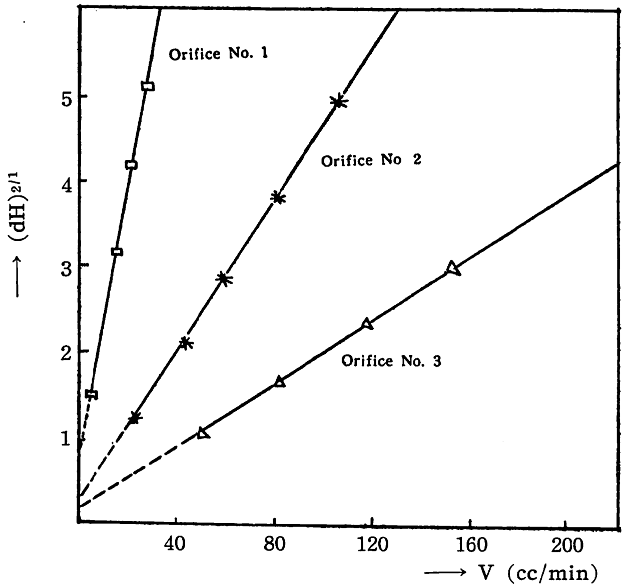

Fig. 2 The relation between $(dH)^{1/2}$ and V (cc/min).

now, the total head loss on the small type of orifice meter is calculated by the following equation,

$$dH = dH_c + dH_1 + av^2 + bv \tag{12}$$

here,

$$a = \frac{8}{T^2 C_0^2 G D_4} \tag{13}$$

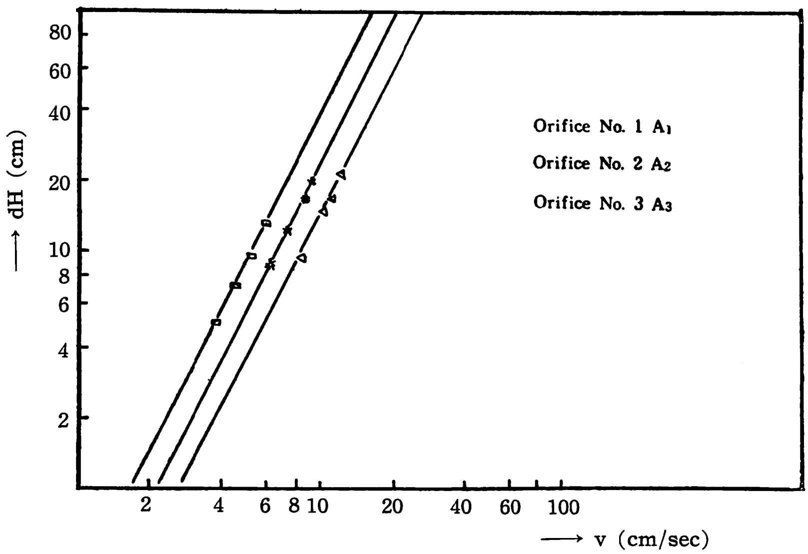

Fig. 3 Representation of dH/V for the orifice No. 1, No. 2 and No. 3, on the log-log paper.

and,

$$b=\frac{128L}{TGD^4}\times M/P \tag{14}$$

if V (cc/min) is taken, in sted of v (cc/sec), these equation are shown as;

$$dH=AV^2+BV \tag{1}$$

here,

$$A=\frac{a}{3600}=\frac{1}{450T^2C_0^2GD^4} \tag{2}$$

and,

$$B=\frac{b}{60}=\frac{32L}{15TGD^4}\times(M/P) \tag{3}$$

This, (1), (2), and (3) are the equations which may be applied for the small type of the orifice meter.
On this equation, A is a constant number which would not be disturbed by the character of the fluids, and B is a function of kinetic viscosity.

$$v=M/P \tag{15}$$

Fig. 4 Picture of the apparatus, the orifice meter is on the center of this picture.

The equation (6) may be express as the following equation,

$$dH/V=AV+B \tag{16}$$

this means, if we ploted V (cc/min) for (dH/V), we may obtained linear relationship between V and dH/V on the section paper.

Fig. 4 is a picture of the apparatus which the small orifice meter were treated and suitable datas were obtained. The left side of this picture is a tank which gave a constant velocity of stream to the orifice meter which is center on this picture.

From the mercury manometer, two pipe of rubber came down and conected each side of the small type of the orifice meter. The water level is an adjustable and a long glass pipe which is on the right side of the picture, is a lead pipe for water which come out from the orifice meter and make the water to be a stream line flow. Therefor it should be long enough to obtained a stream line flow.

3. EQUATION FOR THE SMALL TYPES OF ORIFICE METER.

According to the equation (16), the following datas were obtained for the case of pure water. Constant A and B are determined by the method of least squares.

Table 2 Relation between dH and V

No.	dH	V	dH/V
1	13.18	160	0.0824
2	10.23	146	0.0700
3	8.92	110	0.0811
4	5.42	98.3	0.0551
5	3.51	75.4	0.0466
6	1.13	43.2	0.0261
$\sum_1^3$	—	416	0.2335
$\sum_4^6$	—	216.9	0.1216

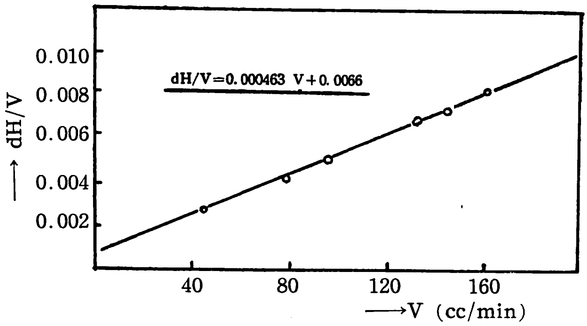

Fig. 5 Linear relation which obtained from dH/V and V.

hence, $$dH/V=0.000463V+0.0066 \quad (17)$$

This, equation (17) is the equation of plastic made orifice meter which particularly for the use of small amount of fluids.

The equation which is shown as (17) may be illustrated on the diagram as a linear line;

For the purpose of checking the equation (17), calculation were made, on the range of V=20 (cc/min) to V=160 (cc/min) and the result of calculation were shown as the table 3;

Since the orifice meter in Industrial use apply for the turbulent flow, this small type of orifice meter is used for especially steady flow. There are not so much diferences between observed dH and calculated dH, therefor the equation (17) is applied for the field of measuring fluids in small amounts at the research work.

Also this data were obtained by pure water at 24° C and it was not bursered by

Table 3 Results of the equation (17) & datas.

V (cc/min)	$0.000463\ V^2$	$0.0066\ V$	dH (calc.)
20	0.185	0.132	0.317
25	0.289	0.165	0.454
30	0.416	0.198	0.614
35	0.567	0.231	0.798
40	0.741	0.264	1.005
45	0.937	0.297	1.234
50	1.158	0.330	1.489
55	1.401	0.363	1.764
60	1.667	0.396	2.063
65	1.913	0.429	2.342
70	2.269	0.462	2.731
75	2.604	0.495	3.099
80	2.963	0.528	3.491
85	3.345	0.561	3.906
90	3.750	0.594	4.344
95	4.178	0.627	4.805
100	4.630	0.660	5.290
105	5.105	0.693	5.798
110	5.602	0.726	6.328
115	6.123	0.759	6.882
120	6.667	0.792	7.459

the deperature and viscosity at all.

On the further study on this orifice meter, may be some more high viscus liquid or fluid will be examined.

4. CONCLUSION.

For the purpose of measuring the very small amount of the fluids at the laboratory room, especially on the reserch work. The small type of orifice meter were mady by plastic materials which depend on the equation of Haugen-Poiséuille, and the results came out with very high accuracy.

The following equations are useful for applying this small type of orifice meter;

$$dH = AV^2 + BV \tag{1}$$

$$A = \frac{1}{450\,T^2 C_0^2 G D} \tag{2}$$

$$B = \frac{32\,L}{15TGD^4} \times M/P \tag{3}$$

$$dH/V = 0.000463V + 0.0066 \tag{17}$$

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5. NOMENCLATURE.

a and *A*: Constant. $dH_0=av^2=AV^2$
b and *B*: Constant. $dH_1=bv=BV$
C and C_0: Constant for orifice meter and function of Reynolds number.
D: Diameter in orifice hole.
G: Acceleration of gravity
v and *V*: specific volume of fluid.
dH: Diferences in head of orifice meter.
M: Viscosity.
P: Density.
T: Ratio of the circumference of the circle to the diameter.
Q: Quantity of the fluid.
L: Length of the tube.

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