

Faculty of engineering

Mechanical engineering department

Fluid mechanics Laboratory

ENME312

Section NO.1

Experiment NO.6

**" FLOW MEASURING APPARATUS "**

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**Abstract:**

The purpose of this experiment is to use different apparatus to measure the flow rate of incompressible fluid, by using special devices contains three sections venture, orifice, Rota-meter.

The water is supplied in the system by a hydraulic bench, and then it enters the equipment through a Venture-meter. After the change in cross-section through a rapidly diverging section, the flow enters throw an Orifice plate meter, and then through a right angle bend and a Rota-meter. The Rota-meter is a tube in which a float takes up an equilibrium position. The position which is can be read from the scale on the tube of the Rota-meter, is a measure for the flow rate. The manometer tubes are used to measure pressures at the points.

In order to calculate the theoretical mass flow rate, to compare it against the actual mass flow rate, we put a weight of 4 kg on the lift. The tank empting will start and at the same time we measured the time the tank needs to be refilled with water and gain balance again at different Rota-meter reading.

There is more than one way to measure flow rate, that influences in the accuracy. However, venture meter is more accurate device than the orifice.

**Objectives:**

* To find the ideal and experimental mass flow rate for the Venturi tube and Orifice plate.
* To find the effectiveness using a Rota-meter.
* To compare results graphically by finding the discharge coefficient of both meters.
* To measure the flow rate of an incompressible fluid by several methods.
* This experiment indicates the importance of Bernoulli's equation and the energy equation.

**Sample Calculation:**

**Sample of Calculation for Run #1:**

The value of actual mass flow was calculated using below data and equation:

ṁactual= $\frac{weight }{time}$

 where:

 ṁactual:  mass of flow in kg/sec

weight = 4\*the arm = 4\*3 = 12 kg

time: time of flow in seconds.

ṁactual= $\frac{12kg }{23.47 sec}$ = 0.511kg/sec

 the value of experimental mass flow for Venturi was calculated using below data and equations:

$ṁ\_{Venturi experimental}=ρa\_{B}\sqrt{\frac{2\*g}{1-(\frac{a\_{B}}{a\_{A}})^{2}}×\left(h\_{A}-h\_{B}\right)} $

Where:

 $(ṁ\_{Venturi experimental})$ is the mass flow for Venturi

𝜌 (water density) =1000 kg/$m^{3}$

$a\_{A}$ is the area of cross section at point A, in $m^{2}$

 $a\_{B}$ is the area of cross section at point B, in $m^{2}$

g is the gravity = 9.81 $m^{2}$/sec

$h\_{A }$the height in manometer at point A, in m.

$h\_{B }$the height in manometer at point B, in m.

$=1000\*\frac{π}{4}\*(.016) ^{2}\sqrt{\frac{2\*9.81}{1-(\frac{(.016) ^{2}}{(.026) ^{2}})^{2}}×(0.314-0.081)} $

$=0.2011×\sqrt{\frac{2\*9.81}{1-(0.6154)^{4}}×(0.233)} $ $=0.464 kg/sec $

the value of experimental mass flow for Orifice was calculated using below data and equations:

$ṁ\_{Orifice experimental}=ρa\_{F}\sqrt{\frac{2\*g}{1-(\frac{a\_{F}}{a\_{E}})^{2}}×\left(h\_{E}-h\_{F}\right)} $

Where:

$(ṁ\_{Orifice experimental})$ is the mass flow for Orifice

𝜌 (water density) =1000 kg/$m^{3}$

$a\_{F}$ is the area of cross section at point F, in $m^{2}$

 $a\_{E}$ is the area of cross section at point E, in $m^{2}$

g is the gravity = 9.81 $m^{2}$/sec

$h\_{E }$the height in manometer at point E, in m.

$h\_{F }$the height in manometer at point F, in m.

$=1000\*\frac{π}{4}\*(0.020) ^{2}\sqrt{\frac{2\*9.81}{1-(\frac{(0.02) ^{2}}{(.051) ^{2}})^{2}}×(0.3-0.045)} $

$=0.3142×\sqrt{\frac{2\*9.81}{1-(0.3922)^{4}}×(0.255)} =0.711 kg/sec $

the value of experimental mass flow for Rotameter was found using Rotameter Calibration Curve :

$ṁ\_{Rotameter experimental}=0.425 kg/sec $

The coefficient of discharge of the Venturi, orifice, and Rotameter were calculated using below equation:

$C\_{d}=\frac{ṁ\_{actual}}{ṁ\_{exp.}}$ , where:

Cd is coefficient of discharge

$ṁ\_{actual}$ is the actual mass flow

$ṁ\_{exp.}$ is the experimental mass flow

$$C\_{d vernturi}=\frac{0.511}{0.464}=1.101$$

$$C\_{d orifice}=\frac{0.511 }{0.711}=0.719$$

$$C\_{d rotameter}=\frac{0.511 }{0.425}=1.202$$

**Results:**

Table (1): hA, hB, hE,and hF in mm, time in seconds, rotameter in cm and (kg/sec), mass of flow in kg/sec.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Venturi | Venturi | Orifice | Orifice |  |  |  |  |  |  |
| Run | hA(m) | hB | hE(m) | hF | Time | Rota(cm) | Qrota | Qacutal | Qven | Qori |
| 1 | 0.314 | 0.081 | 0.3 | 0.045 | 23.47 | 20 | 0.425 | 28.23529 | 1.791811 | 6.227605 |
| 2 | 0.296 | 0.086 | 0.285 | 0.053 | 25.66 | 19 | 0.41 | 29.26829 | 2.482359 | 6.068899 |
| 3 | 0.28 | 0.092 | 0.267 | 0.062 | 26.94 | 18 | 0.39 | 30.76923 | 2.876049 | 5.906767 |
| 4 | 0.265 | 0.095 | 0.255 | 0.07 | 27.23 | 17 | 0.36 | 33.33333 | 3.07656 | 5.741784 |
| 5 | 0.25 | 0.096 | 0.237 | 0.075 | 30.12 | 16 | 0.35 | 34.28571 | 3.614472 | 5.568361 |
| 6 | 0.237 | 0.1 | 0.227 | 0.08 | 31.38 | 15 | 0.325 | 36.92308 | 3.893001 | 5.392116 |
| 7 | 0.224 | 0.105 | 0.215 | 0.087 | 34.68 | 14 | 0.31 | 38.70968 | 4.374242 | 5.208011 |
| 8 | 0.214 | 0.107 | 0.205 | 0.09 | 37.43 | 13 | 0.29 | 41.37931 | 4.75433 | 5.018142 |

Figure(1): Rotameter reading vs Flow rate

Figure(2): Theoretical flow rate vs Actual flow rate

**Discussion of results:**

From the graphs it can be notice that the relationships between the actual flow mass rate and theoretical ones that all are liner with a slope equal the coefficient of discharge for the venture-meter, orifice and rotameter. However, the coefficient of the venture-meter and rotameter are more than 1, and the coefficient should be less than 1 since there is a loss in the energy according to friction, so this is an indication of errors in the experiment. On the other hand the coefficient of orifice is 0.73 and this indicate a highly loss of energy and this means that the orifice that used in this experiment is not economic.

Some of the sources of errors are:

* The apparatus was not calibrated well.
* The height of the water in the tubes was not constant so the readings were not exact and this lead to inaccuracy in the theoretical mass flow rate.
* The actual flow rate was inaccurate according to human ability and reaction to take the time that the bench needs to full.
* The mass flow rate for the rotameter was taken from a graph and it was an evaluation process.

**Conclusion:**

In general, the aims of the experiment were achieved, and we got to know the different measuring devices and use them to measure the ideal mass flow rate for three different methods venture-meter, orifice and ratometer .

 From the graphs it can be shown that the relationship between the actual mass flow rate and the flow rate of the three different methods is a linear relationship. The values of the coefficient of discharge are close to a unity for both venture and rotameter, which also, gives us an indication that results are acceptable.

**Appendices:**

* **Data Sheet:**

Data sheet is attached at the end of the report.

* **References:**
1. Fluid Mechanics Lab Manual.
2. Currie, I.G., 2012. Fundamental Mechanics of Fluids, 4th Edition. Boca Raton, FL: CRC Press