

Information System Design Orifice Type Concentric Based on Fuzzy Logic

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Abstract

This study addresses the challenges in orifice bore design by developing automated software for precise calculations to meet field specifications. The research introduces Oricalc, a Delphi 7-based software that automates orifice bore sizing calculations previously performed manually using the AGA Report No.3 standard. The software implements fuzzy logic for parameter interpolation, replacing traditional table-based methods. Comparative testing between Oricalc, manual calculations, and MATLAB simulations demonstrated average error rates of -0.03646, 0.44, and 0.48. The software additionally provides functionalities for calculating Gross Heating Value (GHV), compressibility, standard flow rates, and real-time flow monitoring. Uncertainty analysis revealed that instrumentation/sensors contributed 99.43% of measurement uncertainty, with flow rate and mechanical factors contributing 0.56% and 0.0000002% respectively. The negligible mechanical uncertainty validates the high accuracy of Oricalc's orifice bore calculations, confirming its effectiveness for industrial applications.

1. Introduction

In the oil and gas industry, natural gas is one of the sources of energy from fossil fuels that play an important role in various energy sectors. In 2018, the total natural gas produced in Indonesia was 135.55 billion barrels [1]. The process of buying and selling natural gas or Custody Transfer can allow for losses on the part of the seller and the buyer. To minimize losses, Custody Transfer can be carried out by installing a metering system with the system accuracy tolerance standard issued by the Director General of Oil and Gas in Circular Number: 8361/18.06/DJM.T/2008 is $\pm 1\%$. [2].

The metering system that is often used in the Custody Transfer process for natural gas is to use the principle of pressure difference with the help of an orifice. To assist in determining the orifice specifications, software is needed that is able to calculate each input parameter. Fuzzy-based determination systems have been widely used such as diagnosing hyperthyroidism with an accuracy of 95.45% [3]. The cavitation analysis was implemented using a Fuzzy Rule Base approach, comprising 60 distinct rules. The implementation utilized the Mamdani-type fuzzy method with Min-Max inference, incorporating triangular membership functions for the fuzzification process. This comprehensive approach enabled precise modeling of cavitation behavior through fuzzy logic principles [4].

Other research on liquid flow control is usually used in industrial processes such as in heating tank systems with fuzzy control can obtain liquid flow stability when 50% pipe leakage maximum undershot of 3.33%. [5], fuzzy

is also used for the regulation of constant pressure water supply systems with integrated intelligent inverter controller (CPS-20B type) [6], on wheeled robots. Omni-Directional Wheels [7], Application of Fuzzy Sugeno on the Embedded System to detect indoor fire conditions [8], Sugeno fuzzy was implemented on the Fire and Gas System (FGS) system response which was able to neutralise the condition in about 77.5 seconds [9], and to detect LPG Gas leaks [10].

In a previous study, the design of an orifice system by Novia Nur Sa'adah succeeded in making a design of a flow rate measurement and monitoring system. The tool has an uncertainty value of ± 0.0553 with a 95% confidence level. While the accuracy value reaches 85.43% with an error of 0.015. The orifice bore sizing equations are implemented using LabVIEW software. The front panel display shows calculation results including the bore diameter, beta ratio (the ratio of orifice bore to inner pipe diameter), and correction factors. These orifice specifications can be manually adjusted, with the calculated results automatically updating to match those obtained through manual calculations [11]. The tool is only monitoring but cannot predict or calculate parameters which will later produce orifice flow meter specifications [12]. In the journal by Hari Hadi Santoso, et al, they created an orifice meter monitoring system that works with the principle of a pressure difference using an orifice plate and then converted into a flow rate that is displayed on the PI ProcessBook software. The performance of the orifice flow meter is measured by analyzing the uncertainty of 0.46365. [13]. This research contributes to the field by developing intelligent software that employs fuzzy logic methods to determine standardized and accurate orifice bore sizing specifications. The implementation of this software aims to minimize human error inherent in manual calculation processes that rely on tabulated data and multi-step calculations. Prototype testing demonstrates that the design calculations meet all requirements and achieve minimal error rates, validating the software's effectiveness.

Nomenclature

Q	=	gas flowrate
C	=	orifice flow constant
h_w	=	Pressure difference (inchH2O)
P_f	=	Static Pressure (psia)
Q_m	=	Mass volume flow rate
Q_b	=	Volume flow rate under standard conditions
E_v	=	Velocity approach factor
d	=	Diameter of orifice hole
C_d (FT)	=	Coefficient of discharge for flange-tapped orifice meter
G_i	=	Ideal gas relative density (specific gravity)
G_r	=	Real gas relative density (specific gravity)
ΔP	=	Pressure difference, in inH2O at 60°F
P_f	=	Pressure flowing at the upstream tap, in psia
T_f	=	Temperature flowing condition, in Rankine
Y	=	Expansion factor
Z _b	=	Compressibility at standard condition
Z _f	=	Compressibility at upstream flowing condition
ρ_f	=	Density of the fluid upstream under flowing conditions, in lbm/ft ³
ρ_b	=	Fluid density upstream under standard conditions, in lbm/ft ³

2. Methodology

This research work begins by studying the literature on fuzzy and the standards used in the design of an orifice meter system. The standard studied and used is AGA Report No. 3 [14], [15] in part 1 for general calculations and uncertainty in the measurement process, part 2 for specifications and installation, part 3 for its application, and AGA NX-19 [16] and GPA Standard 2172 [17] which are used to determine GHV and compressibility. In previous research there has been research for borehole sizing equations implemented using LabVIEW software [11]. There are four equations that need to be calculated sequentially and in accordance with the rules, namely: Basic hole factor, Specific gravity factor, Temperature factor when gas flows, Compressibility factor and Interpolation. This complex calculation makes researchers in designing require accuracy so that software is needed to calculate

quickly and precisely. Then the general design is carried out through literacy studies so that the parameters for sizing orifice bores are obtained standardly and using fuzzy logic. After getting the general picture, then fuzzy logic is made through simulation with the help of Matlab software. When the results are in accordance with the standard, then by borrowing the logic from Matlab, the logic was applied to programming in the Delphi software and examined again whether the results in Delphi are appropriate. Fig. 1 presents the overall block diagram of the design.

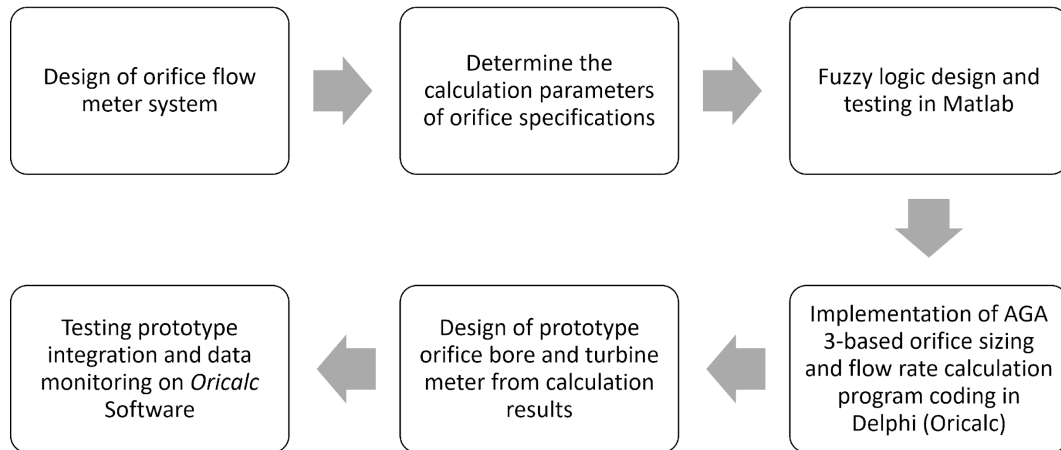


Fig. 1 Block diagram of the design

2.1 Orifice Meter

The orifice flow meter is one of the sensors that is often used in the Custody Transfer process, especially natural gas [18]. This is because the price is more affordable and the maintenance process is easier. The orifice flow meter uses the orifice plate as the main component in creating a pressure difference. The orifice plate is made of thin sheet steel with a hole in the middle. The orifice itself is grouped into a class of flowmeter types which are commonly referred to as differential pressure flowmeters. The type of orifice plate that is often used in Custody Transfer is the square edge concentric type. [19]

The working principle of the orifice flow meter depends on the pressure difference generated by the orifice plate. When a fluid passes through a hole in the orifice plate or also called the orifice bore, the fluid pressure that previously rose will decrease. The pressure will continue to fall until it reaches the vena contracta, the pressure will rise slowly. After passing through the hole in the orifice plate, the pressure will increase until the highest pressure is reached but still lower than the pressure before the fluid passes through the orifice. The increase in fluid velocity as it passes through the hole in the orifice plate is the cause of the pressure drop. After that the fluid velocity will decrease, the pressure tends to rise again but will not be the same as before passing through the hole in the orifice plate. Turbulence and friction losses in the pipe cause pressure loss or all pressure losses cannot be returned again. The flow rate of the fluid is directly proportional or in line with the rise and fall of a pressure in the orifice. If no fluid flows, then there is no pressure difference. Flow Profile of Orifice Flow Meter characteristics are shown as in Fig. 2.

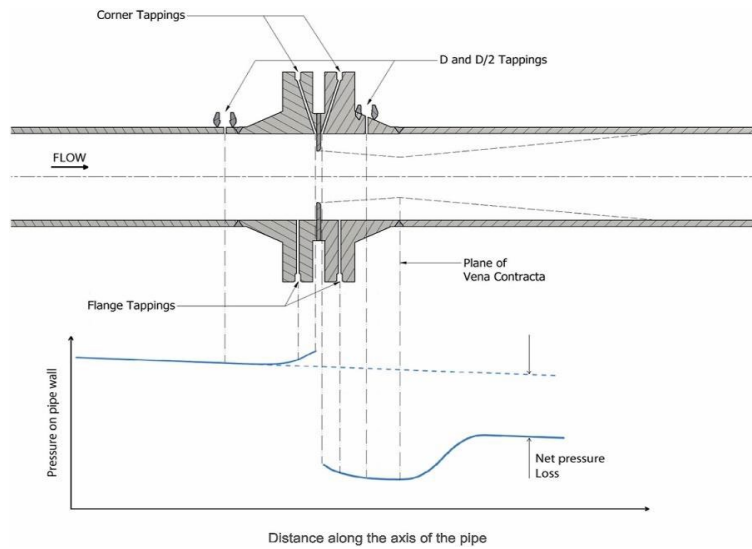


Fig. 2 Flow profile orifice flow meter [20]

2.2 Orifice Bore Design

In determining the diameter of an orifice, a sizing step is needed to determine the appropriate diameter. For sizing calculations in this study using the AGA No. standard. 3 ANSI/API 2530-198 [14]. Improper or inaccurate sizing can cause equipment damage. The calculation of the sizing calculation needs to pay attention to the following parameters:

1. Inner diameter of pipe (inch)
2. Flowrate (MMSCFD)
3. Specific Gravity
4. Gas flow temperature (fahrenheit)
5. Pressure difference (inchH₂O)
6. Pressure Static (psia)

Based on the flowrate calculation according to the AGA (American Gas Association) standard Report No. 3 are as follows:

$$Q = C\sqrt{hw} \times Pf \tag{1}$$

Then to find C, the following formula is obtained:

$$C = \frac{Q}{24\sqrt{hw} \times Pf} \tag{2}$$

by converting MMSCFD units from units per day to per hour. MMSCFD (Millions of Standard Cubic Feet per Day (of Gas)) is used to calculate the Maximum Flow Rate (Q) [21]. Then it is entered into the formula to find the basic orifice factor.

$$Fb = \frac{C}{Fg \times Ftf \times Fpv} \tag{3}$$

It is necessary to calculate the orifice plate thickness or the thickness of the orifice plate which is regulated in the AGA Report No. standard. 3 Part 2 where the thickness has a maximum, minimum and recommendation which relates to the pressure that will be received by the orifice. In the standard AGA Report No. 3 also has a calculation for determining the meter tube in a meter skid orifice. The meter tube is a straight pipe that is used as a pipe where the flow to be measured flows. On the meter tube, there are all parts of the measurement using orifices such as orifice fittings or orifice flange which have an orifice plate inside, tapping for upstream and downstream

pressure and pressure differences, installation of temperature sensors. Determination of the length of the meter tube must also comply with the AGA Report No. standard. 3 Part 2.

2.3 Fuzzy Design

The fuzzy process is created with the help of the Matlab program. Fuzzy logic that has been obtained from Matlab is then translated into Pascal language so that it can be processed in Delphi using logic from the rule base in Matlab. The Fuzzy Inference System (FIS) method used is the Sugeno method. The fuzzy logic system operates within specific constraints aligned with the orifice bore design standards specified in AGA 3. Modifications to the basic parameters or design types require corresponding adjustments to the fuzzy membership function settings. Fuzzy logic has three main processes, namely fuzzification, inference and defuzzification [22].

a. Fuzzification is the process of converting firm input or non-fuzzy input into a form of fuzzy variable which is then applied to a membership function. The calculated sizing parameter then produces the basic orifice factor. This factor will then be used as input to the fuzzy along with the pipe inner diameter. This refers to the basic orifice factor table AGA Report No. 3 which is used to determine the diameter of the orifice bore. For pipe diameter, use the schedule as shown in the basic factor table based on the nominal pipe size. The use of table ranges on pipe sizes 2" to 4".

1) Design of Pipe Diameter Membership Function

In the design of this function, the nominal maximum pipe size range is determined first. In Fig. 3 for pipe 2" schedule 40 (2.067) then a membership function is carried out using a triangular curve, this is so that each nominal pipe has a membership degree of one when inputted. After that, the parameter is [1,939 2,067 2.3]. The same is done up to a diameter of 4".

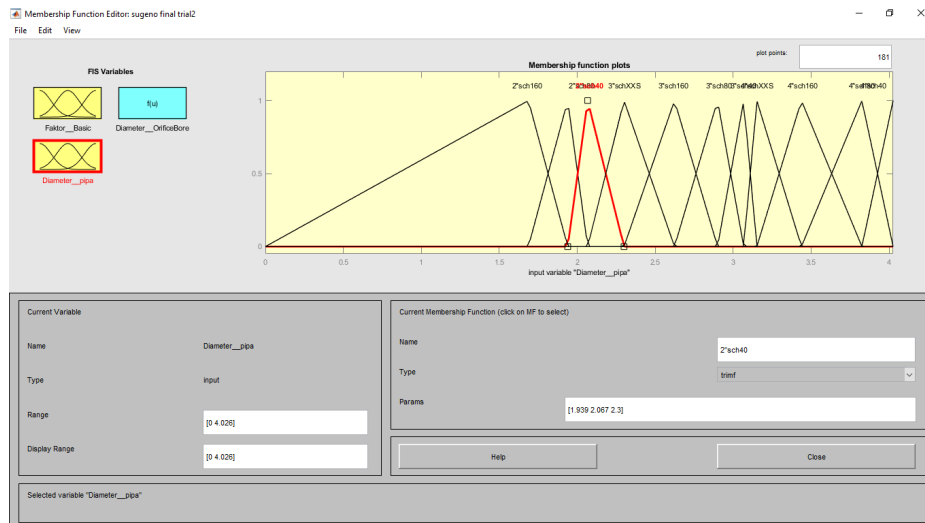


Fig. 3 Pipe membership function design

2) Designing the basic Factor Membership Function

The basic factor membership function design is done first by determining the maximum orifice range. Then the trapezoidal curve function is used, this is because the basic factor table has a range that leads to the diameter of the orifice bore, so it can have a membership degree of 1. It can be seen in Fig. 4 for the membership function design with a maximum range of 2407. In line 0.500 the basic factor table orifice using a range of 50.887-53.713 and a lower limit of 29.362 and an upper limit of 79.837. In the same way, work up to the orifice diameter row to 2.750.

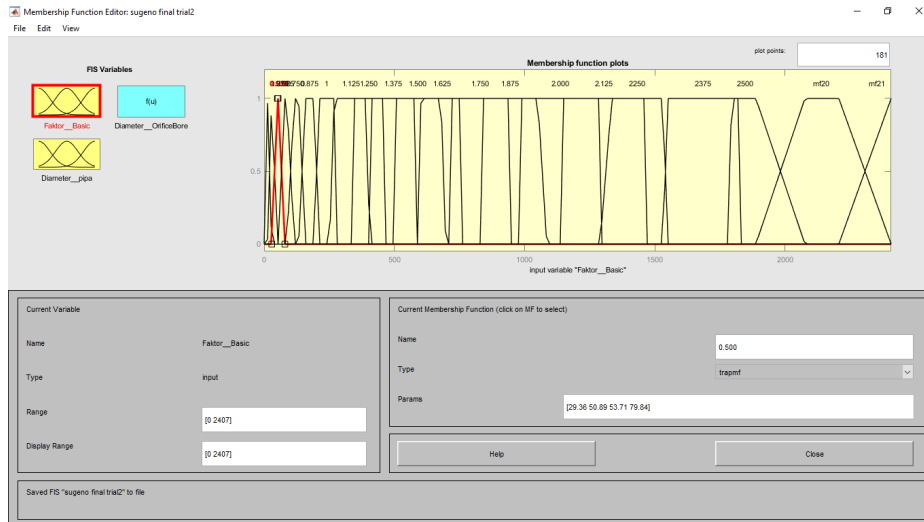


Fig. 4 Factor basic membership function design

- b. System inference is a process in which fuzzy variables are inserted with rules to become a fuzzy output. The fuzzy inference system uses the Sugeno method, which is presented with the IF-THEN command. From the results of the existing membership functions, then a rule is made on the fuzzy rule menu of the Matlab software. The application can be seen in Fig. 5, using the reference from the basic orifice factor table, then applying the rules, namely the basic row range factor of the table 0.250 by using a 2-inch pipe diameter schedule 160 or 1.687 inches, it will get an orifice plate hole diameter of 0.250 inches. according to the table row. The same way is done continuously.

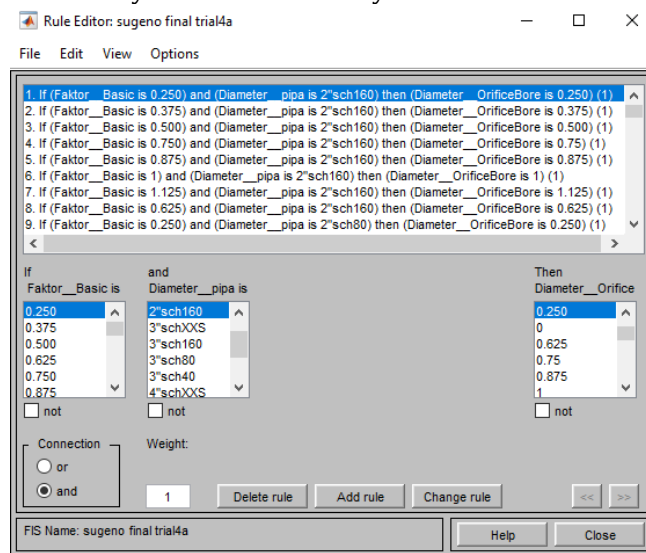


Fig. 5 Rule base design

The fuzzy output is then converted into a firm output form or what is called a defuzzification process with a formula.

$$Fb = \frac{C}{Fg \times Ftf \times Fpv} \tag{4}$$

The defuzzification process in the fuzzy Sugeno method is to find the weighted average value. From the results of this defuzzification, a firm output is obtained in the form of the diameter of the orifice bore plate.

2.4 GHV Equation and Compressibility

The compressibility factor can be calculated using the AGA NX19 calculation equation [23] as a standard for Custody Transfer. Calculations using AGA NX19 have a difference of $\pm 0.02\%$ from the latest standard AGA Report No. 8. The advantage of AGA NX19 compared to AGA Report No. 8 is that there are no iterations or repeated calculation processes. The method of calculating the compressibility factor uses the Gross heating value (GHV) method from AGA NX19 [23]. This calculation begins with the use of the GPA 2172 standard [17] to calculate the GHV and then finds the compressibility value of the flow and base with the equation:

$$GHV = \left[\sum_{i=j}^n x_i \cdot H v_i \right] / Z_b \quad (5)$$

$$Z_f = \frac{1}{\frac{B}{D} - D + \frac{n}{3P}} \quad (6)$$

$$Z_b = 1 - P_b \cdot \left[\sum_{i=j}^n x_i \cdot b_i \right]^2 \quad (7)$$

2.5 Equation of Gas Flow Rate Standard AGA Report No. 3

The American Gas Association (AGA) standard in the oil and gas industry is used as a reference for the flow rate equation to calculate gas fluid in a pipe using an orifice meter. The standard used in calculating the flow rate is AGA Report No. 3 [14]. To find the equation for the mass flow rate of the orifice flow meter in the AGA Report No. 3 and then to find the standard flow rate is as follows:

$$Q_m = C_d E_v Y \left(\frac{\pi}{4} \right) d^2 \sqrt{2 g_c \rho_f \Delta P} \quad (8)$$

$$Q_b = \frac{359.072 C_D (FT) E_v Y_1 d^2 \sqrt{\rho_f h_w}}{\rho_b} \quad (9)$$

2.6 Uncertainty Calculation

Every measuring instrument has uncertainty. Uncertainty is the calculated flow rate with the actual flow rate. The cause of uncertainty is the representation of the actual condition of the mass flow rate equation, the uncertainty of the physical properties of the fluid as measured by the actual fluid, and the measurement accuracy of the installation parameters (orifice diameter and beta ratio). In calculating the uncertainty orifice meter, it is divided into three main parts, namely instrumentation uncertainty, mechanical uncertainty, and flow rate uncertainty. Calculation of uncertainty orifice flow meter, used standard AGA REPORT NO. 3 Report No.3 Part 1 and Part 2 [15]. Determination of the quantitative magnitude of an orifice flow meter in flow measurement used the empirical discharge coefficient method on the flange tap with the following equation:

$$\frac{\delta q_{pps}}{q_{pps}} = \left\{ S C_d^2 \left(\frac{\delta C_D}{C_D} \right)^2 + S Y^2 \left(\frac{\delta Y}{Y} \right)^2 + S d^2 \left(\frac{\delta d}{d} \right)^2 + S D^2 \left(\frac{\delta D}{D} \right)^2 + S \rho_f^2 \left(\frac{\delta \rho_f}{\rho_f} \right)^2 + S \Delta P^2 \left(\frac{\delta \Delta P}{\Delta P} \right)^2 \right\}^{0.5} \quad (10)$$

The above equation shows how much impact the uncertainty of each component on the orifice flow meter has on the calculation results of the mass flow rate. $(\delta \frac{C_D}{C_D})$ is the uncertainty of the discharge coefficient, $(\delta \frac{Y}{Y})$ is the uncertainty of the expansion factor, $(\delta \frac{d}{d})$ is the uncertainty of the bore plate diameter orifice meter, $(\delta \frac{D}{D})$ is the uncertainty of the diameter in the tube orifice meter. $(\delta \frac{\Delta P}{\Delta P})$ uncertainty differential pressure whose magnitude is obtained from the calibration results of measuring instruments or from the manufacturer, and $(\delta \frac{\rho_f}{\rho_f})$ is the uncertainty of fluid density.

2.7 Software Design

The program/Software created contains several functions, namely the program is designed to be able to sizing the bore orifice plate size according to standards, can calculate GHV and compressibility used in sales, calculate mass flowrate, and can directly monitor the fluid flowing in the skid meter. with the help of the Arduino microcontroller. This program/Software is named Oricalc. Oricalc is an acronym for Orifice Calculator. Oricalc is made with the Delphi 7 program which has the Pascal language [24]. In the programming process, the formula or formulas contained in AGA Report No. 3 [14], [25] are then discussed in accordance with the Pascal language so that it can be calculated and displayed to users as shown in Fig. 6.

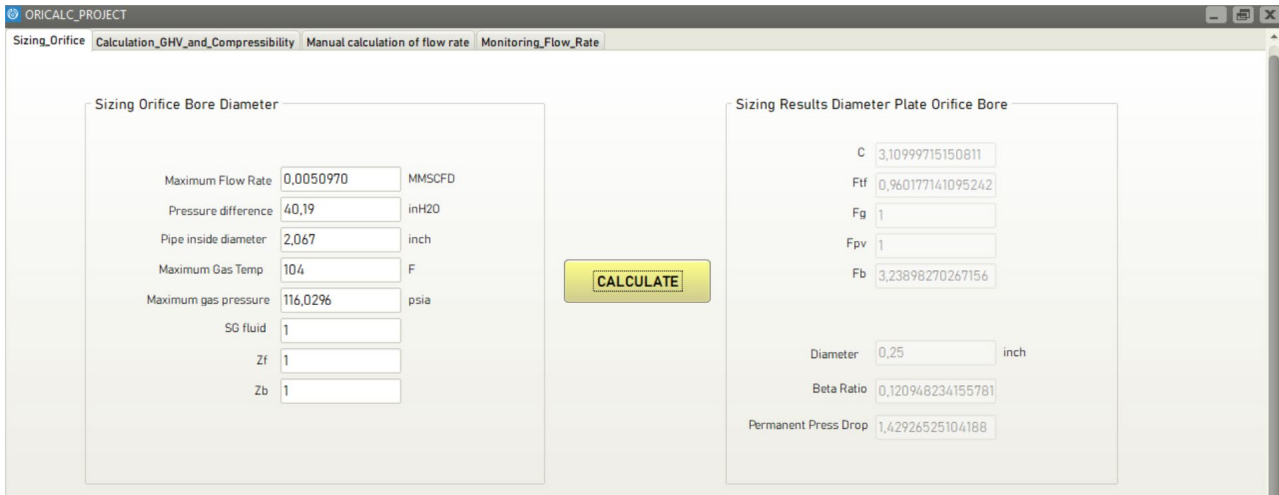


Fig. 6 Software interface design

2.8 Hardware Design

The design of a good and correct skid meter must be adjusted to existing standards, for this reason, a good calculation is needed in order to get the desired results. The design process is carried out on the Oricalc software that has been created. Then hardware design is also carried out in the ansys CFD program to see the graph of the fluid to be measured on the orifice meter later. The sizing process with oricalc in Fig. 6 obtained an orifice diameter of 0.25 inch. The pipe diameter of 2.067 is used, so the thickness recommendation is 0.125 inch. The type of orifice bore used is a concentric orifice. The meter tube is designed according to the standards of AGA Report No. 3 Part 2 [14]. So that the length of the upstream pipe is 13.002 inches and the downstream is 5.7876 inches. The components used in making this hardware are as shown in Table 1 below:

Table 1 Component list

No	Component Name	Total
1	Carbon Steel Pipe	1 Meter
2	Orifice Flange	1 Pair
3	Orifice Plate	1
4	Elbow Carbon Steel 900	1
5	Arduino Uno	1
6	MPX5050DP Pressure Difference Sensor	1
7	MPX5700AP Pressure Difference Sensor	1
8	Temperature Sensor DS18B20	1
9	Pneumatic Nipples	2
10	Silicone Hose	0,5 Meter
11	Compressor	1
12	Jumper Cable	Sufficient

Then the simulation results from the CFD ansys are carried out using air fluid and pipe and orifice materials adjusted to the original conditions and the assumption of a laminar flow rate. By performing simulation iterations for 100 times, the pressure and velocity profiles are obtained as shown in Fig. 7 and 8.

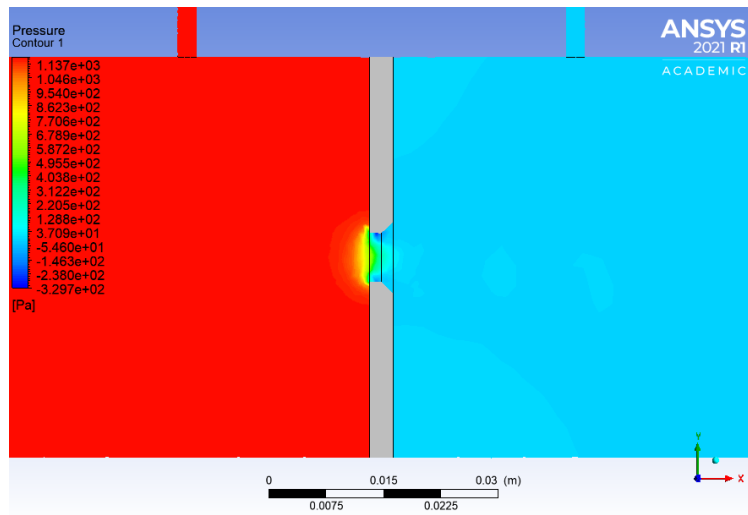


Fig. 7 Pressure graph

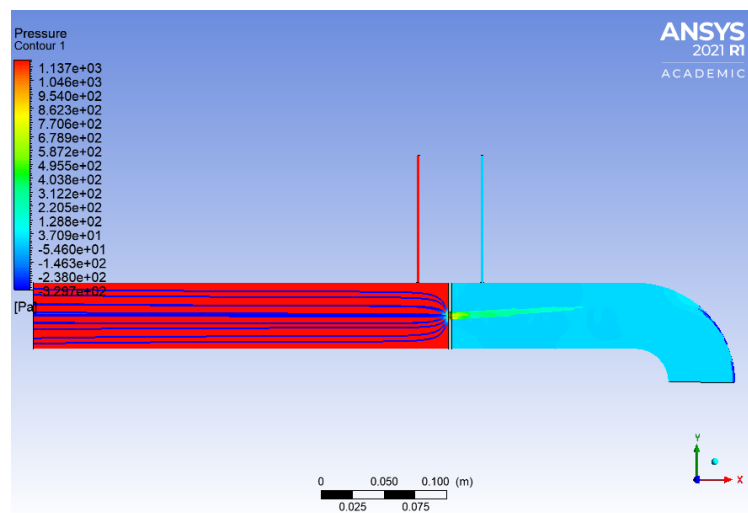


Fig. 8 Flow graph

From the graph it is found that the pressure in the upstream meter tube pipe decreases when it meets the orifice bore, it can be seen from the description of the pressure color which changes from red to orange then yellow and slowly the color of the pressure decreases to green until it meets at vena contracta or lowest pressure which is marked by a dark blue color change. After touching the vena contracta, the dark blue color then rises again to a light blue color which can be concluded that there can be a pressure difference that is in accordance with the graph profile of the fluid flow pressure on the orifice meter. In the integration of hardware, electronic components, and integration into software, wiring is also needed which becomes a communication bridge between the meter tube, sensors, microcontroller and software. The wiring design can be seen in Fig. 9, while the P&ID of the orifice meter system is in Fig. 10.

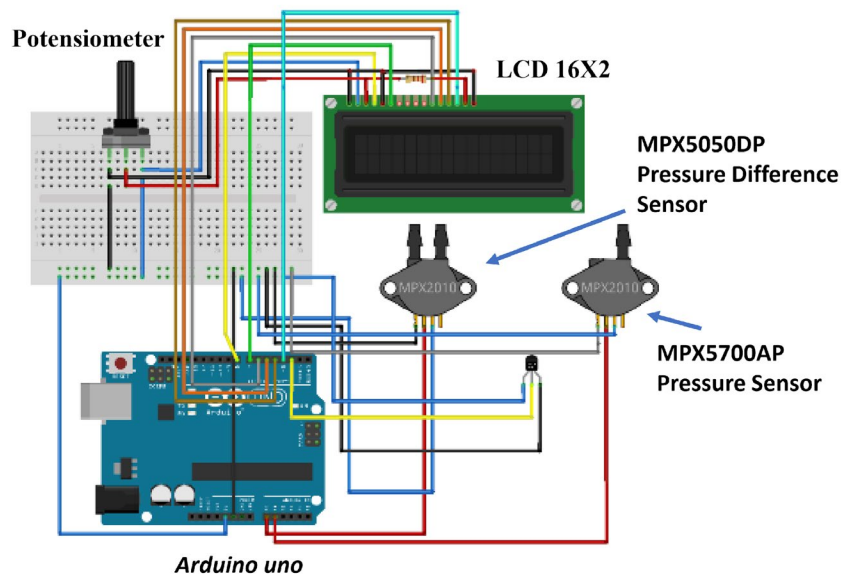


Fig. 9 Wiring design

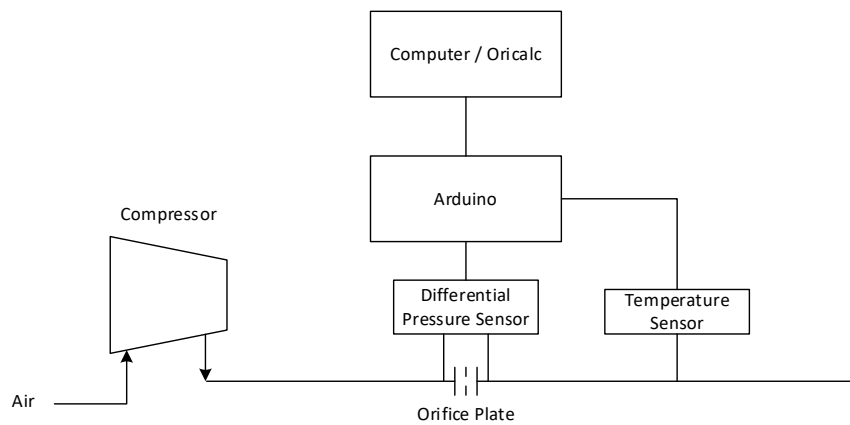


Fig. 10 P&ID orifice meter system

3. Results and Discussion

Oricalc software is made with a user-friendly interface and is comfortable to use. Then carried out the implementation of orifice bore sizing that will be used in the Oricalc software. The sizing results for the hardware can be seen in Fig 11.

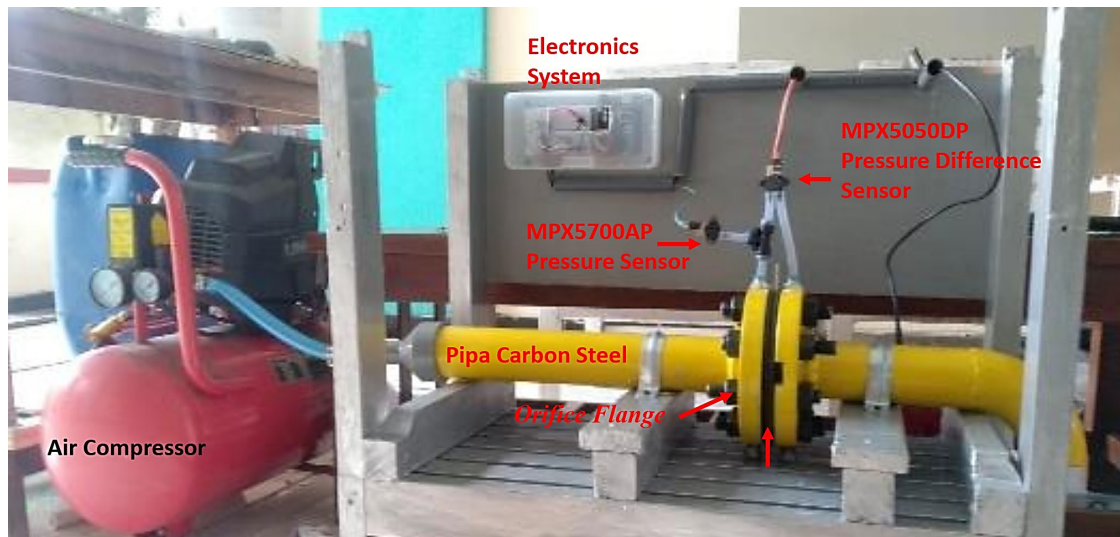


Fig. 11 Hardware design results

The orifice meter will pass air flow from the compressor and then go to the orifice plate so that there is a pressure difference between the upstream and downstream pipes, then the air is directed downwards so that it can be directly discharged and does not interfere with the process in the pipe.

3.1 Sizing and Fuzzy Results

In this process, 5 samples of sizing data were taken from Oricalc software, Matlab and manual calculations. The data obtained from the test results are shown in Table 2 as follows:

Table 2 Sizing results

No	1	2	3	%Error 1 and 2	%Error 1 and 3	%Error 2 and 3
	Oricalc Results	Manual Results	Matlab Results			
1	0,75	0,7505	0,75	0,0667	0	- 0,0006
2	0,625	0,6243	0,625	- 0,1120	0	0,001
3	2,000	2,03	2,06	1,5000	0,03	0,014
4	2,625	2,6008	2,63	- 0,9219	0,0019	0,011
5	2,625	2,60623	2,6	- 0,7150	-0,009	0,002
Average Error				-0,036	0,44	0,48

From the results obtained, it can be seen that the average error of 5 sampling using the Oricalc software is relatively small, so it is more practical and faster and does not require an interpolation process.

3.2 GHV and Compressibility Calculation Results

By using the assumption that the air fluid composition is 78.96% N₂, 20.95% O₂, and 0.09% CO₂. The GHV and compressibility at oricalc are:

$$Z_b = 0,9996, \text{GHV} = 0 \frac{\text{BTU}}{\text{SCF}}, Z_f = 0,9997$$

So that the process obtained a standard compressibility factor of 0.9996 and a flow compressibility factor of 0.9997 and does not have GHV because its constituent components do not have energy that can be sold. The following simulation of the application shows the results of GHV and Compressibility in Fig 12.

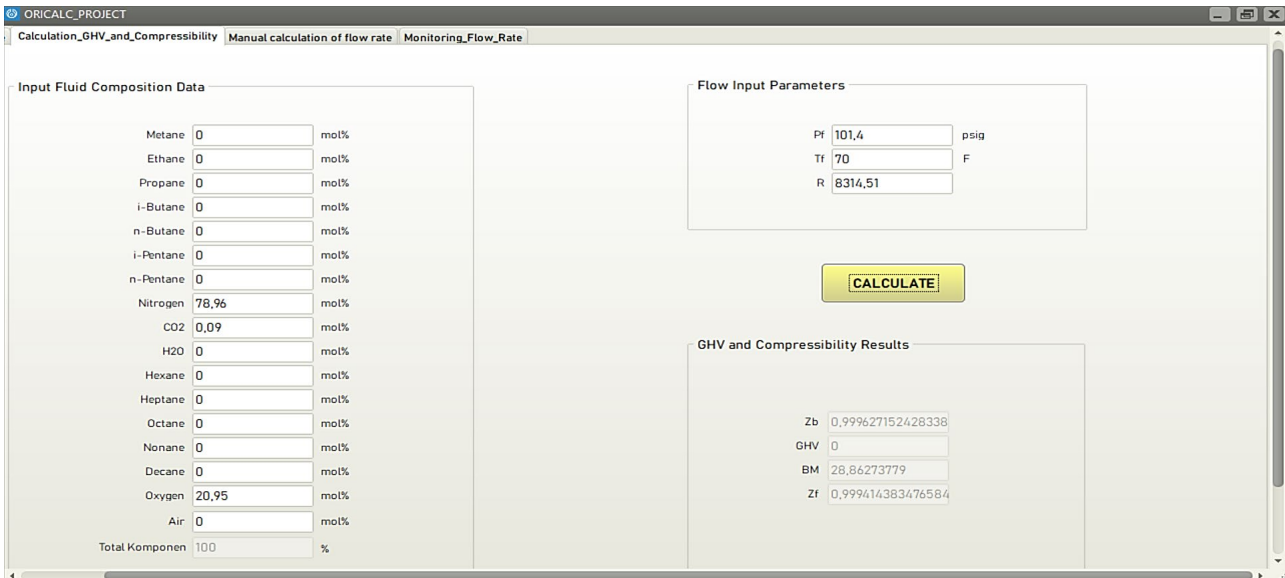


Fig. 12 GHV and compressibility results

3.3 Flow Rate Calculation Results

In the monitoring process that has been carried out, then the flow rate is obtained through sending data received by the sensor, and then three samplings are taken, namely when the reading position is at low, medium, and high flow rates. The results are as follows (Fig. 13).

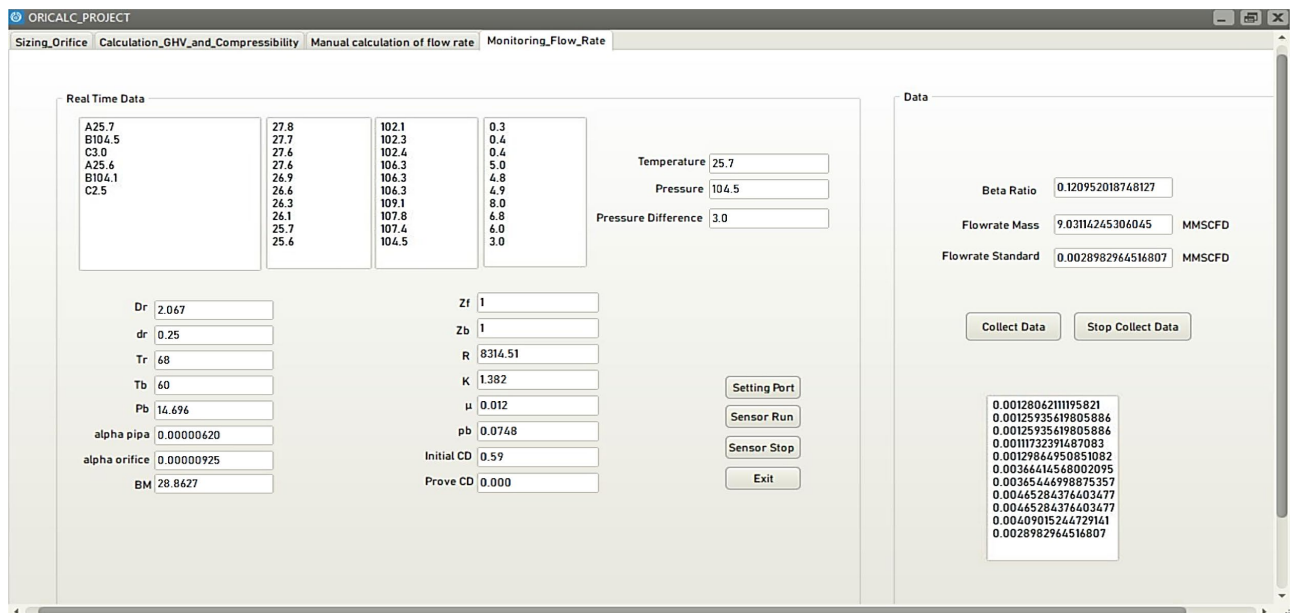


Fig. 13 Flowrate monitoring results

Table 3 Component list

No	Standard Flowrate		Deviation
	Manual	Oricalc	
1	0,0012841	0,0012807	-0,262
2	0,0036554	0,0036554	-0,2654
3	0,0046654	0,0046542	-0,2452
Average Deviation			-0,2575

From the above calculation results, it can be seen that there is an average deviation of measurements between the operating conditions of Oricalc software and AGA-3 manual calculations, which is -0.2575% as shown in Table 3. This result is a small error from the maximum standard error set by the Directorate General of Oil and Gas, which is $\pm 1\%$.

3.4 Uncertainty Calculation

Analysis of uncertainty or uncertainty in measurement so that it can be seen which parts contribute to the greatest uncertainty or uncertainty. Based on the results of the flow rate and with reference to the sensors and mechanics owned, the results of the calculation of uncertainty or uncertainty are shown in table 4 as follows.

Percentage of flow rate by:

I_i = Instrumentation *Uncertainty*

I_m = Mechanical *Uncertainty*

I_q = *Uncertainty* Flow rate

I_T = *Uncertainty* Orifice meter

The *uncertainty* contributor was calculated as following:

$$\%I_i = \frac{\Sigma I_i}{\Sigma I_i + \Sigma I_m + \Sigma I_q} \times 100\%$$

$$\%I_i = \frac{254493,9}{254493,9 + 0,000515 + 1445,10} \times 100\% = 99,435373\%$$

$$\%I_m = \frac{\Sigma I_m}{\Sigma I_i + \Sigma I_m + \Sigma I_q} \times 100\%$$

$$\%I_m = \frac{0,000515}{254493,9 + 0,000515 + 1445,10} \times 100\% = 0,0000002\%$$

$$\%I_q = \frac{\Sigma I_q}{\Sigma I_i + \Sigma I_m + \Sigma I_q} \times 100\%$$

$$\%I_q = \frac{1445,10}{254493,9 + 0,000515 + 1445,10} \times 100\% = 0,5646268\%$$

Table 4 *Uncertainty results*

No	Uncertainty	Error %
1	Uncertainty of Instrument	99,435373
2	Uncertainty of Mechanic	0,0000002
3	Uncertainty of Flowrate	0,5646268

From the results of this uncertainty calculation, it is found that the largest contributor to uncertainty in measurement is the instrumentation factor of 99.43%, in this case the sensor. The sensor error tolerance is too large, resulting in inaccurate measurements. This is also because the sensor used is not a standard sensor in the industry. The smallest uncertainty is from the mechanical factor which is 0.0000002%, this proves that the orifice bore design is very good so that it only contributes very little uncertainty in the measurement. The flow rate contributes to uncertainty of around 0.56%. This comes from the uncertainty that comes from the Reynolds number of 8409.34123, which flows turbulently. This is due to the absence of flow conditioning so that the passing flow experiences turbulence.

4. Conclusion

Based on the results that have been obtained, it can be concluded that, the study succeeded in developing a software with the Oricalc. This software is able to perform sizing and determine orifice specifications. The analysis was done using a pipe with orifice bore diameter of 0.25 inches with a beta ratio of 0.125. By using a pipe diameter of 2 inch schedule 40 or 2.067 inch, the recommendation thickness is 0.125 inch. The type of orifice bore is concentric, and uses a flange tap. The length of the meter tube used is 13.002 inches for upstream and 5.7876 inches for downstream. Five samplings on Oricalc were compared with manual calculations and Matlab in which the average error was obtained, respectively -0.03646%, 0.44% and 0.48%. The results of the flow rate with three times of sampling obtained a calculation deviation of -0.2575%. The greatest uncertainty is instrumentation or sensor factors, which are around 99.43%, flow rate 0.56% and mechanics 0.0000002%. From the very small mechanical uncertainty, it can be proven that the orifice bore sizing results are acceptable.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting.

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