# Development of Simple Correlation to Evaluate Formation Volume Factor for Nigerian Crude Oil

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**Abstract:** ***Accurate reservoir fluid characterization is vital to understanding the flow behavior in the reservoir and proper quantification of reservoir productivity. This study developed a correlation for formation volume factor for Niger Delta crude oil and evaluated the necessity of using locally developed correlation in evaluation of the formation volume factor (Bo). Reservoir fluid data collected from Niger Delta were used to develop correlation for Bo. The result from the model was used to match Laboratory PVT derived Bo and also compared it with existing universal models. The new model had better prediction of Bo. The new correlation can be used for a quick prediction of Bo in the absence of laboratory PVT data.***

**Keywords:** formation volume factor, correlation, crude oil, least square, regression

## 1. Introduction

In the absence of laboratory measured Pressure – Volume – Temperature (PVT) data, property correlation can be used for material balance calculations ranging from simple estimation to detailed studies of reservoir performance. The empirical relationships of reservoir fluid properties like bubble point pressure (Pb), solution gas oil ratio (Rs), fluid formation volume factor (FVF), and viscosity can be used to predict the laboratory data.

Correlation of physical properties of a system implies finding a relationship between the parameter of the given system. In PVT property correlation, effort is made to find the relationship which exists between the physical properties of crude oil. The empirical analysis involves predicting the unknown parameter s from the known ones. Physical properties of crude oil such as the reservoir temperature, API gravity, reservoir pressure, gas gravity and molecular weight of stock tank oil can be used through correlations to predict other PVT parameters like solution gas-oil ratio (Rs), viscosity ($\mu_O$ ), formation volume factor (FVF) and bubble point pressure (Pb).Therefore PVT correlations are those empirical relationships or expressions for Pb, Rs, $\mu_o$ , Bo and Bg.

Among the PVT correlations currently in use in the petroleum industry, Standing (1947) enjoys the widest popularity. He developed correlations for formation volume factor, formation pressure , bubble point pressure Pb and solution gas- oil ratio using Californian crude oil and gas systems. Lasater (1958) published correlation on bubble point pressure developed from 158 experimental data points. The correlation works best in temperature range of $100^0$F – $258^0$F and pressure range of 130 – 7000Psi the correlation was presented in graphical and empirical forms. Cronquist (1973) worked on Gulf coast reservoir and developed a dimensionless PVT correlation. Vazquez et al (1980) developed empirical equations for solution gas oil ratio, formation volume factor for oil at various pressures and temperature.

Obomanu and Okpobori (1987) in their work developed a correlation for oil formation volume factor and solution gas oil ratio for Nigerian crude oil. Mohmond et al (1992) used regression analysis to obtain correlation for bubble point pressure and the oil formation volume factor for United Arab Emirates crude oil. Although standings correlation has gained popularity in petroleum industry, local correlations compete favorably. Generalized correlation claims to have general applicability, this might not be true because of the effect of the composition, parafinicity, and non-hydrocarbon oil behavior on crude oil. This work applied multiple regression analysis which uses the least square method to develop correlation for crude oil formation volume factor for crude oil with API gravity in the range of $15^0$ – $35^0$. It can predict $B_0$ for live crude oil.

PVT Parameters obtained in the laboratory after rigorous detailed and rather expensive PVT laboratory analysis could be readily predicted quickly and within acceptable accuracy with the help of empirical equations. Correlations can be used to predict PVT data when no fluid samples are available especially during the early life of the reservoir. Therefore, in absence of laboratory test, need has always arisen to have fairly accurate correlations of reservoir fluid properties for field measurements. Correlations can also be used in place of PVT laboratory analysis when fluid samples are absent, lab analysis is too expensive and when there are failures associated with the laboratory works.

## 2. PVT Properties and Oil Recovery

Pressure-Volume-Temperature (PVT) analysis data for petroleum reservoir fluids is routinely applied in the petroleum industry to obtain the following;

- Estimate of initial reservoir fluid in place and also the estimate of recoverable reserve using material balance equation.
- Prediction of past and future reservoir performance analysis
- Design of enhanced oil and gas recovery schemes.
- Evaluation of strength of water drive

The formation volume factor of a hydrocarbon is very much related to the volumetric behavior of the reservoir fluid. The volumetric behavior must be determined as a function of pressure and temperature in the laboratory or using correlation. The accuracy with which the pressure volume parameters, compressibility factor and thermal expansion coefficient values may be determined is solely a function of the accuracy of the measuring devices employed.

CHARACTERISTICS OF CRUDE OIL

Crude oils from Nigeria are generally classified into three groups depending on its API gravity. They are

- Blend crudes; have API gravity lying between 26 $^o$ and $35^{0.}$
- Light crudes: have API gravity of $35^o$ and above.
- Medium crudes: these crudes are very heavy with API gravity between 15 to $26^o$.

Nigerian crude oil have very low non-hydrocarbon content, with nitrogen-carbon dioxide ratio content usually below 1% and sulphur content hardly exceeding 0.5%. Table 1 shows typical mole composition of various Nigerian crudes.

**Table 1:** Mole Composition of Reservoir Fluids

| | WELL 1 | WELL 2 | WELL 3 | WELL 4 | WELL 5 | WELL 6 |
|---|---|---|---|---|---|---|
| Components | Mol % | Mol % | Mol % | Mol % | Mol % | Mol % |
| N2 | 0.14 | 0.04 | 0.19 | 0.07 | 0.21 | 0.10 |
| CO2 | 0.07 | 0.18 | 0.13 | 0.62 | 0.38 | 0.43 |
| C1 | 5.98 | 34.22 | 34.1 | 44.31 | 37.49 | 54.52 |
| C2 | 0.21 | 1.46 | 0.84 | 2.94 | 0.36 | 5.03 |
| C3 | 0.59 | 0.51 | 0.20 | 2.55 | 3.60 | 6.65 |
| i C4 | 0.63 | 0.42 | 0.04 | 1.04 | 0.97 | 2.28 |
| n C4 | 0.27 | 1.30 | 0.06 | 1.22 | 1.97 | 4.35 |
| I C5 | 0.65 | 1.10 | 0.02 | 0.55 | 1.05 | 2.27 |
| n-C5 | 0.39 | 0.91 | 0.02 | 0.55 | 1.00 | 2.08 |
| C6 | 1.44 | 3.10 | 0.06 | 1.45 | 1.82 | 2.87 |
| C7+ | 89.63 | 56.76 | 64.33 | 44.70 | 48.70 | 19.42 |
| Total | 100% | 100% | 100% | 100% | 100% | 100% |
| M. Wt of fluid | 386.1 | 154.4 | 175.4 | 119.1 | 124.9 | 60.4 |
| M. Wt. of $C7^+$ | 425.8 | 252.0 | 263.2 | 238.0 | 231.1 | 193.1 |
| API | 15.8 | 18.4 | 23.6 | 28 5 | 31 9 | 40.5 |

**The Approach Used**

The approach used for the correlation of reservoir volume factor for crude oil was based on multiple regression analysis

## 3. Regression Analysis

Regression analysis used the concept of dependent and independent variables to express relationship between the system parameters. This could be explained using two forms; simple linear regression and multiple regressions. Simple Linear Regression: Two variables are used to explain the relationship between a dependent and independent variables. The aim is to determine the dependent variable.

Let Y be the dependent variable and X independent variable. To predict the values of Y based on the values of X, the least square method is used. This mathematical method is designed to produce the best fitting straight line based on the fact that it minimizes the squared sum of the residuals (i.e. the squares of the vertical deviations as of the vertical deviations about the line).

The equation:

$$Y = A+BX \qquad (1)$$

Where
Y = average predicted value
A = estimated value of Y when X = 0
B = regression coefficient of X
X = any value of independent variable
It is assumed that those variables are linearly related. Least square approach tries to estimate the constant A and B using the criterion.

$$A = \frac{\sum X_i^2 \sum Y - \sum X_i \sum (X_i Y_i)}{n\sum X_i^2 - (\sum X_i)^2} \qquad (2)$$

$$B = \frac{n\sum (X_i Y_i) - \sum X_i \sum Y_i}{n\sum (X_i Y_i) - \sum X_i \sum Y_i} \qquad (3)$$

where n = number of observation.
The criterion satisfied by least square fit is

$$\sum (\text{residual})^2 = \sum_{i=1}^{n} (Y - Y_c)_i^2 \qquad (4)$$

Is a minimum value
Y and $Y_c$ are observed and calculated values respectively.

Multiple Regression: In this regression, the dependent variable can only be explained adequately by more than one independent variable. Assuming there is linear relationship between the dependent and independent variables. Then,

$$Y = A + B_1X_1 + B_2X_2 + B_3X_3 + \ldots\ldots\ldots\ldots + B_nX_n \qquad (5)$$

Where
A=Intercept
$B_i$ = Regression coefficient of $X_i$
n = Number of independent variables.
In multiple regressions with n independent variables, there are n+1 unknown equation to be solved simultaneously to get regression coefficient and the intercept of regression function.

$$\sum_{i=1}^{n} Y = na + b_1 \sum_{i=1}^{n} X_1 + b_2 \sum_{i=1}^{n} X_2 + \text{----------} + b_n \sum_{n-1}^{n} X_n$$

$$\sum_{i=1}^{n} YX_1 = a \sum_{i=1}^{n} X_1 + b1 \sum_{i=1}^{n} X_1^2 + b_2 \sum_{i=1}^{n} X_1 X_2 + \cdots b_n \sum_{i=1}^{n} X_n X_1$$

$$\sum_{i=1}^{n} Y X_n = a \sum_{i=1}^{n} n + b_1 \sum_{i=1}^{n} X_1 X_n + b_2 \sum_{i=1}^{n} X_2 X_n + \cdots b_n \sum_{i=1}^{n} X_n^2 \quad (6)$$

Precision of the estimated regression can be obtained by partitioning of some of squares. The total sum of squares about the mean of the (observed) dependent variable Y denoted by TSS, that is the variation of the observation from overall means (Yi – Y) can be partitioned into two component. TSS is the deviation of the observation from the mean; it is the corrected sum of squares of the dependent variable Y.

1) One of the partitions of TSS is SSR, sum of squares due to regression is the deviation of the predicted value of the *i*th observation from the mean. This is given as $Y_{ci} - Y$.
2) The next part is that unaccounted for by the independent variable which is the deviation of the ith observation from its predicted or fitted value Yi – Yci devoted as sum of squares about regression SSE.

Thus
TSS = SSR + SSE
Or

$$\sum_{i=1}^{n}(Yi - Y)^2 = \sum_{i=1}^{n}(Yci - Y)^2 + \sum_{i=1}^{n}(Yi - Yci)^2 \quad (7)$$

Having obtained this partitioning, the ratio of explained variation in the dependent variable (sum of squares due to regression) to total variation in dependent variable Y, is a measure of the degree of correlation. This ratio is called the coefficient of determination $R^2$.

$$R^2 = \frac{SSR}{SSS} = \frac{TSS - SSE}{TSS} \quad (8)$$

The square root of this ratio R is correlation coefficient. This is a less powerful measure of the degree of correlation, another way of assessing how useful the correlation will be as a predictor is to see how much of TSS has fallen into SSR and how much into SEE. If all the observation lie on the regression then SSE = 0 and R = 1.

When R = 0, it does not necessarily mean that there is no correlation between the two variables but rather they can be related to a perfectly curvilinear fashion and not a linear one.

Standard error of estimate (SSE) is another measure used to determine the extent of correlation. This is simply the standard deviation of actual Y values from the predicted Yc values.
Mathematical expressed by

$$SEE = \sqrt{\frac{SSE}{n}} = \sqrt{\frac{\sum(Yi - Yci)^2}{n}} \quad (9)$$

Mathematically as:
RS =f(P,GG,API,T) (10)
Similarly, the correlation of oil formation factor, Bo has been achieved by expressing Bo as empirical functions of solution gas-oil ratio, $R_s$, gas gravity (GG),oil gravity (OG) and reservoir temperature.

Mathematically, it can be expressed as Bo = f (RS,GG,OG,T) these parameters can correlated through regression analysis using least square method.

Use of Least Square Method To Express PVT Parameters
Least square method is a technique used to present data which contains statistical variation. In the prediction of Bo and Rs from pressure, gas gravity GG, API gravity, reservoir temperature, oil gravity OG, Bo and RS may be closely represented as a function of above named parameters by multiplied regression analysis. In other to convert to multiple regressions, geometric regression is used to remove the fraction sign. The multiple regression is used.

Series of simultaneous equations are formed from this analysis. The equations are used to form matrix to determine the coefficient of regression. Therefore, from the prediction of the RS and Bo at any time, we can use given crude oil properties such as Bo, RS, pressure, API gravity, oil gravity, gas gravity and reservoir temperature to generate empirical equation that can do the prediction for low and medium API gravity oil for Nigerian crudes.

Oil Formation Volume Factor
This property of crude oil is affected to a great extent by the API gravity of the crude oil. For this reason formation volume factor is (Bo) is considered for both medium and low API gravity crudes.

The API gravity range used is between $15^o$ and $35^o$ API. The following empirical relationships were used:

$$Bo = 10^a \left(Rs \frac{GG}{OG} x\, T\right)^B \quad (11)$$

$$Bo = a + b \left(Rs \frac{GG}{OG} + T\right)^B \quad (12)$$

To formulate the two equations above, regression analysis is used to determine the values of a, b, B in each case.

## 4. Discussion of Result

Correlation model for Bo prediction for API between $15^o$ and $30^o$ was developed from data collected from different fields. Significance test for regression coefficient at significance level of 5% shows that F critical value is less than F calculated and it is presented in table, therefore, we can conclude from this test that we are 95% confident that there is correlation between the variables. The population multiply determination coefficient, $R^2 = 0$.

The correlation coefficient for this equation is 0.919 which means that the sum of squares about regression (SSE) is very small i.e. is the unexplained variation by regression. The average percentage error, standard error of estimate and average absolute percentage error are within tolerance and small as shown in table 3. The empirical equation is taken as good predictor and is given in table 3 as

$$Bo = 10^{-0.183}\left(\frac{Rs \times GG \times T}{OG}\right)^{0.0555} \qquad (13)$$

The above equation gave best curve fit amongst other equations tested.

**Table 2**: Statistical Analysis of New Correlation.

| S/N | RS | EXPERIMENTAL Bo | NEW CORRELATION (IZUWA'S) | TSS | SSE |
|---|---|---|---|---|---|
| 1 | 126 | 1.098 | 1.112 | 0.000625 | 0.000196 |
| 2 | 87 | 1.085 | 1.116 | 0.00144 | 0.000961 |
| 3 | 49 | 1.071 | 1.082 | 0.002704 | 0.000121 |
| 4 | 641 | 1.283 | 1.225 | 0.0256 | 0.003364 |
| 5 | 554 | 1.239 | 1.210 | 0.0135 | 0.000841 |
| 6 | 459 | 1.207 | 1.198 | 0.00706 | 0.000081 |
| 7 | 288 | 1.140 | 1.167 | 0.000289 | 0.000229 |
| 8 | 377 | 1.175 | 1.184 | 0.002704 | 0.000081 |
| 9 | 200 | 1.116 | 1.143 | 0.4049 | 0.000729 |
| 10 | 139 | 1.088 | 1.121 | 0.001225 | 0.001089 |
| 11 | 72 | 1.064 | 1.084 | 0.003481 | 0.0004 |
| 12 | 30 | 1.054 | 1.031 | 0.00476 | 0.00529 |
| 13 | 205 | 1.116 | 1.138 | 0.000049 | 0.000484 |
| 14 | 156 | 1.099 | 1.121 | 0.000576 | 0.000484 |
| 15 | 106 | 1.083 | 1.099 | 0.0016 | 0.000256 |
| 16 | 56 | 1.068 | 1.058 | 0.00303 | 0.0001 |
| 17 | 30 | 1.056 | 1.024 | 0.004489 | 0.001024 |
| 18 | 357 | 1.177 | 1.167 | 0.00292 | 0.0001 |
| 19 | 309 | 1.153 | 1.158 | 0.0009 | 0.000025 |
| 20 | 258 | 1.133 | 1.146 | 0.001 | 0.00169 |
| 21 | 189 | 1.109 | 1.126 | 0.000196 | 0.000289 |
| 22 | 119 | 1.085 | 1.098 | 0.0016 | 0.000225 |
| | | | TOTAL | 0.078897 | 0.012277 |

The deviation of predicted value from experimental is given
SSE AVG. ERROR
AVG. ERROR =

$$\sum_{i=1}^{n}\frac{(Yi - Y)^2}{N}$$

Average % error = $\frac{SSE}{n} x100 = \frac{0.012277}{22} x\ 100 = 0.0558$

Standard error of estimate = $\sqrt{\frac{0.012277}{22}}$ 0.02362

$R^2 = \frac{0.078897 - 0.012277}{0.078897} = 0.844$

$R = \sqrt{0.844} = 0.919$

$F = \frac{SSR/M}{SSE/n-m-1} = \frac{0.078897 - 0.012277}{1} \quad \frac{22-1-1}{0.0012277}$

**Table 3**: EMPIRICAL EQUATION FOR Bo PREDICTION API $\leq 35$

| EQUATION | NDP | $R^2$ | AVG. % ERR0R | Standard error of estimate | Average ABS% error | F CAL. | F CRITICAL |
|---|---|---|---|---|---|---|---|
| $Bo = 10^{0.183}\frac{(Rs\ X\ GG\ X\ T)^C}{OG}$ C = 0.0555 | 22 | 0.844 | 0.0558 | 0.02362 | 1.821 | 109 | 4.35 |

Validation of New Empirical Correlation

Data used in validating this equation totals 22 data points. To give the validation a good spread some data points from the ones used in forming the equations were used. Comparison of this equation with already existing correlations is presented in table 4. The estimated Bo is tabulated against experimental values as shown. This equation has lower standard deviation compared with Obomanu's equation. The percentage standard deviation is 2.37 against 11.21 by Obomanu's prediction. A graph of experimental Bo against that estimated by this correlation for API $\leq 35^0$ is presented as shown in figure 1.

## 5. Statistical Error

$$\text{Average percentage deviation} = \sum^{n}\frac{(Yi - Yci)^2}{n}\ x\ \frac{100}{1}$$

$$\textit{Standard deviation} = \sqrt{\frac{(Y1 - Yc1)^2}{n}}$$

$$\text{Average absolute error} = \frac{1}{n}\sum^{n}\left(\frac{Yi - Yci}{Yi}\right)$$

**Table 4:** VALIDATION OF Bo EQUATION FOR API $\leq 35^0$

| S/N | RS | T | GG | OG | EXP. Bo | NEW CORRELATION | OBOMANU |
|---|---|---|---|---|---|---|---|
| 1 | 400 | 150 | 0.6150 | 0.9150 | 1.202 | 1.172 | 1.025 |
| 2 | 162 | 170 | 0.5760 | 0.9176 | 1.110 | 1.128 | 1.023 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | 126 | 170 | 0.5760 | 0.9176 | 1.098 | 1.112 | 1.025 |
| 4 | 87 | 170 | 0.5830 | 0.9176 | 1.085 | 1.09 | 1.025 |
| 5 | 641 | 154 | 0.6880 | 0.8810 | 1.283 | 1.225 | 1.028 |
| 6 | 554 | 154 | 0.6390 | 0.8810 | 1.239 | 1.21 | 1.027 |
| 7 | 459 | 154 | 0.6380 | 0.8810 | 1.207 | 1.198 | 1.027 |
| 8 | 200 | 154 | 0.6350 | 0.8810 | 1.116 | 1.143 | 1.026 |
| 9 | 205 | 160 | 0.5640 | 0.9125 | 1.116 | 1.138 | 1.026 |
| 10 | 156 | 160 | 0.5640 | 0.9125 | 1.099 | 1.121 | 1.025 |
| 11 | 106 | 160 | 0.565 | 0.9125 | 1.083 | 1.099 | 1.025 |
| 12 | 58 | 160 | 0.5620 | 0.9125 | 1.068 | 1.058 | 1.029 |
| 13 | 30 | 160 | 0.575 | 0.9125 | 1.056 | 1.024 | 1.025 |
| 14 | 23 | 127 | 0.7300 | 0.9607 | 1.047 | 1.006 | 1.025 |
| 15 | 357 | 144 | 0.577 | 0.9206 | 1.177 | 1.167 | 1.026 |
| 16 | 309 | 144 | 0.577 | 0.9206 | 1.153 | 1.158 | 1.026 |
| 17 | 258 | 144 | 0.573 | 0.9206 | 1.133 | 1.146 | 1.026 |
| 18 | 189 | 144 | 0.576 | 0.9206 | 1.1090 | 1.127 | 1.026 |
| 19 | 119 | 144 | 0.582 | 0.9206 | 1.085 | 1.099 | 1.026 |
| 20 | 34 | 189 | 0.577 | 0.9240 | 1.037 | 1.040 | 1.051 |
| 21 | 328 | 170 | 0.598 | 0.885 | 1.171 | 1.178 | 1.178 |
| 22 | 46 | 141 | 0.6310 | 0.9090 | 1.048 | 1.047 | 1.052 |
| | | | Average percentage deviation | | | 0.056 | 1.257 |
| | | | Standard deviation | | | 0.0237 | 0.1121 |

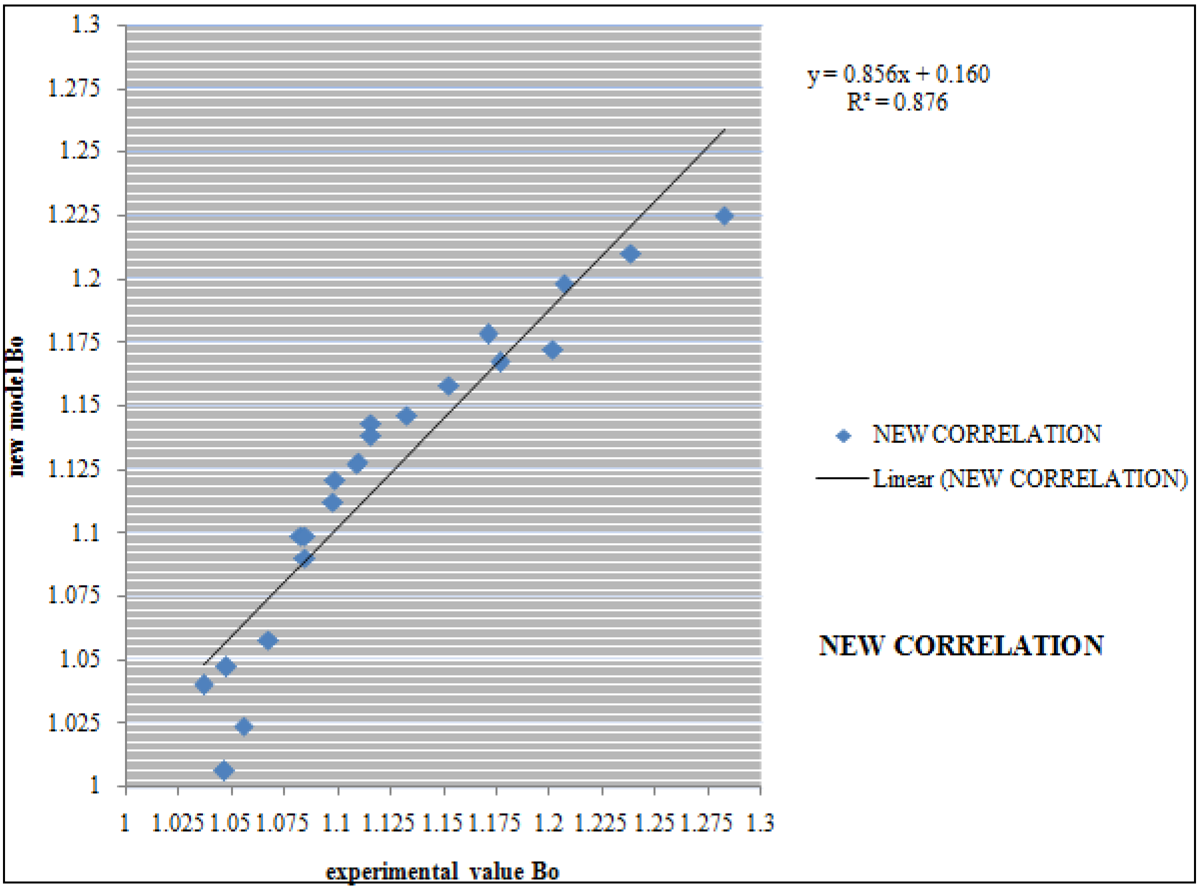


**Figure 1:** Correlation between Experimental and Correlated Values

Based on Figure 1 the predicted value can be converted to the laboratory value using the correlation $Y = 0.856x + 0.1602$
14. Where, x is the predicted value.

Universal Formation Volume Factor Correlation versus the New Correlation. Further comparative evaluation of PVT correlations used for Bo prediction was ran to test the validity of the new equation. This data was not part of data used in the development of the correlation.

**Table 5:** Well and Field data used for the Program

| Property | Well 1 | Well 2 | Well 3 | Well 4 | Well 5 |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| API | 21.97 | 21.97 | 21.97 | 21.97 | 21.97 |
| GOR | 277 | 277 | 192 | 146 | 101 |
| Yg | 0.5670 | 0.5770 | 0.5790 | 0.5830 | 0.5890 |
| P(psia) | 2148 | 1792 | 1442 | 1082 | 724 |
| $T^{O}$ | 155 | 155 | 155 | 155 | 155 |
| Psep(Psia) | 155 | 155 | 155 | 155 | 155 |
| Tsep ($^{o}$F) | 100 | 100 | 100 | 100 | 100 |
| Z | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**Table 6:** Data obtained from laboratory experiment

| Properties | Experimental Values | | | | |
|---|---|---|---|---|---|
| | Well 1 | Well 2 | Well 3 | Well 4 | Well 5 |
| Density(lb/ft3) | 51.2728 | 51.5481 | 52.2610 | 52.7887 | 53.1930 |
| Bo(rb/stb) | 1.1590 | 1.1450 | 1.1290 | 1.110 | 1.0960 |
| Viscosity µ(cp) | 0.534 | 0,550 | 0.573 | 0,600 | 0.649 |
| Bubble point pressure Pb | 2015 | 1715 | 1442 | 1082 | 724 |
| Solution GOR (SCF/STB) | 277 | 237 | 192 | 146 | 101 |

**Table 7:** Result obtained from the Program.

| *Well* | *Lab result* | *Standing's correlation* | | | *Vasquez & Beggs* | | | *Izuwa's (new correlation)* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Predicted value | error | % error | Predicted value | error | % error | Predicted value | error | % error |
| 1 | 1.1590 | 1.404 | -0.245 | 21.14 | 1.0633 | 0.957 | 8.26 | 1.1553 | 0.0037 | 0.32 |
| 2 | 1.1450 | 1.249 | -0.104 | 9.08 | 1.0632 | 0.0818 | 7.14 | 1.1556 | -0.0106 | 9.26 |
| 3 | 1.290 | 1.1745 | -0.455 | 4.03 | 1.0030 | 0.0660 | 5.85 | 1.1326 | -0.0176 | 0.32 |
| 4 | 1.1110 | 1.129 | -0.018 | 1.62 | 1.0625 | 0.0485 | 4.37 | 1.1159 | -0.0196 | 0.014 |
| 5 | 1.0960 | 1.09827 | -0.0023 | 0.21 | 1.0619 | 0.0341 | 3.11 | 1.0940 | 0.0020 | 1.82 |

Standing's mean error (%) = 7.22
Vasquez and Beggs mean error (%) = 5.746
Izuwa's mean error (%) = 2.28

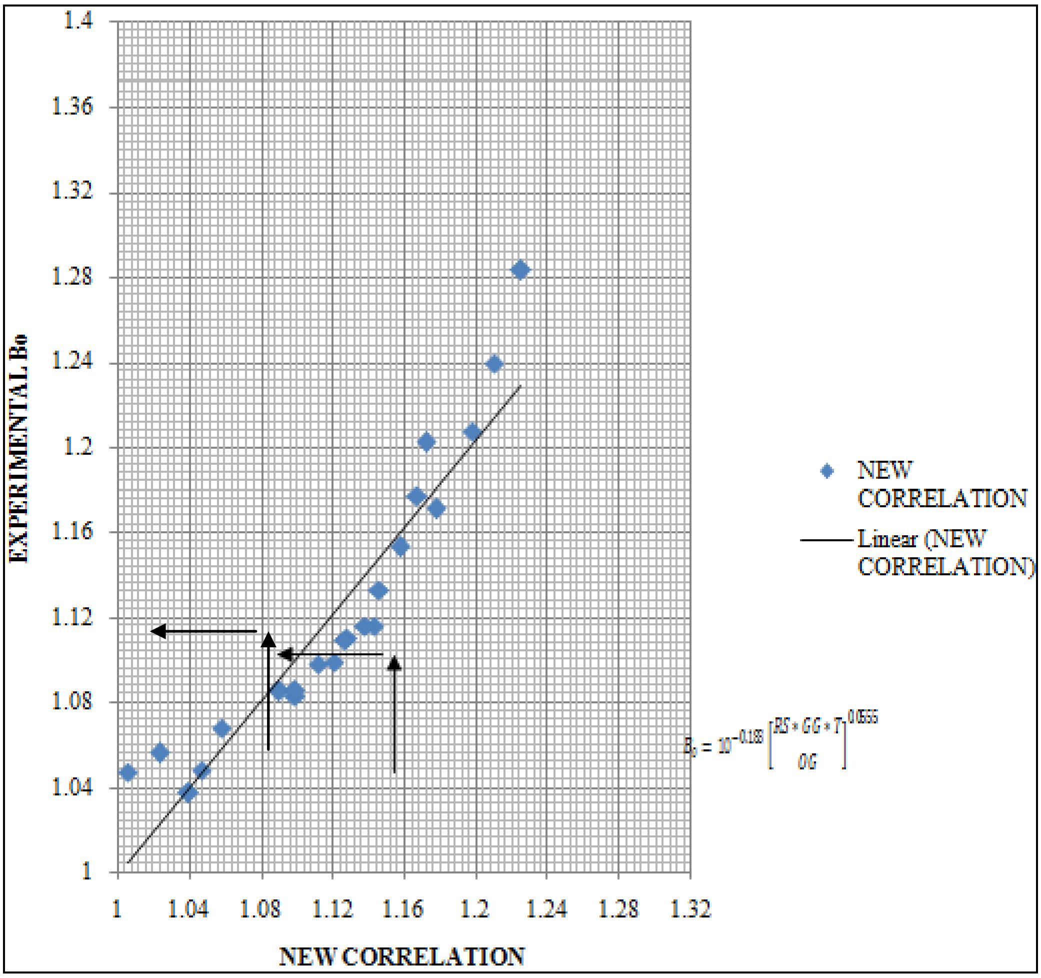


**Figure 2:** Monograph for obtaining experimental Bo form the new correlation

Figure 2 is an alternative to using equation 14. Once the estimate is made with equation 13 the equivalent value of laboratory measurement is read from the graph following the arrow.

## 6. Conclusion

A new correlation for oil formation volume factor has been developed. From this work it appears reasonable to conclude that least square approach is a useful tool in correlation of physical properties of crude oil because it minimizes the sum of squares of the deviation. From the test for regression coefficient, we are 92% confident that the variables correlate.

Comparison of available PVT correlation from the literature such as Standing (1947), Vasquez and Beggs (1980) and Owolabi shows that no universal correlation exits and that data from local regions should be used to develop local correlations. The new correlation predicted the experimental Bo better than the other correlations used in the study. This implies that the Bo obtained from this model will give better evaluation of reservoir performance when applied in material balance evaluation.

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