Paper ID: 2004912

Error Estimation in calculating two phase flow by different correlations considering the wells of Cluster-7 Marginal Field Mumbai India.

Pandey Saurabh, Kamat V.V., Dr. Pratap Mahendra ONGC Mumbai.

4th Floor, Vasudhara Bhavan, ONGC, Bandra(E), Mumbai-400051

Presenting author, E-mail: *spandey06@gmail.com*

Abstract

Understanding the uncertainty in prediction of two-phase liquid flow through different choke sizes is required for production facilities design and optimization of oil well performance. Several correlations that relate the liquid rate with other variables such as choke size, upstream pressure and Gas to oil ratio in the two phase flow phenomena have been developed and published in the past. The validity of these correlations for Cluster-7 marginal Field has been discussed in this study.

Most of the petroleum engineers use Gilbert, Poettmann & Beck's and Ashford's approach for flow rate calculations. Gilbert approach is empirical based whereas two other correlations are for critical and subcritical flow regimes. The second group derived equations of two-phase flow incorporated PVT properties. Selection of the best correlation is justified by statistical error analysis, range of validity and number of involved variables to be measured in the field. These correlations provide more accurate results than any other correlations involving the same variables.

This study is an attempt to estimate the errors in measured and calculated liquid rates with different correlations considering wells of Cluster-7 marginal field Mumbai. Study also includes error estimation in prediction with respect to observed rates which will help us to comprehend the correlation best suitable for this field. Best suited correlation may be used to predict liquid rates of wells of Cluster-7 marginal field in future.

Introduction

Cluster-7 marginal Field is located in the BH-DCS block of Mumbai offshore Basin at a distance of about 210 km to the west of Mumbai city and about 20 to 40 kms to the south-west of producing Bombay High field. Cluster-7 comprises of B-192-1, 5 and 8, WO-24 and B-45 structures. Recently rising prices of crude encourages the development of these small marginal fields. Subsequently, twenty strings are completed from three platforms B-192-1, 5 and 8. Collected thirty data points of these wells have been considered for this study.

A choke malfunctioning may cause the downstream pressure disturbances to be transmitted upstream leading to de-optimization of production of oil well. Therefore, the prediction of flow behaviour of multi-phase through different chokes is of great importance during the facility design. Several correlations for estimation of liquid rates of multi-phase flow through varying chokes sizes have been developed in the past. Most of the correlations exist for limited range of production ranges. Thus best suitable correlation for cluster-7 marginal Field with least error is determined. Two-phase flow through chokes may be either critical or subcritical. Most of the models presented in the literature were developed for critical flow. This study indicates the accuracy of the existing flow correlations Gilbert, Ros, Achong, Poettmann and Beck and ashford .

Concept and Methodology Adopted:

Different Models developed is categorized on the basis of their dependence on 3, 4 and 5 parameters. First empirical Correlation Gilbert-type is proportional to three parameter ie. upstream pressure, choke size and Gas to Liquid ratio. This relationship was revised by Ros, Baxendell, Achong, Pilehvari, Secen and Osman and Dokla. On the basis of different empirical coefficients these correlations are tuned up to studied field requirement.

Gilbert Type Correlations:

$$Ql = \frac{a\,D^b}{Rp^c}\,P^d$$

where

Ql: Liquid flow rate, bpd
D : Choke size in (1/64) inch.
P : Upstream wellhead pressure, psi
Rp: Producing Gas to liquid ratio,SCF/STB
a, b, c, d: empirical coefficients for various Gilbert type correlations.(Table:1)

Another category of correlations developed by Surbey etal which is dependent on 4 parameters. Fourth parameter considered was oil API. They stated that this correlation is restrictive to multiple orifice valve chokes but later on Al-Towailib and Al-Marhoun's applied this correlation for the Middle-East field data and achieved reasonable results.

Above correlations does not depend on the PVT properties of produced fluids. Attempt is made to incorporate the fluid properties in Al-Attar and Abdul-Majeed's correlation by including the tank oil API to their four parameters correlation resulted in five parameters equation.

Al-Attar and Abdul-Majeed's Correlation

$$Qo = 0.33567 D^{1.796} P^{0.8756} R^{-0.2693} API^{-0.43957}$$

Later on Al Towailib and Al-Marhoun further modified the above correlation and added gravity of gas/ oil mixture instead of produced GOR and oil gravity.

$$Q_o = \frac{1.886 \times 10^{-3} D^{2.07} P^{0.981}}{\Upsilon_M^{1.464}}$$

Where $\Upsilon_m = \Upsilon_0 + 2.18 \times 10^{-4} R \Upsilon_g$

where:

Υ_0**:** oil specific gravity
Υ_g **:** Gas specific gravity

In a further progression Poettmann and Beck presented a different correlation that comprises more PVT data about the produced fluids. However, this correlation is limited to wells producing clean oil.

$$Q_o = \frac{86400 C A_o}{\rho_m} \sqrt{\frac{9273.6P}{V_l\,(1 + 0.5Ml)}} \times \frac{0.4513(R_f + 0.766)^{0.5}}{R_f + 0.5663}$$

where:
C=Flow coefficient

Ao= Choke throat area, sq ft

Where $\rho_m = 350.4\Upsilon_0 + 0.0765\Upsilon_g R$

$$R_f = \frac{Vsg}{Vsl} = \frac{0.0504TZ(R - Rs)}{P\beta_o}$$

$$V_l = \frac{M_l}{\rho_l}, M_l = \frac{1}{1 + Rf\frac{\rho_g}{\rho_l}}$$

Theoretical models that were derived from the basic fluid flow principles include Ashford, Fortunati and Sachdeva et al. These models incorporate the PVT properties of the produced fluids.

Moreover, these models were formally modified to fit the test data by adjusting the choke discharge coefficient in the equations.

$$V_l = \frac{M_l}{\rho_l}, M_l = \frac{1}{1 + Rf\frac{\rho_g}{\rho_l}}$$

Ashfords Correlations:

$$Qo = \frac{1.53CD^2P_1}{(\beta_o + f_w)^{1/2}} \frac{\{[T_1Z_1(R - R_s) + 151P_1](\Upsilon_0 + 0.000217\Upsilon_g R_s + f_w\Upsilon_w)\}^{1/2}}{[T_1Z_1(R - R_s + 111P_1](\Upsilon_0 + 0.000217\Upsilon_g R + f_w\Upsilon_w)}$$

Fortunati's correlation:

$$Qo = \frac{P_2A_0}{\left[(R - R_{s2})(\rho_{\sigma 2} - \rho_{g2}R\frac{P_{sc}Z_2T_2}{T_{sc}}\right]^{1/2}}$$

Statistics:

Relative accuracies have been determined by calculating the following statistical parameters.

$$Percentage\ Error = E_p = \frac{Q_{measured} - Q_{estimated}}{Q_{measured}} \times 100$$

$$\text{Average Percentage Error(APE)} = \frac{\sum_{i=1}^{n} E_{pi}}{n}$$

$$Absolute\ average\ percentage\ Error(AAPE) = \frac{\sum_{i=1}^{n} |E_{pi}|}{n}$$

It is very important to use the absolute average percentage error (AAPE) as a base of comparison instead of average percentage error (APE), because when the later is used, the negative errors cancel the positive errors and thus the error may appears smaller. Using the AAPE removes this cancellation effect by transforming all negative error to equal magnitude to positive error and thus showing a better magnitude of error for analysis.

Results and Discussion:

Existing correlations are tested against the measured rates through 30 data points. Attempt is made to find the best suitable correlation for the cluster-7 marginal field. Plots were generated for rates estimated to the measured. (Fig:1-12) considering the various empirical as well as theoretical models. Statistical error like Average Percentage relative deviation, Average absolute percent relative deviation, Standard deviation and correlation coefficient is determined. It is observed that Gilbert modified Ros correlation is the best among the empirical correlations with APD value of 3.25 and Correlation Coefficient of more than 0.86. **(Table:2.** Among the PVT dependent models correlation coefficient value of 0.86 is calculated for Ashford modell.

Nomenclature:

Symbol: Description

fw: fraction of water flowing
R: Producing GOR(V/V) scf/stb
Rf: Free gas to Liquid.
Ү: Specific gravity of fluid.
ρ : density, lb/cuft

T : Temperature,degR
SD: Standard Deviation.

REFERENCES:

1) Gilbert, W.E.: "Flowing and Gas-Lift Well Performance," Drill. and Prod. Prac., API (1954) pp. 143.
2) A.A.M.· Elgibaly, I.S. Nashawi:" Prediction of Two-Phase Flow Through Chokes for Middle-East OnWeUs."SPE:36274.
3) U.H. Abdul-Majeed, University of Baghdad," Correlations developed to predict two phase flow through wellhead chokes, USMS 015839.
4) A.A.M. Elgibaly, I.S. Nashaw " New Correlations for Critical and Subcritical Two-phase Flow Through Wellhead Chokes" JCPT
5) Ros,N.C.J:" Theoretical approach to the study of Critical Gas Liquid Flow through Beans", 1959

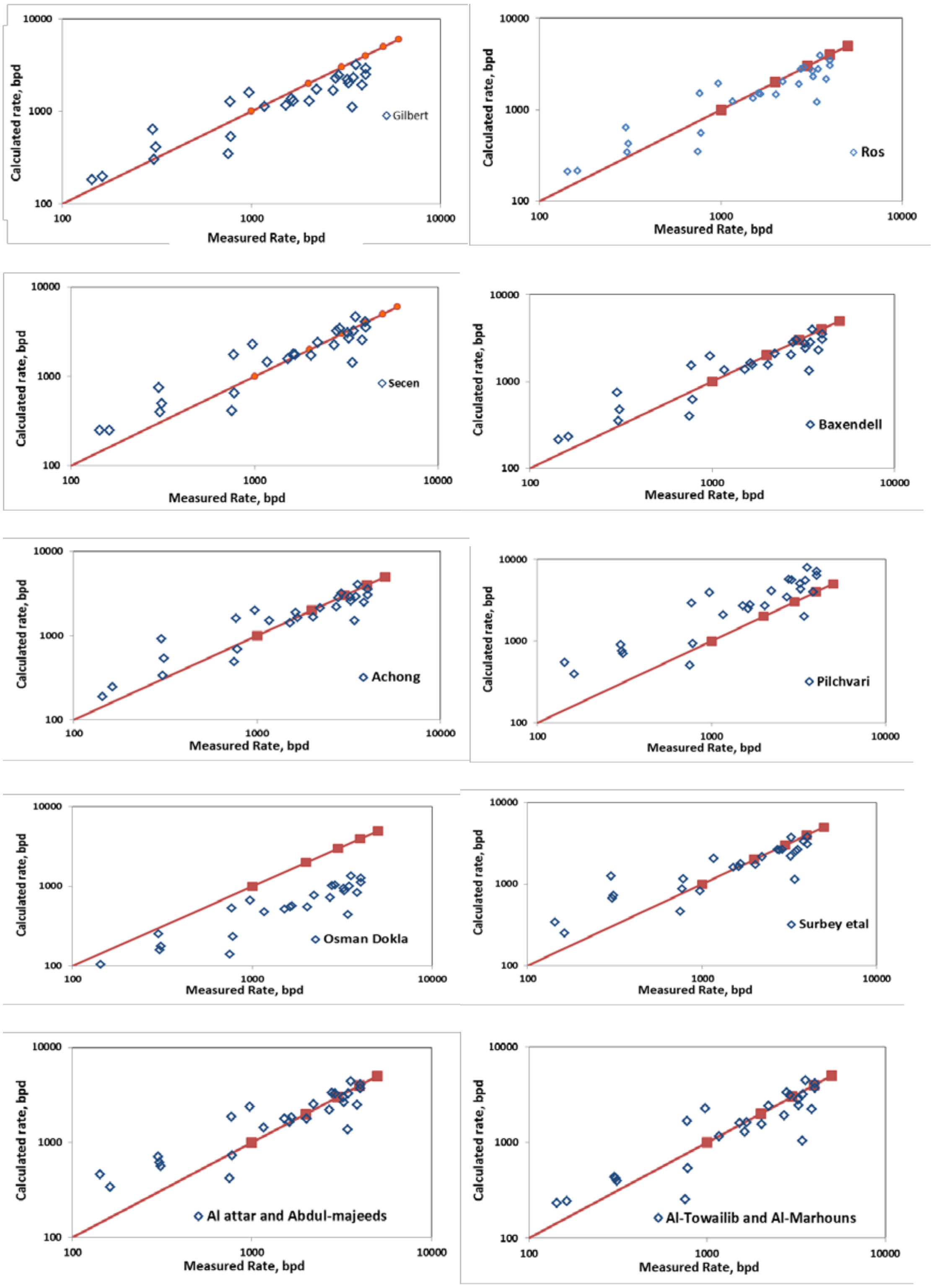
Tables-1: a,b,c and d coefficient value for different empirical correlations.

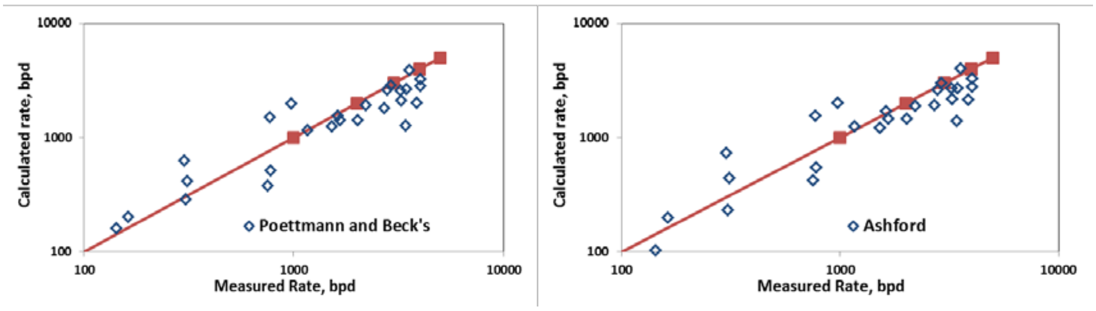
Correlation	**a**	**b**	**c**	**d**
Gilbert	0.10000	1.89000	0.54600	1.00000
Ros	0.05747	2.00000	0.50000	1.00000
Secen	0.06740	2.00000	0.50000	1.00000
Baxendell	0.10460	1.93000	0.54600	1.00000
Achong	0.26178	1.88000	0.65000	1.00000
Pilehwari	0.021427	2.11000	0.31300	1.00000
Osman Dokla	0.0242258	1.84780	0.43440	1.00000
Surbey Etal	0.01012	1.57640	0.66840	1.69000
Al Attar and Abdul Majeed	0.42100	0.63000	0.47100	0.83200

Table:2

Correlation	**APE**	**AAPE**	**SD**	**CC**
Gilbert	**-9.05**	**34.38**	**40.84**	0.88
Ros	3.25	32.64	44.72	0.86
Secen	21.08	38.00	52.44	0.86
Baxendell	9.01	33.98	48.42	0.87
Achong	15.87	35.97	55.56	0.88
Pilehwari	96.27	53.17	88.43	0.84
Osman Dokla	-59.88	59.88	18.00	0.88
Surbey Etal	25.86	46.72	78.07	0.87
Al Attar and Abdul Majeed	33.40	49.61	68.30	0.86
Al-Towailib and Al-Marhoun's	8.68	34.06	46.68	0.84
Poettmann and Beck's	-1.86	32.11	44.02	0.86
Asford's	-1.74	34.77	48.49	0.86

Plots showing the accuracy of measured and calculated rates from different correlations





Poettmann and Beck's
Calculated rate, bpd
Measured Rate, bpd
10000
1000
100
Ashford
Calculated rate, bpd
Measured Rate, bpd