Application of New Ipr for Solution Gas Drive Oil Reservoirs

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Abstract

Inflow performance relationship (IPR) of wells is an essential piece of information required in production well modeling, optimization, nodal analysis calculations, and designing artificial lift. It quantifies the production rate in addition to understanding the well behavior as a function of well's flowing pressure. Various IPR models exist today which are used in the industry, especially Vogel's and Fetkovich's models are extensively employed.

In this work the new IPR model (Elias et al; 2009) is applied on real data and its validation tested among the most common empirical models. Furthermore, future IPR prediction is done using the new as well as the available models. The new developed IPR model is simple in application, covers wide range of reservoir parameters, and requires only one test point. Therefore, it provides a considerable advantage compared to the multipoint test method of Fetkovich. Moreover, due to its accuracy and simplicity, the new IPR provides a considerable advantage compared to the widely used method of Vogel.

The productivity index is given by:

$$J = \frac{0.00708kh}{ln(^{re}/_{rw}) - 0.75 + S}\left\{\frac{kro}{\mu oBo}\right\}$$

This clearly indicates that the productivity index depends on oil mobility factors (kro, μo, Bo). Consequently, the inflow performance curves are hence affected by the oil mobility factor and its relation to the average reservoir pressure.

Previously, the derived empirical correlations did not take into account fully the effect of the oil mobility function, and this as a result puts question marks on the accuracy and applicability of these equations.

Although, Fetkovich and Wiggins incorporated the oil mobility factor, the relationship which they used (linear by Fetkovich and third polynomial form by Wiggins) of this factor with average reservoir pressure is not a true and accurate depiction of the actual scenario.

Another parameter should be considered in the selecting of the IPR method, is the aspect of conducting the flow tests. Finally, the range of applicability will also influence the selecting of the IPR methods to predict the well performance.

The scope of work includes:

- Select a newly developed, more general, simple, and consistent method to correlate inflow performance trends for solution gas drive oilreservoirs. This new method takes into consideration the behavior of the oil mobility function with the average reservoir pressurewithout the direct knowledge of this behavior.
- Determine the applicability and accuracy of the new model by applying it on different cases with a comparisonwith some of the most known and used IPR equations.
- Test some of the available IPR methods on field data.

- Address the prediction of future performance from current test information.

The older empirical methods including Vogel, Fetkovich and Wiggins are applied using the basic correlations which have been discussed by various different authors.

The new IPR derived by Elias et al; 2009, is applied using the following steps:

1. Calculate the oil mobility factor, □□using the following equations:
   (For Pr <= 1600)
   $\alpha = \frac{1}{a.Pr + b}$□□
   Where, a=-0.981, b=-152.585
   (For Pr>1600)
   $$\alpha = c + d.Pr + e.Pr^2 + f.Pr^3 + g.Pr^4 + h.Pr^5,$$
   Where c = -0.0043065, d = 4.98E-06, e = -2.41E-09, f = 5.69E-13, g = -6.48E-17, h= 2.85E-21
2. Calculate q_o (max) at any test point and also q_o at different values of Pwf using the following equation:
   $$\frac{q_o}{q_{o\ max)}} = 1 - \frac{\ln(\alpha.Pwf + 1)}{\ln(\alpha.Pr + 1)}$$
3. For future IPR calculate □$_f$ using the future value of Pr by the previous mentioned equations.
4. Solve for $q_{o,}$ (max) using Fetkovich equation: $q_o max(f = q_o max(p * \left[\frac{Pr\ (f}{Pr(p}\right]^3$
5. Generate the future inflow performance curves using the equation in step 2 using the variables of step 3 and 4.

Table-1 represents the prediction of the well's performance at testing bottom hole flowing pressure of 1194 psia. As is evident that the maximum well deliverability ranges from about 2550 to 4265 STB/D and it is also observed that the smallest flow rate was achieved by Fetkovich while largest flow rate was obtained using Wiggins model.

Table-1: Comparison of New IPR with other empirical models

Test Data		New IPR	Vogel	Fetkovich	Sukarnoo	Wiggins
Pwf (psia)	qo (STB/D)	qo (STB/D)	qo (STB/D)	qo (STB/D)	qo (STB/D)	qo (STB/D)
1600	0	0	0	0	0	0
1558	235	296.686619	169.399305	322.721908	181.492769	163.332337
1497	565	613.929288	408.309276	599.893221	431.731628	397.121506
1476	610	703.461186	488.604927	680.638441	514.532248	476.22607
1470	720	727.641014	511.3629	702.773287	537.879104	498.697527
1342	1045	1139.84365	977.42297	1106.74193	1003.90044	964.340792
1267	1260	1320.63858	1233.24612	1301.41839	1249.50356	1224.97538
1194	1470	1470	1470	1470	1470	1470
1066	1625	1687.89884	1855.96506	1725.87482	1814.63858	1879.0105
996	1765	1789.68253	2051.32814	1847.7302	1981.66159	2091.57894
867	1895	1953.87574	2382.25396	2043.57669	2252.3376	2462.73618
787	1965	2043.6743	2568.52563	2148.11775	2397.46856	2679.50967
534	2260	2284.10817	3062.10589	2403.31238	2754.00349	3297.52787
351	2353	2427.95246	3328.67548	2522.96344	2927.66433	3680.60059
183	2435	2544.01098	3506.54951	2588.23374	3035.9053	3985.00939
166	2450	2555.04093	3520.98353	2592.52611	3044.48786	4013.29186
0		2656.81908	3627.4912	2612.42362	3108.71033	4265.113

Figure-1 displays the resultant IPR curves from the data of table 1 for the various calculation methods adopted here in comparison with the actual field data and the newly used IPR model. This figure clearly shows that the new IPR model succeeds in predicting the actual well performance. Moreover, it can also be seen that both the New IPR model and Fetkovich model predict nearly the same results as indicated compared to the other models.

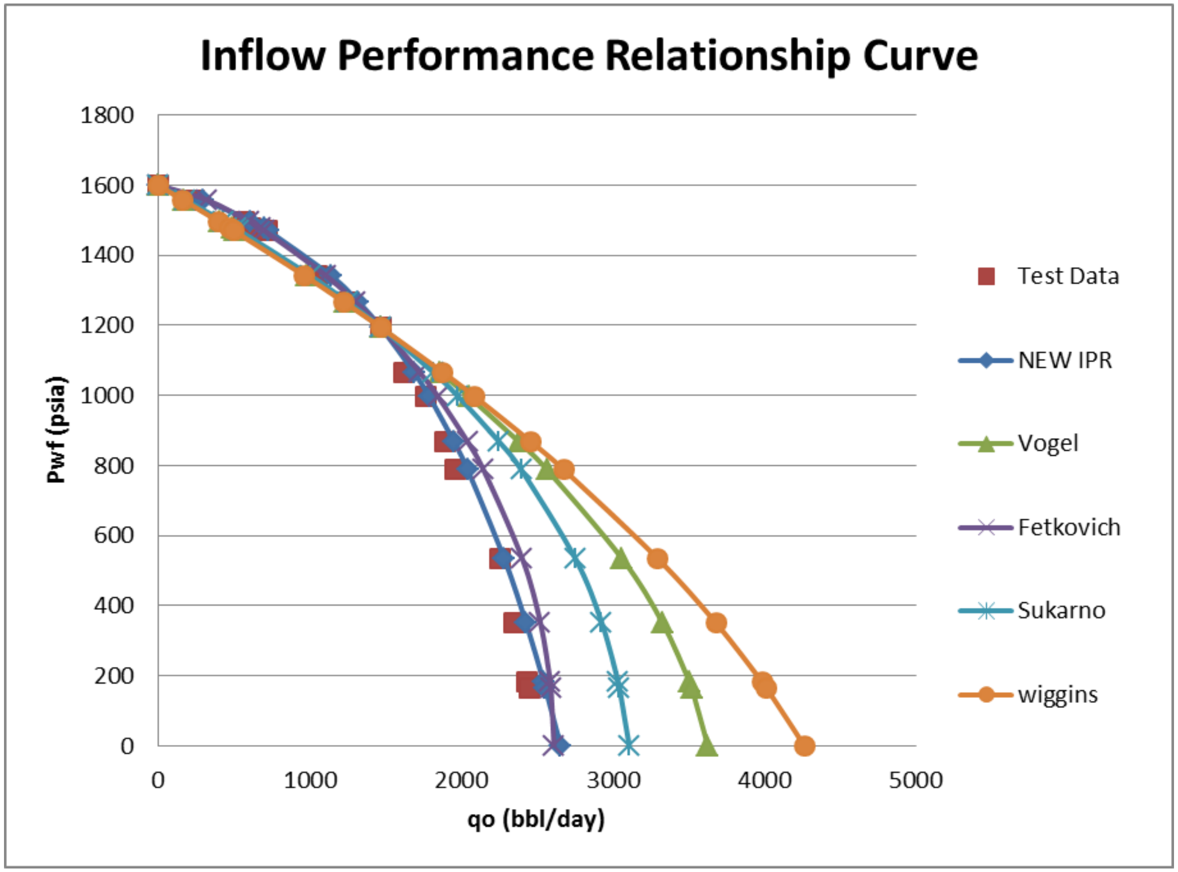

Figure-1: IPR Curves Comparison of the Various Models

Figure-2 represents the average errors in using the different models. It is clearly indicated that the New IPR produces the least amount of errors among the tested models.

Figure-2:The absolute percentage error in the tested models

CONCLUSION

In this work, the new IPR model developed by Elias et al; 2009 and also the most commonly used IPR models are applied to a solution gas drive oil reservoir. Based on this work we conclude that the validity of the new IPR model was tested through its application on the real data in comparison with the behavior of the most common methods that are used in the industry. The results of this validation showed that new IPR model ranked the first model that succeeded to predict the behavior of the IPR curves for the examined field cases, while the other models of Fetkovich, Sukarno Vogel and Wiggins ranked the second, the third, the forth and the fifth respectively.

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