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Research Article

PRODUCTION PROFILE ANALYSIS; CASE STUDY OF WELLEY IN NIGER DELTA, NIGERIA

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ABSTRACT

Nigeria has abundant hydrocarbon reserves. This work is aimed at reviewing the production profile of an existing Well-Y in Niger Delta and simulating the process using petroleum Experts IPM 7.0 software (precisely MBAL) with Microsoft office excel 2007. For the case study, the pressure , PVT and production data at Niger Delta are used. From the production history table, the reservoir pressure is continuously above the bubble point pressure,2200 psig. The producing Gas-Oil ratio (GOR) is estimated to be the solution GOR, 500 SCF/STB. Hence, the data is consistent with the PVT, since there is no free gas. Based on the response of the Campbell plot, the presence of an acquifer as a source of energy is very likely. Therefore Hurst-van Everdingen-Modified model is used as the aquifer model. The energy plot shows that th dominant drive mechanism is the water drive. From the decline curve analysis, it is observed that the decline curve type is hyperbolic with the smallest standard deviation of 0.0200079 STB/ day and exponent of 1.24149. The results demonstrate that the approach is suitable for decline curve fitting and offers a new insight in decline curve analysis in the presence of unusual observations. This study is useful for the unconventional fields.It is deduced that the thickness of reservoir is high enough and the pont of perforation is far from the Oil-water contact (OWC) to the extent that the water produced is negligible compare to the oil production. Hence, water encroachment is not considered for the economic limit. The economic limit is estimated to be 191.60bbl/day theoretically but in pratical sense, no company in Nigeria would produce at that rate. Based on the prediction plot, it is recommended that the production should continue till at least 01/01/2015 because the reservoir pressure is still sufficiently high.

INTRODUCTION

Production profile is an indispensible tool; it is the production history of the well and could serve as a tracer of the historical pathway of the producing well giving details on how reservoirs fluid could have evolved during production i.e. on its pathway from a high temperature high pressure regime to a much more settle environment. The production profile reflects the production history and could serve as the cash flow history of a producing well, modifiers which are the elements are used to study the production trend, these serves to predict cash flows and possible potential projects. By combining the production profile analysis from a horizontal well with the modelled time-lapse borehole gravity data, a complete understanding of the fluid movements (migration direction) in the well borehole and up to two hundred feet into the formation can be obtained. Viscosity, gravity drainage and capillary effects are the main forces governing the flow (Satter et al., 2008). Volumetric methods when sufficient data is available to establish a reliable trend and applicable to both oil and gas wells. Accordingly, production decline analysis is most applicable to producing pools with well established trends. It is most often used to estimate remaining recoverable reserves for corporate evaluations but it is also useful for water flooding and in enhanced oil recovery (EOR) performance assessments and identification of production issues or mechanical problems. Deviations from theoretical performance can help identify underperforming wells and highlight where well workovers and/or changes in operating ices could enhance performance and increase recovery. To the geologist, production decline analysis of an analogous producing pool ides a basis for forecasting production and ultimate recovery from an exploration prospect or step-out drilling location. A well's production capability declines as it produced, mainly due to some combination of pressure depletion, displacement of another fluid (i.e. gas and/or water) and changes in relative fluid permeability.

Objectives of the Study: The objectives of the study were to unravel the drive mechanism of the reservoir forecast production and history match using the production data with pressure and PVT data; to use the profile to predict or determine decline curve type and when production was no more viable; to optimize production process; to find a more cost effective way of producing hydrocarbon from the subsurface by elimination of some expensive conventional steps; to provide additional source of profit to the nation's petroleum production; to minimize the loss of productive time and cost due to pressure depIetion.

LITERATURE SURVEY

(a) Basic Analysis of Production: The Arps work was the systematic first attempt to c1ate production data in the petroleum literature and is considered to be an essential starting point for analysis. Mattar and McNeil provide' a coupling of material balance and pseudo-stready-state flow theory which provides an analysis/interpretation methodology of production data on a per-well basis. Li and Home provide a recent attempt to legitimize" production analysis by providing a theoretical basis (where possible) for several of the more common production analysis relations.

Blasingame & Rushing (2005) provided a synopsis of the historical methods used simplified production analysis and lend some theoretical support for common applications (e.g., the exponential and hyperbolic decline relations, as well as semi1ytical solutions for gas flow). Camacho & Raghavan (1989), which was not a production data analysis by design, provided the theoretical basis for boundary dominated flow in solution gas-drive reservoirs — and should be considered to be an essential reference on production analysis.

(b) Decline Type Curve Analysis: The required reference for production decline curve analysis using type cures is the original work on the subject by Fetkovich (1980). The analytical basis and "integral" plotting functions for variable-rate/variable pressure drop production data are provided by Palacio & Blasingame (1993) (for gas wells) and Doublet and Blasingame (1994) for oil wells).

Production profiles of giant fields generally have a long plateau phase, rather than sharp peak often seen in smaller fields. The end of the plateau phase is the point where production enters the decline phase. The end -of-plateau was adopted as the point where production lastingly leaves a 4% fluctuation band. In this analysis the exponential decline model, originally developed by Arps (1945), was used to model field behaviors aid to forecast future production. One advantage of the decline curve analysis is that it generally applies independent of the size and shape of the reservoir or the actual drive- mechanism (Doublet, 1994), avoiding the need for more detailed reservoir data.

METHODOLOGY

This method allows for better matches and results in higher confidence level if wells in the field have logs. By having access to logs; porosity, thickness and saturation can be calculated and used individually for each well during the analysis. If and when such logs are not available or prove to be too expensive to analyze then the procedure allows the user to input an average value (as the best guess) for all wells.

(i) Single-Well Reservoir Simulation: This step of the analysis calls for history matching the production data using a single-well, radial reservoir simulator. Reservoir characterization data that is the result of type curve matching is used as the starting point for the history matching process and the objective is to match the production data of a particular well..

(ii) Materials: The process simulator used is Petroleum Experts 1PM 7.0 (MBAL version 10.0 precisely) software (2004) with excel spreadsheet. The aquifer model is the Hurst-van Everdingen-Modified model and the Black Oil correlations used are:

1. Glaso for Bubble Point, GOR and Oil FVF

2. Beal et al for Oil viscosity

The data used entails pressure data, PVT data and production data from well-Y in Niger- Delta field.

(iii) Process Description: Material balance model is used to perform the classical history matching to determine fluid originally;' in place as well as aquifer influx. Prediction is also made using relative permeabilities and well performances to evaluate future reservoir performance based on different production strategies. The Hurst-van Everdingen-Modified model is used with the following PVT fluid properties.

The production history is entered by tank and the fluid is been defined as oil. The production data is transferred from Excel into MBAL. The PVT data is entered. The water salinity is also specified and indicated that the produced gas has no CO_2, H_2S or N_2 in it.

These laboratory measured data for this fluid at bubble point conditions are matched to the available correlations by regression. The correlations that best match the fluid (require the least correction) is then selected for use in the model. The initial data is then used for the reservoir model. The OOIP used is only an estimate, obtained from geology.

Subsequently, the aquifer support is defined. However, as there is yet no evidence to suggest the presence or an aquifer at the initial stage, the water influx is ignored. The rock compressibility is specified from the correlation. The relative permeability is also specified from the data using the Corey function. The water and gas sweep efficiencies are taken as 80% each.

The last data supplied is the production history of the reservoir. This finishes the setting up of the reservoir model.

The model is then history matched, in terms of identifying and quantifying its various drive mechanisms and determining the OOIP and aquifer support. In history matching, the first thing s to see whether the production history data is consistent with the PVT data by comparing the solution GOR (500scf/STB) at bubble point pressure (2200psi) with the producing GOR from the production history.

Having determined that there is no inconsistency in the data, the history matching process begins by plotting the graphs (The energy plot, showing the relative importance of each drive mechanism currently in the model, the Graphical method (Campbell plot) where the diagnostics in terms of drives can be done, and the Analytical method plot that shows the reservoir pressure Vs Cum Production from the historical data and the model). Campbell plot determines if there is a barrier or water influx.

Based on the response of the Campbell plot, the presence of an aquifer as a source of energy is very likely. Therefore Hurst-van Everdingen-Modified model is used as the aquifer model in the tank data for the water influx.

The model is now history matched again to see the effect of the aquifer. With the current aquifer model, the model predicts production rates higher than those actually observed. The aquifer parameters along with the OOIP can now be changed so that the Campbell plot will become a straight horizontal line and the model matches the measured data in the analytical method plot.

PRESENTATION OF RESULT

The methodology described in this paper was applied to production data from Well-Y in Niger-Delta. The only data used to perform the analysis shown here are the production data that are publicly available; therefore, all these analyses can be performed on any field throughout the Niger-Delta. This may prove to be a valuable tool for independent asset valuation prior to any acquisition.

Having modelled and simulated the production profile using Petroleum Expert 7.0 (MBAL version 10.0) (2009) software for the process, the following results are obtained.

(A) Material Balance: Petroleum Expert 7.0 (MBAL version 10.0) (2009) Software was used to model the production profile using Hurst-van Everdingen-Modified model as the aquifer model.

The production profile was modeled to identify the drive mechanism that serves as the source of energy for the production.

The Material balance was used as the basis for:

1. Quantifying different parameters of a reservoir such as hydrocarbon in place, gas cap size.

2. Determination of the presence, the type and size of an aquifer, encroachment angle.

3. Estimation of the depth of the Gas/Oil, Water/Oil, Gas/Water contacts.

4. Prediction of the reservoir pressure for a given production and/or injection schedule,

5. Prediction of the reservoir performance and manifold back pressures for a given production schedule.

6. Prediction of the reservoir performance and well production for a given manifold pressure schedule

(B) Decline Curve Analysis: Working with rate-time curves, a declining pattern was observed and the future trend could be forecasted. This future trend is extrapolated to the economic limit of the property. Production is abandoned before it would cease due to natural causes (depletion), because it deck declines to a rate where it costs more to produce the hydrocarbons than those hydrocarbons ire worth. Therefore, the economic limit is computed from equation (2.2) as follows with these parameters available.

Royalty 20% = 0 2

Water Treatment= $5/barrel

Oil Price, P0 $ 113 .2/barrel

Operating Cost = (WI * LOE) = $16,000/day

Net Revenue Interest, NRI = (1- Royalty) = 1- 0.2 = 0.8

GOR = 500scf/stb

Oil Severance/ production taxes, T0 = 5%

Ad valorem tax, T 3%

$$EL_{ou} = \frac{WI\ xLOE}{NRI\left[P_o(1-T_O)+P_g\left(\frac{GOR}{1{,}000}\right)\right](1-T)}$$

$$= \frac{\$16{,}000/day}{0.8\left[\left(\frac{\$113.2}{stb}\right)(1-0.05)+\left(\frac{\$0.15}{stf}\right)\left(\frac{500cf/stb}{1{,}000}\right)\right](1-0.03)}$$

= 191. 6Obbl/day

5824. 64bb1/month

DISCUSSION OF RESULT AND CONCLUSION

It is observed that the production started on 02/04/1990. A well model is not necessary for performing forecasts in MBAL. However, it provides a more realistic basis on which the forecasts can be made compared to the simpler fixed withdrawal options. Of course, the most realistic profile will be obtained if the effect of the surface network is modelled by importing the MBAL model in GAP.

The Correlations used are the ones with least correction which are: Glaso for Bubble Point, GOR and Oil FVF and Beal et al for Oil viscosity.

From the production history data, the reservoir pressure is continuously above the bubble point pressure, 2200 psig. The producing Gas-Oil Ratio (GOR) is estimated to be the solution GOR, 500 SCF/STB. Hence, the data is consistent with the PVT, since there is no free gas. If this were not the case, then there would be an inconsistency between PVT and production data. The source of this inconsistency would need to be identified before progressing with the history match. Based on the response of the Campbell plot, the presence of an aquifer as a source of energy is very" likely. Therefore Hurst-van Everdingen-Modified model vas used as the aquifer model

Looking at the analytical method plot, it is observed that with the current aquifer model, the model is predicting, production rates higher than those actually observed. The aquifer parameters along with the OIIP are now changed so that the Campbell plot will become a straight horizontal line and the model matched the measured data in the analytical method plot. From the energy plot, it is observed that the dominant drive mechanism for the reservoir is water drive.

It is also observed that OIIP and porosity have largest effect. After regression, the parameters are:

At the end of regression the values for which the best match is achieved are displayed. If they are accepted, then the "Best Fit" button can be selected in order to transfer these values into the model.

The model obtained at this stage in terms of OHP and various drive mechanisms satisfies all the methods and is therefore acceptable, The oil in place is estimated to be 95.82O5MMSTB with aquifer permeability of O.762854md and encroachment angle of 286.823°.

At this stage it must be noted that in the regression analysis that is done in the analytical plot, the tank pressure and non primary phase production is fixed and production rate of the primary phase, oil in this case, is calculated based on the material balance equations.

The simulation option will perform the opposite calculation. With the model now history matched, the phase rates from the history are kept and the pressure is calculated from the material balance equations. If the model has been properly history matched, there should be no discrepancy between reservoir pressures predicted from simulation and historical, measured reservoir pressures.

Running the simulation, this plot has the pressure with time plotted both from simulation and production history data. In this case both are identical and thus the match attained is good.

The model is not ready at this stage to go ahead with predictions and study various development alternatives. Fractional flow matching should be done that will create pseudo relative permeability curves based on history. This is the best way to ensure that WC and GOI evolution in the future will be predicted correctly.

The following parameters are generated by regression from the production history:

Initial Rate	0.55062.5 STB/day
Exponent	1.0
Standard Deviation	0.0203471 STB/day
Decline Rate	0.0181 728/month

Table 1: Match Parameters for Harmonic Decline Curve

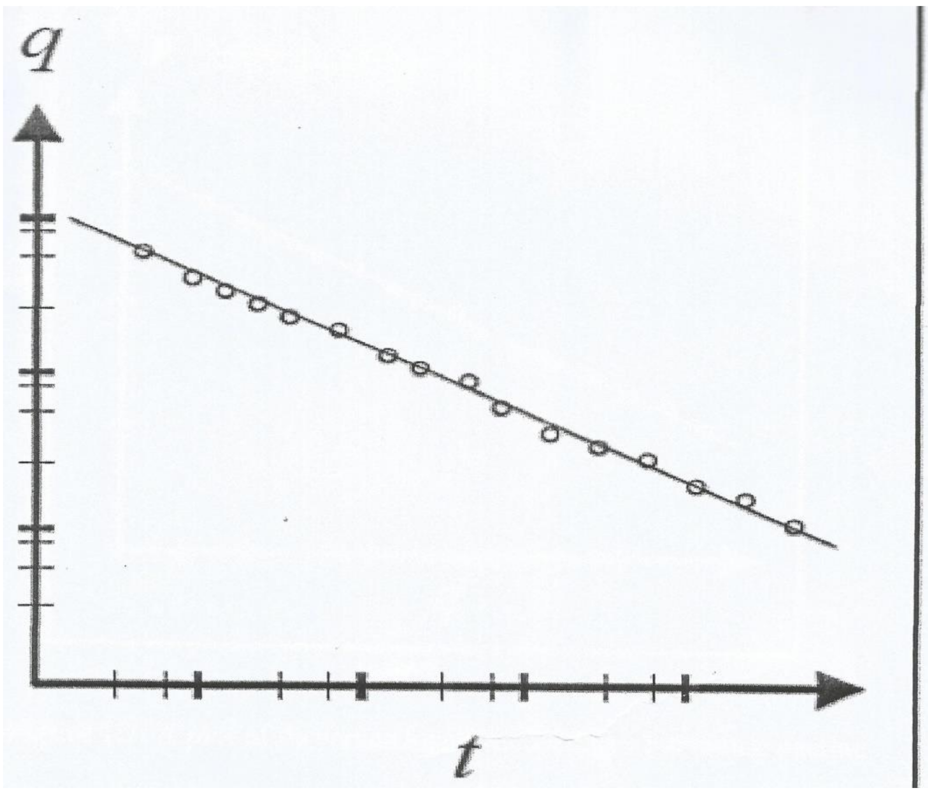

Figure 1: A plot of log *(q)* versus *(t)* indicating a harmonic decline

Initial Rate	0.485125 STB/day
Exponent	0
Standard Deviation	0.0278273 STB/day
Decline Rate	0.00882)54/month

Table 2: Match Parameters for Exponential Decline Curve

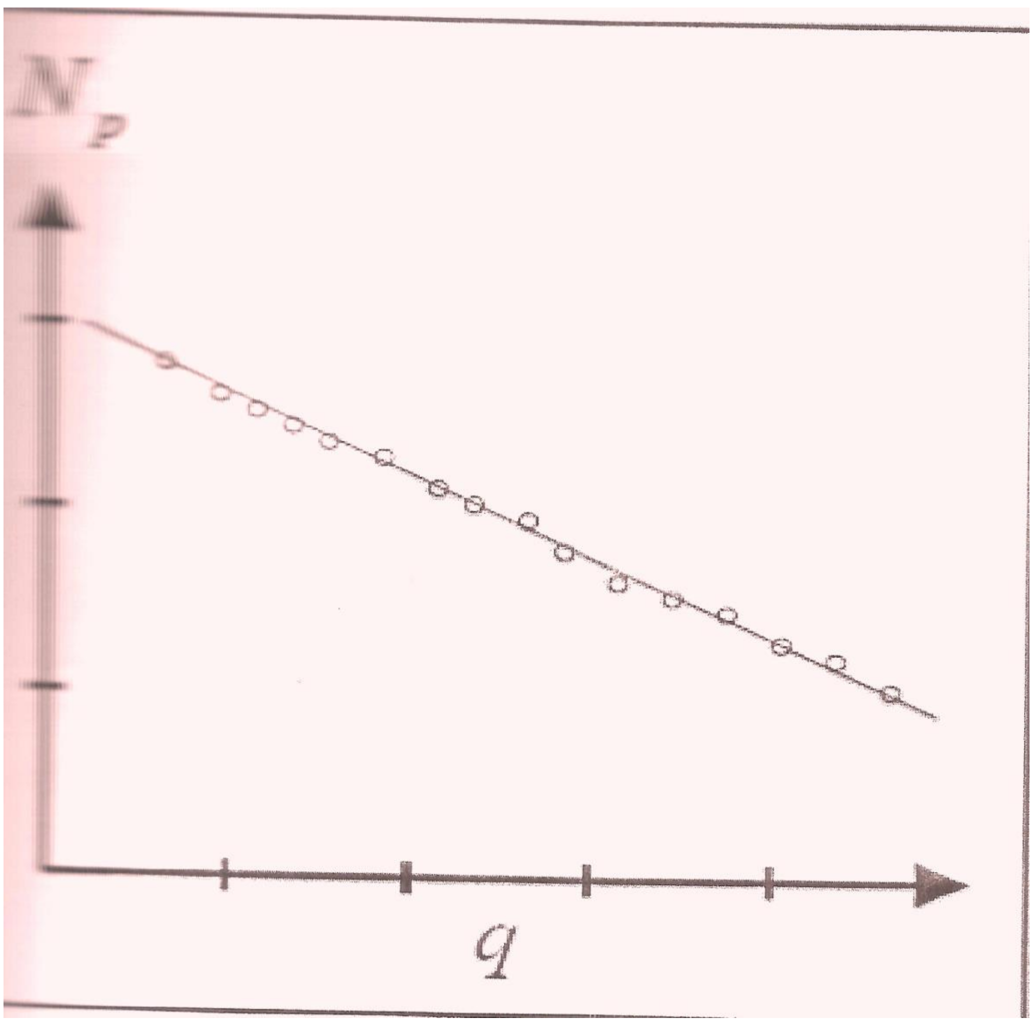

Figure 2: A plot of log (q) versus (t) indicating an exponentiak declin

Initial Rate	0.567163 STB/day
Exponent	1.24149
Standard Deviation	0.0200079 STB/day
Decline Rate	0.022026/month

Table 3: Match Parameters for Hyperbolic Decline Curve

From the decline curve analysis, it is observed that the decline curve type is hyperbolic with the smallest standard deviation of 0.0.200079 STB/day and exponent of 1.24149. The results demonstrate that the approach is suitable for decline curve fitting and offers a new insight in decline curve analysis in the presence of unusual observations.

In normal petroleum operations, the value of decline rate, b ranges btw 0 and 1 with b0 being an exponential decline and b1 being harmonic decline (special case of hyperbolic decline). However, it is found that in fractured tight (low-permeability) formations, exponents in excess of 1.0 may be calculated. Care should be exercise in these cases, as a large value of b will result in an unrealistically low decline rate late in the well life. This study is useful for the unconventional fields.

It is deduced that the thickness of the reservoir is high enough and the point of perforation is far from the Oil-water Contact (OWC) to the extent that the water produced is negligible compare to the oil production. Probably, the well is positioned at the crest, not at the flank (i.e. the well is located at structurally higher positions).

Hence, water treatment cost is not considered for the economic limit because there is no significant water encroachment. From the discussion, the economic limit is estimated to be 191.6Obbl/day (5824.64bb1/month). This is a theoretical value. Practical, no company in Nigeria will produce at this rate without running into loss. However, in countries like USA where an individual owns a field, the value is reasonable.

Considering the production profile graph, it is deduced that the thickness of the reservoir is high enough and the point of perforation is far from the Oil-water Contact (OWC) to the extent that the water production is negligible compared to the Oil production. Probably the well is positioned at the crest not at d flank, when wells are located at structurally higher positions. So water treatment cost is not considered for the economic limit because there is no significant water encroachment. The economic limit is 191.6Obbl/day theoretically. Practically, no company in Nigeria will produce at this rate without running into loss. However, in countries like USA where an individual owns a field, the value is reasonable.

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