



P 078

Reservoir characterization through pressure transient test - A case study from the field of Cambay Sub - Asset

**J.P.Srivastava, Aditya Kumar, Vikash Chowksey, Anupam Banerjee, Dr. D.K.Baishya*

Summary

Reservoir characterization is a collection of process for describing and quantifying spatial variations in rock and fluid properties associated with reservoir. Given the right planning, technology and implementation, well testing can provide vital information related to reservoir pressure, distance to boundaries, areal extent, fluid properties, permeability, flow rates, drawdown pressures, formation heterogeneities, vertical layering, production capacity, formation damage, productivity index, completion efficiency and more. Pressure Transient test is one of the valuable test related to geological modeling. Analysing pressure Transient data gives the most useful information regarding reservoir characteristics and reservoir boundaries /discontinuities. The reservoir parameters evaluated from Pressure Transient Analysis are very useful in updating geological model. Interpretation of Build-up data of Anklav#9 indicates that there is an increasing trend in derivative plot reservoir is having a radial homogenous, single phase flow, constant compressibility with a single fault effect at a distance of 1789 ft. The log-log plot revealed the transition phase from radial flow which can be considered as a presence of boundary effect. This is also in conformity with the geological and structural set up of the study area.

Keywords: PI=Productivity Index, SBHP=Static Bottom Hole Pressure, FBHP= Flowing Bottom Hole Pressure, k = Reservoir permeability, kH =Capacity, S = skin around wellbore, P_i = initial reservoir pressure, h =Reservoir thickness

Introduction

The three components of the classic well testing problem are flow rate, pressure and the formation. During a well test, the reservoir is subjected to a known and controllable flow rate. Reservoir response is measured as pressure versus time. The goal is then to characterize reservoir properties. For a typical pressure buildup test, the test would have to be run until all after flow and phase redistribution effects cease.

Types of Pressure Transient Test

Various types of pressure transient test carried out in oil, gas and water injection wells are as follows:

- Pressure Build up test
- Pressure draw down / Reservoir Limit test
- Pressure fall off test
- Interference test/ Pulse test
- Two rate flow test

The following generic analysis procedure is used to test and evaluate wells after completion:

1. Stabilize the well's rate for some time after well completion and estimate the well productivity index based on estimates of reservoir parameters.
2. Establish a well-reservoir model for rate-time prediction (based on Step 1) and tune the model by history matching the observed data.
3. Design and conduct a pressure buildup test based on the parameters estimated from the previous two steps
4. Interpret the pressure test data and confirm the model established by the available rate-time data via an iterative process.

Interpretation Method

The goal of pressure transient testing is to determine reservoir and well properties in the well drainage area so that the well performance can be predicted. The pressure transient response can take on several particular flow regime early radial flow, early linear flow, late radial flow and boundary –affected flow. Results that can be obtained from well testing analysis are a function of the range and the quality of pressure and rate data available, and of the approach used for the analysis.

With the introduction of the pressure derivative analysis in 1983 and the development of complex interpretation models that are able to account for detailed geological features, well test analysis has become a powerful tool for reservoir characterization. A new milestone has been reached by the introduction of the deconvolution. The deconvolution process converts any variable rate pressure record into an equivalent constant rate drawdown response with duration equal to the total duration of the pressure record. Thus more data available for the interpretation than the original data set, where only periods at constant rate are analyzed. Consequently, it is possible to see boundaries in the deconvolution, a considerable advantage compared to conventional analysis, where boundaries are not seen and must be inferred. This has a significant impact on ability to certify reserves.

Case Study

Anklav field is located on the rising flank of Cambay-Tarapur block between Kathana and Padra field. Nine wells have been drilled in this area, out of which the Anklav#7 & Anklav#3 is hydrocarbon bearing. In Anklav#7 Block, EP-1 is the main producer sand and the structure contour map on top of EP-1 sand shows that the Anklav#7 Block is a fault closure which trends N-S in direction and dip towards east (Fig 1)

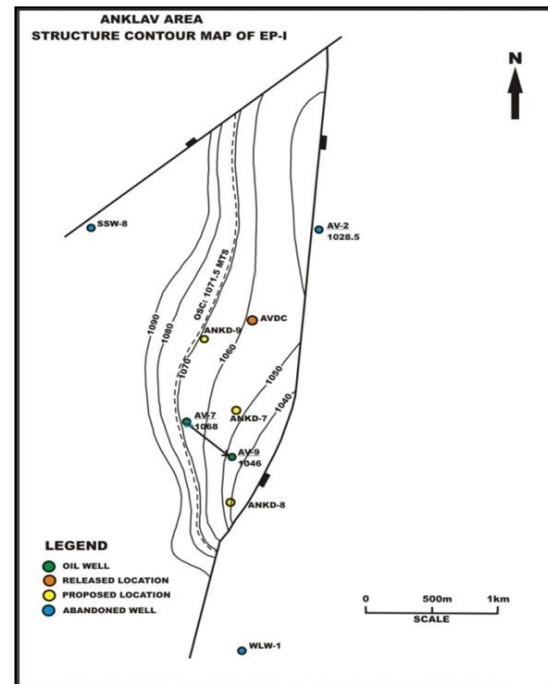


Figure 1: Structure Contour Map

The structure is broad in South side relatively narrow to the North side. Based on the encouraging results of exploratory well Anklav#7, which is situated structurally in the downdip position and has encountered EP-1 sand top at 1068 m at MSL, which is structurally down by around 40 m w.r.t. Anklav#2 and shallow by 88m w.r.t. Siswa#8. Anklav#7 has produced oil @ 35 M³/D and oil shale contact has been seen at 1072.5 m at MSL. The performance of the Anklav#7 and effective thickness of 6m sand body has resulted in release of Anklav#9 development well.

A comprehensive reservoir studies plan was made with a view to get a clearer picture of the Reservoir characteristics. Identifying and mapping fractures/faults networks would help in understanding the reservoir fluid movements and improve reservoir development plans. The general well data is given in Table-1.

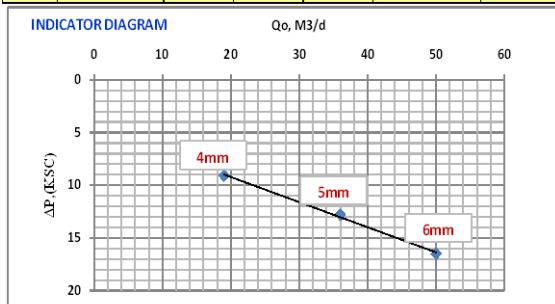


TABLE-1	
Well number	Anklav#09
Name of the field	Anklav
Name of the basin	Cambay
Tectonic block	Cambay-Tarapur
Well category	B
Well type	Development
Drilled depth	1265m (MD), 1134m (TVD)
Status of well	Oil producer from EP-I b Sand

Three Bean Study

Multi-bean study was conducted by continuous recording of flowing bottom hole pressure with the help of EMG through three beans in ascending order along with stabilized flow rate measurements at surface. Indicator diagram has been made by plotting oil rate v/s drawdown to determine productivity index.

PRODUCTION TESTING RESULTS OF ANKLAV#9						
Bean size	Depth of measurement	SBHP (KSC)	FBHP (KSC)	Delta P (KSC)	Oil production (m ³ /d)	PI (M ³ /d/ksc)
		107.89				
4	1176 m.		98.8	9.09	18.17	1.9988999
5	1176 m.		95.1	12.79	36	2.814699
6	1176 m.		91.4	16.49	50	3.0321407



It is observed that, the curve of indicator diagram is a straight line obeying Darcy's law. This indicates, that there is single phase flow in the reservoir and the reservoir is undersaturated. PVT analysis also confirm the fluid is undersaturated under reservoir conditions. From the indicator diagram it is inferred that the average PI of the well is around 2.61 M³/d/ksc.

Pressure Build-up Study

The techniques for analyzing transient tests rely only on pressure measurements and assume a constant flow rate during the test period. The constant flow - rate situation, in practice, prevails only during shut-in conditions. Thus,

buildup tests have become the most commonly practiced well testing method. Pressure Build-up study was conducted by continuous recording of pressure transient data by Electronic Memory Gauge The test overview is given in Figure-1&2. The pressure transient analysis was done through the well test software PAN System: Version2011. The formation and reservoir fluid properties used for build-up analysis are given in table-2

TABLE-2	
DEPTH OF MEASUREMENT (m)	1175 m
PAY THICKNESS, h (m)	4 m
WELL BORE RADIUS (inch)	8 1/2
PRODUCTION RATE (m ³ /d)	50 (6 mm)
PESUDO PRODUCTION PERIOD, (hrs.)	288 (HRS)
AVERAGE POROSITY (%)	15
OIL VISCOSITY AT RESERVOIR TEMP. (cp)	1.0448
OIL FORMATION VOL. FACTOR (Bo)	1.2116
COMPRESSIBILITY (Ct)	17.1207X10 ⁻⁵
RESERVOIR TEMPERATURE (°C)	81.15
BUBBLE POINT (Pb) (kg/cm ²)	42
API GRAVITY	30.7

During the present analysis two different models were used for interpreting the data generated from the 94 hours Pressure Buildup Study. The two models selected for interpretation of data are: Radial composite-infinitely acting (Figure-3 & 4) and Single fault model (Figure-5 & 6). It is observed that there is an increasing trend in derivative plot. reservoir is having a radial homogenous, single phase flow, constant compressibility with a single fault effect at a distance of 1789 ft... The log-log plot revealed the transition phase from radial flow which can be considered as a presence of boundary effect. This is also in conformity with the geological and structural set up of the study area. The results obtained from straight line analysis for Radial Composite Model are as K=451.68 md, S=9.03, Distance to anomaly=540 m and for Single non-sealing fault model are K=450.44 md, S=9.01, Distance to anomaly=1789 ft respectively. A comparison of the results generated by both the models is given in table-3

The comparison study reveals that there is not much difference in parameters like the Permeability (k), Skin factor (S), and estimated reservoir pressure. But, considering the Geological and structural set up of the study area along with the subsurface position of the well presumes the Single non-sealing fault model to be best fit.



Resulted Parameters	TABLE-3	
	Radial composite Infinitely acting model	Single non- sealing fault model
Estimated Permeability (k)	451.688 md	450.443
Capacity (kh)	5943.8527 md.ft	5927.4695 md.ft
Skin Factor (S)	9.03	9.01
Estimated Initial Reservoir Pressure (kg/cm ²)	107.79 kg/cm ² at 1175 m depth	107.89 kg/cm ² at 1175 m depth
Radius of Investigation (Ri)	540 m	
Pressure drop due to skin factor (dpS)	6.06 kg/cm ²	6.048 kg/cm ²
Mobility Ratio (M)	0.6	-
Pseudo-radial skin factor (Spr)	2.0165	-
Distance to boundary (L ₁)	-	1789 ft

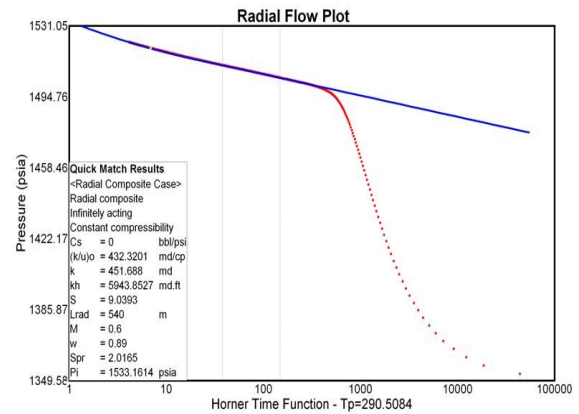


Figure-4 Radial Composite Case

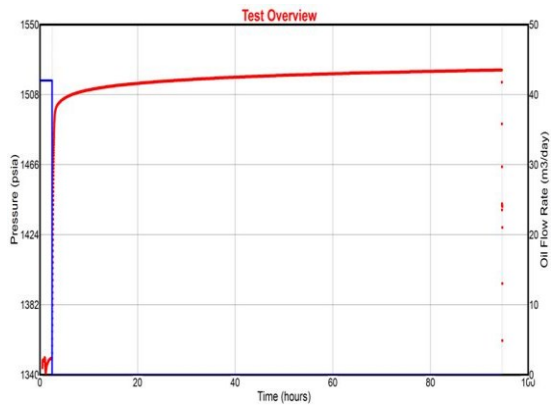


Figure-2: Pressure Transient Test Overview

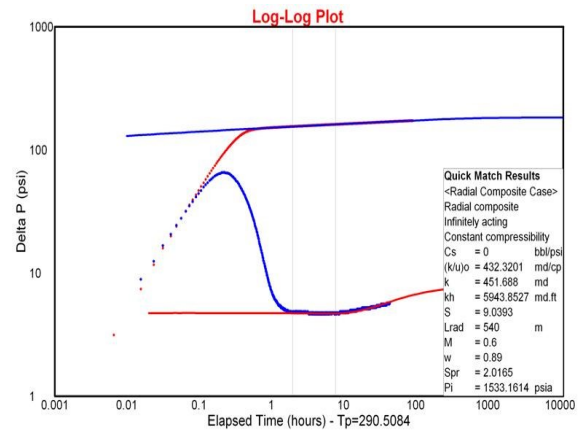


Figure-5: Radial Composite Case

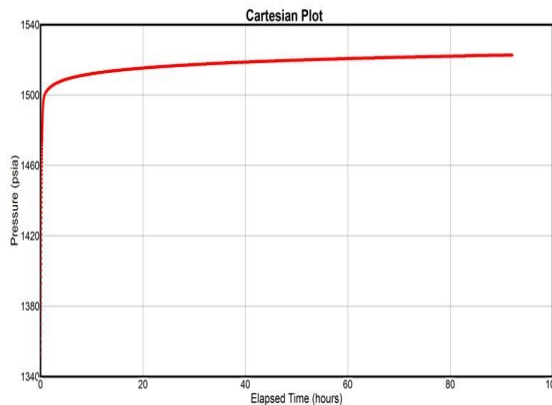


Figure-3: Pressure Transient Test Overview

SINGLE FAULT CASE

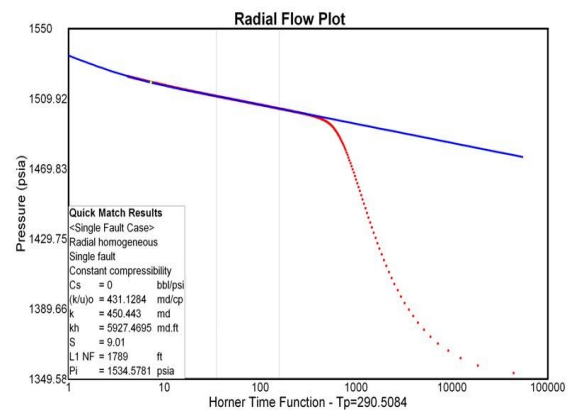


Figure-6: Single Fault Model

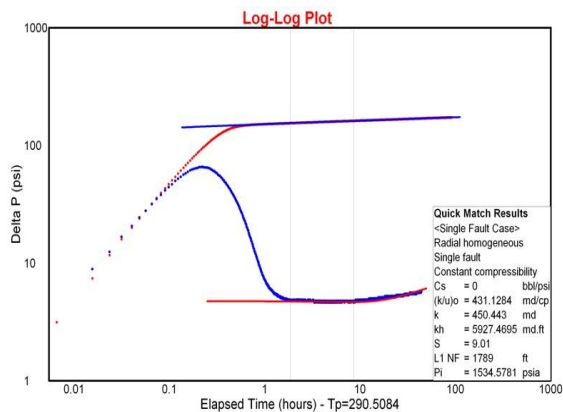


Figure-7: Single Fault Model

Conclusion

With the advancement in technology in acquiring reservoir data using precision Quartz and Strain electronic gauges and advanced transient software it is significant to interpret complex reservoir parameters which can be most use full in Reservoir characterization of field.

Interpretation of Pressure Transient contributes to the improvement of the Geological understanding and model.

Identifying and mapping faults networks would help in understanding the reservoir fluid movements and improve reservoir development plans.

Fault could be a leaky fault as the derivative does not completely stabilize at $\frac{1}{2}$ unit slope (Figure-6 & 7). We could have got a better picture of the boundary condition, if the well been shut for more than 100 Hrs.

Acknowledgements

The authors express their thanks to ONGC management for allowing presenting this work in the international conference. The authors are further thankful to Mr.Sanjay Kumar, Manager (Reservoir), RFS, MH Asset for his appreciated effort and cooperation.

References

Inhouse Report No. CBY/RFSG/PTA/AV-09 /Report /2013(1), by Vikash Chowksey, Anupam Banerjee, Dr. D.K. Baishya. From straight line to deconvolution: the evolution of state of art in well test analysis. By A.C.Gringarten, Imperial college London.