Sudan University of Science and Technology
College of Petroleum Engineering and Technology
Department of Petroleum Engineering

Decline Curve Analysis for a Sudanese Oil Field

Case Study (Block 6 Field)

تحليل منحنى الهبوط لحقل نفط سوداني

دراسة حالة (مربع 6)

A Project Submitted as a Partial Fulfillment for the Degree of B-Tech in Petroleum Engineering

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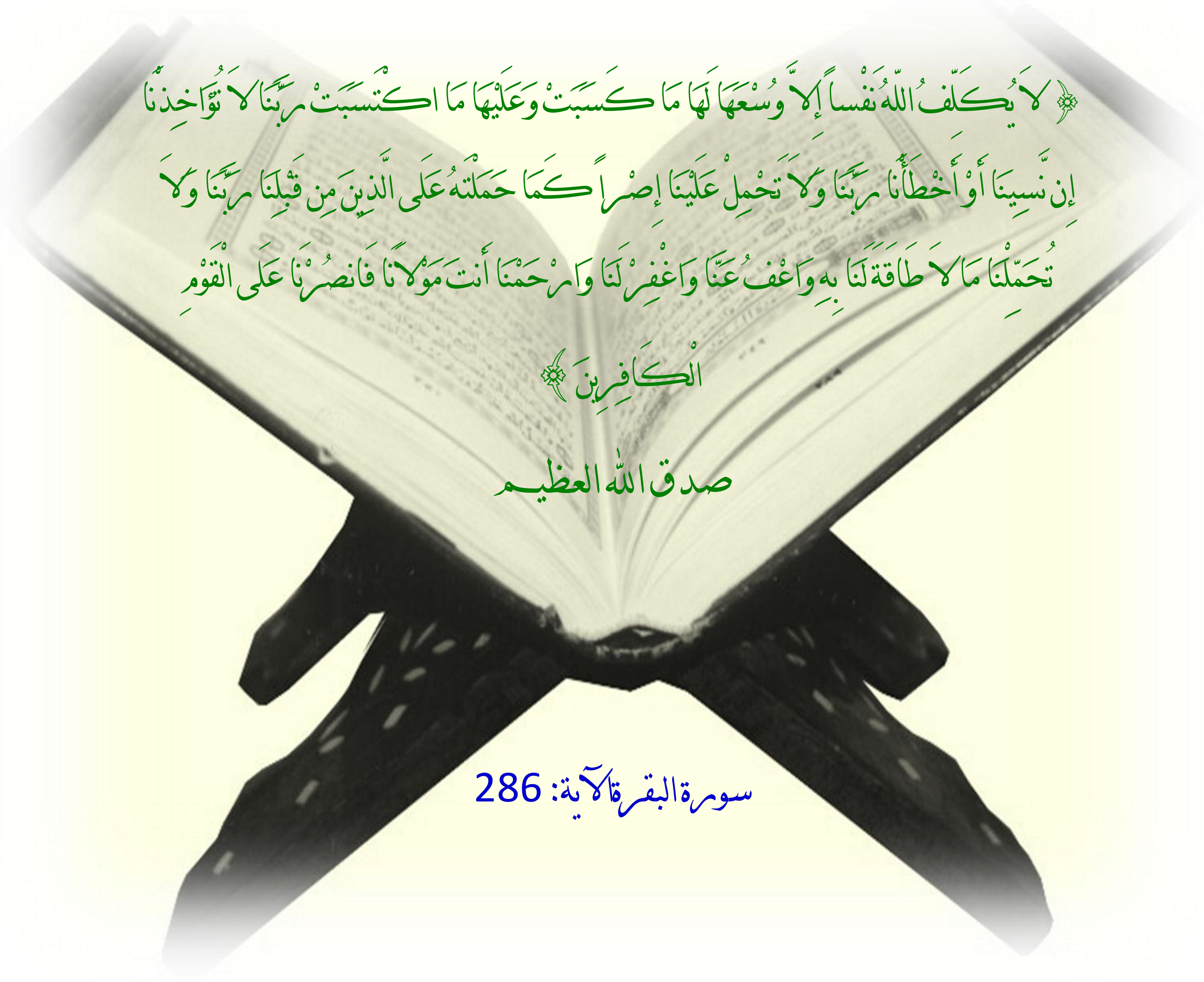

﴿لَا يُكَلِّفُ اللَّهُ نَفْسًا إِلَّا وُسْعَهَا لَهَا مَا كَسَبَتْ وَعَلَيْهَا مَا اكْتَسَبَتْ رَبَّنَا لَا تُؤَاخِذْنَا
إِن نَّسِينَا أَوْ أَخْطَأْنَا رَبَّنَا وَلَا تَحْمِلْ عَلَيْنَا إِصْرًا كَمَا حَمَلْتَهُ عَلَى الَّذِينَ مِن قَبْلِنَا رَبَّنَا وَلَا
تُحَمِّلْنَا مَا لَا طَاقَةَ لَنَا بِهِ وَاعْفُ عَنَّا وَاغْفِرْ لَنَا وَارْحَمْنَا أَنتَ مَوْلَانَا فَانصُرْنَا عَلَى الْقَوْمِ
الْكَافِرِينَ﴾

صدق الله العظيم

سورة البقرة الآية: 286

DEDICATION

Without you I could not go left or right and life would be darkness, world has no hope no light:

(My parents)

To whom that they made our life colorful

(My brothers and my sisters)

To all special people in our life

With all love.

Acknowledgment

We would like to express our sincere gratitude to Mr.Mohanned khairy for all his supports and Guidance through our B-tech study at the SUST College of petroleum engineering and Technology. We want to thank him for all the time and efforts he put to help us in our research. We would like to extend our appreciation to all colleage of petroleum staff for their support during our research.

We also want to thank Dr. Mohammed Naeem (god bless him), Dr. Elham Khiar and Mr. Abdullah Abdelgabar for all their helps, insightful suggestions and comments. Also, We thank Petro-Energy E&P for the help, And OPEA for data provided and the limitless support during the study specially Mr. Rmzi Haroun. Our special thanks also to all our dear's friends.

This dissertation is dedicated to us, for all their supports, motivations, and their unconditional love.

ABSTRACT

The objective for the work described in this research a rose from a need to analyze production decline data where the flowing bottom hole pressure varies significantly.

The variance of the bottom hole pressure with time excludes the use of the exponential decline model for conventional decline curve analysis (semi log plots and type curve) through OFM software.

Using pressure normalized flow rate rather than flow rate usually does not remedy this problem, the method we present uses historical production data regression and a rigorous superposition function to account for the variance of rate and pressure during production of the subfield and the big field's case of study.

In this project case of study Block 6 west of Sudan , which is belong to petro energy E&P petroleum operating company and its produced about 46063 bbl/day and the a cumulative production about 714863 bbl and it's the total of seven fields .

We applied the decline curve analysis for hole block 6 completely and predicting the ratio of decline production and the a cumulative production and maximum recovery determined and the last economic production by using the OIL FIELD MANAGER (OFM) Program.

We apply these relations to analytical solution for verification and the use of (OFM) on the field of study.

تجريد

الهدف من هذا البحث وصف حاجه لتحليل بيانات انخفاض الانتاج حيث يختلف ضغط التدفق من اسفل البئر، لضغط البئر السفلي مع مرور الوقت يستبعد استخدام نموزج الانخفاض اللاتقليدي لتحليل منحني التراجع من خلال برنامج OFM باستخدام معدل التدفق عادة لعلاج هذه المشكلة، وطريقة تقديم بيانات الانتاج، وظيفة تراكب صارمة لحساب التباين في معدل الإنتاج والضغط اثناء عملية الاتناج من الحقول الفرعية والحقول الكبري حالة الدراسة.

في هذا البحث حقل الدراسة هو مربع 6 في غرب السودان المملوك لشركه بتروانرجي والذي تقدر انتاجيته بحوالي 46063 برميل في اليوم وانتاجه التراكمي هو 714863 برميل وهو مجموع سبعه حقول.

وتم تطبيق تحليلات منحنيات الهبوط لمربع 6 كاملا وللسبع حقول المكونه له لنستنبط معدل الهبوط والانتاج التراكمي واقصي استخلاص مقدر واخر انتاج اقتصادي باستخدام برنامج OIL FIELD MANAGER.

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CHAPTER ONE

1 INTRODUCTION

1.1 Introduction:

Decline curve analysis is a graphical procedure used for analyzing declining production rates and forecasting future performance of oil and gas wells. A curve fit of past production performance is done using certain standard curves. This curve fit is then extrapolated to predict potential future performance. Decline curve analysis is a basic tool for estimating recoverable reserves.

Conventional or basic decline curve analysis can be used only when the production history is long enough that a trend can be identified. Decline curve analysis is not grounded in fundamental theory but is based on empirical observations of production decline. Three types of decline curves have been identified; exponential, hyperbolic, and harmonic. There are theoretical equivalents to these decline curves (for example, it can be demonstrated that under certain circumstances, such as constant well backpressure, equations of fluid flow through porous media under "boundary-dominated flow" conditions are equivalent to "exponential" decline). However, decline curve analysis is fundamentally an empirical process based on historical observations of well performance. Because of its empirical nature, decline curve analysis is applied, as deemed appropriate for any particular situation, on single or multi-fluid streams. For example, in certain instances, the oil rate may exhibit an exponential decline, while in other situations it is the total liquids (oil + water) that exhibit the exponential trend. Thus, in some instances, the analysis is conducted on one fluid, sometimes on the total fluids, sometimes on the ratio (for example Water-Oil-Ratio (WOR) or even (WOR + 1)).

Since there is no overwhelming justification for any single variable to follow a particular trend, the practical approach to decline curve analysis is to choose the variable (gas, oil, oil + water, WOR, WGR etc.) that results in a recognizable trend, and to use that decline curve to forecast future performance.

araps et al,(1980) It is implicitly assumed, when using decline curve analysis, the factors causing the historical decline continue unchanged during the forecast period. These factors include both reservoir conditions and operating conditions. Some of the reservoir factors that affect the decline rate include; pressure depletion, number of producing wells, drive mechanism, reservoir characteristics, saturation changes, and relative permeability. Operating conditions that influence the decline rate are: separator pressure, tubing size, choke setting, work overs, compression, operating hours, and artificial lift. As long as these conditions do not change, the trend in decline can be analyzed and extrapolated to forecast future well performance. If these conditions are altered, for example through a well workover, then the decline rate determined pre-workover will not be applicable to the post-workover period.

When analyzing rate decline, two sets of curves are normally used. The flow rate is plotted against either time or cumulative production. Time is the most convenient independent variable because extrapolation of rate-time graphs can be directly used for production forecasting and economic evaluations. However, plots of rate vs. cumulative production have their own advantages; Not only do they provide a direct estimate of the ultimate recovery at a specified economic limit, but will also yield a more rigorous interpretation in situations where the production is influenced by intermittent operations.

Good engineering practice demands that, whenever possible, decline curve analysis should be reconciled with other indicators of reserves, such as volumetric calculations, material balance, and recovery factors. It should be noted that decline curve analysis results in an estimate of Recoverable Hydrocarbons, and NOT in Hydrocarbons-in-Place. Whereas the Hydrocarbons-in- Place are fixed by nature, the Recoverable hydrocarbons are affected by the operating conditions.

For example a well producing from a reservoir containing 1 BBL of gas-in-place may recover either 0.7 BBL or 0.9 BBL, depending on whether or not there is a compressor connected at the wellhead.

The following steps are taken for exponential decline analysis, and for predicting future flow rates and recoverable reserves:

1. 1.Plot flow rate vs. time on a semi-log plot (y-axis is logarithmic) and flow rate vs. cumulative production on a Cartesian (arithmetic coordinate) scale.
2. Allowing for the fact that the early time data may not be linear, fit a straight line through the linear portion of the data, and determine the decline rate "D" from the slope (-D/2.303) of the semi-log plot, or directly from the slope (D) of the rate-cumulative production plot.
3. Extrapolate to q = qE to obtain the recoverable hydrocarbons.
4. Extrapolate to any specified time or abandonment rate to obtain a rate forecast and the cumulative recoverable hydrocarbons to that point in time.

1.2 Research objective:

- To identify the major sub-field that affects the overall production.
- To predict the future production rate if the conditions are stable.
- Understand the causes of changes in decline rate and calculate the EUR for each field.

1.3 Problem statement.

Through the life of oil fields it's very important from an economic way to identify the accurate production scheme; decline curve could help predicting the production scenarios with time.

This study is aimed to analyze the production data with decline curve analysis for sub fields and identify their effect on the production of the big field.

1.4 About the field.

In this project the targeted Sudanese field is Block 6 which owned by Petro-energy E&P, area about 17,875 km² which is currently divided into seven subfields.

Bloc-6 Existing Fields and Western Area Fields Locations:

- Greater Fula Central Processing Facility
- Moga Field Processing Facility
- FNE Field Processing Facility
- Jake Field Processing Facility
- Keyi Field Processing Facility
- Hadida Early production Facility
- Sufyan Early production Facility

1.4.1 Moga Field Processing Facility

Moga FPF is located at Moga oil field northwest of Fula Central Processing Facilities (CPF) and connected to Fula CPF via 10" transit line with total length 17.16 km. Moga FPF has been commissioned and put into production on Nov.18,2006.

The main purpose of FPF is to separate water and gas from the raw crude oil to meet transit line specifications and separate solid granule and condensed liquid from the raw natural gas to meet the power generating requirements in FPF facilities.

Moga field consists of 38 Heavy crude oil wells and 23 light crude well gathering in 5 OMGs & 3 OGMs respectively, 9 heavy crude oil wells & 3 light crude oil wells are connected directly to FPF and are flowing as a single wells.

The crude oil from Moga Field is processed in the Moga FPF.

1.4.1.1 Moga FPF Design

Moga FPF designed to process 18,182 BLPD heavy crude oil with water cut of 45% and 4,000 BLPD light crude oil with water cut of 50% , which leads to oil production of 12,000 BOPD.

The FPF was designed to operate on a continuous basis with oil export 12,000 BOPD with maximum 10% water content through Transit Line to CPF for further treatment.

1.4.2 FNE Field Processing Facility

FNE FPF is located at FNE oil field northeast of Fula Central Processing Facilities (CPF) and connected to Fula CPF via 12” transit line with total length 10 km.

FNE FPF has been commissioned and put into production on July.08,2010

1.4.3 Jake Field Processing Facility

Jake field production facilities is apart of the phase III upstream facilities project within Block-6 .Jake FPF is located approximately 48 km northwest of the existing Fula oil field.

Jake FPF has been commissioned and put into production on July.27,2010.

Jake FPF shall be designed for 15000 BOPD with 73.7 water cut ,the crud oil is treated for the separation of oil ,water and associated gas to the required specification ,and then the crude oil is pumped to Fula CPF with export pipeline.

1.4.4 Keyi Field Processing Facility

KEYI Field Process Facility (KEYI FPF) Is A Part Of The Phase III Upstream Surface Facilities’ Project Within Block 6. It’s Located Approximately 25km West Of The Existing FULA Oil Field And Approximate Elevation Of 520 M Above MSL.

KEYI Field Is A One Of Newest And Modern Fields In Block 6; Also Its Product Two Types Of Crude Oil .The Super Fine Light Crude And The Medium One.

1.4.5 Hadida Early production Facility

Hadida FPF located at the western area of Block 6 it fars about 150km for Central Processing Facility (CPF) at Fula Field.

Put into production on 27 of Dec.2012 with total capacity 10.000 BBL/D of light and medium crude and connected with CPF at Fula Field with trunk line(length /150 Km ,Diameter 12’’ and design capacity 60,000 bbl/d).

Running with total(12) wells (6 light cured +6 Medium crude).

1.4.6 Sufyan Early Production Facility

Sufyan EPF has been commissioned and put into production on Mar.15.2015.

Production Forecast

As short term plan PE intended to implement the following facilities:

4,000BOPD expected oil production from Sufyan Fields through early tie-in by the end of 4th quarter of 2014.

A long term plan with following facilities was also envisaged:

Sufyan (medium crude and light crude) was targeted to produce 10,000BOPD by the 3rd quarter of 2016, and sustain for 2 years by PED (subject to reserve discovery).

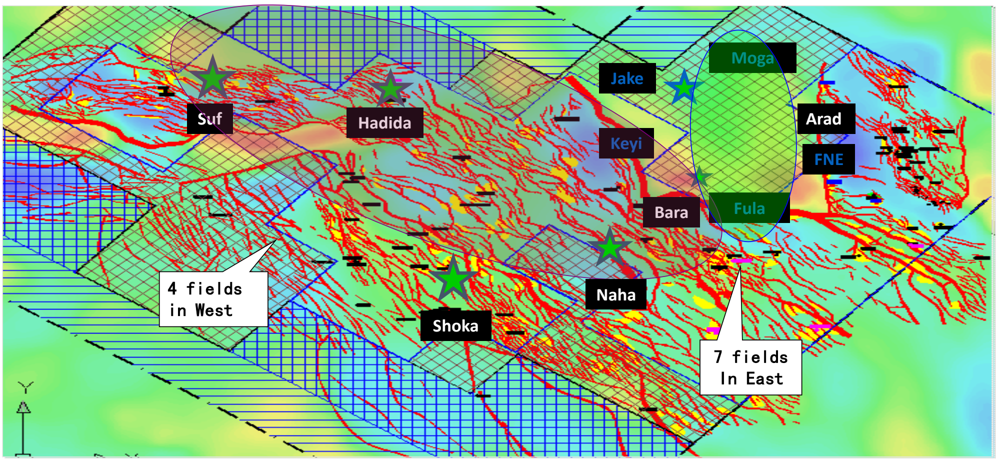

Figure (1. 1) Overview of all Block 6 Fields

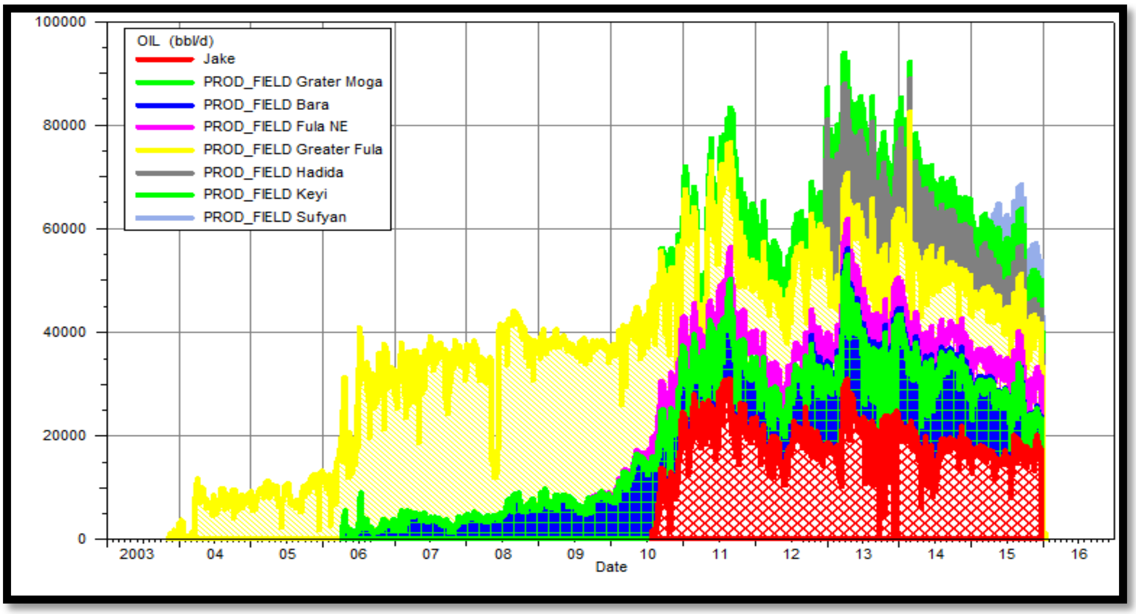

Figure (1. 2) All Fields Oil Production VS. Time

CHAPTER TWO

2 LITERATURE REVIEW AND THEORETICAL BACKGROUND

2.1 Introduction

This demonstrates that decline curve analysis not only has a solid fundamental base but also provides a tool with more diagnostic power than has been suspected previously. The type curve approach provides unique solutions on which engineers can agree or shows when a unique solution is not possible with a type curve only.

Ramsay, (1968) Rate-time decline curve extrapolation is one of the oldest and most often used tools of the petroleum engineer. The various methods used always have been regarded as strictly empirical and generally not scientific. Results obtained for a well or leases are subject to a wide range of alternate interpretations, mostly as a function of the experience and objectives of the evaluator. Recent efforts in the area of decline curve analysis have been directed toward a purely computerized statistical approach, its basic objective being to arrive at a unique "unbiased" interpretation. As pointed out in a comprehensive review of the literature by Ramsay,[1] "In the period from 1964 to date (1968), several additional papers were published which contribute to the understanding of decline curves but add little new technology.

S. Mohaghegh and T, Ertekin, (1991) A family of pressure and production decline curves is generated for wet-gas sands with closed outer boundaries. Wet-gas sands are characterized as gas reservoirs which produce substantial amounts of water together with ~as. Production of water introduces complications when practicing engineers use decline curves designed for gas reservoirs in which gas is the only flowing phase. This usually translates to over estimation of the production performance of the reservoir, In this paper a series of pressure and production decline curves which accounts for the water production in wet-gas sands is presented. These decline curves provide a simple way of extracting valuable information from available data, using graphical methods and simple calculations, The proposed decline curves arc generated for a radial system with closed outer boundary with one centrally located well which fully penetrates the formation.

S. Mohaghegh, et aa (1991) In the case of pressure decline curves, pressure-time data generated by the simulator was used to calculate the dimensionless pressure drop and the dimensionless time groups. These dimensionless values were then plotted on log-log scale. Pressure decline type curves are generated for different initial formation pressures.

Gashari, R, et al (2006) The most common data that engineers can count on, especially in the case of mature fields is production data. Practical methods for production data analysis have come a long way since their introduction to the industry several decades ago and they all fall into two categories.

Type Curve Matching is a very subjective procedure.

State of the art in production data analysis can provide reasonable reservoir characteristics but it has two major shortcomings:

For reservoir characterization, the process requires bottomhole or well-head pressure data in addition to rate data.

Bottom-hole or well-head pressure data are not usually available in most of the mature fields.

A technique that would allow the integration of results from hundreds of individual wells into a cohesive field-wide or reservoir-wide analysis for business decision making is not part of today's production data analysis toolkit.

In order to overcome these shortcomings a new methodology is introduced in this paper that has three unique specifications:

1. It does not require pressure data (bottom-hole or wellhead);
2. It integrates decline curve analysis, type curve matching, and numerical reservoir simulation (history matching) in order to iteratively converge to a near unique set of reservoir characteristics for each well;
3. It uses fuzzy pattern recognition technology in order to achieve field-wide decisions from the findings of the analysis.

Estimating reserves and predicting production in geothermal reservoirs has been challenge for a long time. Many methods have been developed in the last several decades. One frequently-used technique is decline curve analysis approach. Most of the existing decline curve analysis techniques are based on the empirical Arps equation. The equation was proposed sixty years ago. However a great number of studies on production decline analysis are still based on this empirical method. This paper proposed stochastic approaches of Arps equation in decline curve analysis. The method starts with identifying no trend for loss ratio with sign test. This study shows that the exponential decline can be represented as an AR (1) process. The application of this approach to Kamojang geothermal field in West Java will be discussed.

Arps used loss ratio method to determined the type curve. The simplest method to recognize exponential decline is the loss ratios appear to be approximately constant, which leads to differential equation $qt/dqt/dt=a$ where $a<0$

Based on the present study, the following may be drawn in the case studied:

1. Arps exponential equation can be represented as process with stochastic approach.
2. Production rate estimation from AR(1)representation of Arps exponential equation may have a better accuracy than the Arps exponential equation.

Decline curve analysis models are frequently used but still have many limitations. Approaches of decline curve analysis used for naturally-fractured reservoirs developed by water flooding have been few. To this end, a decline analysis model derived based on fluid flow mechanisms was proposed and Used to analyze the oil production data from naturally fractured reservoirs developed by water flooding. Relative permeability and capillary pressure were included in this model. The model reveals a linear relationship between the oil production rate and the reciprocal of the oil recovery or the accumulated oil production. We applied the model to the oil production data from different types of reservoirs and found a linear relationship between the production rate and the reciprocal of the oil recovery as foreseen by the model, especially at the late period of production. The values of the maximum oil recovery for the example reservoirs were evaluated using the parameters determined from the linear relationship. The results demonstrated that the analytical decline analysis model is not only suitable for naturally fractured reservoirs developed by water flooding but also for other types of water drive reservoirs. An analytical oil recovery model was also proposed. The results showed that the analytical model could match the oil production data satisfactorily. We also demonstrated that the frequently-used nonlinear type curves could be transformed to linear relationships in a log-log plot. This may facilitate the production decline analysis.

As stated previously, one unique feature of naturally fractured reservoirs developed by water injection is that incremental oil production by infill drilling wells is very little.

This practical observation implies that the dominant driving force in water flooding naturally-fractured reservoirs is capillary pressure. The effect of pressure drop between injection and production wells on oil production may not be significant. The explanation to this is discussed as follows.

The fracture permeability and relative permeability are usually much greater than those of matrix. On the other hand, the well spacing may be far greater than the fracture spacing even after infill drilling (the fracture spacing in Spraberry estimated by Baker et al.6 was about 3 feet). Therefore the pressure drop applied on each matrix is small even though the pressure drop between injection and production wells is great.

Water injected in injection wells will be produced at the production wells very fast through high permeability fractures.

Based on the description, one can see that the effect of pressure drop between injection and production wells on oil production may be small. the following conclusions may be drawn:

1. The proposed decline analysis model derived from fluid flow mechanisms works satisfactorily in naturally fractured reservoirs as well as in other types of reservoirs developed by water flooding.
2. The production data of oil recovery in reservoirs studied (naturally-fractured or highly heterogeneous) could be matched adequately using the analytical model of oil recovery.
3. The frequently-used nonlinear type curves based on the empirical Arps equation could be transferred to linear relationships in a log-log plot.

A new direction for decline curve analysis was given by Slider with his development of an overlay method to analyze rate-time data. Because his method was rapid and easily applied, it was used extensively by Ramsay in his evaluation of some 200 wells to determine the distribution of the decline curve exponent b. Gentry's displaying the Arps exponential, hypbolic, and harmonic solutions all on one curve also could be used as an overlay to match all of a well's decline data. However, he did not illustrate this in his example application of the curve.

The overlay method of Slider is similar in principle to the log-log type curve matching procedure presently being employed to analyze constant-rate pressure buildup and drawdown data. The exponential decline, often used in decline curve analysis, readily can be shown to be a long-time solution of the constant-pressure. It followed then that a log-log type curve matching procedure could be developed to analyze decline curve data

Decline curve analysis is a graphical procedure used for analyzing declining production rates and forecasting future performance of oil and gas wells. A curve fit of past production performance is done using certain standard curves. This curve fit is then extrapolated to predict potential future performance. Decline curve analysis is a basic tool for estimating recoverable reserves. Conventional or basic decline curve analysis can be used only when the production history is long enough that a trend can be identified

Decline curve analysis is not grounded in fundamental theory but is based on empirical observations of production decline. Three types of decline curves have been identified; exponential, hyperbolic, and harmonic. There are theoretical equivalents to these decline curves (for example, it can be demonstrated that under certain circumstances, such as constant well backpressure, equations of fluid flow through porous media under "boundary-dominated flow "conditions are equivalent to "exponential" decline). However, decline curve analysis is fundamentally an empirical process based on historical observations of well performance. Because of its empirical nature, decline curve analysis is applied, as deemed appropriate for any particular situation, on single or multi-fluid streams. For example, in certain instances, the oil rate may exhibit an exponential decline, while in other situations it is the total liquids (oil + water) that exhibit the exponential trend. Thus, in some instances, the analysis is conducted on one fluid, sometimes on the total fluids, sometimes on the ratio (for example Water-Oil-Ratio (WOR) or even (WOR + 1)).Since there is no overwhelming justification for any single variable to follow a particular trend, the practical approach to decline curve analysis is to choose the variable (gas, oil, oil + water, WOR,WGR etc.) that results in a recognizable trend, and to use that decline curve to forecast future performance.

It is implicitly assumed, when using decline curve analysis, the factors causing the historical decline continue unchanged during the forecast period. These factors include both reservoir conditions and operating conditions. Some of the reservoir factors that affect the decline rate include; pressure depletion, number of producing wells, drive mechanism, reservoir characteristics, saturation changes, and relative permeability. Operating conditions that influence the decline rateare: separator pressure, tubing size, choke setting, workovers, compression, operating hours, and artificial lift. As long as these conditions do not change, the trend in decline can be analyzed and extrapolated to forecast future well performance. If these conditions are altered, for example through a well workover, then the decline rate determined pre-workover will not be applicable tothe post-workover period.

When analyzing rate decline, two sets of curves are normally used. The flow rate is plotted against either time or cumulative production. Time is the most convenient independent variable because extrapolation of rate-time graphs can be directly used for production forecasting and economic evaluations. However, plots of rate vs. cumulative production have their own advantages; Not onlydo they provide a direct estimate of the ultimate recovery at a specified economic limit, but will also yield a more rigorous interpretation in situations where the production is influenced by intermittent operations.

2.2 Analysis Methods

Good engineering practice demands that, whenever possible, decline curve analysis should bereconciled with other indicators of reserves, such as volumetric calculations, material balance, andrecovery factors. It should be noted that decline curve analysis results in an estimate ofRecoverable Hydrocarbons, and NOT in Hydrocarbons-in-Place. Whereas the Hydrocarbons-in-Place are fixed by nature, the Recoverable hydrocarbons are affected by the operating conditions.For example a well producing from a reservoir containing 1BCF of gas-in-place may recover either0.7 BCF or 0.9 BCF, depending on whether or not there is a compressor connected at the wellhead.

2.3 Production Decline Equations

Decline curve analysis is derived from empirical observations of the production performance of oiland gas wells. Three types of decline have been observed historically: exponential, hyperbolic, andharmonic

Decline curves represent production from the reservoir under "boundary dominated flow"conditions. This means that during the early life of a well, while it is still in "transient flow" and thereservoir boundaries have not been reached, decline curves should NOT be expected to beapplicable. Typically, during transient flow, the decline rate is high, but it stabilizes once boundarydominated flow is reached. For most wells this happens within a few months of production.However, for low permeability wells (tight gas wells, in particular) transient flow conditions can last several years, and strictly speaking, should not be analyzed by decline curve methods until after they have reached stabilization.

All decline curve theory starts from the definition of the instantaneous or current decline rate (D) as follow

D = -(dq/q)/dt = (dq/dt)/q

D is "the fractional change in rate per unit time", frequently expressed in "% per year". In thefollowing diagram, D = Slope/Rate.

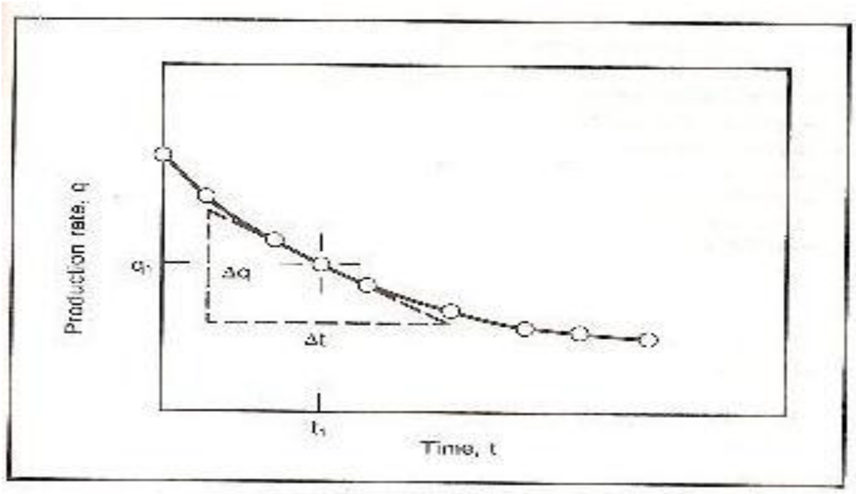

Figure (2. 1) Flow rate VS. Time Decline curve

- The most common decline curve relationship is the constant percentage decline
- (exponential). With more and more low productivity wells coming on stream, there
- is currently a swing toward decline rates proportional to production rates
- (hyperbolic and harmonic). Although some wells exhibit these trends, hyperbolic or
- harmonic decline extrapolations should only be used for these specific cases.

2.3.1 Exponential Decline

In the exponential decline, the well's production data plots as a straight line on a semi log paper. The equation of the straight line on the semi log paper is given by:

$$q = q_1 e^{-Dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

Where:

q	= well's production rate at time t, STB/day
q_i	= well's production rate at time 0, STB/day
D	= nominal exponential decline rate, 1/day
t	= time, day

Table (2 .1) Exponential Equations

Exponential Decline b = 0

Description	Equation
Rate	$q = q_i e^{-Dt}$
Cumulative Oil Production	$N_p = \frac{q_i - q}{D}$
Nominal Decline Rate	$D = -\ln(1 - D_e)$ $D_e = \frac{q_i - q}{q_i}$
Effective Decline Rate	$D_e = 1 - e^{-D}$
Life	$t = \frac{\ln(q_i / q)}{D}$

2.3.2 Hyperbolic Decline

Alternatively, if the well's production data plotted on a semilog paper concaves upward, then it is modeled with a hyperbolic decline. The equation of the hyperbolic decline is given by:

$$q = q_i(1 + bD_i t)^{-\frac{1}{b}} \quad \text{……………………..} \ (2.2)$$

Where:

q	= well's production rate at time t, STB/day
q_i	= well's production rate at time 0, STB/day
D_i	= initial nominal exponential decline rate (t = 0), 1/day
b	= hyperbolic exponent
t	= time, day

Table (2.2) Hyperbolic Equations

Hyperbolic Decline b > 0, b ≠ 1

Description	Equation
Rate	$q = q_i(1 + bD_i t)^{-\frac{1}{b}}$
Cumulative Oil Production	$N_p = \frac{q_i^b}{D_i(1-b)}\left(q_i^{1-b} - q^{1-b}\right)$
Nominal Decline Rate	$D_i = \frac{1}{b}\left[(1 - D_{ei})^{-b} - 1\right]$ $D_{ei} = \frac{q_i - q}{q_i}$
Effective Decline Rate	$D_e = 1 - e^{-D}$
Life	$t = \frac{(q_i / q)^b - 1}{bD_i}$

2.3.3 Harmonic Decline

A special case of the hyperbolic decline is known as "harmonic decline", where b is taken to be equal to 1. The following table summarizes the equations used in harmonic decline:

Table (2.3) Harmonic Equations

Harmonic Decline b = 1

Description	Equation
Rate	$q = \frac{q_i}{1 + bD_i t}$
Cumulative Oil Production	$N_p = \frac{q_i}{D_i} \ln \frac{q_i}{q}$
Nominal Decline Rate	$D_i = \frac{D_{ei}}{1 - D_{ei}}$
Effective Decline Rate	$D_{ei} = \frac{q_i - q}{q_i}$
Life	$t = \frac{(q_i / q) - 1}{D_i}$

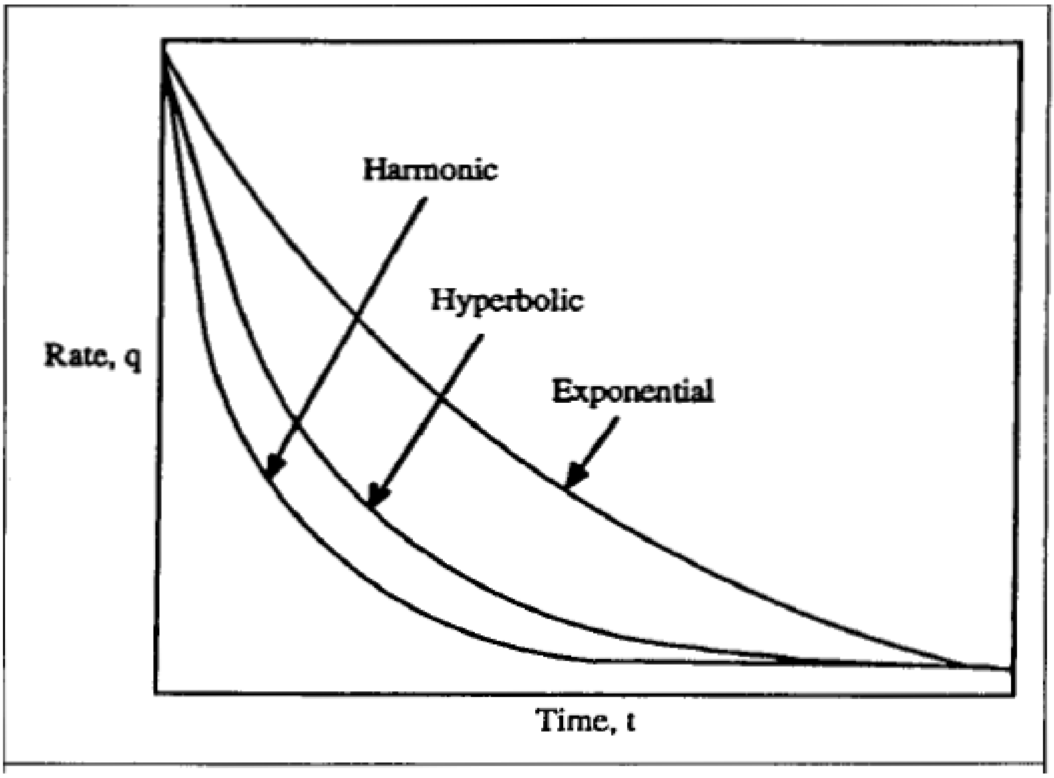

Figure (2. 2) Decline Curve Shapes for a Semi log plot of Rate VS. Time [21]

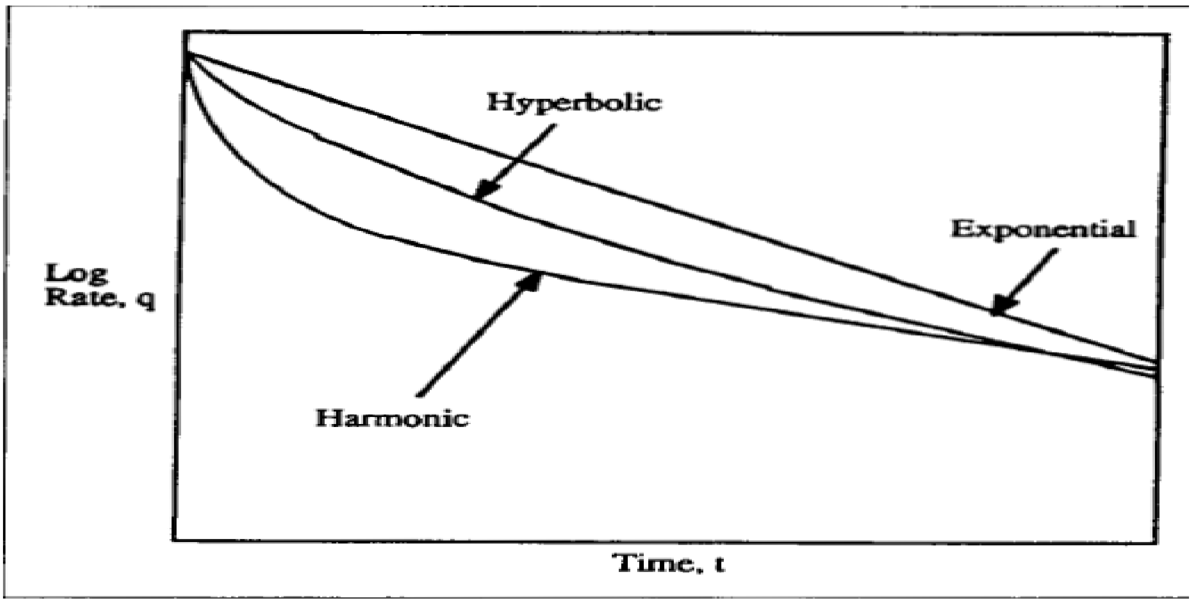

Figure (2. 3) Decline Curve Shapes for a Semi log plot of Rate VS. Time [21]

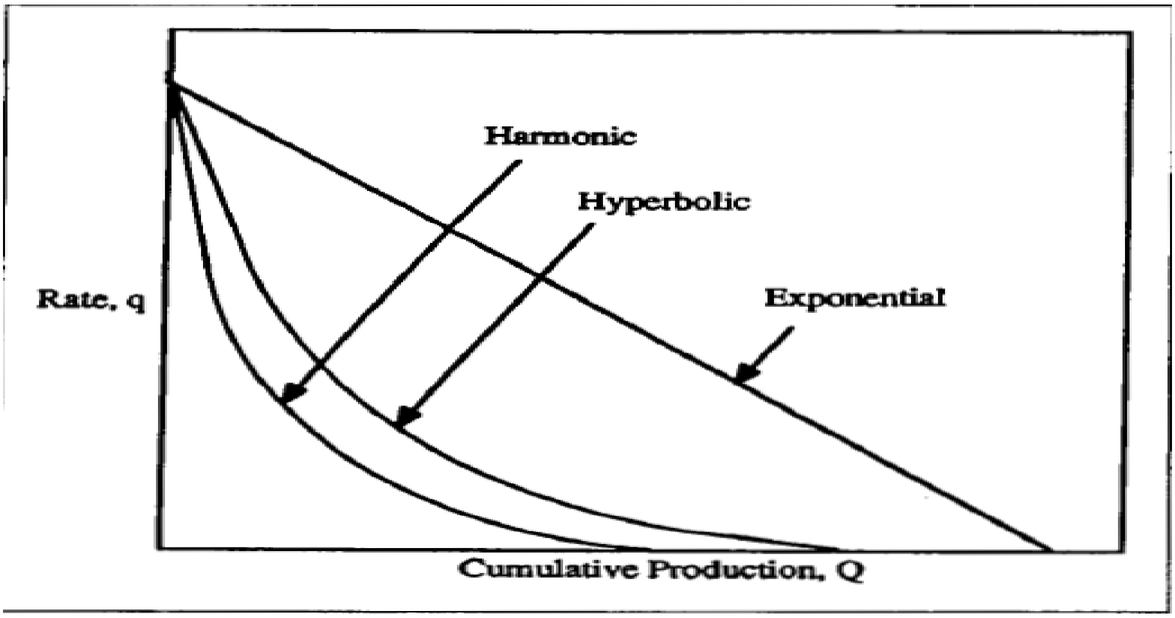

Figure (2. 4) Decline Curve Shapes for a Cartesian plot of Rate VS. Cumulative [21]

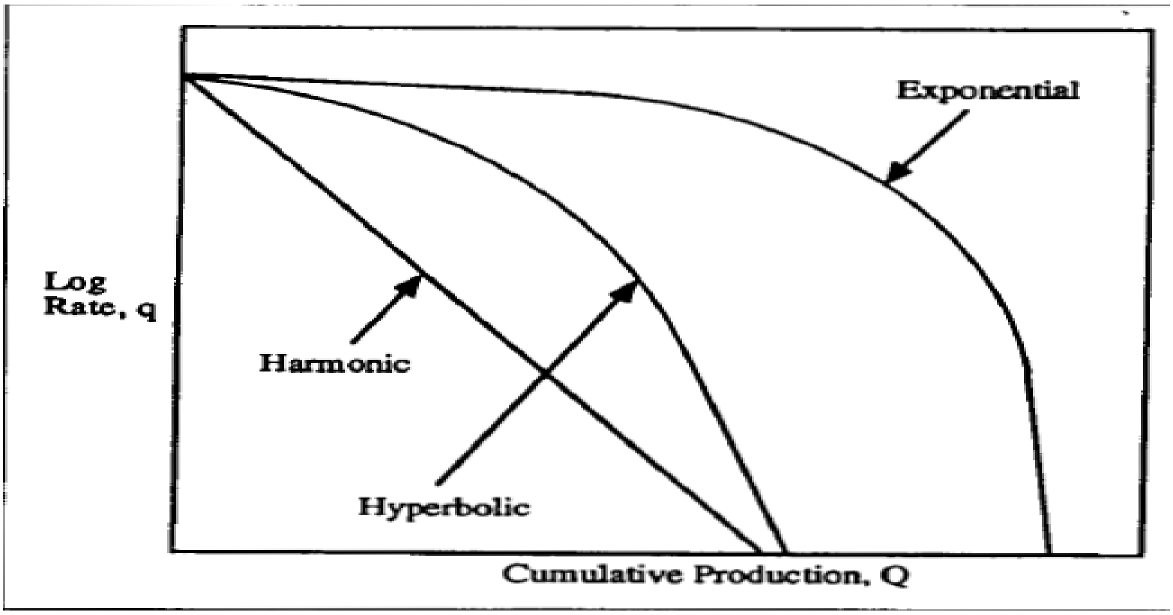

Figure (2. 5) Decline Curve Shapes for a Cartesian plot of Rate VS. Cumulative [21]

CHAPTER THREE

3 METHODOLOGY

3.1 Introduction:

One of the most important tasks of a petroleum engineer is estimating, by factual prediction, the amount of oil and gas that could be recovered from a reservoir.

Choosing the methodology is critical for accurate forecasts that are, in turn, vital for sound managerial planning. Risks have to be minimized in the process of making decisions based on the recoverable percentage of the original hydrocarbon in place, as well as the residual amount of this oil when the economic limit is reached before the need for any secondary recovery mechanism is involved, for the case of a naturally producing reservoir-well relationship.

DCA is a method used for the prediction of future hydrocarbon production by analyzing past production. A decline curve of a well is simply a plot of the well's production rates against the respective times of recording. It was recognized early in the history of petroleum engineering that calculating reserves and production forecasts were possible by studying past production trends.

Forecasting crude oil production can be done in many different ways, but in order to provide realistic outlooks, one must be mindful of the physical laws that affect extraction of hydrocarbons from a reservoir. Decline curve analysis is a long established tool for developing future outlooks for oil production from an individual well or an entire oilfield.

Extrapolation of production history has long been considered the most accurate and defendable method of estimating the remaining recoverable reserve from a well and, in turn, a reservoir.

Using decline rate analysis gives a better tool for describing future oil production on a field-by-field level. Reliable and reasonable forecasts are essential for planning and necessary in order to understand likely future world oil production.

3.1.1 Determining the type of decline

Based on what has been covered so far, the engineer performing a DCA analysis needs to be aware of the following:

1. The most representative period in history that will also represent future.
2. The decline trend during that period.
3. The start point(rate) of forecast .
4. The constraints under which the forecast needs to be made.

However one more factor, also extremely important at this stage is to determine type of decline. Since the signature of shape may not be apparent on a log q vs. time (most used plot), literature provides many ways was to look at the same data, combine this information with other knowledge about the fields before we make our conclusions.

3.1.2 Decline curves for reserve estimates

A major use of decline curve analysis is made in estimation of reserves. Even for the assets where history matched simulation models are available, a cross check with DCA is normally made to give increased confidence in numbers.

The fact that DCA does not have a theoretical basis is an asset here since financial institutions are more acceptable to DCA estimates than other more technical methodologies. A major difference when applying DCA for estimation of reserves arises understandably due the very nature of definitions of reserves and financial implications associated with the process. The ultimate recovery numbers become more important than the profiles. Application of constraints in the production system, operating costs, capital costs and well behavior itself all need to be put into right perspective to come up with reliable estimations.

While everything else remains same, estimation of reserves does come up with several typical situations to which there are no ready answers. Some of these situations are listed out below for reference. The solutions to these problems could vary from engineer to engineer or organization to organization. Some of the best practices have however been compiled and can be found in production forecasting principles and definition.

In this project we are going to use Oil Field Manager (OFM) Software to plot a decline Curves and to do accurate and easy analysis for over all field, sub fields and single well to establish a good production performance forecast of production wells.

3.1.3 What is Oil Field Manager (OFM) Software?

OFM well and reservoir analysis software offers advanced production surveillance views and powerful production forecasting tools to manage and improve oil and gas field performance throughout the entire life cycle. OFM software allows view, relate, and analyze reservoir and production data with comprehensive workflow tools, such as interactive base maps with production trends, bubble plots, diagnostic plots, decline curve analysis, and type curve analysis. Recent architectural changes and usability improvements further enable organization to be more productive.

The OFM application allows you to connect to data quickly, wherever it may be located—spreadsheets, databases, or other repositories. It also acts as a single point of analysis for reservoir and production engineers to collaborate and manage more wells in less time. OFM enables early detection and diagnosis of production problems for any asset type (conventional, unconventional, thermal, etc.). The multiple visualization canvases (charts, reports, and maps) and fast filtering capabilities enable improved field performance by promptly identifying the well or wells that offer an opportunity to increase production.

OFM software supports rapid, scalable deployments of enterprise-wide workflows for a portfolio of assets. It also enables the implementation of engineering workflow standards for sharing best practices and benchmarking multiple assets, and provides the flexibility needed by individual users and assets to capture unique analysis solutions or techniques.

3.1.4 OFM Workflow Capabilities:

- Production Surveillance—OFM software facilitates early detection and diagnostics of production problems, quick generation of production trends, diagnostic plots, reports, maps, grids, and bubbles directly from corporate data. It also supports validation of remedial well work benefits via integration with Avocet production operations software platform.
- Water flood Surveillance—Water flood patterns can be defined from production and reservoir data using the OFM Streamline module. When combined with pressure data and PVT algorithms, reservoir volumes and voidage can be determined and further diagnostics can be carried out with different diagnostic plots.
- Production Forecasting—Traditional decline curve analysis and advanced forecasting techniques (e.g., analytical decline and numerical forecasts) are available to generate better, faster, and more reliable forecasts. Connect to Petrel reservoir simulation software and import simulation results to verify and compare to production rates and assist in forecasting.

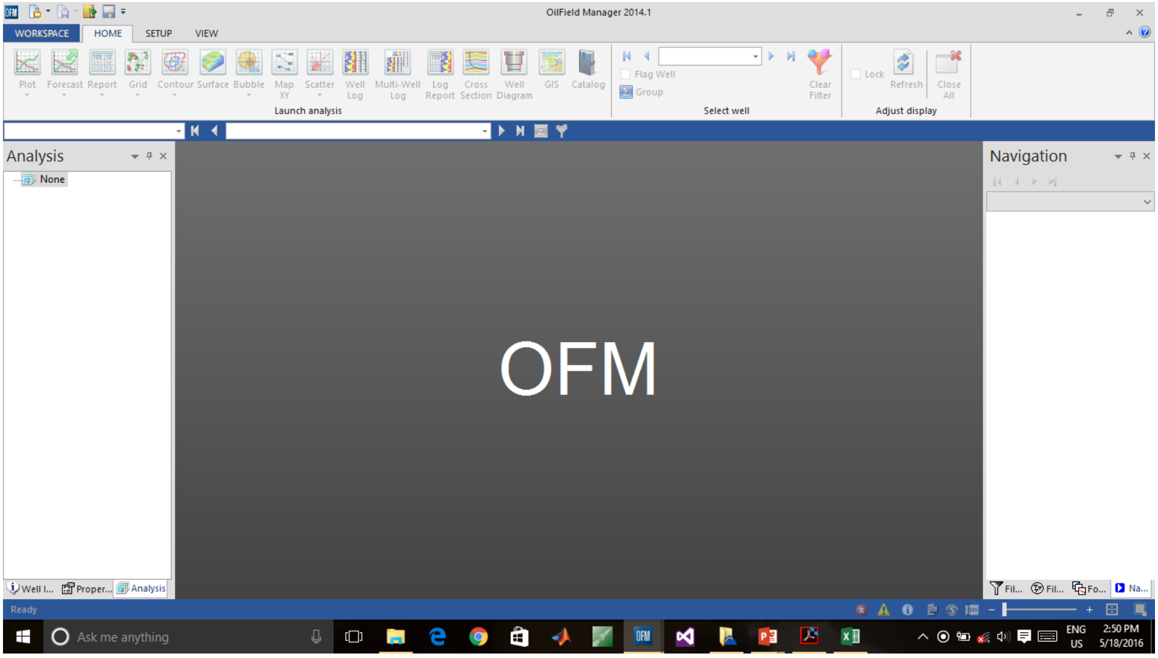

Figure (3. 1) OFM Software Interface

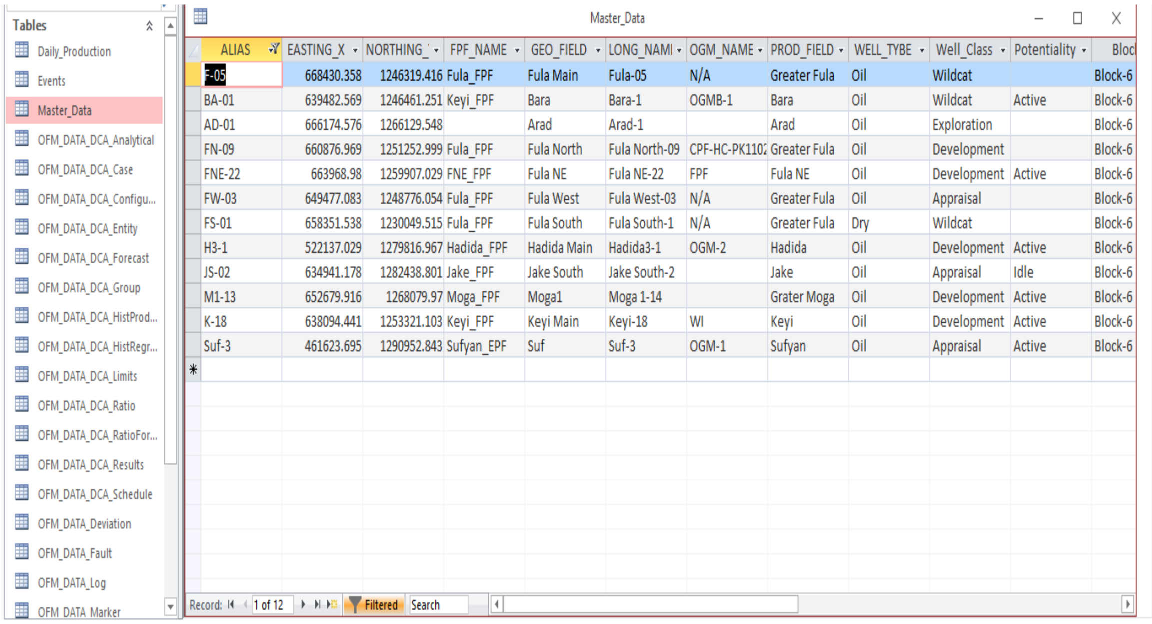

Figure (3. 2) OFM Master Data Base

3.1.5 OFM Database

OFM can be viewed as having two integrated layers - database and application. Basically, the database layer handles the data part; and the application controls the user interface, as well as the processing data/information per request. OFM database is Microsoft Access-based. All data/information are stored in tables (and sometimes views). Therefore, OFM database has all the characteristics of a relational database, including constraints, keys, and indices. (As illustrated in figure 3-3)

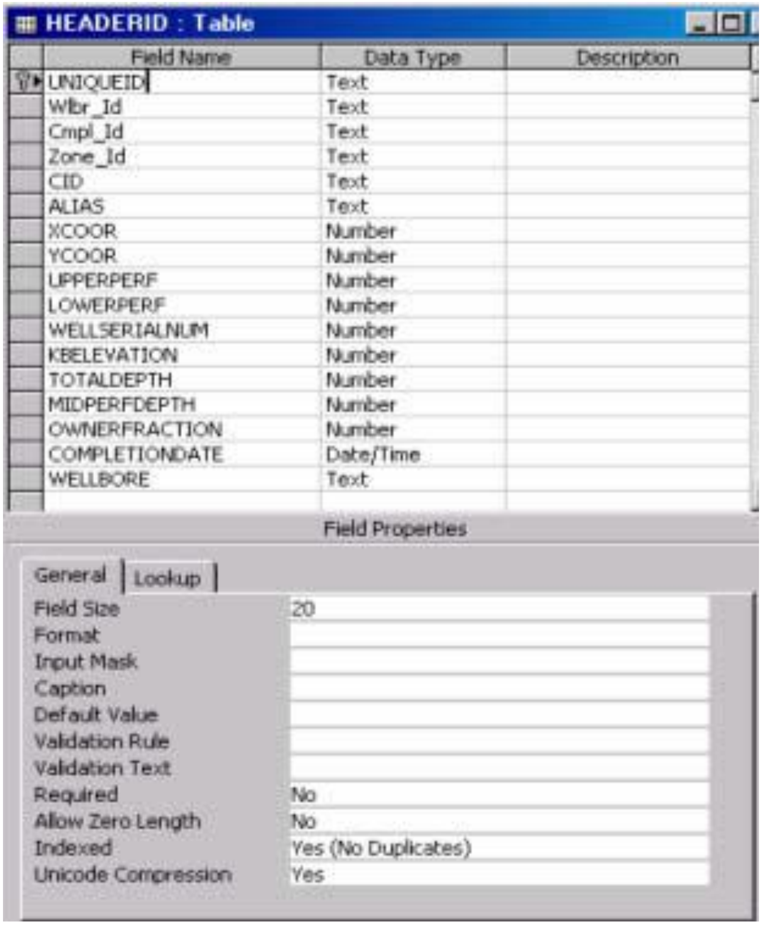

Figure (3. 3) OFM Data base filling table

3.2 Setting Up a Forecast Scenario

- We are going to choose the active producing wells which already entered in OFM data base. (As illustrated in figure 3-4)

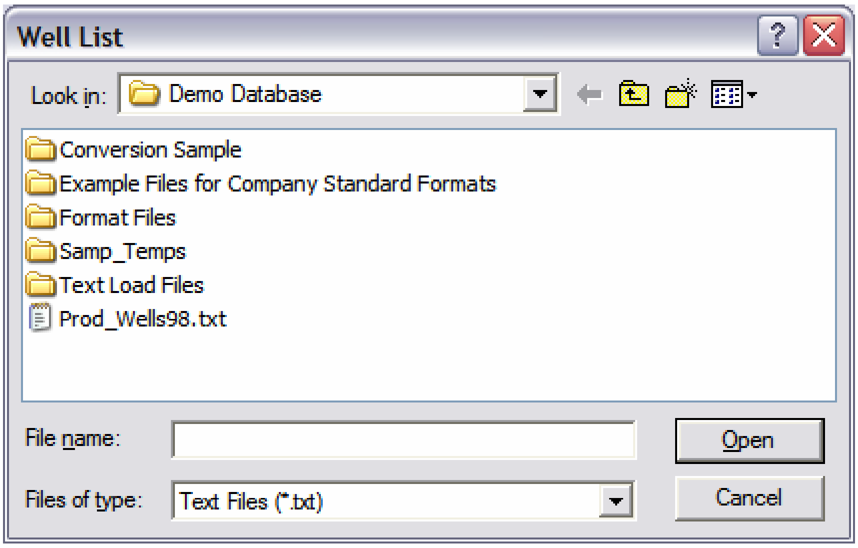

Figure (3. 4) Choosing active wells from OFM Data base

- Select the created filter to apply the wells conditions to the base map. (As illustrated in figure 3-5)

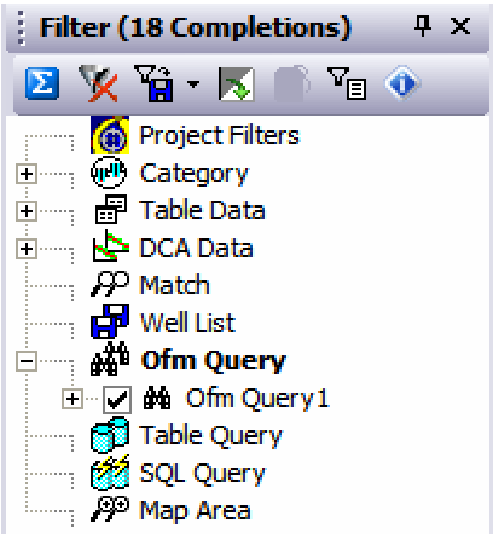

Figure (3. 5) Applying wells conditions to base map

- Then select the forecast tabbed to display the analysis. (As illustrated in figure 3-4)
- Even though you can generate forecast from monthly, daily, or even sporadic data, the forecast (rate) results in OFM.

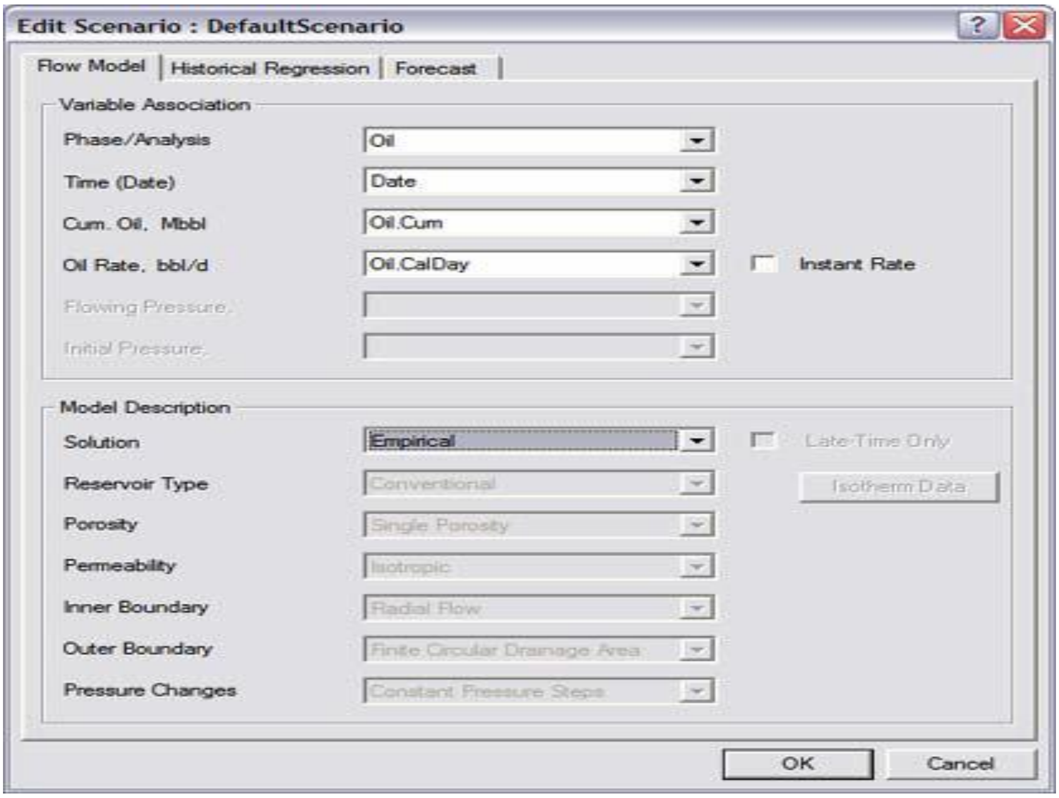

Figure (3. 6) Phase Analysis List

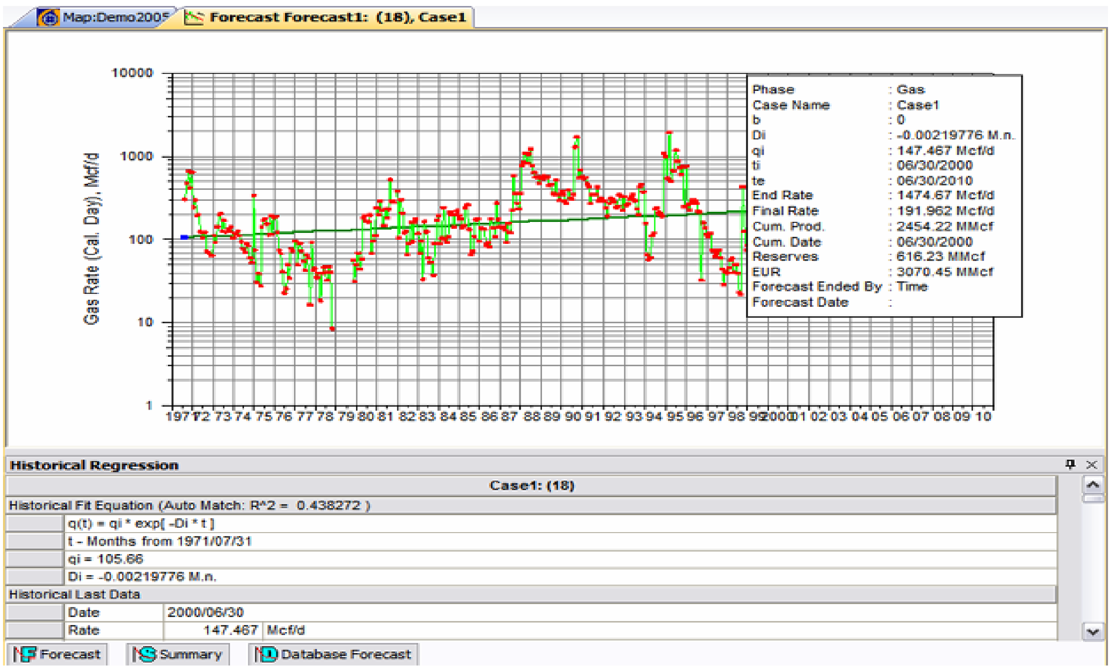

Figure (3. 7) OFM Rate-Time decline on semi log axis

Historical Regression

Case1: RED_4:CI_3

Historical Fit Equation (Auto Match: R^2 = 0.727312)

q(t) = qi * exp[-Di * t]

t - Months from 1980/02/29

qi = 37.468

Di = 0.000920428 M.n.

Historical Last Data

Date	2000/06/30	
Rate	27.167	bbl/d
Cumulative	299.359	Mbbl

		Cummulative Production			Average Rate			Rate		
		Historical	Fitted	Error	Historical	Fitted	Error	Historical	Fitted	Error
	Date	Mbbl	Mbbl	(%)	bbl/d	bbl/d	(%)	bbl/d	bbl/d	(%)
1	1980/03/15	0.508	0.562	10.61	33.87	37.46	10.61	16.39	37.45	128.54
2	1980/04/15	2.371	1.722	-27.36	60.10	37.43	-37.71	62.10	37.42	-39.75
3	1980/05/15	4.262	2.844	-33.26	63.03	37.40	-40.67	61.00	37.38	-38.72

Figure (3. 8) OFM Forecast Data analysis

This tabbed page above enables to read the information about real historical data and the fitted data, the fit equation, and its correlation coefficient.

After analyzing our historical data so we can fit it with one of Decline Curve Types.

3.2.1 Hyperbolic Fit Type

We locate the historical match section of the properties pane and set the fit type to hyperbolic. (As illustrated in figures below)

Properties

History Match	
Fit Type	Hyperbolic
Method	Auto
b Value	
Method	User
User	0.6

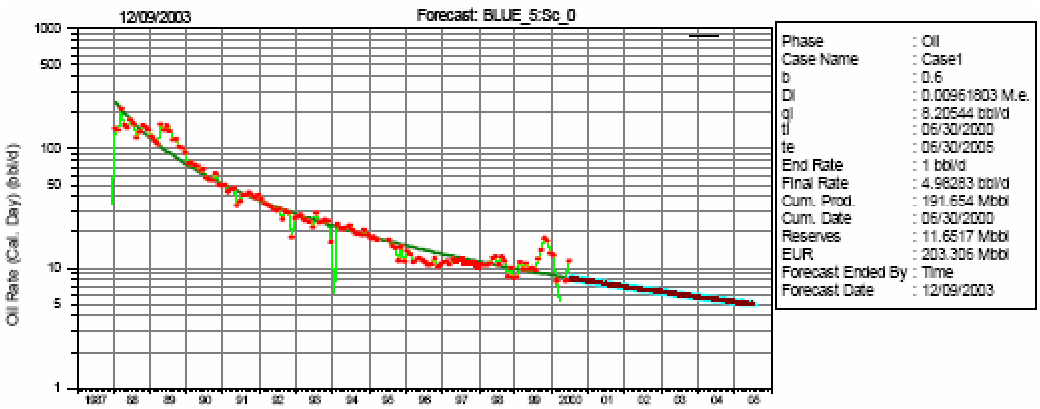

Figure (3. 9) OFM Rate-Time Hyperbolic decline on semi log axis

3.2.2 Exponential Fit Type

We did the same steps in Hyperbolic fit type then figure appear as below.

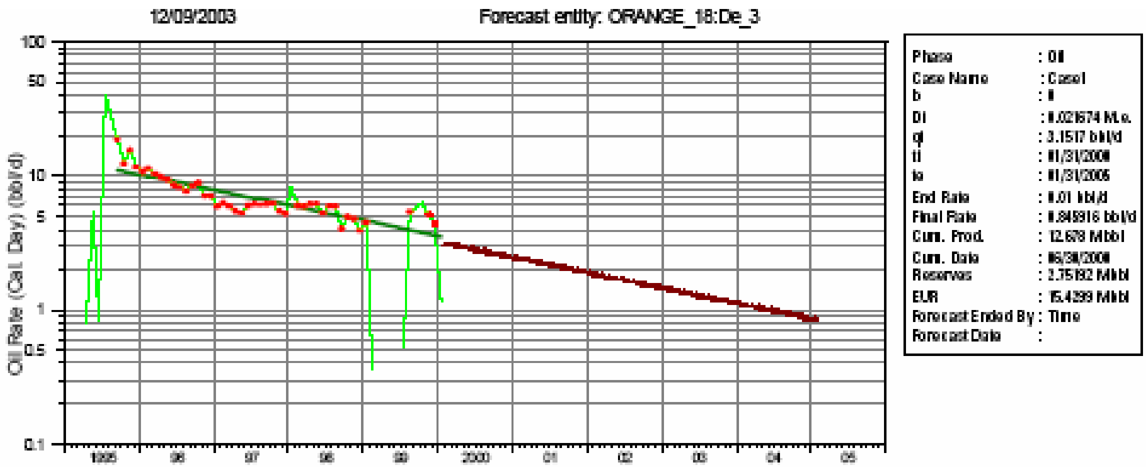

Figure (3. 10) OFM Rate-Time Exponential decline on semi log axis

By default, OFM activates four report tabs, Historical Regression Report, Forecast Report, Summary Report, and Database Forecast Report. (As illustrated in figures 3.8)

Forecast

Case1: RED_4:CI_3			
Equation			
# 1	q = 30.6009 * exp(-0.000920428 * t); t - Months from 1998/06/29		
Working Forecast and Actual Production Comparison			
	Working Forecast Period	06/29/1998 - 06/30/2005	
	Forecasted Production	75.326	Mbbl
	During the Period of	06/29/1998 - 06/30/2000	
	Actual Production	21.520	Mbbl
	Forecasted Production	22.154	Mbbl
	Difference Compared to Actual	0.634	Mbbl
	Relative Difference	2.945	%
	Remaining Forecasted Period	06/30/2000 - 06/30/2005	
	Remaining Forecasted Reserves	53.172	Mbbl
	Ultimate Recoverable Reserves	352.531	Mbbl

	Date	Instant. Rate bbl/d	Average Rate bbl/d	Monthly Volu Mbbl	Cumulative V Mbbl	Hist & Fcst C Mbbl	Remaining Re Mbbl	Schedule
								Schedule: # 1 (Ended By: Time)
1	1998/06/30	30.60	30.60	0.031	0.031			# 1
2	1998/07/31	30.57	30.59	0.948	0.979			# 1
3	1998/08/31	30.54	30.56	0.947	1.926			# 1

Summary

Case1: RED_4:CI_3					
Schedul	Start Date	Start Rate	End Date	End Rate	Reserves
		bbl/d		bbl/d	Mbbl
# 1	1998/06	30.60	2005/06	28.32	75.326

Figure (3. 11) OFM Forecast Data analysis

CHAPTER FOUR

4 RESULTS & DISCUSSION

4.1 Results:

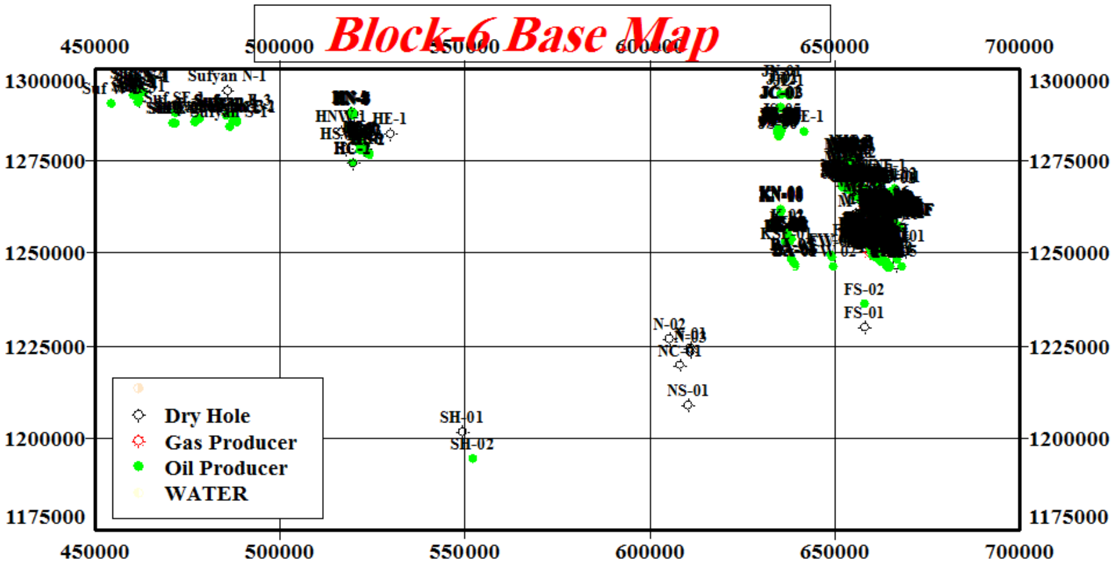

Figure (4. 1) Block -6 Base Map

* The above figure showing all block 6 wells location .

Block 6 crude oil decline analysis:

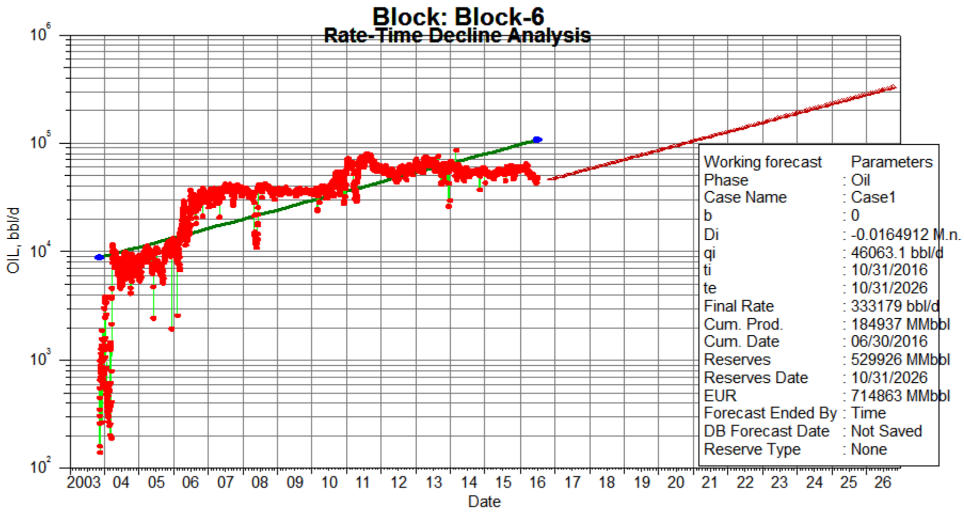

Figure (4. 2) Block-6 Oil Phase Decline

The above figure showing crude oil decline curve, historical regression and future forecast with EUR and final economical rate for all Block 6 after 10 years predicting time.

Historical Regression:

Program requirement (production history data).

Cumulative Production 184937 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.01649	8825.507	11/07/2003

Working forecast

Program requirement (Future predicting).

EUR 714863 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	-0.01649	46063.090	06/30/2016	06/30/2026	0.000	4031.031	Time

Block 6 water phase decline analysis:

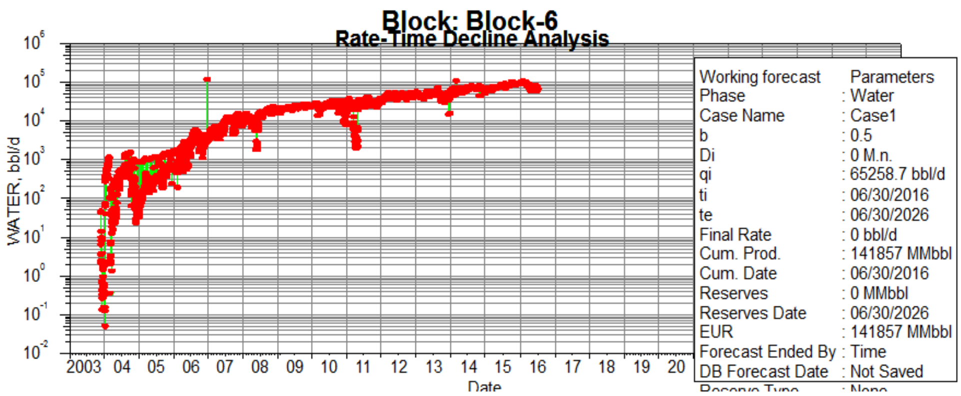

Figure (4. 3) Block-6 Water Phase Decline

The above figure showing water phase decline curve historical regression and future forecast with EUR and cumulative production for all block 6 after 10 years predicting time.

Historical Regression

Cumulative Production 141857 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
1.00	0.00000	0.000	11/21/2003

Working forecast

EUR 141857 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	Ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	**0.000**	**65258.653**	**06/30/2016**	**06/30/2026**	**0.000**	**0.000**	**Time**

Fula NE crude oil decline analysis:

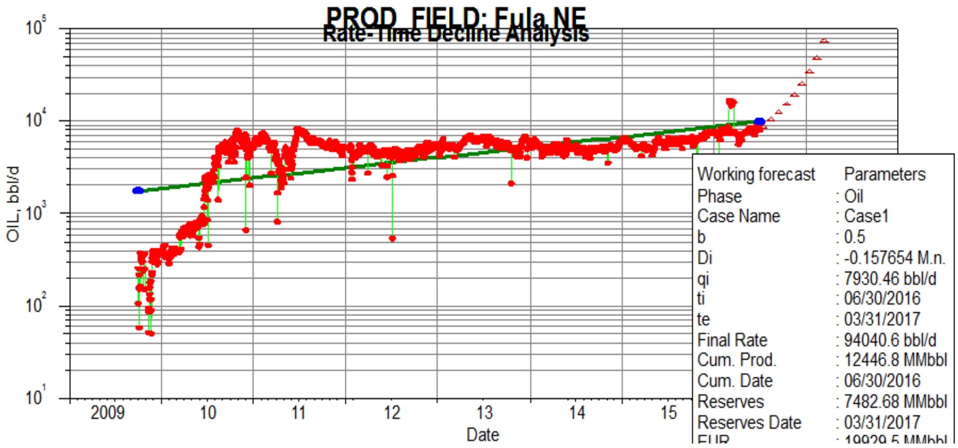

Figure (4. 4) Fula NE Oil Phase Decline Curve

The above figure showing crude oil decline curve historical regression and future forecast with EUR and cumulative production for Fula NE feild.

Historical Regression

Cumulative Production 12446.8 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.0	**-0.02135**	**1760.200**	**09/30/2009**

Working forecast

EUR 19929.5 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	**-0.15765**	**7930.459**	**06/30/2016**	**03/31/2017**	**94040.602**	**7482.684**	**Rate**

Fula NE water phase analysis:

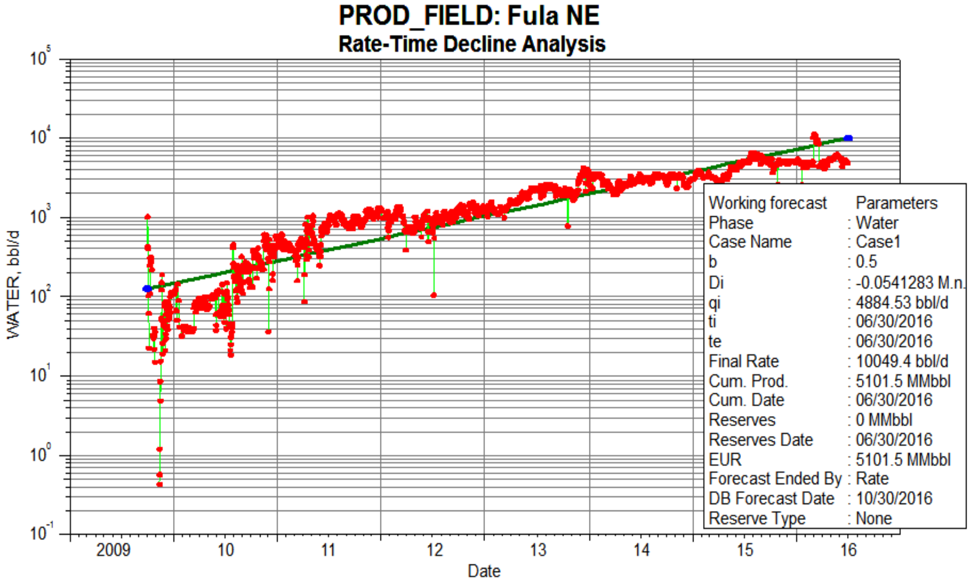

Figure (4. 5) Fula NE Water Phase Decline Curve

The above figure showing water phase decline curve historical regression and future forecast with EUR and cumulative production for Fula NE feild.

Historical Regression

Cumulative Production 5101.5 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.0	-0.05413	125.418	09/30/2009

Working forecast

EUR 5101.5 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	-0.05413	4884.530	06/30/2016	06/30/2016	10049.4	25473.028	Rate

Greater Fula crude oil decline analysis:

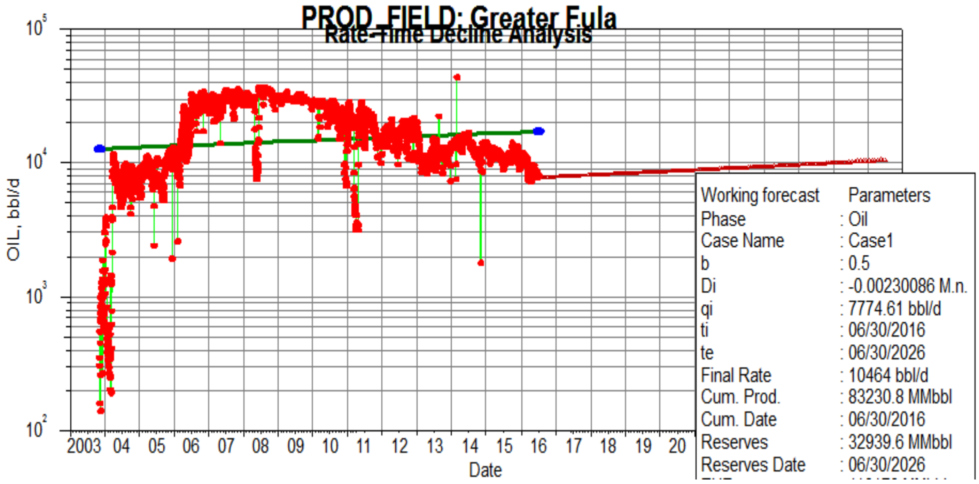

Figure (4. 6) Greater Fula Oil Phase Decline Curve

The above figure showing crude oil decline curve historical regression and future forecast with EUR and cumulative production for Greater Fula.

Historical Regression

Cumulative Production 83230.8 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.00196	12774.048	11/07/2003

Working forecast

EUR 118111 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	-0.00230	7774.608	06/30/2016	06/30/2026	10463.978	32939.608	Time

Greater Fula water phase decline analysis:

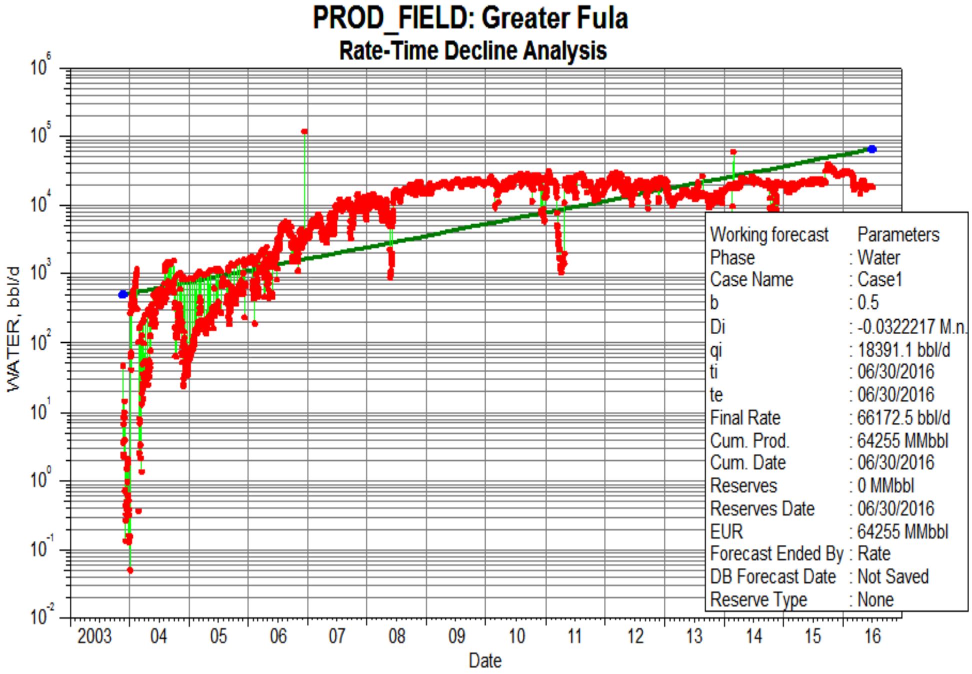

Figure (4. 7) Greater Fula Water Phase Decline Curve

The above figure showing water phase decline curve historical regression and future forecast with EUR and cumulative production for Greater Fula.

Historical Regression

Cumulative Production 64255 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.03222	579.170	11/21/2003

Working forecast

EUR 64255 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	-0.03222	18391.051	06/30/2016	06/30/2016	0.000	32939.608	Time

Greater Moga crude oil decline analysis:

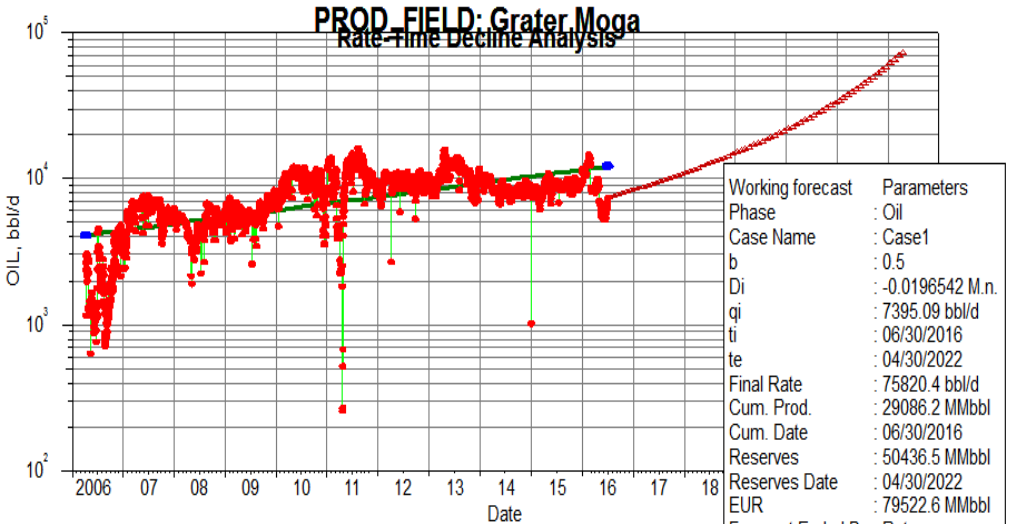

Figure (4. 8) Greater Moga Oil Phase Decline Curve

The above figure showing crude oil decline curve historical regression and future forecast with EUR and cumulative production for Moga.

Historical Regression

Cumulative Production 29086.2 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.00891	4080.282	04/07/2006

Working forecast

EUR 79522.6 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	-0.01965	7395.094	06/30/2016	04/30/2022	75820.422	50436.456	Rate

Greater Moga water phase decline analysis:

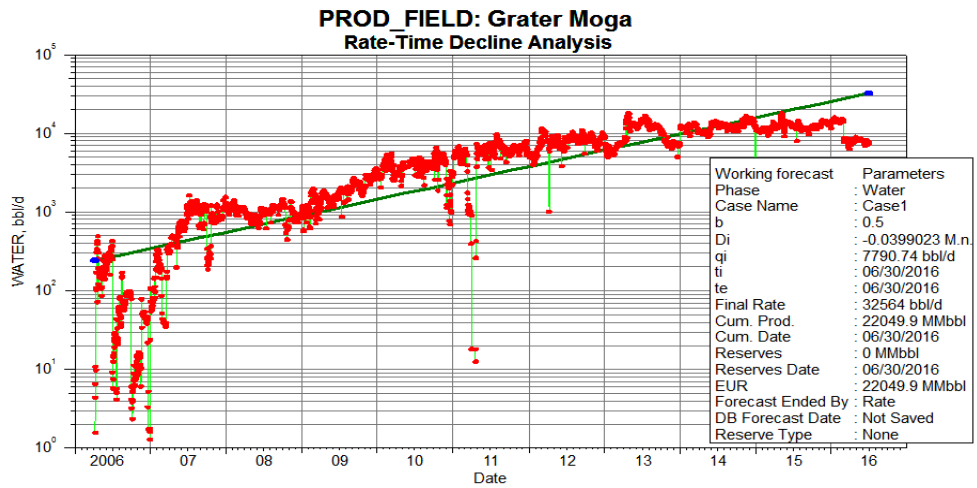

Figure (4. 9) Greater Moga Water Phase Decline Curve

The above figure showing water phase decline curve historical regression and future forecast with EUR and cumulative production for Moga.

Historical Regression

Cumulative Production 22049.9 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.03990	242.719	04/07/2006

Working forecast

EUR 22049.9 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	**-0.03990**	**7790.741**	**06/30/2016**	**06/30/2016**	**0.000**	**54157.877**	**Rate**

Keyi crude oil decline analysis:

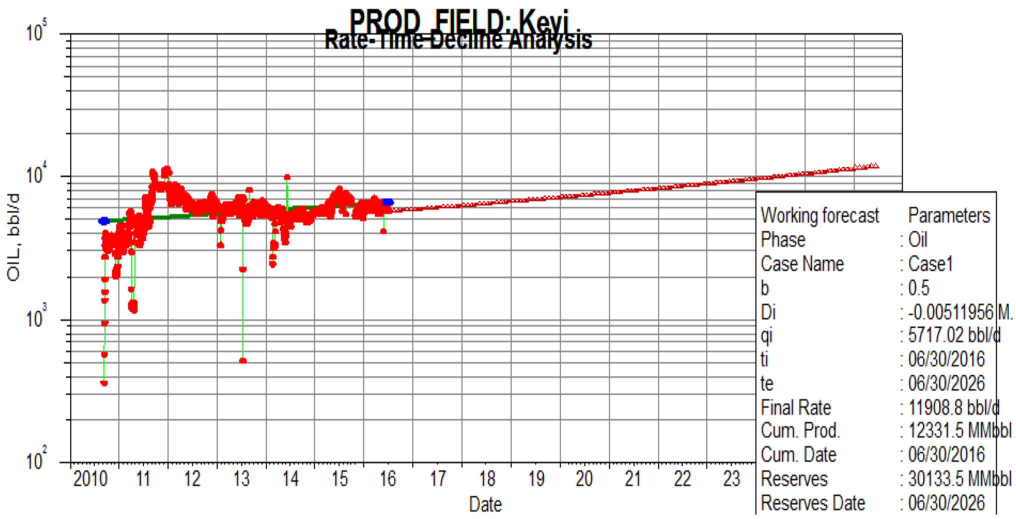

Figure (4. 10) Keyi Oil Phase Decline Curve

The above figure showing crude oil decline curve historical regression and future forecast with EUR and cumulative production for Keyi.

Historical Regression Cumulative Production 12331.5 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	**-0.00435**	**4881.057**	**09/11/2010**

Working forecast

EUR 42465 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	**-0.00512**	**5717.018**	**06/30/2016**	**06/30/2026**	**11908.799**	**30133.497**	**Time**

Keyi water phase decline analysis:

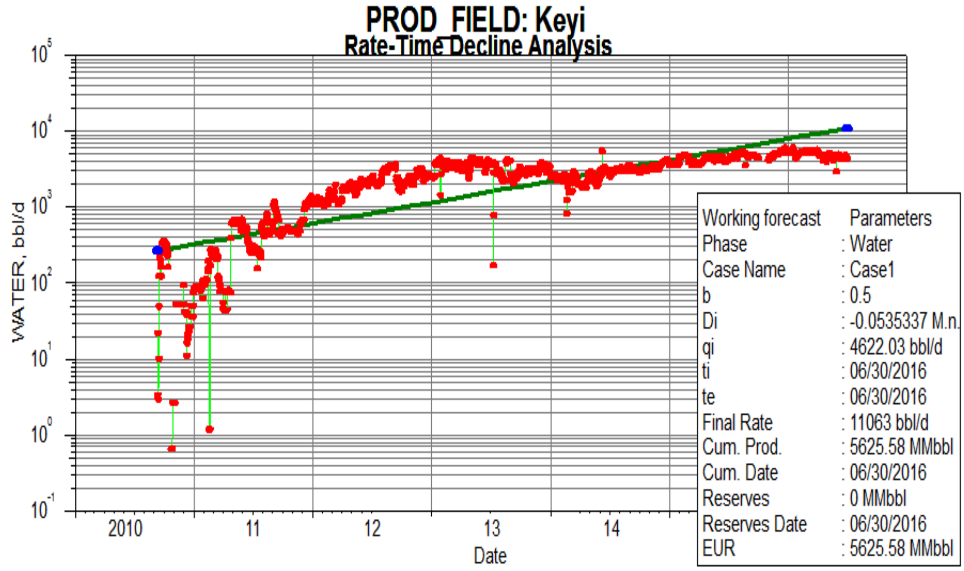

Figure (4. 11) Keyi Water Phase Decline Curve

The above figure showing Water phase decline curve historical regression and future forecast with EUR and cumulative production for Keyi.

Historical Regression

Cumulative Production 5625.58 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.05353	266.255	09/11/2010

Working forecast

EUR 29315.1 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.00	-0.05353	4622.025	06/30/2016	01/31/2020	46287.346	23689.551	Rate

Jake crude oil decline analysis:

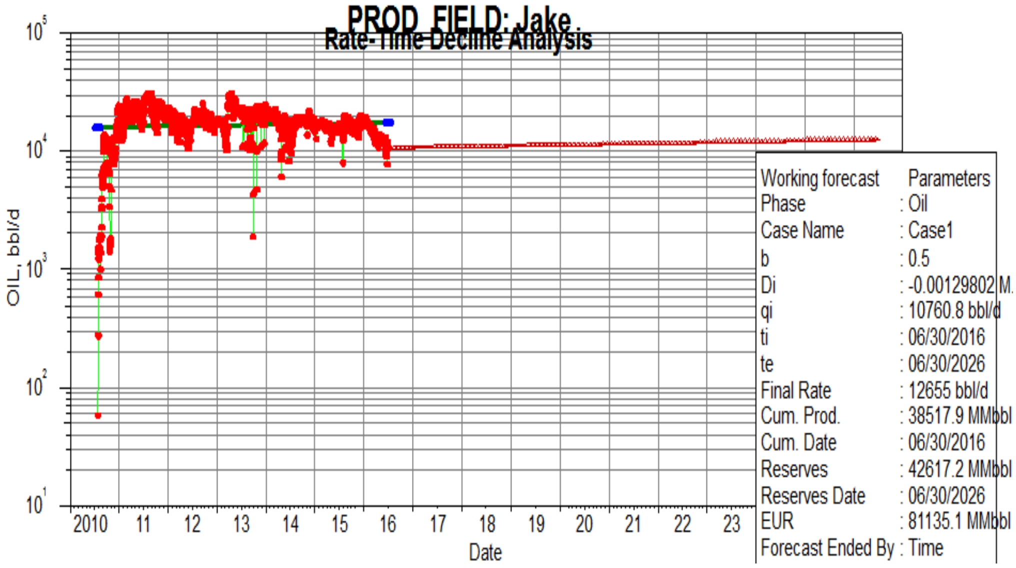

Figure (4. 12) Jake Oil Phase Decline Curve

The above figure showing crude oil decline curve historical regression and future forecast with EUR and cumulative production for Jake.

Historical Regression

Cumulative Production 38517.9 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.00124	16015.512	07/26/2010

Working forecast

EUR 83473.6 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	-0.00130	10760.841	06/30/2016	06/30/2026	12655.010	42617.221	Time

Jake water phase decline analysis:

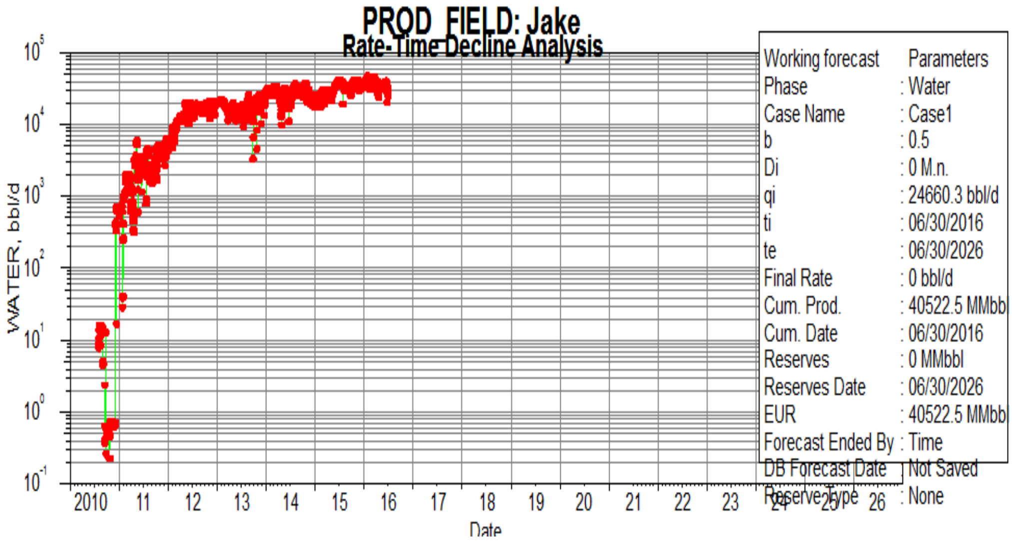

Figure (4. 13) Jake Water Phase Decline Curve

The above figure showing water phase decline curve historical regression and future forecast with EUR and cumulative production for Jake.

Historical Regression

Cumulative Production 40522.5 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
1.00	0.00000	0.000	07/30/2010

Working forecast

EUR 40522.5 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	0.00000	24660.275	06/30/2016	06/30/2016	0.000	0.000	Time

Hadida crude oil decline analysis:

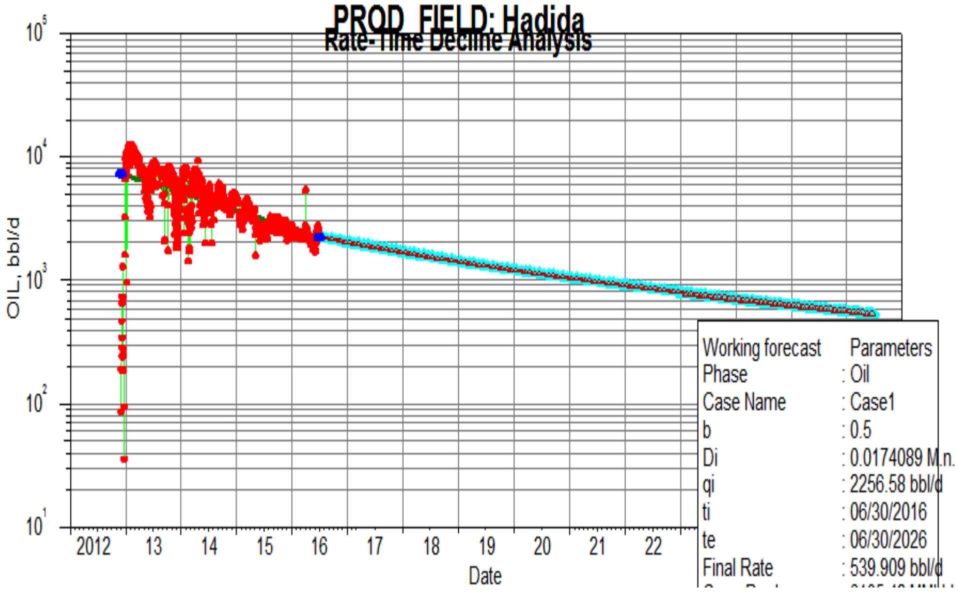

Figure (4. 14) Hadida Oil Phase Decline Curve

The above figure showing crude oil decline curve historical regression and future forecast with EUR and cumulative production for Hadida.

Historical Regression

Cumulative Production 6135.42 MMbbl thru 06/30/2026

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.0	0.0174089	2256.58	06/30/2016

Working forecast

EUR 10166.5 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.5	0.0174089	2256.58	06/30/2016	06/30/2026	539.909	4031.03	time

Hadida water phase decline analysis:

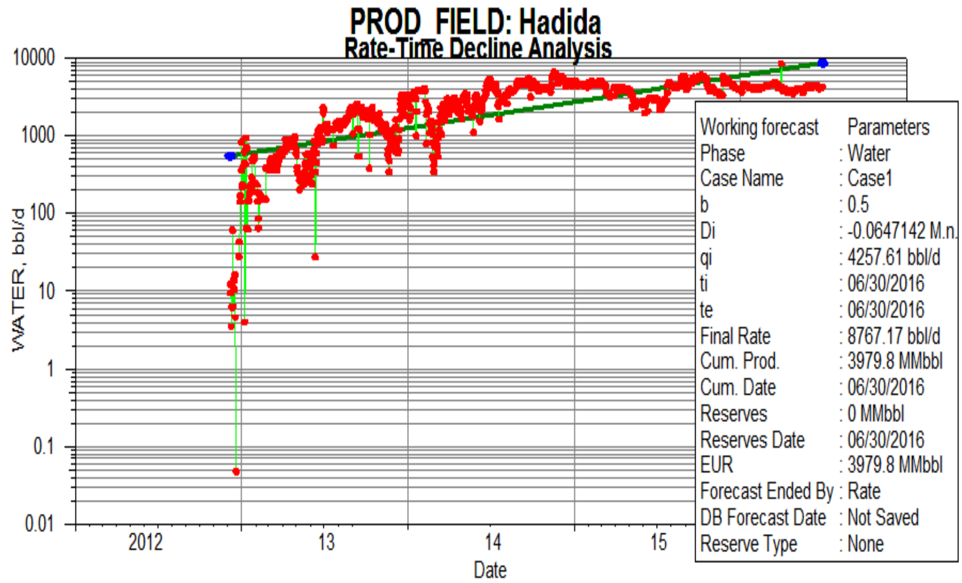

Figure (4. 15) Hadida Water Phase Decline Curve

The above figure showing water phase decline curve historical regression and future forecast with EUR and cumulative production for Hadida.

Historical Regression

Cumulative Production 3979.8 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.06471	550.345	12/06/2012

Working forecast

EUR 3979.8 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	-0.06471	4257.611	06/30/2016	06/30/2016	0.000	18540.453	Rate

Sufyan crude oil decline analysis:

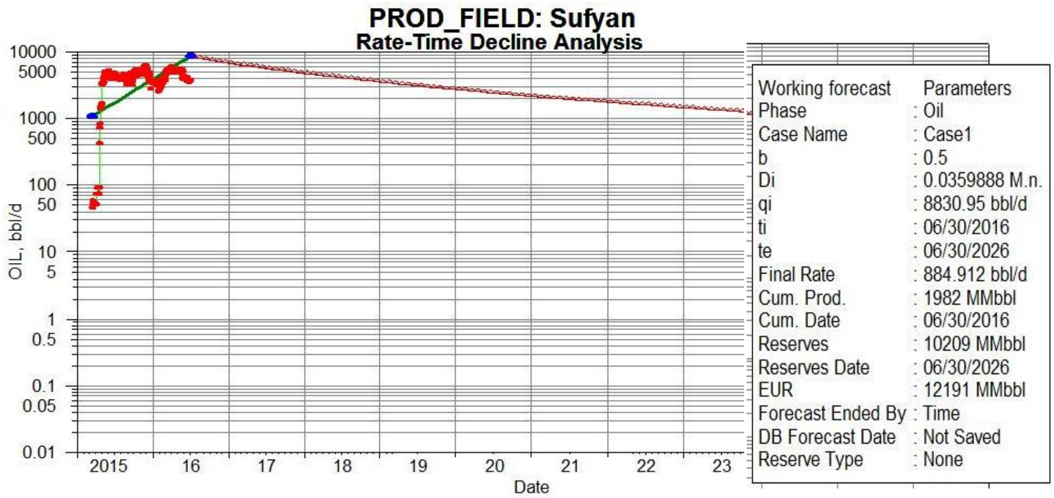

Figure (4. 16) Sufyan Oil Phase Decline Curve

The above figure showing crude oil decline curve historical regression and future forecast with EUR and cumulative production for Sufyan.

Historical Regression

Cumulative Production 1982 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.13394	1096.770	03/14/2015

Working forecast

EUR 1982 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	0.13394	3805.491	06/30/2016	06/30/2016	0.000	4031.031	Time

Sufyan water phase decline analysis:

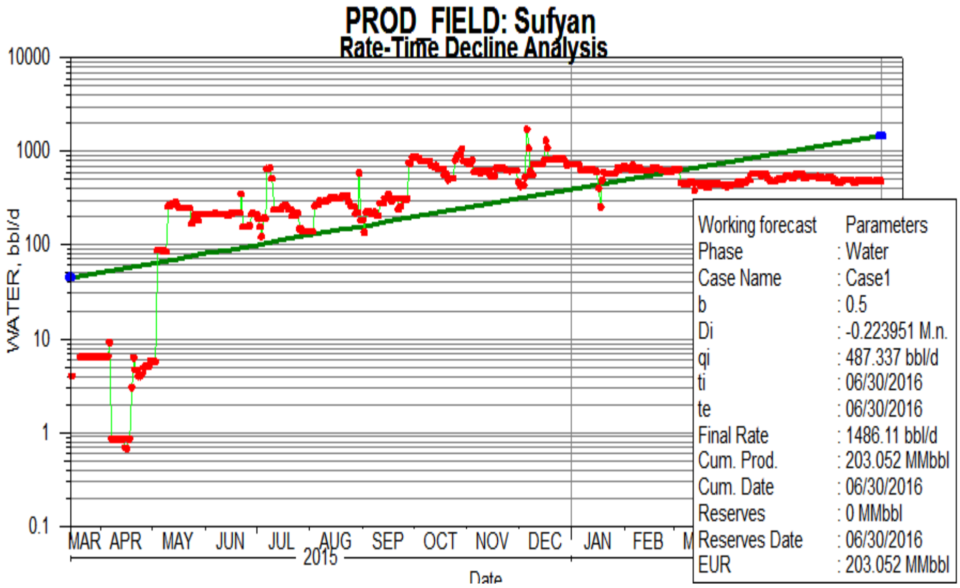

Figure (4. 17) Sufyan Water Phase Decline Curve

The above figure showing water phase decline curve historical regression and future forecast with EUR and cumulative production for Sufyan.

Historical Regression

Cumulative Production 203.052 MMbbl thru 06/30/2016

b Value	Di (M.n.)	qi (bbl/d)	Ti
0.00	-0.22395	45.438	03/14/2015

Working forecast

EUR 203.052 MMbbl

b Value	Di (M.n.)	qi (bbl/d)	ti	Te	qe (bbl/d)	Res. (MMbbl)	Ended By
0.50	**-0.22395**	**487.337**	**06/30/2016**	**06/30/2016**	**0.000**	**0.000**	**Time**

Table (4. 1) Final results

Field Name	Di	EUR, MMbbl
Greater Fula	-0.00230086	118111
Greater Moga	-0.0196542	79522.6
Greater Fula North East	-0.157654	19929.5
Hadida	0.0174089	10166.5
Jake	-0.00129802	83473.6
Keyi	-0.00511956	44706.3
Sufyan	0.036	12191
Block 6	**-0.0164912**	**714863**

Chapter Five

5 Conclusion and Recommendations

5.1 Conclusion

- The historical production data for the fields were collected from the start till the end of June 2016.
- the collected data were uploaded in OFM table data base for further analysis.
- OFM organized the data as it inserted and each field wells were grouped as completions and sub fields.
- Historical data analysis was performed to define the decline rate cases and select the best fit to be used as decline curve base.
- With the consideration of the historical regression the hyperbolic decline method was used to give a reasonable result.
- A new case was introduced to discuss the effect of the water production by analyze the water production rate and found to be the major effect on the total field production.
- The EUR was calculated by the end of 2026 for each field.

5.2 Recommendations

- This analysis for block 6 could be performed on a different scenarios and assumption to find the most accurate prediction method, as we did in our research for the main resones of historical production regression decline curve analysis through our tool (OFM) software and the future prediction as well as.
- Using the decline curve with the historical regression to give optimum results, and determining the time for other in enhancement methods when its necessary.
- Perform this analysis on the wells level for more accurate an detailed results on the reasons for production decline.

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