Investigation of Reservoir Production Performance Using Decline Curve Analysis

Dr. Khulud Mustafa Rahuma
Pertroleum Engineering Department
Tripoli University

Abstract:

DCA (Decline Curve Analysis) is a technique that can be applied to whole reservoir, cumulative company production, or even on national level. DCA aims at estimating reservoir production performance at different points in time based on the actual documented production history long senlen le break it in to two helps in developing distribution of oil production rate in wells, forecasting future production rate, estimating remaining reserve, and predicting total reserve.

In this study, the actual oil rate technique is incorporated with the D.C.A program, F.A.S.T.RTA TM software, Ecrin software, and screening data points to calculate remaining and recoverable reserves. The remaining reserve depends on the production data points that are selected and believed

reflecting the true well/reservoir behavior. informal, some data points should be excluded because of their no-representative of the actual behavior of the well/reservoir. If kept, these points would lead to a wrong behavioral trend. Human error, gauge failure, production cut/increase due to political/market motivation, etc. might be responsible for such non-representative behavior. This approach is implemented by analyzing production trend for separated number of segments. Production data points for each interval are evaluated to diagnose its effect on the remaining reserves.

Key Words: Decline curve, initial rate, remaining reserve, software, scenario.

Introduction:

Decline Curve Analysis are traditionally used to provide deterministic estimates for future performance and remaining reserves. However, this method usually involves some manipulation of the data, such as adjusting scales with type curves, some introduce bias into the data previous to the prediction, such as graphically choosing one or two parameters to represent trends of varying data.[(1)]

Using an efficient curve-fitting equation, a general hyperbolic curve can fit to the raw monthly oil production data. A continuation of this hyperbolic curve beyond the period of known production gives a prediction based only on the production values and not on any interpretation by the evaluation.

The most popular decline curve is that which represents the decline in the oil or gas production rate with time (rate/time plot), Another common technique is the plot of production rates versus cumulative oil or cumulative gas production, normally termed (rate-cumulative plots). Naturally, oil production rate will decline with the production time increase, as long as there is no pressure support.

If oil rate of a producing well/reservoir drops to the economic limit, it will be called for shut-off. The two basic problems in appraisal work are the determination of most probable life span of wells and estimation of its future production. Sometimes these vital parameters can be calculated by volumetric method if sufficient reliable data is available. In those cases, the possibility of extrapolating the trends of some variable characteristics of such producing well(s)/reservoir(s) may be of considerable help.

Traditionally, rate/time or rate/cumulative plots are used to obtain main decisive parameters required to understand futuristic behaviours of well(s)/reservoir(s). The extrapolated trend intersects with the predefined economic flow rate dictates the time of the economic limit. The basic of such an estimate is the assumption that history controls the future performance. This assumption puts the extrapolation method on a strictly empirical basis and it must be realized that this may make the results sometimes inferior to the more reliable volumetric methods. [(2)]

Estimating oil reserves is one of the most important factors that decide the fate of any petroleum venture. Operating cost plays a major role as well.[(3)] The production decline observed should truly reflect reservoir productivity and none natural causes, such as a change in production conditions well damage, production controls, and equipment failure should be overlooked.

Stable reservoir condition must also prevail in order to extrapolate decline curves with a reasonable degree of reliability. This condition will normally be met as long as the producing mechanism is not altered.

However, when action is taken to improve oil/gas recovery, such as infill drilling, fluid injection, stimulation, decline curve analysis can be used to estimate the performance of the well/reservoir taking in consideration such imposed changes and their effects on disturbing the natural behavior.(4)

The objective of this study is to predict the main economic well/reservoir parameters under all these complexities.

Software Packages Used:

In this study, new software packages used to analyze production decline curve namely Ecrin software (Topaze), F.A.S.T.RTA TM software, and Decline Curve Analysis (D.C.A) program.

Ecrin software is the software environment under which all the KAPPA (petroleum engineering software company) dynamic data analysis modules operate.

F.A.S.T.RTA software is the another practical toolkit from Fekete.

Decline Curve Analysis is a Program was designed by visual basic languages, and connected with Excel Worksheet using the least of sum of error squares.

These packages used collectively and systematically to produce best results. Following sections describe steps to implement the proposed approach.

Preparing Data for Software:

Relation of actual flow rate versus time drew in excel sheet with selected appropriate production period to be used for the analysis figure 1.

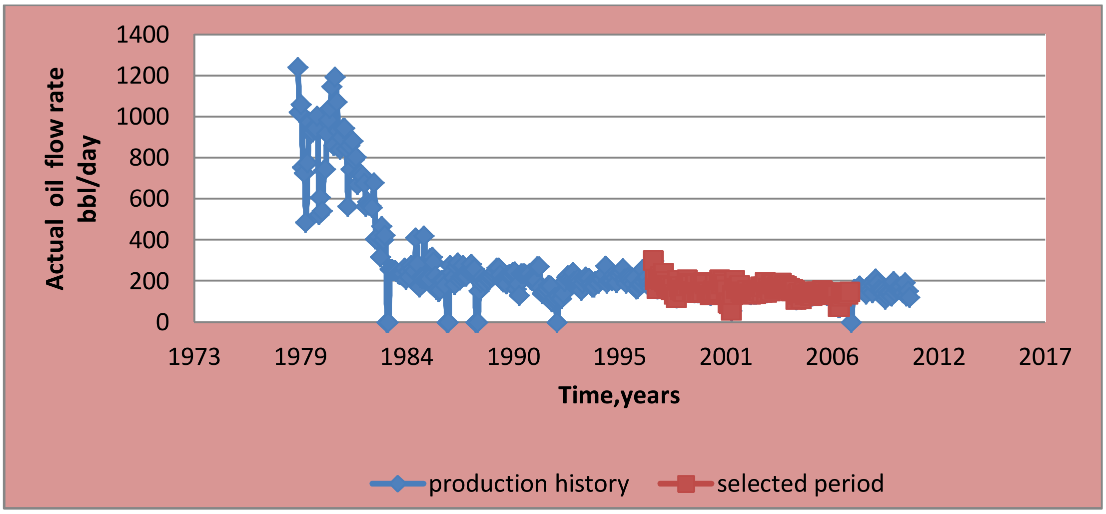


Figure (1) production history with selected period

Transfer selected period to another sheet input flow rate vs. production time (production period) by inserting/ date in cell A1 and flow rate in cell B1.

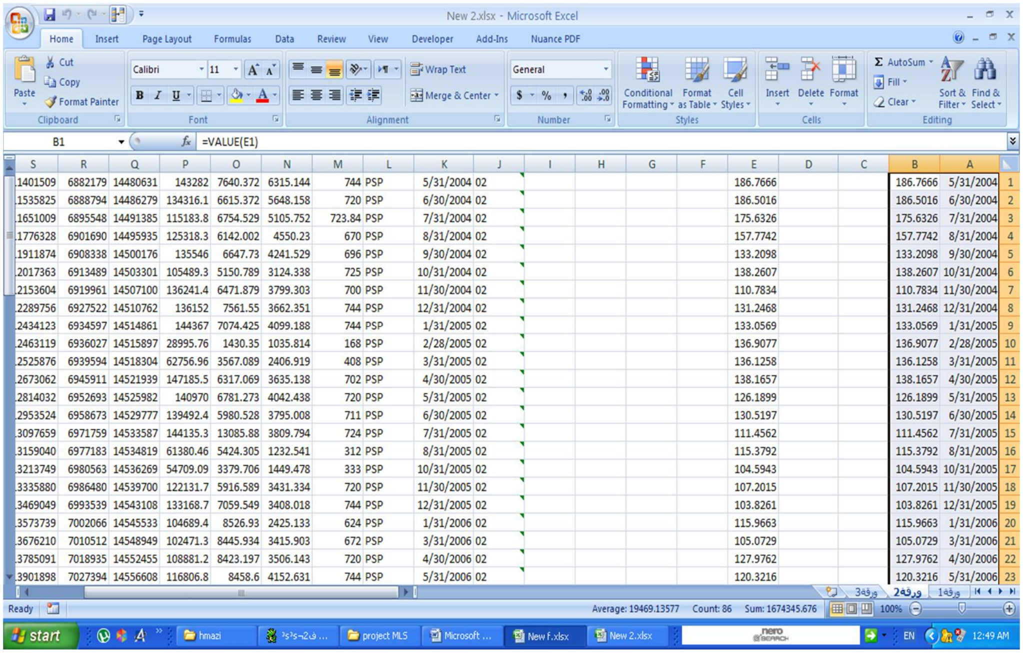


Figure (2) prepared data in excel sheet

Ecrin Software:

Ecrin provides a complete interconnectivity between the modules and allows the sharing of common technical objects. This seamless workflow saves time, repetition and frustration. All objects such as PVT data are available to all modules, at any time, by drag/drop.

Ecrin, is the industry standard for the analysis of dynamic data, that includes modules for Pressure Transient Analysis (Saphir), Production Analysis (Topaze) and a full field numerical model for History Matching (Rubis). Topaze was the first developed in response to Production Analysis (PA) evolving from empirical methods to methodology more closely aligned to modern transient analysis.

2. F.A.S.T.RTA TM Software:

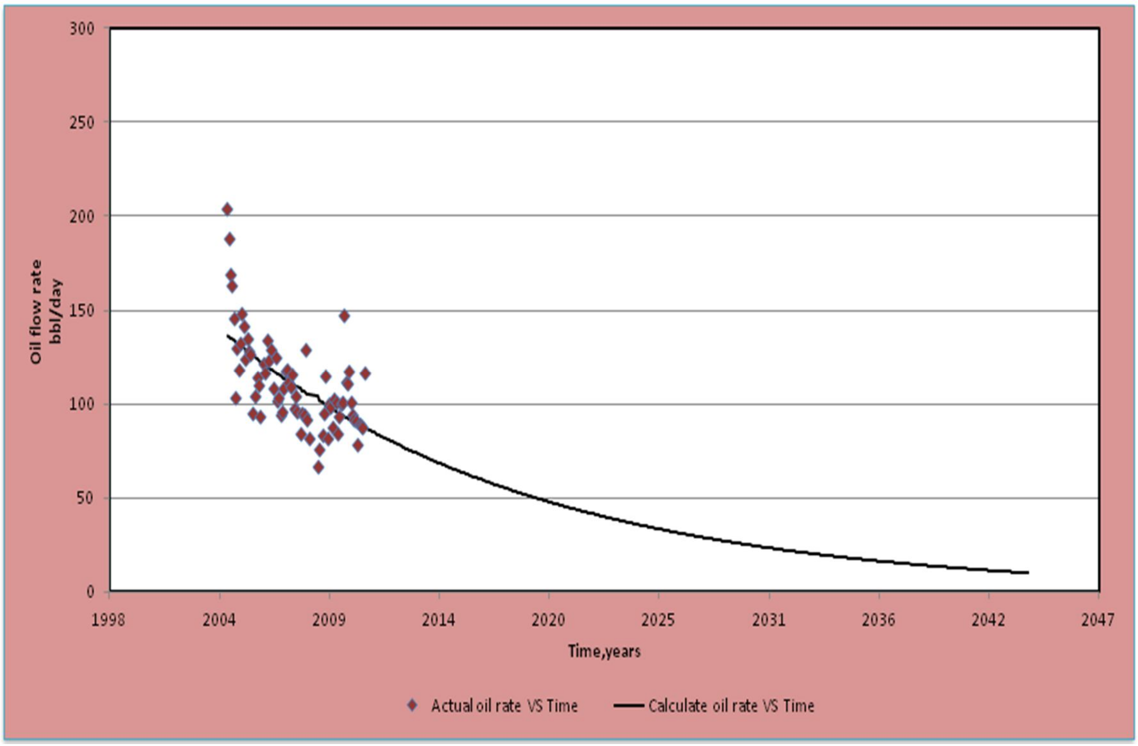
F.A.S.T.RTA is another practical toolkit from Fekete that enables you to conduct advanced decline analysis on both production and flowing pressure data at the same time. It allows determination of expected ultimate recovery. F.A.S.T.RTA TM can be used in both oil and gas reservoirs.

Discussion and Results:

In this study actual field data were used to calculate the remaining reserves of the field. The economic limit flow rate that used for calculation is (qe =60 bbl /day) as determined by the operating company of this field based on their economic assessment.

Decline Curve Analysis for Wells:

The remaining reserve calculation becomes more reliable whenever data points are well screened as shown in figure (3) of well1. Figure (4) represents the results of the analyses. As well as tables (1 and 2) represent the results of the analysis incorporated with wells 1,2,3, and4. Table 1 includes results of wells using Hand Calculation and D.C.A. Program, while table 2 shows the results of wells using Ecrin and Fekete Softwares.



Figure(3) Well1 Screening method

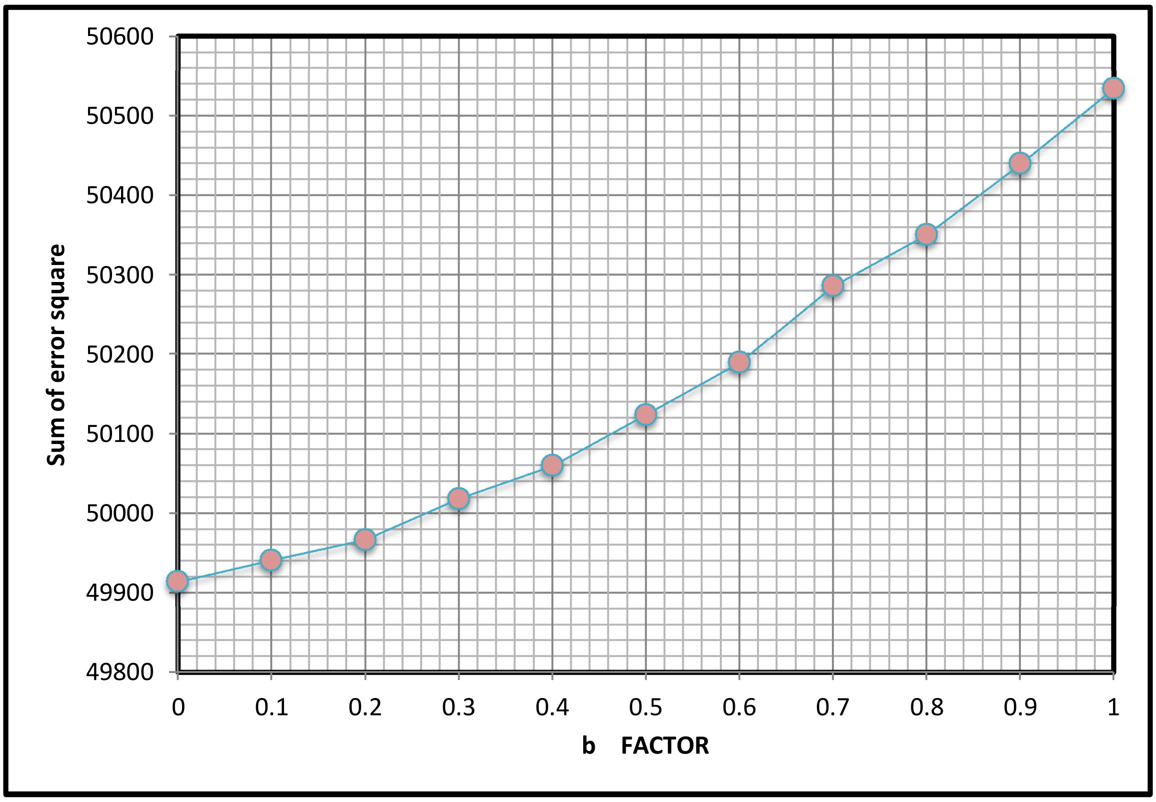


Figure (4) Well1(Sum of error square vs b factor)

Table (1) results of wells using Hand Calculation and D.C.A. Program

Cut-off Criteria:15 bbl/day Correlated period: from 31/30/1999 .to : 3/31/2011	Hand Calculation				D.C.A program			
	Well 1	Well 2	Well 3	Well 4	Well 1	Well 2	Well 3	Well 4
Decline Exponent	0	0	0.4	0.4	0	0	0.4	0.4
Decline Factor (1/month)	0.00456	0.00638	0.011519	0.013532	0.005507	0.006377	0.01151	0.01353
Initial Decline Rate (bbl/day)	138	238	228	342	138	238	228	343
Economic Recoverable Reserves (bbl)	568,884	506,104	504,415	505,385	564,458	506,291	504,842	505,411
Abandonment Time (years)	33.831	36.118	38.44	38.44	33.61	36.131	35.679	38.446

Table (2) results of wells using Ecrin and Fekete Softwares

Cut-off Criteria:15 bbl/day Correlated period: from 31/30/1999 .to : 3/31/2011	**Ecrin software**				**Fekete software**			
	Well 1	Well 2	Well 3	Well 4	Well 1	Well 2	Well 3	Well 4
Decline Exponent	0	0	0.383	0.4	0	0	0.4	0.4
Decline Factor (1/month)	0.005301	0.00629	0.01341	0.013401	0.005631	0.006431	0.011431	0.013421
Initial Decline Rate (bbl/day)	137	237	261	345	139	240	230	347
Economic Recoverable Reserves (bbl)	565,433	506,090	520,560	506,930	569,358	508,704	509,579	507,889
Abandonment Time (years)	33.71	36.017	40	38.723	34	37.2	39.34	39.05

Decline Curve Analysis for the Whole Field:

The decline type of the reservoir is a hyperbolic b= 0.2. Figures (5) and (6) represent the results of the analyses from table (3). Comparing remaining reserve of the whole field with sum of the wells indicates 303,599 bbls for the whole field and 2,084,788 bbls from the sum of the wells. There is a large difference (1,781,189 bbls) of reserve estimate between the two approaches. Reserve discrepancy maybe due to the fact that some of the wells were shut-in at the time of reserves calculations. Therefore, it is necessary to adopt the approach of well by well method during calculation of DCA. Initial operating company estimate of the reserve for this field is 95 MMbbls. Cumulative oil production until 31/3/2011 is given at 92 MMbbls. There are a lot of shut-in periods because of several workover and ESP maintenance and replacement jobs during this period.

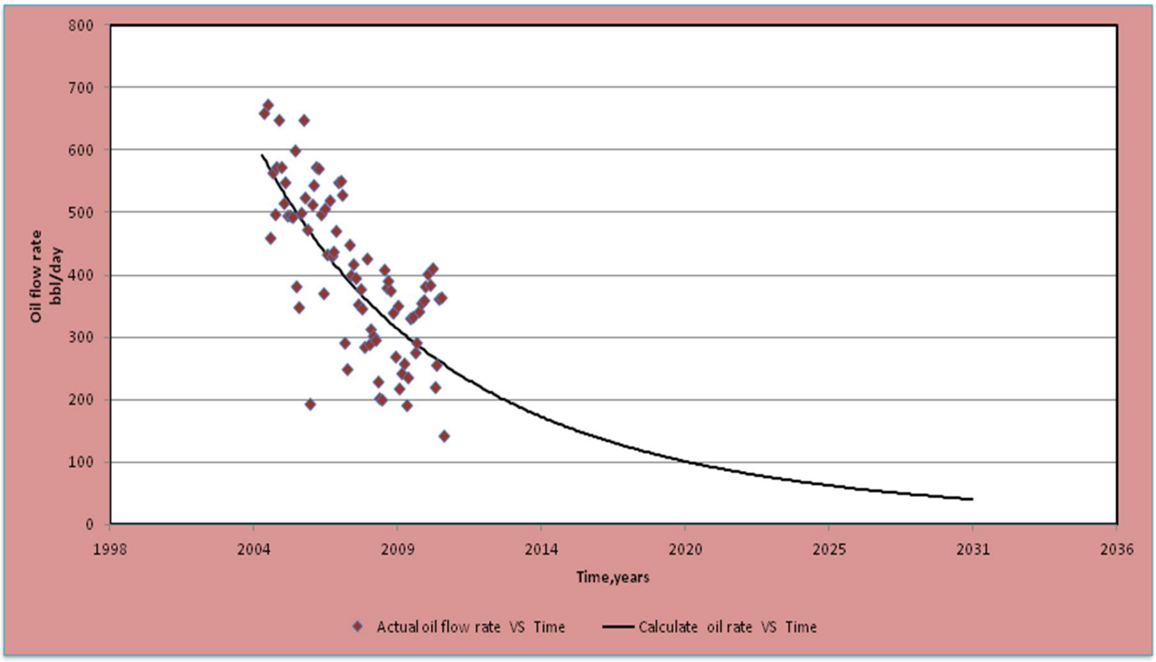


Figure (5) Field Screening method

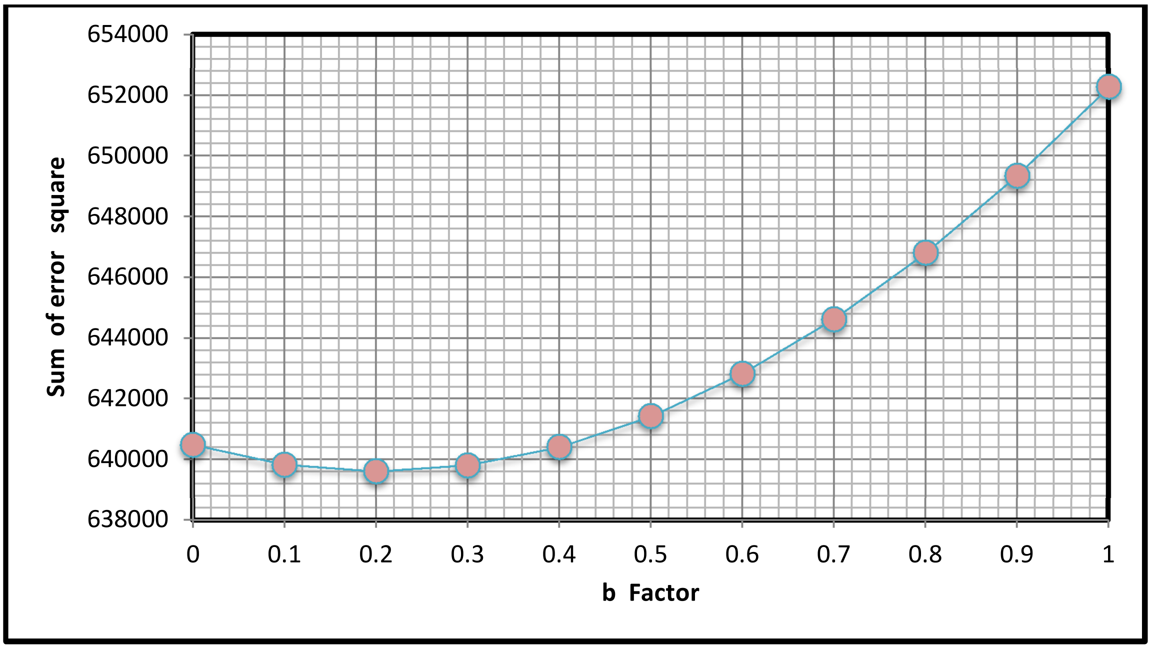


Figure (6) Field (sum of error square vs b factor)

Table (3) results of field using different methods

Solution	Decline Exponent (b)	Decline Factor (1/Month)	Initial Decline Rate (bbl/day)	Economic Recoverable Reserves (bbl)	Abandonment Time(years)
Hand calculation	0.2	0.01101	600	303,599	21.185
Ecrin software	0.2	0.012401	600	304,816	21.997
Fekete software	0.2	0.012431	598	300,084	20.106
D.C.A	0.2	0.011007	600	303,714	21.197

Conclusion:

The multi-software package approach used for analyzing DCA proven efficient and much better than the traditional analyses. Decline rate factor (b) is equal to 0.2 indicates a combination of reservoir drive mechanisms. Disagreement between well-to-well and whole field approaches indicates a large distance between producers and injectors. DCA Analyses implementing D.C.A program, F.A.S.T.RTA TM software and Ecrin softwares are more reliable and time saving as compared to traditional methods. The recoverable reserves estimate seems irrecoverable utilizing the existing wells due to shut-in time for workover and maintaining ESP. It is recommended to conduct a routine workover program for both producers and injectors. In-fill drilling program also is very well recommended. These measures will contribute in maximizing recovery to achieve the target recoverable reserves. Optimization of water injection can help in maintaining effective pressure support. A comprehensive (whole field) DCA should be performed regularly. This helps evaluating recovery techniques influence on producing the remaining reserves.

Nomenclature:

ai = nominal decline rate
b = reservoir factor
Bg = gas formation volume factor
Q = oil production rate at time t
q_{cal} = calculated flow rate
q_e = economic oil production rate
q_i = initial oil production rate
R_p = cumulative gas-oil ratio
R_{si} = initial solution gas-oil ratio
S_{wi} = initial water saturation
t = time

Acknowledgments:

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