Available online at <u>www.vurup.sk/petroleum-coal</u> Petroleum & Coal 54 (3) 225-237, 2012

DECLINE CURVE ANALYSIS FOR ZELLA OIL FIELD - "CASE STUDY"

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Received March 1, 2012, Accepted September 10, 2012

Abstract

In this work the decline curve analysis is implemented to study the effect of some parameters on calculated reserves of Zella Oil Field. The basic concepts and applications of decline curve analysis are determining the remaining reserve, total reserve and forecasting future production rate. The production intervals selected long enough so, the data will be sufficient to give good and reliable results. The production data points for each interval are analyzed separately to evaluate the effect of the change in the production and reservoir conditions on the remaining reserves. In this work, production decline curve was analyzed for five wells producing from the reservoirs under strong water drive mechanism; perform well by well and total field performance decline curve analysis using three scenarios (all data, averaging data and screening data).

Key Word: Decline curve; field performance; remaining reserve; scenario.

1. Introduction

Decline curve analysis is a technique used to predict future production rates, estimating oil reserves, and estimating remaining productive life. It is found that the calculated remaining reserve depends on: production points that are selected to represent the real well behavior, way of dealing with the production data, production operations implemented in the Field, human errors that might happen during the life course of the Field.

The most popular decline curve is that represents the decline in the oil or gas production rate with time (rate time plot), another common technique is the plot of the production rates versus cumulative oil or cumulative gas production, normally termed (rate-cumulative plots).

These techniques can be applied to single well, total reservoir, cumulative company production, or even on a national level. The production rates are normally expressed as STB or MMSCF per day however, monthly and yearly rates are also popular^[1].

Decline curve analysis can only be used as long as the mechanical condition and reservoir drainage remain constant in well and the well is produced at capacity ^[2].

The two basic problems in appraisal work are the determination of the most probable future life wells and the estimation of its future production. Sometimes one or both problems can be solved by volumetric calculations, but sufficient data are not available to eliminate all guesswork.

In those cases, the possibility of extrapolating the trend of some variable characteristic of such a producing well may be of considerable help. The simplest and most readily available variable characteristic of producing well is its production rate, and the logical way to find an answer to the two problems mentioned above, by extrapolation is to plot this variable production rate either against time or against cumulative production extending the curves thus obtained to the economic limit. The point of intersection of the extrapolated curve with the economic limit then indicates the possible future life or the future oil recovery.

The basic of such an estimate is the assumption that the future behaviour of a well will be governed by whatever trend or mathematical relationship is apparent in its past 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 exact volumetric methods ^[3].

Estimating oil reserves is one of the most important phases of the work of petroleum engineer since the solutions to the problems it deals with usually depend on a comparison of the estimated cost in terms of barrels of oil ^[4].

Forecasting future production is the most important part in the economic analysis of exploration and production expenditures. Frequently this can be the weakest part of our analysis, for it may be based on little if any actual production performance^[5].

Estimation of petroleum reserves are prepared for a specific reason. The purpose of the estimate will in large measure dictate the method employed and the time spent in making the estimate. The estimate is seldom an end in itself, but is merely the first step in a series of calculations for the purpose of gaining knowledge that will influence current or future decisions ^[6].

The main objectives of this study are: to perform well by well and total field performance decline curve analysis in order to predict the future oil flow rate and estimate the remaining reserves for the field, **(a)** investigate the value of reservoir factor **(b)** to know the type of reservoir driving mechanism, studying the effect of some parameters such as multi layered system and water injection on the field performance, comparing the results we obtained with the results we obtained with the screening, averaging, all date point and DCA program, estimate the remaining reserve of the reservoir, and study management of the field.

2. Procedure Followed

In this work the following procedure was followed:

- 1. The production history of the field as well as the wells was collected.
- 2. The production history was plot as a flow rate versus time for each well and for the reservoir.
- 3. Then, the decline intervals were selected to perform the DCA.
- 4. The DCA was repeated under three scenarios: all data points were considered, averaging the data points and screening the data points.
- 5. The results were interpreted and plotted in figures from (1 to 24).
- 6. The effect of operations done on the selected wells was studied.
- Using visual basic program to determine production decline curve by following steps: Input flow rate and date or time (production period) in excel sheet by input date in cell A1 and flow rate in cell B1.

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Open the program and enter click into button import chose the excel file it was prepared and after that chose sheet it was pre-pared in the excel file.

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date Bow	b = 0	Initial flow rate of (bbl/ 200)	a (i/year)		Exponential decline analysis (b = 0) Harmonic decline analysis (b = 1)	
3 4 5 6	b = 0.1 b = 0.2				Hyperbolic decline analysis (b between 0 and 1)	
7 8 9	b = 0.3	[[<u></u>	Decline exponent (b)	_
10	b = 0.4	[[]			Initial flow rate (q)	
12	b = 0.5				- Decline rate (a)	1/ye
14	b = 0.6				Flow rate of economic limit (ge)	bbl/d
16 17 18	b = 0.7				Flow rate now (q now)	bbl/d
19 20 21	b = 0.8	· · · ·			Economic reserves under decline	ммы
22 23 24 25	b = 0.9				Remaining ecnomoic reserves	ммы
*		1			abandonment time (ta)	yes
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date flow rate 1 12/31/1996 7419354839	b =0		Exponential decline analysis (b = 0) C
2 1/31/1987 5161290323			Harmonic decline analysis (b =1)
3 2/28/1997 3295714296 4 3/31/1987 3967741935	b = 0.1		Hyperbolic decline analysis
4 3/31/1387 J96/741335 5 4/30/1987 36666666667	b = 0.2		[b between 0 and 1]
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8 7/31/1987 1612903226	b = 0.3	ENTER NUMBER OF DATA	Decline exponent (b)
9 8/31/1987 1290322581 10 9/30/1987 8457.2	10000	ENTER NUMBER OF DATA	
11 10/31/1987 3451612903	b = 0.4		Initial flow rate (q)
12 11/30/1987 3333333333	b = 0.5		Decline sate (4)
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14 1/31/1988 2903225806 15 2/29/1988 5517241379	b =0.6		Flow rate of economic limit (ge)
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17 4/30/1988 7954.4			Powrate now (gnow)
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20 7/31/1988 2903225806	b = 0.9		Economic reserves under
21 8/31/1988 3870967742	D = 0.8		decline
22 9/30/1988 7306.3	b = 0.9		
23 10/31/1998 3322580645 24 11/30/1988 3666666667	D = 0.3		Ramaining ecnomoic reserves
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import C. \Documents and Settings	Decline exponent [b]	ew Folder (7) کی ds (34) Initial flow rate of (26) / day)	Decline rate a 11 Aveari	sum of error square	type of decline	
date flow rate +		7975594	7.030959E-02	130891817.567174	Exponential decline analysis(b = 0)	
1 12/31/1386 7413354633	b -0	Prorobow	1,000000000	100001017.007174	Hamonic decline analysis (b =1)	
3 2/28/1987 3285714286	h =01	8139.77	7.633324E-02	90108835.1346116		
4 3/31/1987 3967741935					Hyperbolic decine analysis (bbetween 0 and 1)	
5 4/30/1987 36666666667 6 5/31/1987 3774193549	b =0.2	8335.66	8.341851E-02	79133117.8729524		
7 6/30/1987 9823.1			1			
8 7/31/1987 1€12903226	b =0.3	8571.539	9.187461E-02	6310857.426774	Decline exponent (b)	-
9 8/31/1987 1290322581 10 9/30/1987 8457.2	b =0.4			Terroris and the second second	Initial flow rate (g)	-
11 10/31/1987 3451612903	0.=0.4	8858.96	0.102144	57378240.9787791	Inside now race (Q)	bbl/d
12 11/30/1987 333333333 13 12/31/1987 5806451613	b =0.5	9214594	0.1148825	47608982 74053	Decline rate (a)	1/yea
14 1/01/1900 2003225006		[acresse	o Treates	1.0000000.14000	Flow sate of economic limit [ge]	
15 2/29/1988 517241379	b =0.6	9663521	0.1311062	40101149.8771535		bbl/d
16 3/31/1988 2903225806 17 4/30/1988 7954.4		1	1	1	Flow sate now fig now!	bbl/d
18 5/31/1988 7419354839	b =0.7	3024545	0.353477	37371365.76Axxx1		
19 6/30/1988 3666666667 20 7/31/1988 2903225806		-			Economic reserves under	- Service of
21 8/31/1988 370967742	b =0.8	11027.57	0.1819141	44492692.3052522	decline	MMER
22 9/30/1988 7306.3	b =0.9	T				
23 10/31/1988 3322580645 24 11/30/1988 3666666667	0 =0.9	12134.2	0.2250583	72344282.6734824	Remaining ecromoic reserves	-
25 12/31/1988 3225806452	b =1	13825.7	0.2944095	147220495 563371	(NP)	MMER
26 1/31/1929 8483827937	01	13025.7	0.2344035	14/220405.5633/1		
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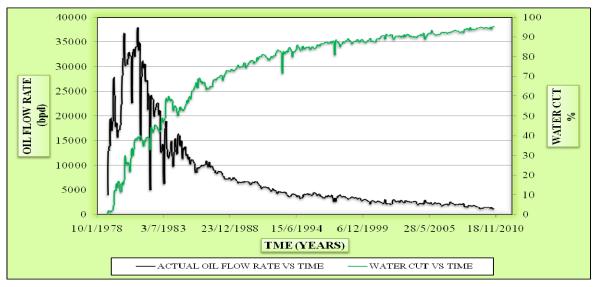
take the value of Decline exponent (b), Decline rate (a), Initial flow rate (qi), after that transfer these data into has place and input flow rate of economic limit (qe) and input flow rate now (the last flow rate in the excel sheet period).

	Decline exponent (b)	Initial flow rate gi (bbi/day)	Decline rate a (1/year)	sum of error square			
date Bow rate	b = 0	7975.594	7.0309596-02	100891817.567174	Exponential decline analysis (b = Harmonic decline analysis (b =1)		
264 11/30/2008 3666666667 265 12/31/2008 4193548387	b = 0.1	8139.77	7.633324E-02	90108835.1346116	Hyperbolic decline analysis (b between 0 and 1)	с с	
266 1/31/2009 3064516129 267 2/28/2009 7857142857 268 3/31/2009 1935483871	b =0.2	8335.66	8.341851E-02	79133117.8729524	(D between 0 and 1)		
269 4/30/2009 3333333333 270 5/31/2009 4838709677	b = 0.3	6571.539	9.187461E-02	68110857.426774	Decline exponent (b)	0.7	-32
271 6/30/2009 1233.7 272 7/31/2009 3709677419 273 8/31/2009 5483870968	b = 0.4	8858.96	0.102144	57378240.9787791	And	10245.45	ьы
274 9/30/2009 333333333 275 10/31/2009 3322580645	b = 0.5	9214.594	0.1148825	47608982.74053	Decline rate (a) Flow rate of economic limit (ge)	0.152477	1/34
276 11/30/2009 5666666667 277 12/31/2009 3677419355 278 1/31/2010 3225806452	b = 0.6	9663.521	0.1311062	40101149.8771535		1213	- 660
279 2/28/2010 3714285714 280 3/31/2010 2580645161	b = 0.7	10245-45	0.163477	27271252548302			
281 4/30/2010 3333336333 282 5/31/2010 2580645161 283 6/30/2010 3666666667	b = 0.8	11027.57	0.1819141	44482692 3092522	Economic reserves under decline		мм
284 7/31/2010 \$129032258 285 8/31/2010 3322580645	b = 0.9	12134.2	0.2250583	72344282.6734824	Remaining ecnomoic reserves		мм
296	b = 1	13826.7	0.2944095	147220485 563371	INPI		
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	9. J.						

Chose the type of decline after it gives reserve and remaining reserve and abandonment time.

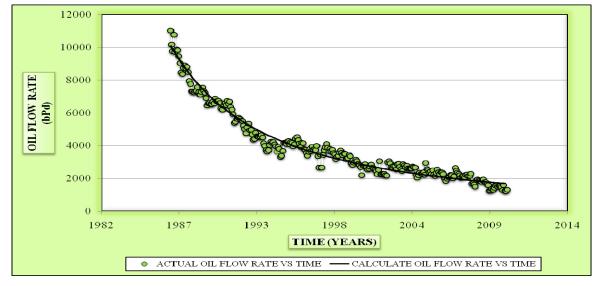
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364 11/30/2008 3556566667 b = 0.1 (9139.77 7.533324E-02 (90108051346116 Hyperbolic decline analysis 265 12/31/2009 95964516126 b = 0.2 (8335.66 8.341851E-02 7913317.8729524 Hiperbolic decline analysis 266 2/31/2009 95974.5287 b = 0.2 (8335.66 8.341851E-02 7913317.8729524 Hiperbolic decline analysis 266 2/31/2009 95974.529 b = 0.3 (6571.529 9.107461E-02 (69110657.425774 Decline exponent (b) 0.7 270 5/31/2009 15/33.77 b = 0.4 (6659.66 0.10724.4 (67170240.972779) Intel® How take (c) (0.7	-
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SSE 1/37/2003 S64516123 b = 0.2 8335 565 8.341851E.02 [79133117.8729524 (b) Between 0 and 1) SSE 2.07/2000 7677 44557 b = 0.3 (6571.559 9.107461E.02 [69110857.455774 Decline exponent (b) 0.7 2270 5/07/2000 103761527 b = 0.4 (6671.659.66 [6110857.455774 Decline exponent (b) 0.7	
Still U17/2000 1959468071 Decline exponent (b) D27 Still Stilli Still Still <t< td=""><td>Ì.</td></t<>	Ì.
268 4/20/2009 33333333 b = 0.3 9571 528 9.197461E-02 60110857.436774 Decline exponent (b) 0.7 270 5/37/2009 630709677 b = 0.4 5055 92 1107144 572720.00 9707791 Initial flow rate (a) 110745.45	42
270 5/31/2009 403070577 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	-
	bbl
272 7/31/2009 3705677419 0000.00 0 100100 0 100100 0 0 100100 0 0 100100	
273 0/31/2005 948.87/0056 b = 0.5 9214.594 0.1148825 4760982.74053 Decline rate (a) 0.152477	1.5
275 10/31/2009 3322590645 275 11/32/2009 3322590645 Flow rate of economic limit (se) 200	bbl
9963.521 U.1311062 40101149.8771535	
278 1/31/2010 3225806452	bbl
279 2/28/2010 3714265714 b = 0.7 H035.46 B163472 B737346 7140001	
281 4/30/2010 3333333333 E Economic reserves under 56.653472	683623 MB
282 5/31/2010 2500645161	
2803 6/30/2910 (200200667 2884 /731/2010 (2202258 b = 0.9 [12134.2 [0.2250583 [72344282.6734824	
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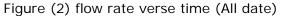
To find values of Decline exponent (b), Decline rate (a), Initial flow rate (qi), to get the values of reserve under decline, abandonment time and remaining reserves. The calculated remaining reserve becomes more reliable whenever data points are well screening and well averaging. Averaging the data points will minimize the effect of unwanted data points on the accuracy of the results; on the other hand the screening (canceling the faulty or non representative data point) is the best way to get more reliable remaining reserve from the production decline curve analysis.



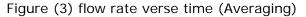
Zella Field

Figure (1) production field history









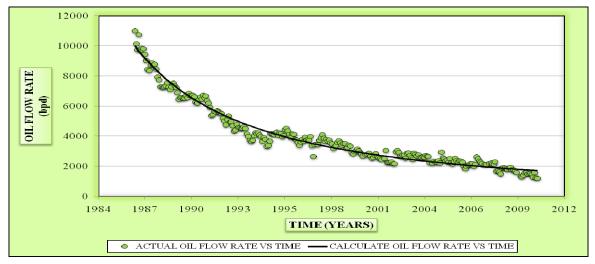


Figure (4) flow rate verse time (Screening)



Figure (5) production performance of well A15

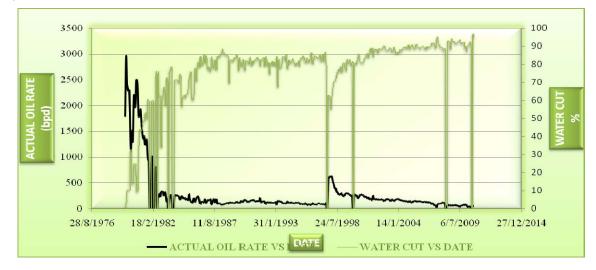


Figure (6) production performance of well 22



Figure (7) production performance of well A25



Figure (8) production performance of well A28

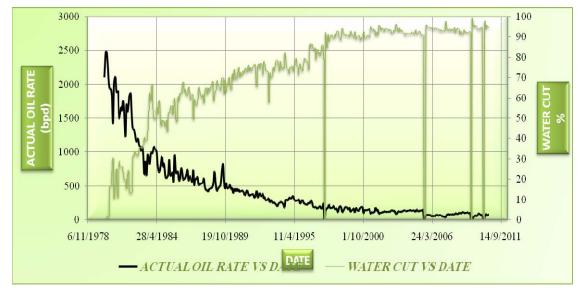


Figure (9) production performance of well A39

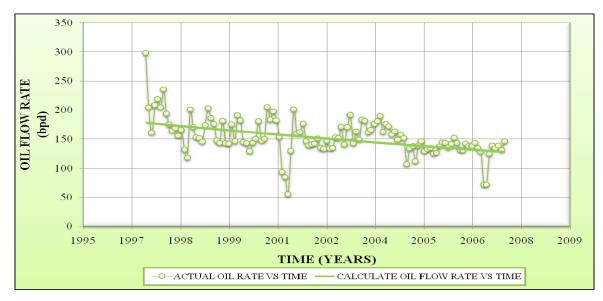


Figure (10) well A15 flow rate verse time (All date)

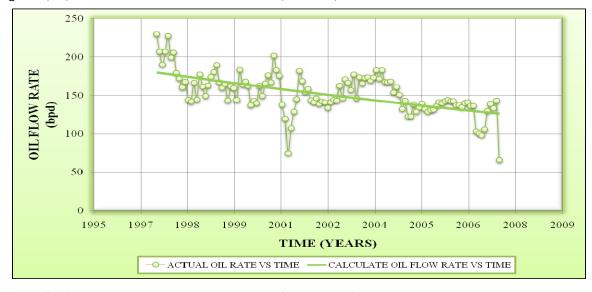


Figure (11) well A15 flow rate verse time (Averaging)

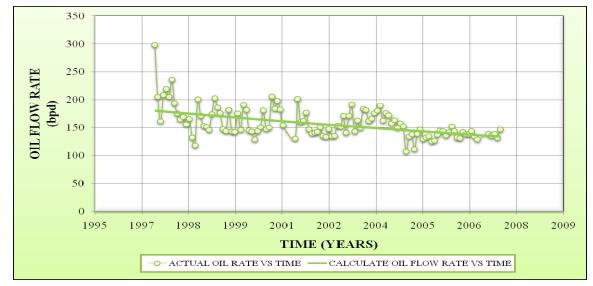


Figure (12) well A15 flow rate verse time (Screening)

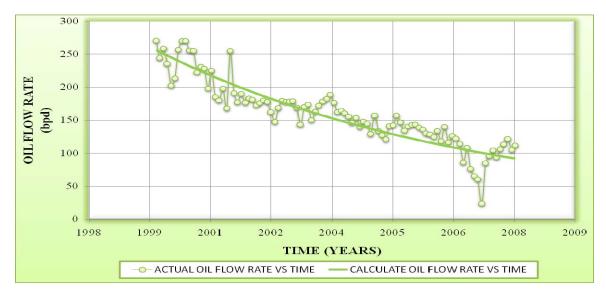


Figure (13) well A22 flow rate verse time (All date)

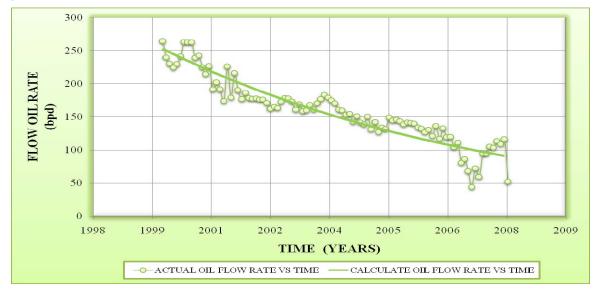


Figure (14) well A22 flow rate verse time (Averaging)



Figure (15) well A22 flow rate verse time (Screening)

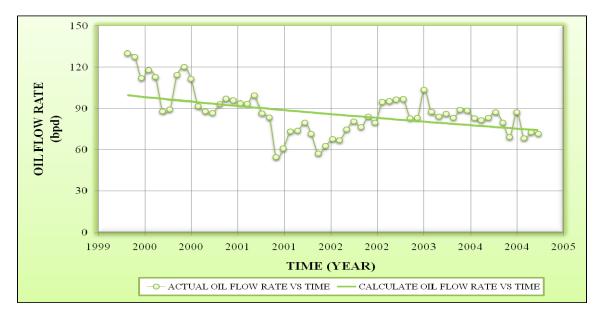


Figure (16) well A25 flow rate verse time (All date)



Figure (17) well A25 flow rate verse time (Averaging)

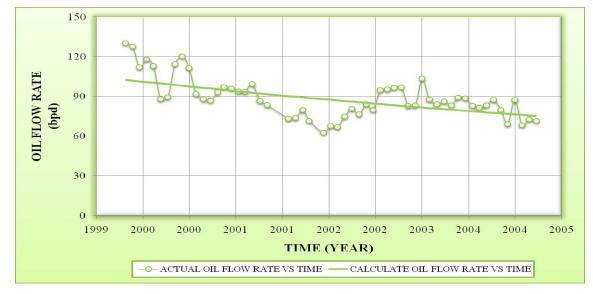


Figure (18) well A25 flow rate verse time (Screening)

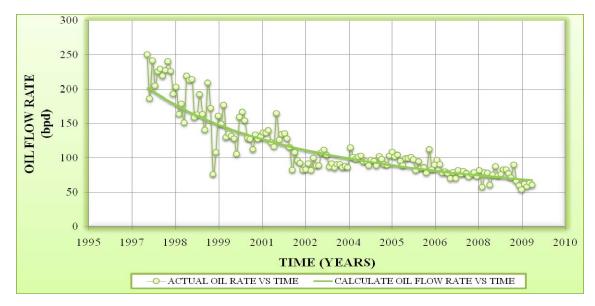
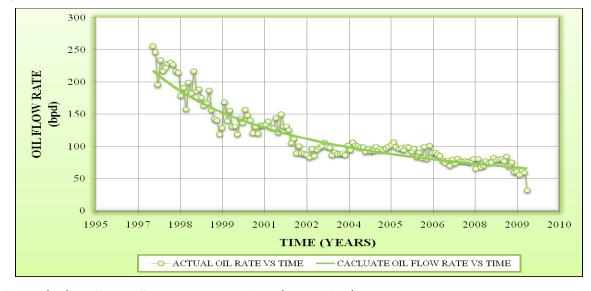


Figure (19) well A28 flow rate verse time (All date)



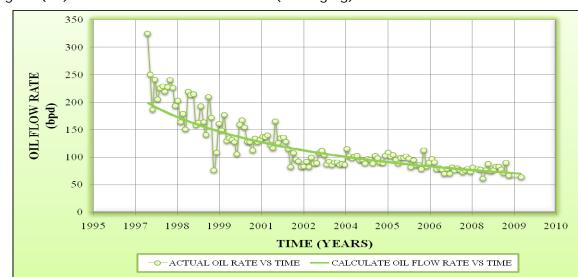
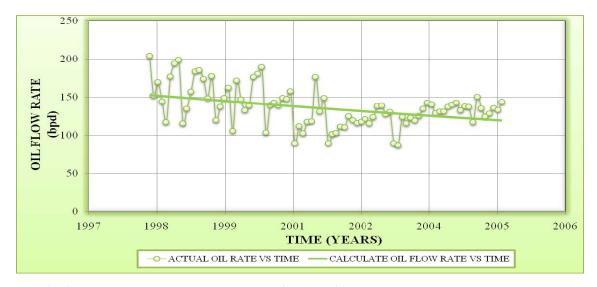
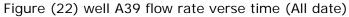


Figure (20) well A28 flow rate verse time (Averaging)

Figure (21) well A28 flow rate verse time (Screening)





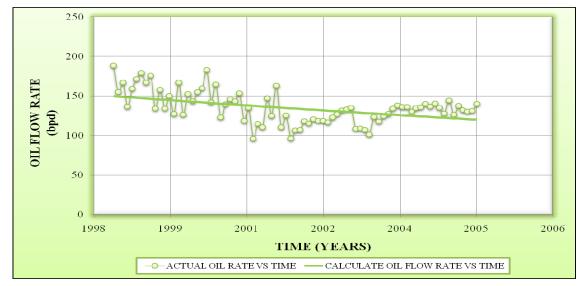


Figure (23) well A39 flow rate verse time (Averaging)

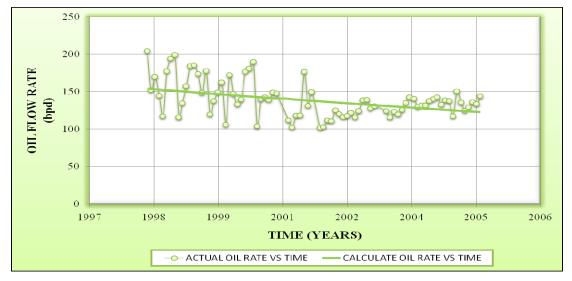


Figure (24) well A39 flow rate verse time (Screening)

3. Conclusions & Recommendation:

The main conclusions & recommendations of this study can be summarized as follows:

1. Not long initial oil rate plateau is indicative of successive oil fronts breaking through multiple layers and/or limited pump capacity, where the Short fill up period means little free gas in system.

2. The value of reservoir factor (b) is almost equal to zero which mean the water injection applied in the reservoir are working as water drive mechanism.

3. It was noticed that the value of reservoir factor (b) differs from one well to the other within the reservoir, this is a result of that some of the wells are far from the injector wells.

4. The wells which located near to the water injection wells have a value of (b) equal to zero which mean the water injection project was successful.

5. The calculated remaining reserves by DCA are affected by:

- The type of decline exhibited by the production history
- The operating procedure implemented on the well and hence on the reservoir
- The way the production data was handled
- The effect of human error
- Production Conditions
- The diagnostic plot showed that the water injection profile in Zella field is edgewater flood
- Two breakthroughs took place during the field life indicating that two layers are taking the injection
- Water injection has a regional effect as a result of permeability variation and fracture flow system
- WOR in Zella is in critical phase and need to be optimized
- Analysis by production decline curve program takes the less time comparing by hand analysis.

6. We recommend that after sufficiently production history is obtained a comprehensive DCA should be performed to see the effect of the orations procedure on the remaining reserves.

7. It is recommended to optimize the water injection pattern on regions basis in order to decrease the WOR to an acceptable range by reduce water injection.

8. In order to have better understanding for the effect of injectors on production wells and due to fracture flow system and permeability variation, it is recommended to do the recommended actions for each well separately based on time schedule and keep the most nearby wells under close monitoring.

9. Pressure records is an important control to continue optimization, so it is recommended to keep monitoring on reservoir pressure while doing the injection optimization.

Acknowledgement

The authors would like to express their deep appreciation to the Zueitina Oil Company for their help and providing with the required data.

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