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

5th year

A final year project

Evaluation the effect of Chemical Water Shutoff by Using OFM Software case study-Heglig oil field

تقييم تاثير الطرق الكيميائية في إيقاف المياه المنتجة في حقل هجليج باستخدام برنامج حاسوبي

Project Submitted to College Of Petroleum Engineering & Technology In Partial Fulfillment Of The Requirements for The Degree Of B.Sc. In Petroleum Engineering

Prepared by:

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November 2020

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This project is accepted by College of Petroleum Engineering and Technology to Department of Petroleum Engineering.

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Signature……………………………………………..........

Dean of College…………………………………………...….

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Date: \ \ 2020

الاستـهلال

يقول الله تـعالـى :

بسم الله الرحمن الرحيم

{وَقُـل رَّبِّ زِدْنِـي عِلْمـاً }

صدق الله العظيم

سورة: طه الاية 114

Dedication

We would like to donate this unpretentious effort to

Our Parents;

Who have endless presence and for the never ending love and encouragement

Our brothers and sisters;

Who sustained us in our life and still

Our teachers;

Who lighted candle in our ways and provided us with light of knowledge Finally;

our best friends;

Our Classmates

Acknowledgements

we must thank Allah before every think…

First and foremost; the greatest thanking to our parents, our supervisor Dr. Fatima Ahmed Elbrir for continuous support and for her great efforts.

Finally; we would like to extend my appreciation to all college of petroleum staff, our teachers, colleagues and

workers at College of Petroleum Engineering & minerals for their cooperation

Abstract

Excessive water production is one of the major problems in Heglig oil field in Sudan. Heglig field is located in southeast and middle of Block 2B, Muglad Basin, It consists of (Heglig main, Toma, El Bakh, El Full, Laloba, Kanga, Barki, Hamra, Simbir East and Rihan). In this project four wells were taken.

To solve this problem partially or completely, a number of techniques such as chemical water shutoff (polymer) have been used to reduce the produced water . This project aims to evaluate and clarify the effect of polymer by using OFM software which draw the performance plots. The result shows that the effect of polymer success in three wells (HE-38, TO-02, TO-03) and failure in one well (HE-04). In well (TO-02) the water cut reduce from (94.5 to 20) %.

Keyword: Water Production Problems, Methods of Chemical Water Shutoff, Polymer Treatment.

التجريد

الإنتاج المفرط للمياه احد المشاكل التي تواجه حقل هجليج النفطي في السودان.حقل هجليج يقع في الجنوب الغربي وفي وسط مربع 2B من حوض المجلد ويحتوي على (هجليج الرئيسي، توما، الباخ، لالوبة،.....) في هذا المشروع تم اخذ أربعة ابار للدراسة لمعالجة هذه المشكلة جزئيا او كليا تم استخدام عدد من التقنيات واضافة مواد (البوليمر) لتقليل هذه المياه. هذا المشروع يهدف الى تقييم وتوضيح تاثر البوليمر باستخدام برنامج (OFM software) . والنتيجة توضح ان تأثير البوليمر نجح انها في ثلاثة من الابار وهي (HE-38,TO-02,TO-03) و فشلت في بئر واحدة وهي (HE-04.). في بئر (TO-02) قلت نسبة المياه (94 الى 20)%.

CONTENTS

LIST OF FIGURES:

LIST OF TABLES:

Nomenclatures

W.C	Water cut
WOR	Water oil ratio
Cum.O	Cumulative oil production
Cum.W	Cumulative water production
Cum.F	Cumulative fluid production

Chapter 1

Chapter 1

Introduction

1.1 General Introduction

Water production is one of the major technical, environmental, and economical problems associated with oil and gas production. it can limit the productive life of the oil and gas wells and can cause several problems including corrosion of tubular, fines migration, and hydrostatic loading. (Bedaiwi *et al.*, 2009).

Excessive water production can be treated with several chemical and mechanical solutions. Chemical systems play a crucial role in field process for improving oil recovery and water shut-off treatments. Chemical treatments are not suitable for all types of excessive water production but in the right circumstances major economic benefits can be realized. Chemical treatments require accurate fluid displacement to successfully enter the formation and thus shutting– off the water, different types of gel systems, organic cross linkers, metallic cross linkers for improving flooding efficiency to reduce water production and improve oil recovery.(Mohamednour, Saeed and Ahmed, 2019).

1.2 Field Background:

Heglig oil field is one of the largest fields of oil and gas deposits in Sudan. It has been the site of conventional petroleum production for more than one decade (since 1999), but recently it has become producing water exceed the economic range Heglig field is located in southeast and middle of Block 2B, Muglad Basin. It consists of 10 fields (Heglig main, Toma, El Bakh, El Full, Laloba, Kanga, Barki, Hamra, Simbir East and Rihan).

The Oilfield has excessive water production and the water cut was reached 95% with non-economical oil production resulting in many operational problems.

The tables bellow illustrate the events that applied in the wells.

Table (1.1): The event of HE-04

Date	**Action**	**Interval**	**layer**
July ,1999	Completion Convert PCP to ESP	1642.8 -1649	B1A/B
Sep ,2000	Re- completion (perforate upper B1A)	1637.4 -1640.1 1642.9 -1649	B1A B1A/B
Feb ,2002	Re- completion (isolate B1A, &Re	1637 -1640 1640.9 -1649 1869 -1875	B1A B1A/B B3A
April ,2003	Re- completion (perforate whole B1A)	1636 -1646 1869 -1875	B1A B3A
Nov ,2013	Re- completion &CWSO (isolate B1A & lower part of B3A	1636 -1646 1869 -1873	B1A B3A
Feb ,2014	Re- completion & (isolate B3A, Reperforate B1A)	1636 -1640	B1A

Table (1.2): The event of HE-38

Date	**Action**	**Intervals**	**layer**
March,2006	Recompletion –isolate B3A	1627 -1633 1637 -1647	AF B1F
Dec ,2010	Recompletion –isolate lower part of B1A	1627 -1633 1637 -1647	AF B1F
Oct ,2012	Recompletion –squeeze all, Re –perf B3A&CWSO	1870 -1875	B3A

Table (1.3): The event of TO-02

Date	Action	Interval	Layers
July 2001	Work over convert PCP to ESP	1607.8 – 1615.1 1616 – 1621.8 1627 – 1631.6	B1A B1B B1B
Nov 2006	PLT	1607.8 – 1615.1 1616 – 1621.8 1627 – 1631.6	B1A B1B B1B
March 2007	Re- completion (isolate Mid B1B)	1607.8 – 1614 1627 – 1631.6	B1A B1B
January 2013	Re- completion (isolate B1B)	1607.8 -1614	B1A
December 2014	Re- completion lower power part of B1A & CWSO	1607.8 -1612	

Table (1.4): The event of TO-03

Date	Action	Intervals	Layer
June, 1999	Completion	1633 -1644.7	B1A/B
January ,2003	Recompletion (isolate B1B& add new perforation)	1629 -1638.9	B1A
October, 2014	Chemical water shut off using polymer	1629 -1638.9	B1A

1.3 Problem Statement:

Produced water represents the largest waste stream associated with oil and gas production; the environmental impact, treating, and disposing of this water can seriously affect the profitability of oil industry (Engineering and Engineering, 2018) to reduce excessive water and then increase the productivity and the profitability of the production wells Water shutoff operations are required to eliminating unwanted water production.

1.4 Research Objectives:

The main objectives of this project include:

1.Compare the cumulative water and oil production before and after using polymer.

2. Evaluate the result and effect of chemical water shutoff.

Chapter 2

Theoretical Background and Literature review

2.1 Introduction:

All oil wells producing water at their life, it comes from the aquifers as a natural drive or even a water flood. However, the water becomes a problem (Excess) when it bypasses the oil and lead to unrecovered accumulation(Thesis, 2016).Excessive water production is one of the main well-known problems that would face any oil operator in the world. It causes numerous economic problems for oil production companies Such as it effects the performance of the production wells and shortens their lifespan. The presence of the water in the wellbore increase the weight of the fluid column which leads to an increase in the lifting requirements and the operating cost , also enhances the presence of scales, corrosion, and degradation in the field facilities ,Another major problem is that the cost of separating, treating, and disposing the produced water (Taha and Amani, 2019).

2.2 Types of water:-

Water production is defined as the water brought up from the hydrocarbon bearing formation strata during the extraction of oil and gas and can include formation water injection water and any water production in oilfield can occur in two from first in that which in occurs later in the life of a water flooding and is coproduced with oil (Ahmed,2015).

Water which affects the productive performance of reservoirs can be classified into three distinct Categories as; sweep, good and bad water.(Solutions *et al.*, 2000).

2.2.1 Sweep water:

It come from either an injection well or active aquifer that is controlling to the sweeping of oil from the reservoir the management of this water is vital part of reservoir management and can be a determining factor in weir productivity and the ultimate reservoir.(Ahmed, 2015).

2.2.2 Good water:

Good water can be defined as the amount of waters that must be produced together with the oil in order to produce the oil. water production occurs when the flow of oil and water is commingled through the formation matrix the fictional water flow is dictated by the natural mixing behavior that gradually increases the WOR(Ahmed, 2015).

2.2.3 Bad water:

Bad water is the excess water produced into the wellbore which produces no oil or insufficient oil to pay for the cost of handling it. The water that is produced is above the WOR economic limit and its management has been a major concern for hydrocarbon industry despite the multitude of techniques available.(Joseph and Ajienka, 2010).

2.3 Sources of Unwanted Water Production:

It is important to identify the reasons which lead to problems associated with unwanted water production, in order to be able to accomplish a successful water shutoff operation (Taha and Amani, 2019) The production of unwanted water can occur for different reasons like tubing leak, flow behind casing, coning , channeling as following :

2.3.1 Casing, tubing or packer leaks:

Leaks can arise from inherent defects in the casing, corrosion due to chemical reactions with the casing or sand production and this allow water from non-oil productive zones to enter the production string(Joseph and Ajienka, 2010).

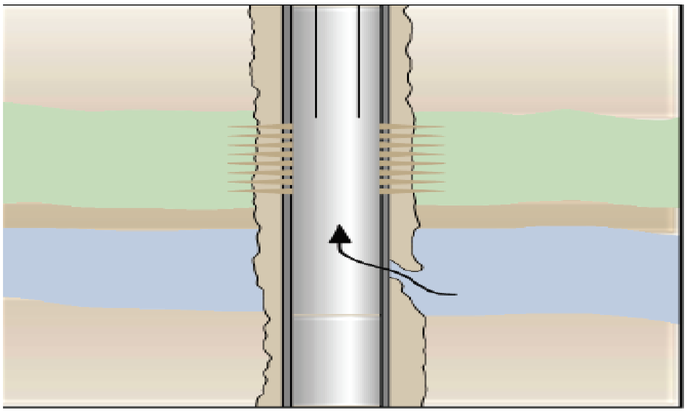


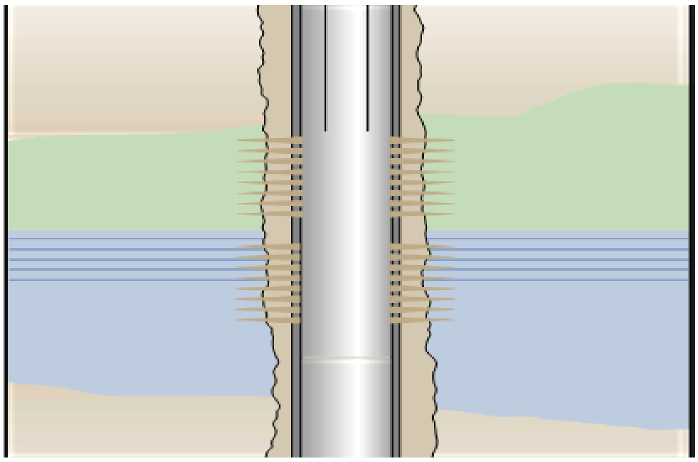
Figure (2.1): Casing, tubing or packer leaks(Solutions *et al.*, 2000).

2.3.2 Channel flow behind casing:

Failed primary cementing can connect water-bearing zones to the pay zone these channels allow water to flow behind casing in the annulus (Solutions *et al.*, 2000).

2. 3.3 Moving oil-water contact:

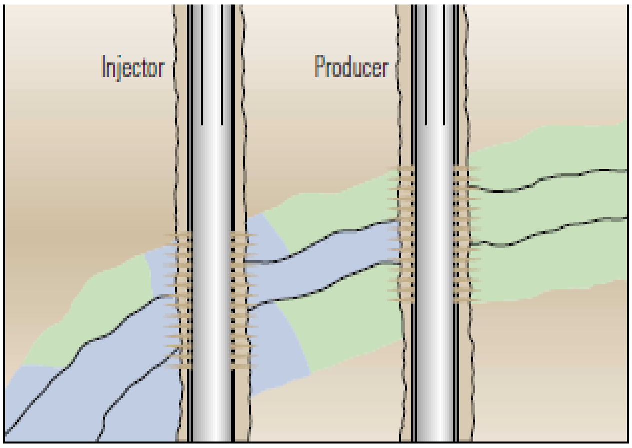
Oil water contact moving up into a perforated zone in a well during normal water driven production, this happens wherever there is very low vertical permeability (Solutions *et al.*, 2000)



Figure(2.2): Moving oil-water contact(Solutions *et al.*, 2000).

2.3.4 Watered-out layer without cross flow:

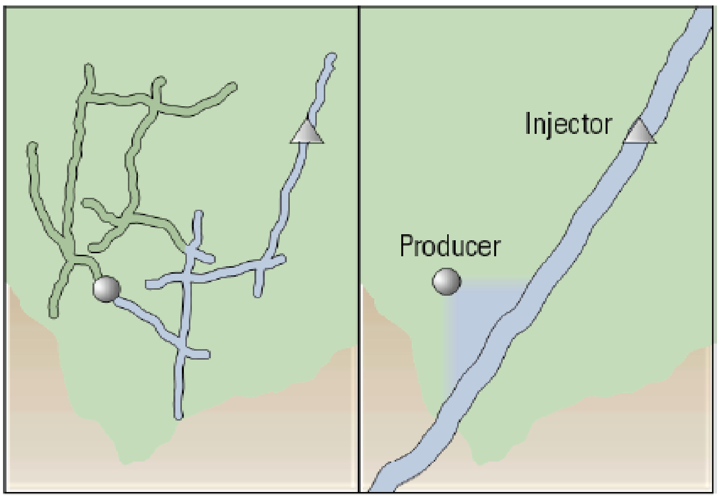
Occurs when a high permeability zone with flow barrier above and below is water out , in this case the water source may be from an active aquifer or a water flood injection well (Solutions *et al.*, 2000).



Figure(2.3): Watered-out layer without cross flow (Solutions *et al.*, 2000).

2.3.5 Fractures or Faults between Injector and Produces:

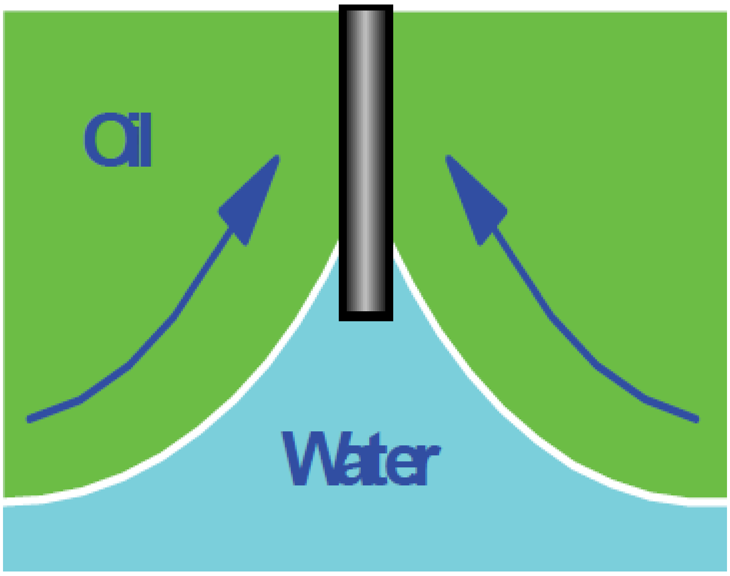
Fractures existing between injection and producers often quickens water breakthrough , these fractures can be created during water flooding , completion or workover operations also can be caused by subsurface movements in the earth crust (Joseph and Ajienka, 2010).



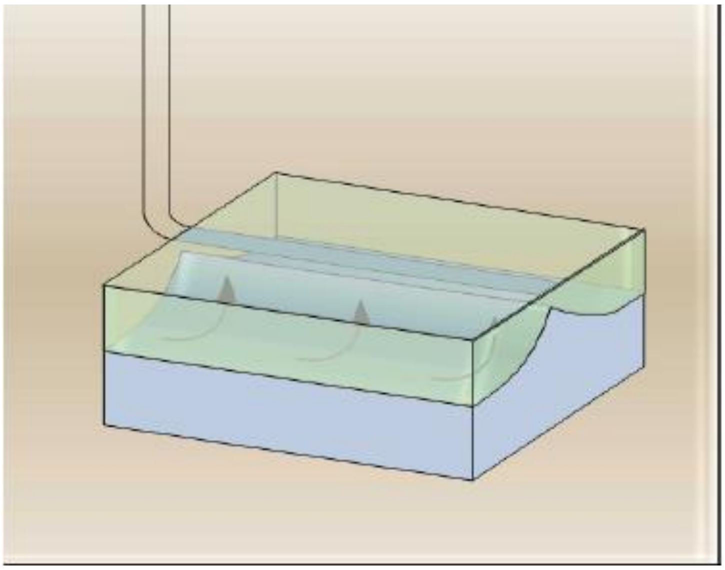
Figure(2.4): Fractures or Faults between Injector and Produces(Solutions *et al.*, 2000).

2.3.6 Coning or cusping:

Coning or cusping occurs when the oil water contact is near the perforations in formation having relatively high vertical permeability which coupled with rate of production accelerates the rate at which the rising OWC reaches the perforations (Joseph and Ajienka, 2010).



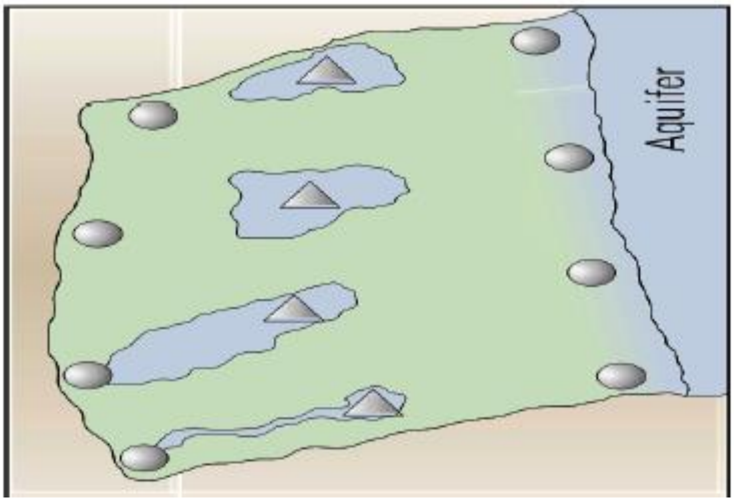
Figure(2.5) water Coning (Joseph and Ajienka, 2010).



Figure(2.6): water Cusping (Joseph and Ajienka, 2010)

2.3.7 Poor areal sweep:

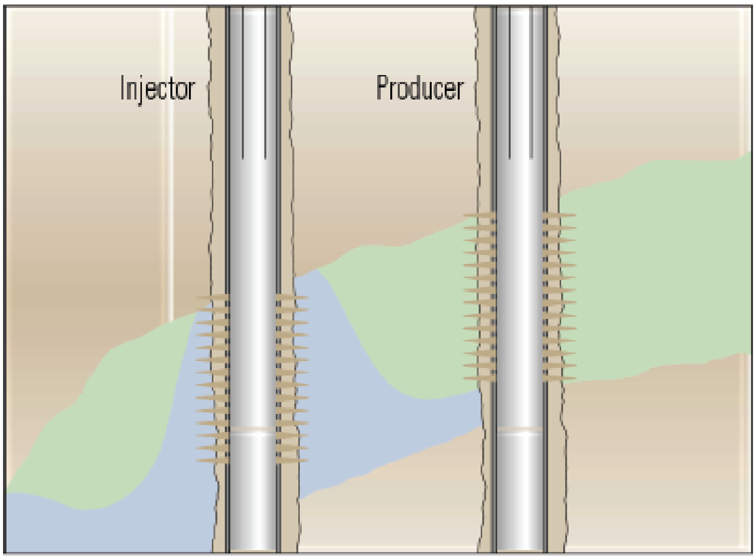
This is common with sand channel deposits which are edge water driven , it caused by edge water from n aquifer or an injector water flooding , the water by passes the oil and makes its way into the well bore.(Joseph and Ajienka, 2010)



Figure(2.7): Poor areal sweep (Solutions *et al.*, 2000) .

2.3.8 Gravity-Segregated layer:

This occurs in reservoir having thick strata with good vertical permeability , the source of the water can be from an aquifer or an injector (Joseph and Ajienka, 2010).



Figure(2.8) Gravity-Segregated layer(Solutions *et al.*, 2000).

2.4 Water Shutoff Methods:

Water shut off is defined as any operation that hinders water to reach and enter production wells. The concept of shutting unwanted g water from an oil producer is nothing new and has been being applied since early days of the industry.(Kabir *et al.*, 1999).

The main objectives of water shutoff treatment are to:

1. Shut off water without seriously damaging hydrocarbon productive zone.
2. Maximize blocking agent penetration into water source pathways, while minimizing it into hydrocarbon zones.
3. Maximize permeability reduction in water source pathways, while minimizing it in hydrocarbon zones. (Pender, 2009).

Many different materials and methods can be used to mitigate water production problems. Generally, these methods can be categorized as:

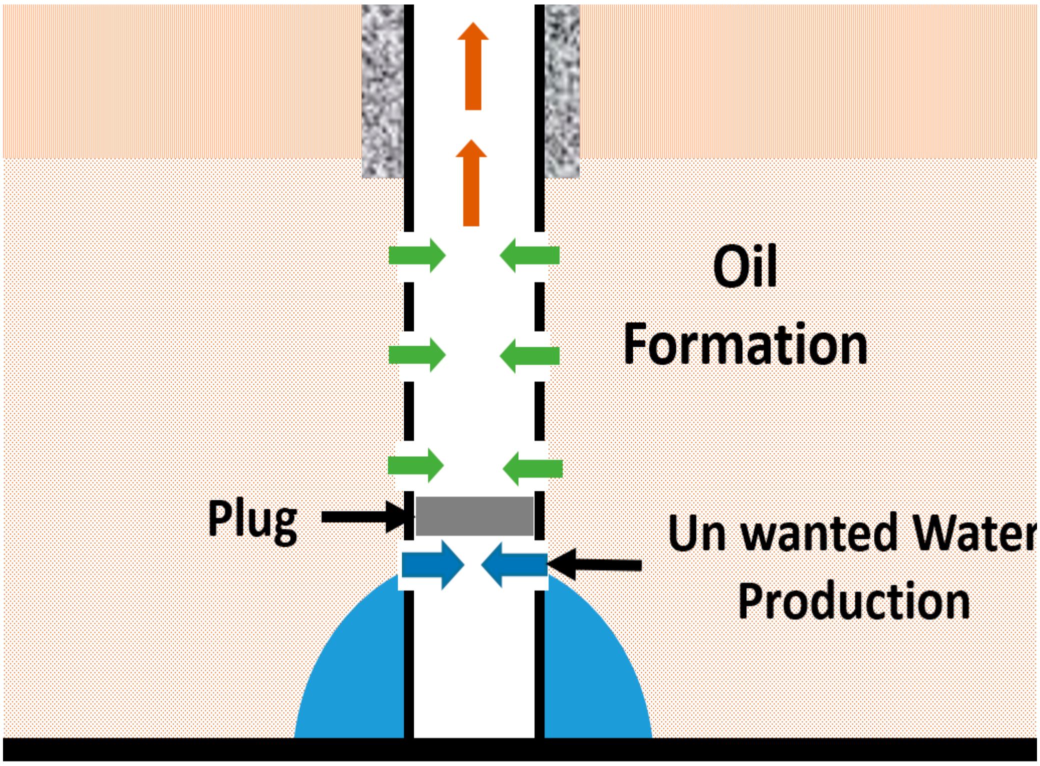
1. Mechanical Water Shut Off:
2. Cement-squeeze, packer or plug.
3. Chemical Water Shut Off:
4. Polymer or gel injection.

2.4.1 Mechanical Method:

In many near wellbore problems, such as casing leaks flow behind casing, rising bottom water and watered out layers without crossflow, and in the case of bottom water beginning to dominate the fluid production, the perforations are sealed-off with a cement-squeeze, packer or plug.(Bedaiwi *et al.*, 2009).

2.4.1.1 Plugs and Packers:

One of the most well-known mechanical solutions for water shut off. simply the concept of packers and plugs is a small diameter element, mainly rubber, which can expand down hole the wellbore into larger diameters, creating a seal and isolating the well from unwanted features or zones, it can be installed without pulling the production tubing and without the drilling rig also can be installed by using coiled tubing which can run them through the wellbore.(Taha and Amani, 2019).



Figure(2.9) plug shut off the production of water from the bottom(Taha and Amani, 2019).

2.4.1.2 Squeeze Cement:

Squeeze cementing, sometimes referred to as remedial cementing, is the process of using pump pressure to inject or squeeze cement into a problematic void space at a desired location in the well. Squeeze cementing operations may be performed at any time during the life of the well: drilling, completions or producing phases.

2.4.2 Chemical Methods:

Chemical treatments require accurate fluid placement, and including polymer and gel injection , also can combined between them as means of improving flooding efficiency are needed to reduce water production and improve oil recovery(ELbedawi.2001).

2.4.2.1 Gel:

Gel injection is one of the most famous chemical solutions for water shut off operations. It is used to reduce the water oil ratio and increase the conformance of the pattern. That happens through the ability of the gel to reduce the permeability and block the open fractures, and high permeability water zones(Taha and Amani, 2019) It is very effective in reducing the permeability of unwanted zones and has proven its ability to improve the sweep efficiency and shutting-off the unwater water zones.

2.4.2.2 Polymer Flooding:

Another common technique for water shutoff operations is the usage of the polymer flooding method. This technique is applied to increase the viscosity of the drive fluid (water) which helps in mobilizing and displacing the oil in the reservoir matrix. It can be prepared by dissolving the polymers in the injected water and inject it through injection wells (Taha and Amani, 2019).

2.4.2.2.1 The Components of Chemical Slurry:

- Type of gel polymer
- Type of crosslinking agent
- Fluid used to mix the gel

2.4.2.2.2 Main Requirements:

1- Hydro Wave Generator
2- Mixing tank
3- Mud pump
4- Packer
5- Jet pump

2.4.2.2.3 Summary of Operation:

1- Circulate the well utilizing Hydro Wave Generator to enhance the infectivity of targeted zone

2- Inject 27 m³ of Gel into the formation using mud pump.

3- Inject 9 m³ of crude oil to displace the chemical slurry into the formation.

4- Shut in the well for 36 hours as set up time.

5- Flow back the well using Jet Pump to test the formation fluid.

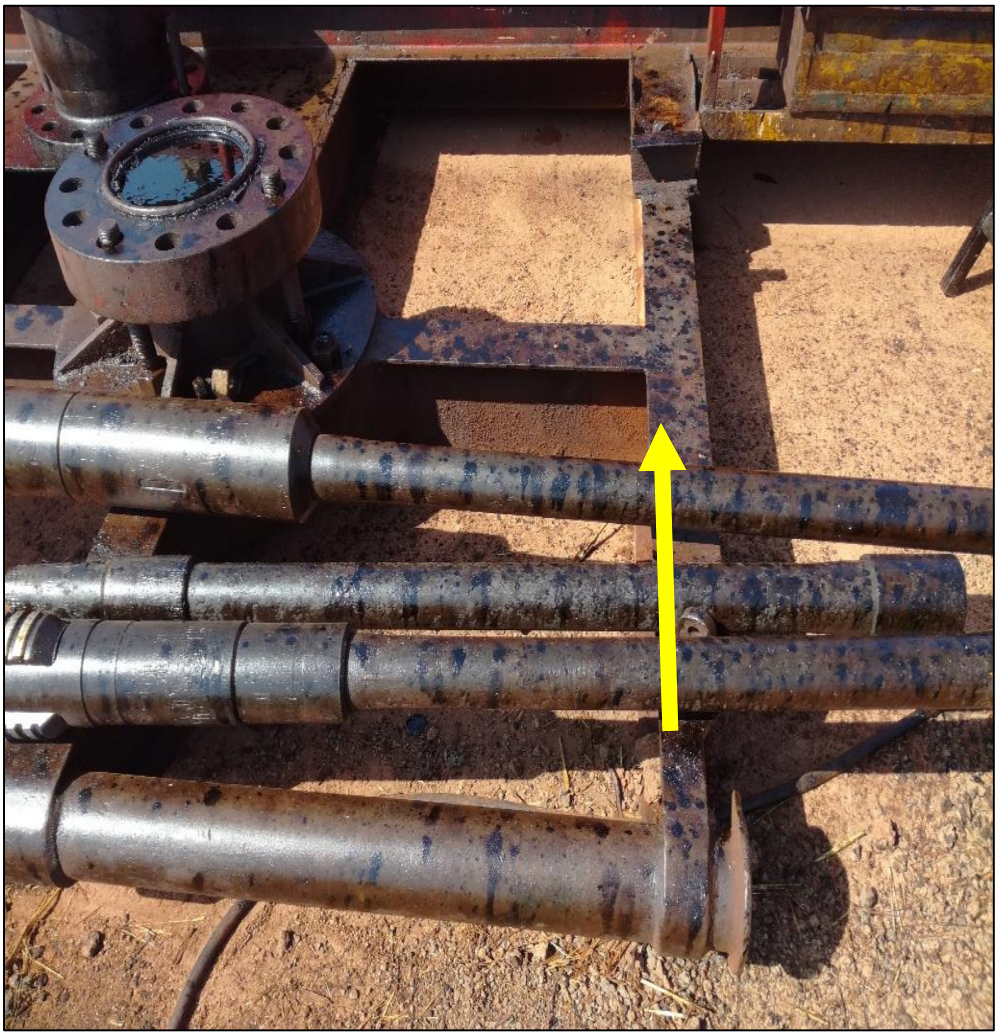


Figure (2.10): Hydro Dynamic Wave Generator

Figure (2.11) Flow Jet Pump

Figure (2.12) Polymer Gel Slurry

Chapter 3

Methodology

3.1 Introduction

Here In this project we draw deferent charts and evaluate chemical water shutoff (CWSO) by using type of petroleum software called Oil Field Manager software (OFM) 2014.1 Version (Schlumberger 2014.1).

OFM software is a powerful suite of modules developed by Schlumberger Information Solutions, designed to aid in the day-to-day surveillance and management of oil and gas fields. use to modify, analyze production and reservoir data, develop new analysis methods and connect to any data source. In addition, it can improve oil and gas field performance throughout the entire life cycle. And providing users with the greatest flexibility for engineers to build customized workflows. we can perform basic and complex analyses for individual or multiple completions, groups of wells, an entire field, or several fields. this software enables us to access or load data from both a local desktop and corporate repositories.

((https://www.software.slb.com/products/ofm/ofm-2014.1))

3.2. Required data:

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- Master (header) data. It includes:
  - Coordinate for each well (X-Y) access.
  - Block\field\wells name.
  - Reservoir\well depth.
- Daily\monthly production data.

3.3 Process:

1. prepared and arrangement the master and daily\monthly production data in excel sheet.
2. Loading the data in the software.

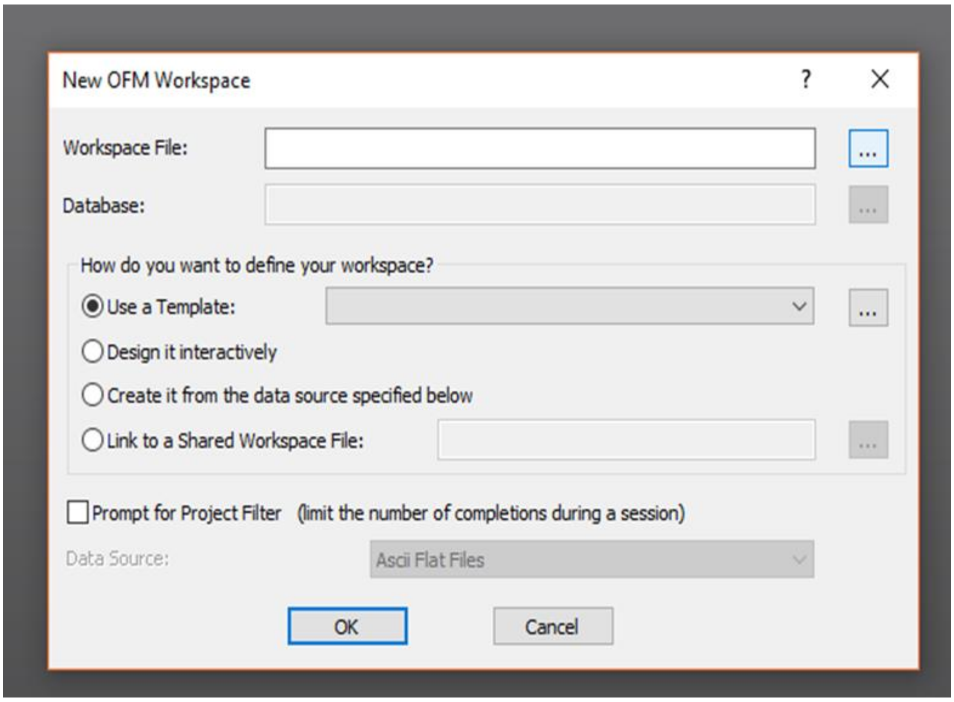


Figure (3.1): Select the design

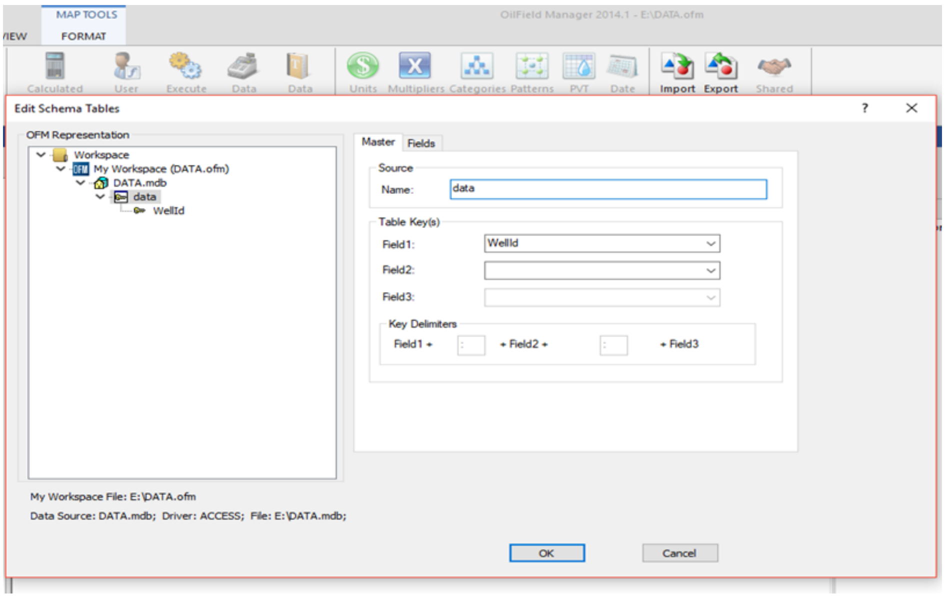


Figure (3.2): Workspace and database files have the same name

3. adding the variables that help us to draw and plot the charts.

Table(3.1): The required variables

Calculated Variable	**Equation**
Freq.Monthly	@Change(@Month(Date))
Prod Days	@ClrTSum(Dailyproduction.Uptime ,Freq.Month)/24
WOR	@If(Dailyproduction.Oil > 0 ,Dailyproduction.Water / Dailyproduction.Oil ,@Null( ))
W.C	@If(Dailyproduction.Fluid > 0 ,Dailyproduction.Water / Dailyproduction.Fluid ,@Null( ))
Monthly Oil	@ClrTSum(Dailyproduction.Oil ,Freq.Month)
Monthly water	@ClrTSum(Dailyproduction.Water ,Freq.Month)
Monthly Oil Rate	@If(Prod_Days > 0 ,Monthly.Oil / Prod_Days ,@Null( ))
Monthly water rate	@If(Prod_Days > 0 ,Monthly.Water / Prod_Days ,@Null( ))
Monthly fluid rate	Monthly.Oil_Rate + Monthly.Water_Rate
D.WOR	@ABS((Cum.Water-@PREVIOUS(Cum.Water))/(Cum.Oil - @Previous(Cum.Oil))/(Days - @Previous(Days)))
Days	@ElapsedDays(Date, @first(Date))
Cum. Water	@CumInput(Dailyproduction.Water)
Cum. Oil	@CumInput(Dailyproduction.Oil)
Cum. Fluid	Cum.Oil + Cum.Water
Fit, dWOR	@FIT(Days,dWOR,dWOR>0,@daily(Days),"deg 2 opt ylog")
Fit, WOR	@Fit(Days ,WOR , WOR>@null(),@daily(Days),"deg 2 opt ylog")

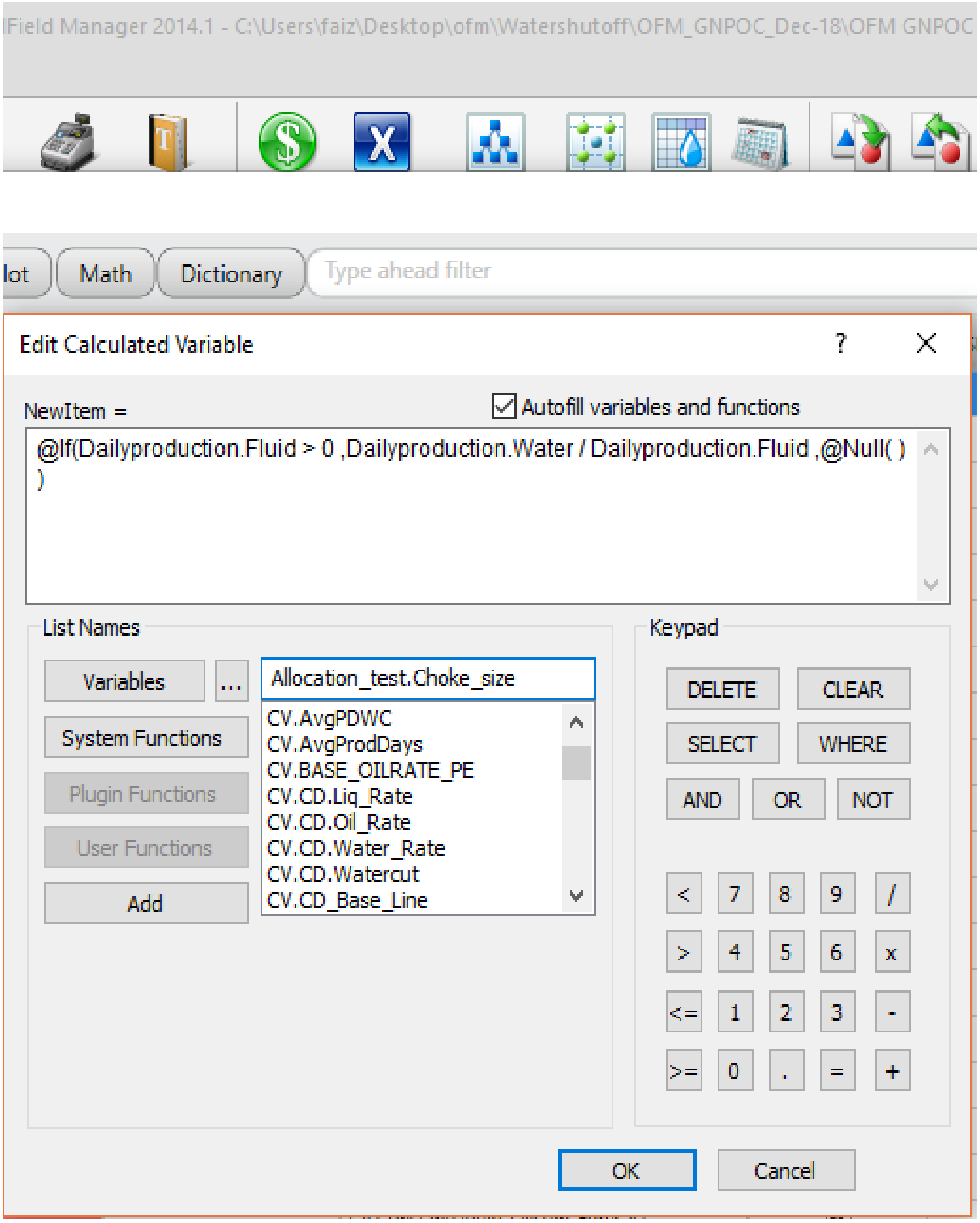


Figure (3.3): calculating the variable

4. select the plot window in OFM and add the variables to draw the performance plot for all wells.

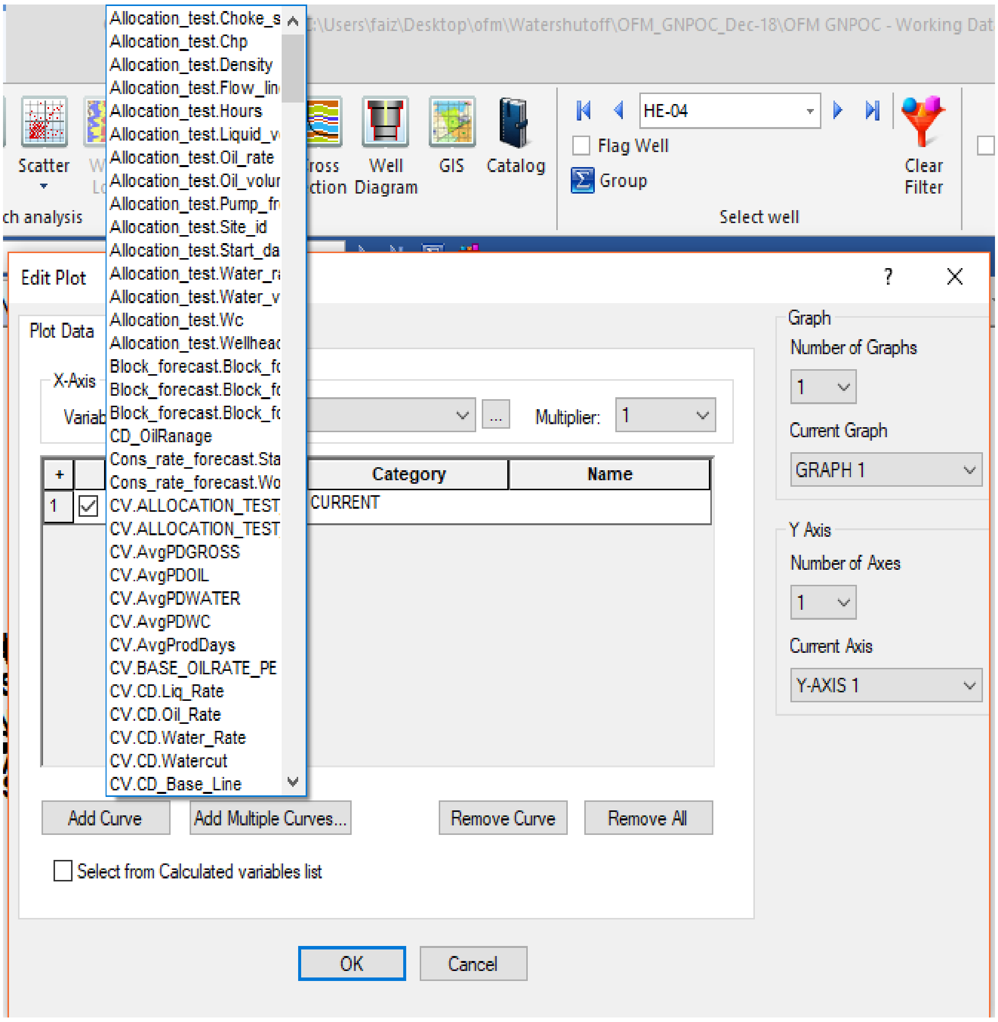


Figure (3.4): the requires variable to draw the plot

Chapter 4

Results and Discuss

4.1 Introduction:

The current stage of the study presents the result analysis of field data and the diagnostic results: also, the screening criteria for selecting the candidate wells for analyze was presented. The complicated situation in the field lead to many unexpected production performances; it was observed that the water cut in the field has a very complicated history.

The wells in Heglig and Toma Oil Fields is polymer injection wells as water shut-off job, analysis of the production data presented that polymer Injection has a good effect in reducing water cut in some wells; the overall water cut of the field also decreased from 94.5 % to 30.

Field production performance was analyzed using Shallenberger Advocate package software OFM combined with normal production analysis tools, (the oil production, Water cut, liquid production) was cross-plotted with time to present the performance analysis.

Table(4.1): The master data

ALIAS	BLOCKNAME	EASTING_X	FPF_NAME	GEO_FIELD	LONG_NAME	NORTHING_Y	OGM_NAME
HE-04	Block 2B	763189.11	FPF Heglig	Heglig Main	HEGLIG-4	1106851.35	
HE-38	Block 2B	763969.11	FPF_Heglig	Heglig Main	HEGLIG-38	1104299.98	OGM30G_Heglig
TO-02	Block 2B	770380.65	FPF_Heglig	Toma	TOMA-2	1105388.65	OGM30B_Heglig
TO-03	Block 2B	770820.32	FPF_Heglig	Toma	TOMA-3	1102930.38	OGM30B_Heglig

Table (4.2): The monthly production data for HE-04

ALIAS	Date	ALLOCATED_OIL	ESTIMATED_OIL	ALLOCATEDWATER	ESTIMATEDWATER	PROD_DAYS
HE-04	31-Dec-18	9927.2698	10671.5881	1078.5995	167.8003	31
HE-04	30-Nov-18	9597.9217	10373.0766	974.8068	150.5361	30
HE-04	31-Oct-18	10205.6424	11013.8597	862.5575	131.8005	31
HE-04	30-Sep-18	9877.6589	10526.4039	826.1184	125.9672	29.8771
HE-04	31-Aug-18	10436.514	10830.7798	855.3726	129.6096	31
HE-04	31-Jul-18	10479.424	10634.3236	826.9043	125.3446	30.9791
HE-04	30-Jun-18	10375.8152	10526.167	715.2582	106.8208	30
HE-04	31-May-18	10785.3453	10837.4678	822.4759	109.9799	30.8534
HE-04	30-Apr-18	10498.8019	10617.464	789.2612	107.7473	29.9562

Table (4.3): daily production for HE-38

ALIAS	Date	ALLOCATED_OIL	ESTIMATED_OIL	ALLOCATEDWATER	ESTIMATEDWATER	PROD_DAYS
HE-38	31-Dec-18	2291.5514	2463.3653	50.673	7.8833	31
HE-38	30-Nov-18	2220.4485	2399.7781	35.0802	5.4173	29.3235
HE-38	31-Oct-18	2464.8328	2660.0308	39.2981	6.0048	31
HE-38	30-Sep-18	2422.2632	2581.3526	38.216	5.8272	29.6826
HE-38	31-Aug-18	2576.364	2673.6927	39.833	6.0356	30.7443
HE-38	31-Jul-18	2542.2568	2579.8347	38.4197	5.8237	29.6651
HE-38	30-Jun-18	2578.8925	2616.2622	39.5459	5.906	29.7166
HE-38	31-May-18	2637.108	2649.8524	44.7347	5.9818	29.8608
HE-38	30-Apr-18	2547.3707	2576.1622	54.1395	7.3909	29.6944
HE-38	31-Mar-18	2529.1042	2626.1294	73.253	10.2669	30.5068

Table (4.4): daily production for TO-02

ALIAS	Date	ALLOCATED_OIL	ESTIMATED_OIL	ALLOCATEDWATER	ESTIMATEDWATER	PROD_DAYS
TO-02	31-Dec-18	831.8042	894.1705	29546.1492	4596.564	30.9227
TO-02	30-Nov-18	771.9197	834.262	27771.113	4288.5989	29.3368
TO-02	31-Oct-18	956.6446	1032.4043	29458.684	4501.3461	30.9639
TO-02	30-Sep-18	997.1421	1062.6324	28483.0971	4343.1269	29.8771
TO-02	31-Aug-18	1107.3568	1149.19	29694.4678	4499.4299	31
TO-02	31-Jul-18	1252.0855	1270.593	28281.948	4287.0622	30.3025
TO-02	30-Jun-18	1257.2541	1275.4725	28748.6784	4293.4965	30
TO-02	31-May-18	1339.3364	1345.8091	33185.3184	4437.4807	31
TO-02	30-Apr-18	1277.5019	1291.9408	31203.964	4259.863	30
TO-02	31-Mar-18	1297.5038	1347.2805	31509.7334	4416.3076	30.9659

Table (4.5): daily production for TO-03

ALIAS	Date	ALLOCATED_OIL	ESTIMATED_OIL	ALLOCATEDWATER	ESTIMATEDWATER	PROD_DAY
TO-03	31-Dec-18	752.1475	808.5414	11744.4145	1827.1062	30.9284
TO-03	30-Nov-18	911.1366	984.7225	11253.5151	1737.8422	30
TO-03	31-Oct-18	1218.1002	1314.5654	10847.0865	1657.4566	30.9653
TO-03	30-Sep-18	1327.2278	1414.3975	10516.3632	1603.544	29.9714
TO-03	31-Aug-18	1518.0083	1575.355	10591.1056	1604.8086	30.8971
TO-03	31-Jul-18	1435.6032	1456.8233	10520.3788	1594.7104	30.9537
TO-03	30-Jun-18	1344.6902	1364.1755	10649.7872	1590.5018	30
TO-03	31-May-18	1540.8026	1548.2489	12129.2973	1621.9076	31
TO-03	30-Apr-18	1604.4296	1622.5635	11607.7686	1584.6545	30

4.1. Well HE-04:

Well HE-04 is a vertical well located in Heglig Oil Field, started production on Jun1999 from zones (Aradeiba F, Bentiu-1, Bentiu-.2 Bentiu-3A)

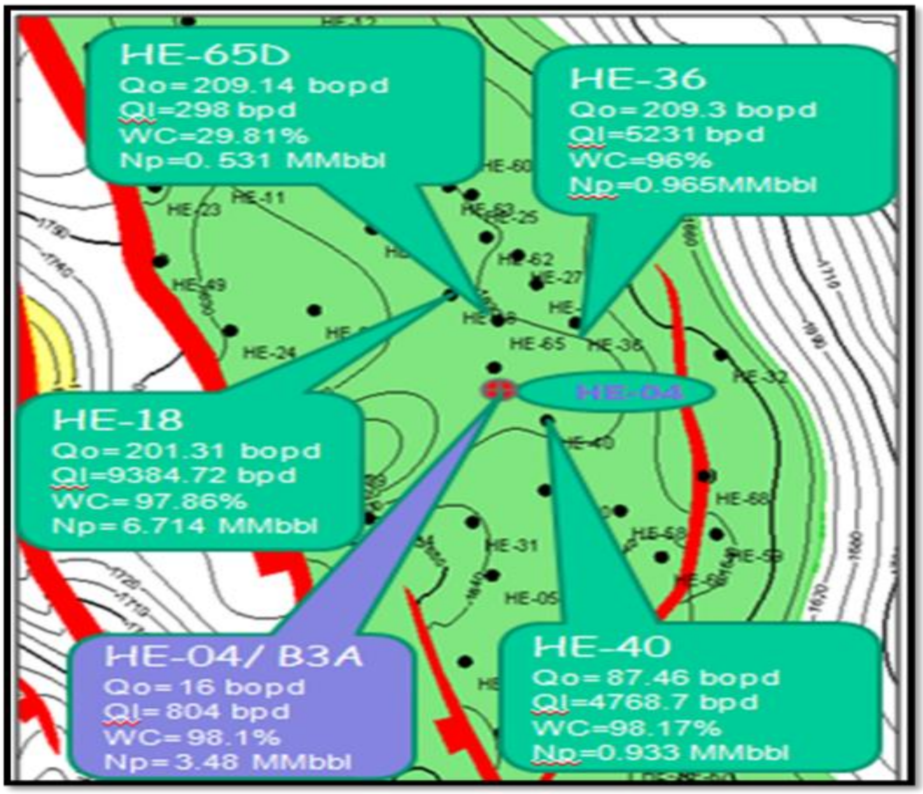


Figure (4.1): HE-04 location Profile

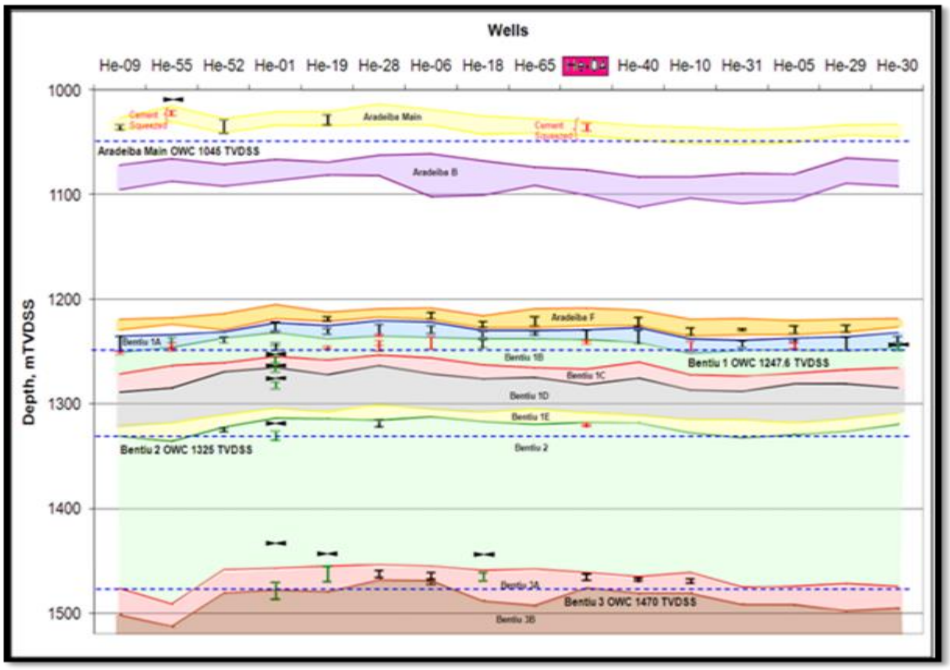


Figure (4.2): HE-04 well production layers Profile

HE-04 shown good injectivity & total planned chemical volume injected Performance plot of (Bentiu-3A , Bentiu-1A) refers to the fig (), The figure presented that in 2013 CWSO job increase the water cut up to 20% and produce oil decrease gradually,. In 2014 the zone (Bentiu-3A) was isolated and well continuous production from zone (Bentiu-1A) which lead to decrease water cut and increase oil production, total liquid rate decreased from 10,700 to 1000 bbl/day, that made the CWSO in this well is failure.

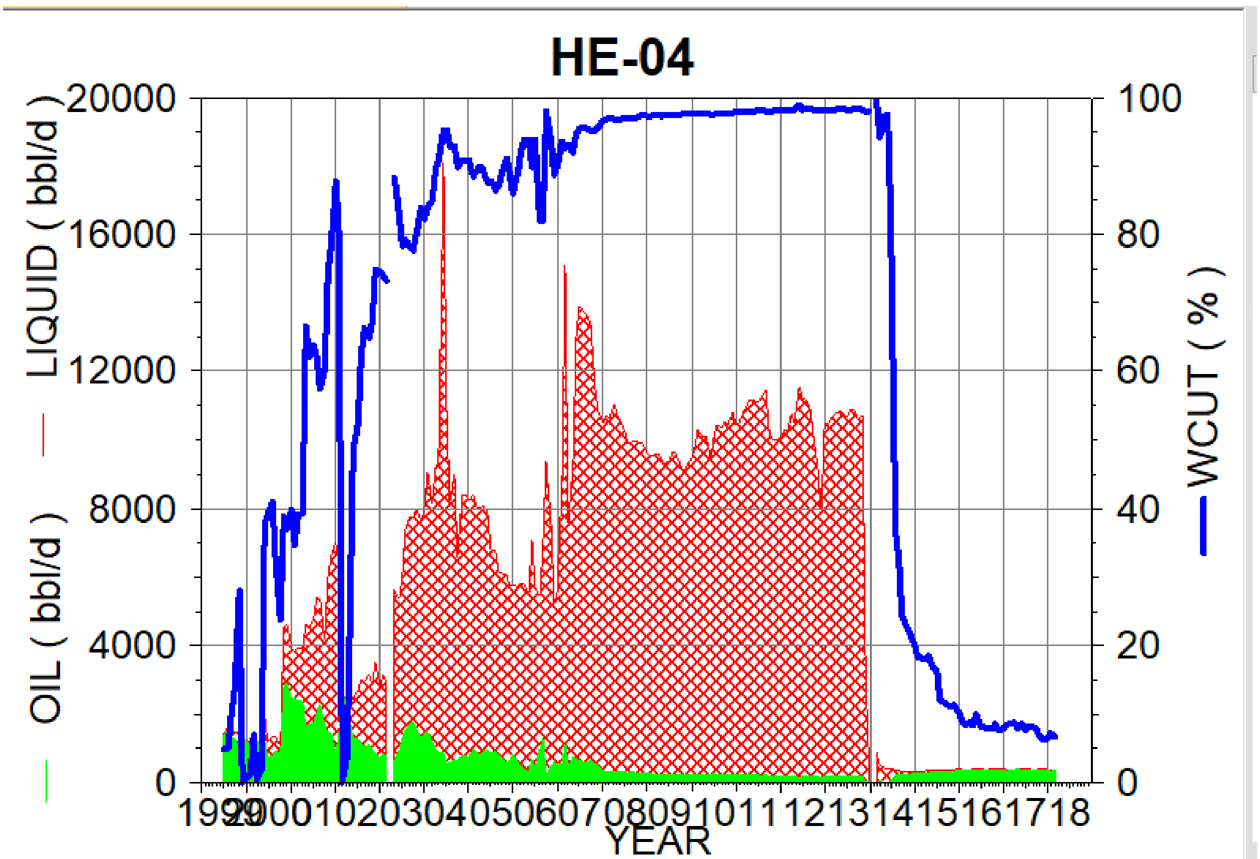


Figure (4-3) HE-04 well Performance Profile.

4.2. Well HE-38:

Well HE-38 is a vertical well located in Heglig Oil Field, started production on Jun-1999 from zones (Aradeiba F, Bentiu-1, Bentiu-2, Bentiu-3A).

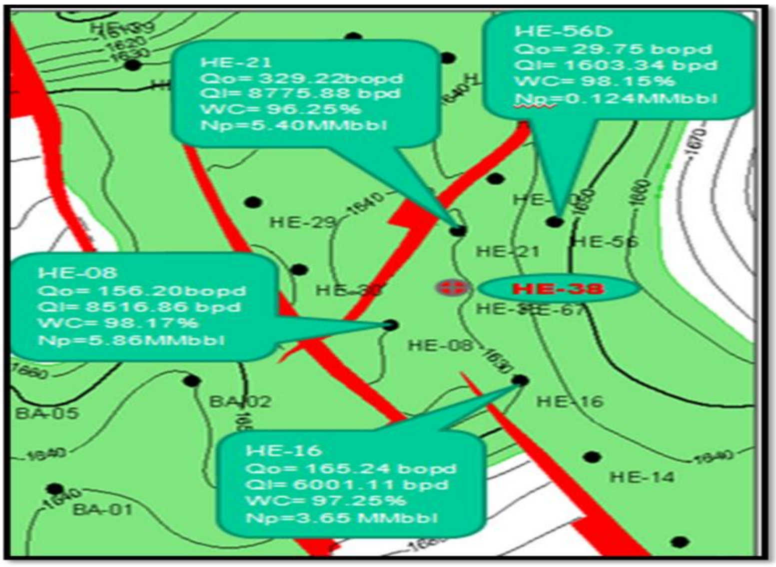


Figure (4-4) HE-38 well location Profile

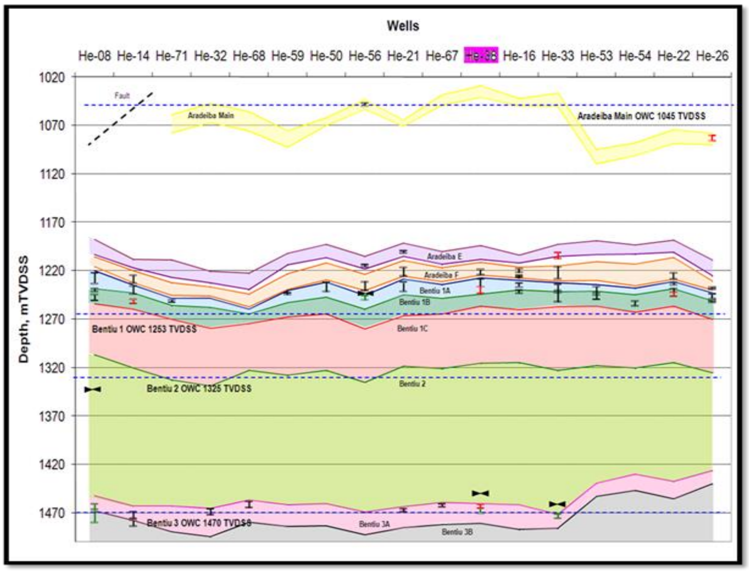


Figure (4-5) HE- 38well production layers Profile

The well started produce in 2005 from zone (Aradeiba F, Bentiu-1, Bentiu-2, and Bentiu-3A) with high water cut up to 90%.

In 2010 recompletion and isolate (Bentiu-3A) and lower part of (Bentiu-1A) lead to reduce water cut and increase in oil production.

In 2012 after chemical water shut-off implemented in B3A the w/c decreased to 44 % for two months, after six months the average water production increase gradually to average of 74%, but the oil produce increase, depended on it the job is successful, but not effective.

In 2015 additional work in HE-38 to reduce water cut it was cement the zone (Bentiu-3A) and re-perforated with different interval that make water cut reduce to 2%.

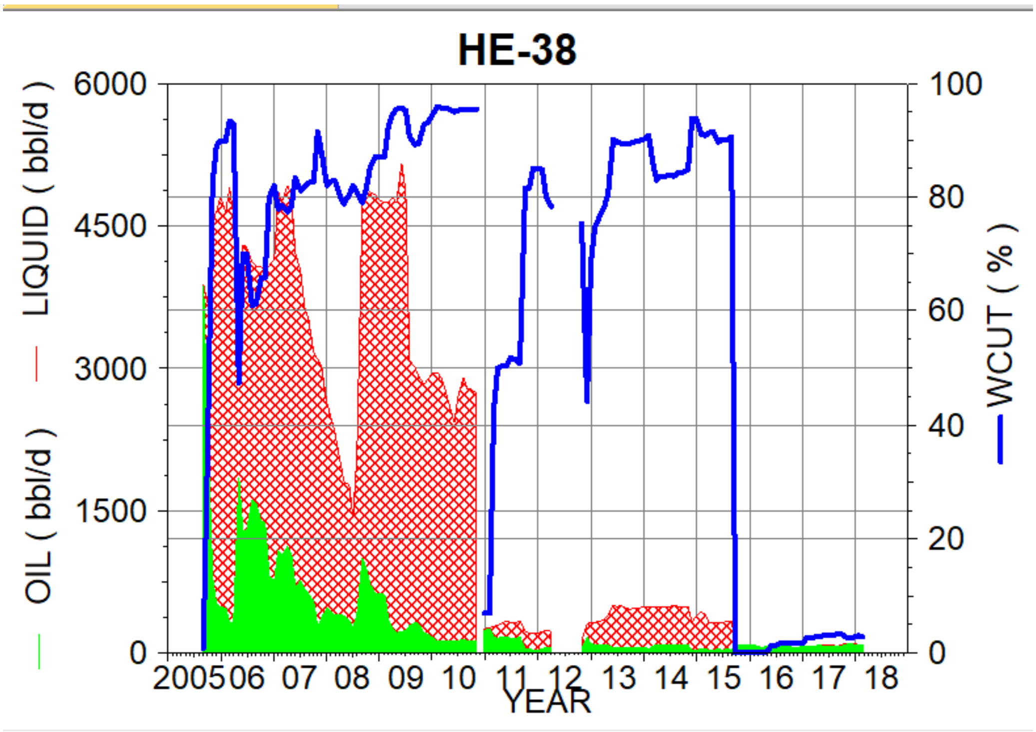
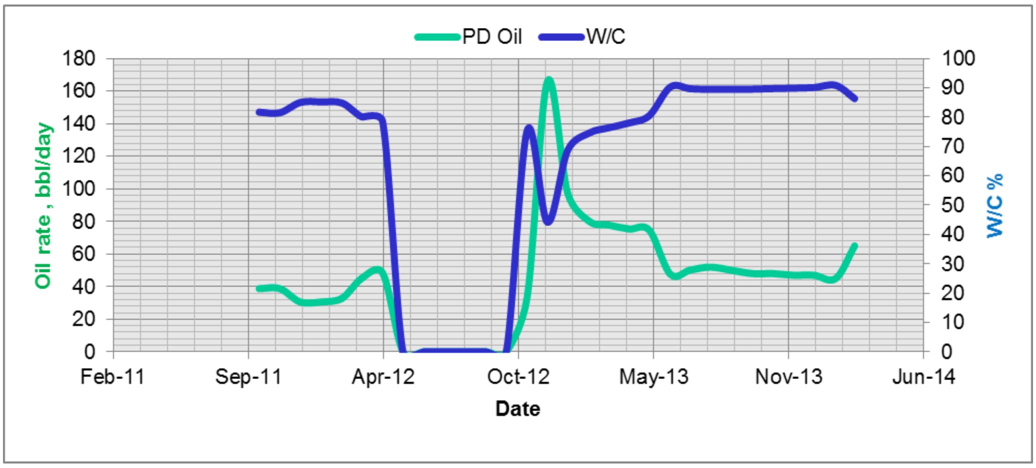


Figure (4-6) HE-38 well Performance Profile.



Figure(4-7) HE-38 Production performance analysis Profile.

4.3. Well TO-02:

Well TO-02 is a vertical well located in Toma Oil Field, started production on Jun-1999 from zones (Aradeiba F, Bentiu-1, Bentiu-2, Bentiu-3A).

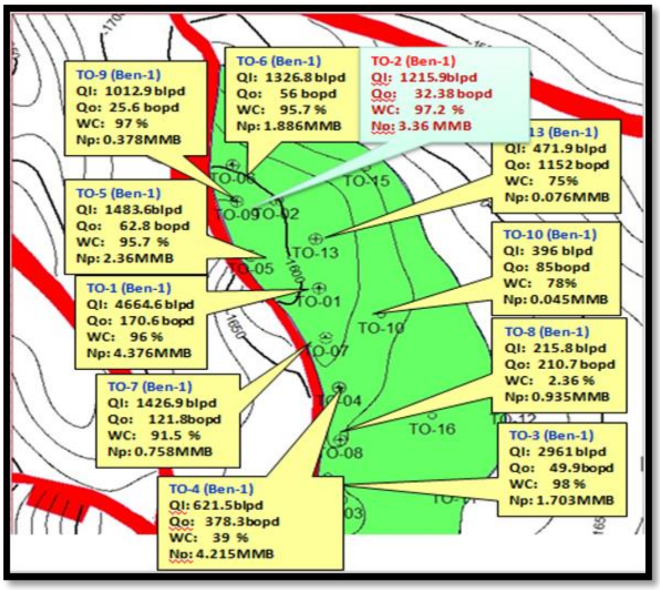
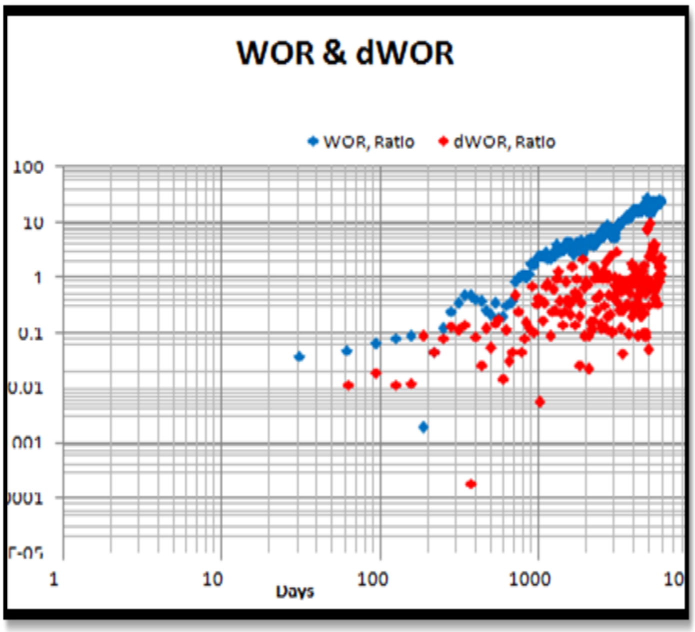


Figure (4-8) TO-02 well location Profile



Figure(4-9) TO- 02 Diagnostic plot

Based on the WOR & dWOR in log – log plot above which reflect well production behavior and compared with Chan Type curves the well suffering from one of the bellow:

- Near wellbore water channeling.
- Normal displacement with high WOR.

In 2014 TO-02 during the job shown positive results W/C reach zero,To-02 appeared good performance after commissioning ,initial production after treatment start with low water cut around 20% with high oil rate around 432 bbl//day & the liquid rate reduced comparing with well production before job implementation , after one month w/c started to increase rabidly even after reduce Pump frequency & choke to the minimum value ,total liquid continue increasing that reflect mature channeling and lead to increase water production , Last well test result W/C 88% & oil rate 63 bopd ,depending on production oil the job is successful.

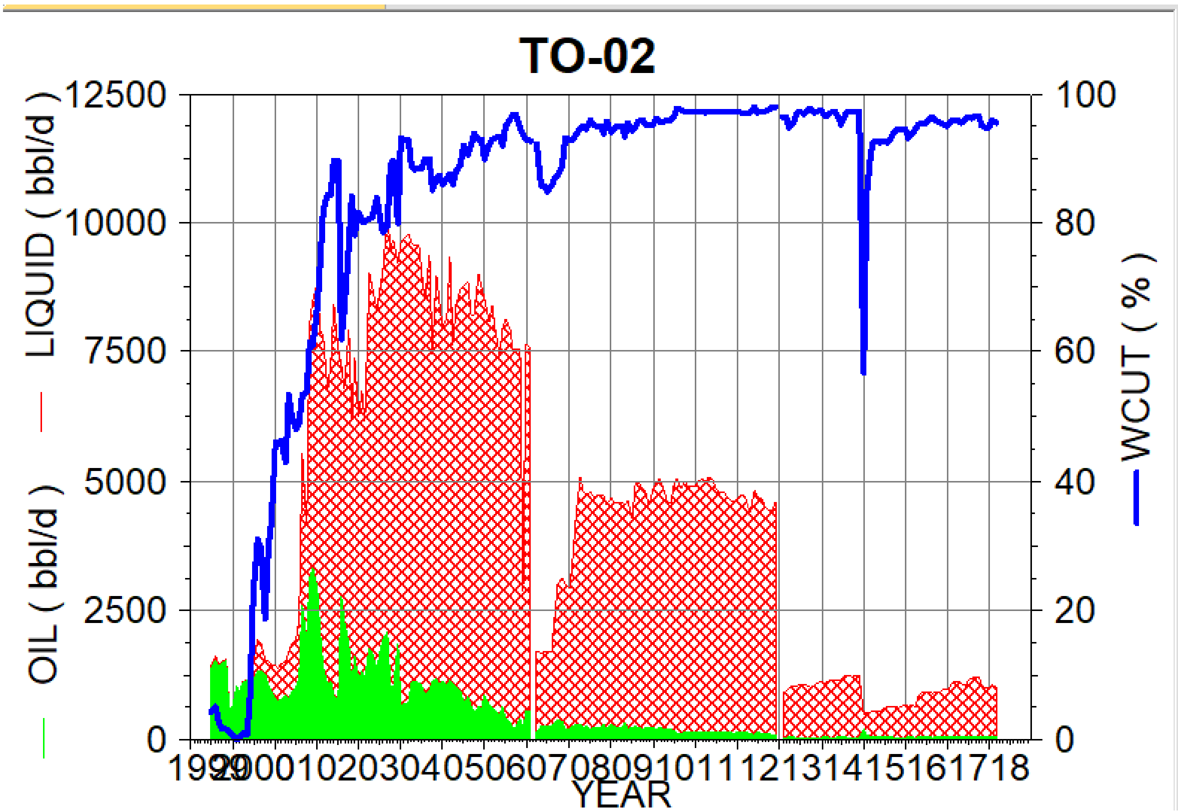


Figure (4-10) TO-02 Production Performance Analysis

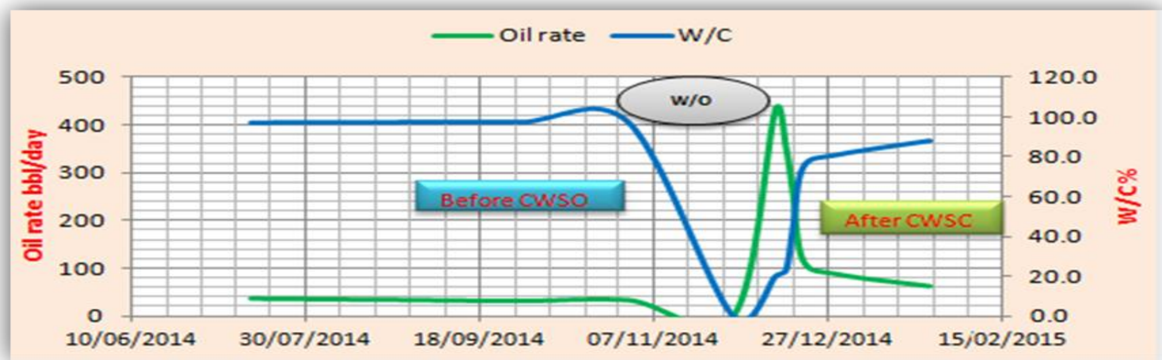


Figure (4-11) TO-02 Production Performance Analysis Profile.

4.4. Well TO-03:

Well TO-03 is a vertical well located in Toma Oil Field, started production on Jun-1999 from zones (Aradeiba F, Bentiu-1, Bentiu-2, Bentiu-3A).

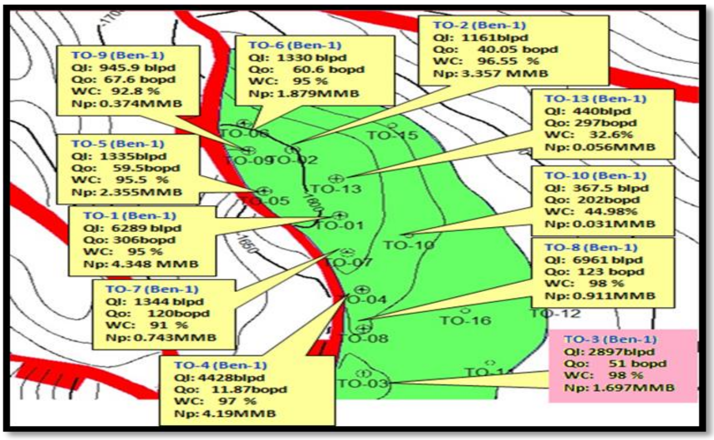
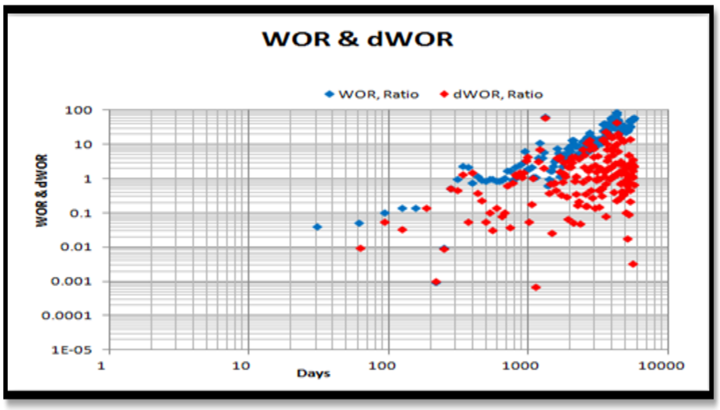


Figure (4-12) To-03 location Profile



Figure(4-13)To-03Well Diagnostic plot

Base on the WOR & dWOR in log – log plot above which reflect well production behavior and compared with Chan Type curves the well suffering from one of the bellow:-

- Multi-layers channeling with production changes.
- Near wellbore water channeling.
- Normal displacement with high WOR

In 2014 TO-03 initial production after treatment start with high water cut around 84% with low oil rate around 2 bbl//day , but the total liquid rate reduced comparing with well production before job implementation (3000-370) blpd with passage of time and closed monitoring by frequent w/c testing the well start to show good performance especially in water cut reduction after two month reach 76% and oil rate around 85 bopd, depended on this result the job is successful.

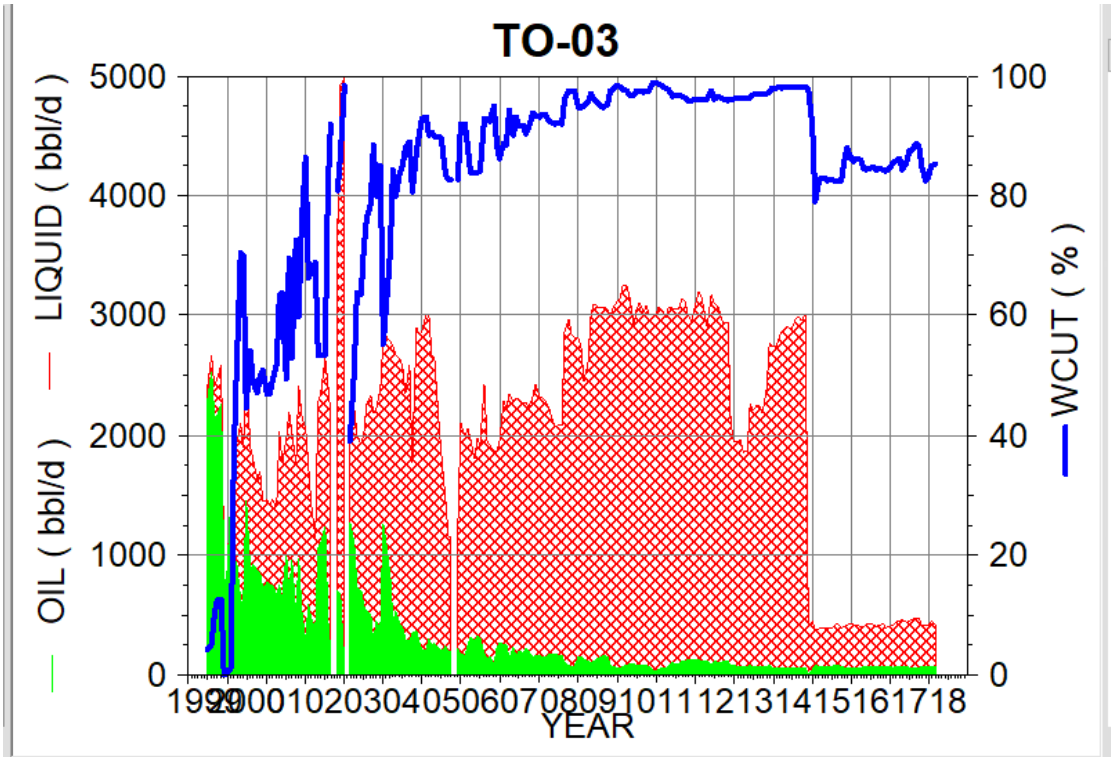


Figure (4-14) To-03 Production Performance Analysis

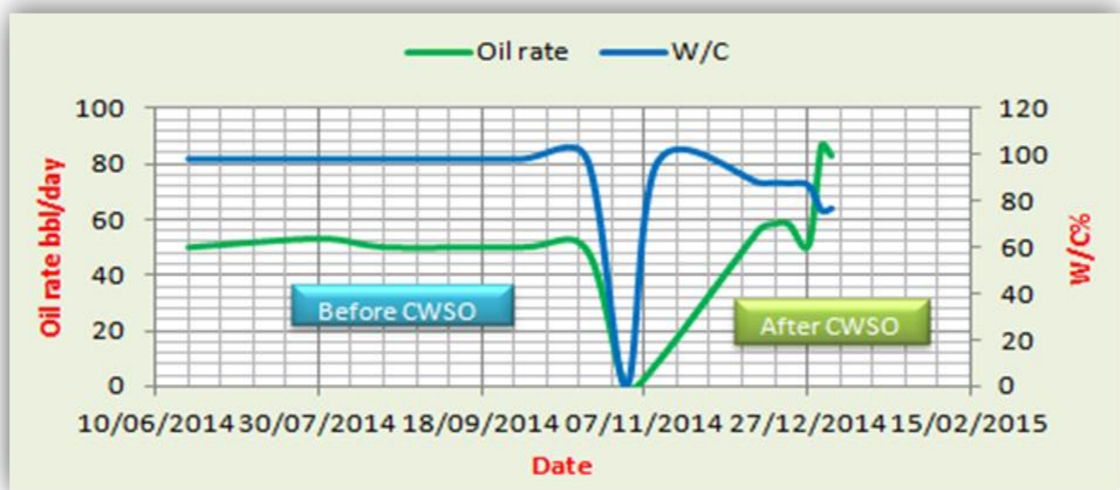


Figure (4-15): T0-03 Production Performance Analysis Profile.

CHAPTER 5

Conclusion and Recommendation

5.1. Conclusions

- Polymer/gel is one chemical water shut-off methods and used for sandstone and carbonate formations.
- HE-04 the water cut after job increase up to 20% and oil produce decreased gradually and total liquid rate decreased from 10,700 to 1000 bbl/day. So depend on the oil production is decreased to may that the job has failure in this well.
- HE-38 after water shut-off in B3A the water cut decreased to 44% for two month after six month water production increase gradually to average 74% but the oil produce increase.
- TO-02 initial production after treatment start with low water cut with high oil rate and the liquid rate reduced comparing with well production before job.
- TO-03 after water shut-off start with high water cut 84% and low oil rate 2bbl/day and total liquid reduced comparing before job (3000-370) After two month the water cut reach 76% and oil rate around 85 bopd.

5.2. Recommendation

1. The Injectivity test is necessary to be calculated early in order to avert exceeding fracture pressure and simultaneously to avoid chemical (Polymer) losing into formation.

2.Through our evaluation that this method failed in well (HE-04), so they have to review the properties of the polymer that were injected inside the wells, which may not match the well specification.

3. in HE-38 after six month the water cut increased from 44% to 76% and additional work (cement the zone –bentiu-3A) water cut reduce to 2%. so that from result of cement comparing with water shut-off the cement is good than the water shut-off if water cut increased in future, recompletion by cement again in this well.

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