

# Study of Secondary Oil Recovery in Buzurganoil Field South Eastern of Iraq by Water Injection

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## Abstract

Oil & gas are one of the most important sources of energy during the past decade until now and even in the future. Some of the oil and gas produced by natural forces in the reservoirs (primary recovery), this quantity still a small percentage comparing with the enormous amounts of oil & gas discovered, so it is necessary now to develop new techniques to produce the maximum amount of oil & gas and to strengthen the reservoir pressure. These methods named enhanced oil recovery (EOR). In this research we will study one of these methods which is water injection. The aim of this research is to study the possibility of using water injection technique For Mishrif reservoir on Buzurgan oil field.

We assumed three cases :

1- The first case we did nothing and the recovery was 4.8%.

2- The second case we add 20 production wells and the recovery will become 7.08%.

3- The third case we add 20 production wells & 10 as injection wells (this case is the best due to increase in oil recovery to 17.1%)

**Key Words :** secondary oil recovery, Water injection, Buzurgan oil Field, Iraq.

## I. INTRODUCTION

### 1.1 Background

Recuperation of hydrocarbons from an oil repository is regularly perceived to happen in a few recuperation stages. These are essential recuperation, Secondary recuperation and Tertiary recuperation. Essential recuperation alludes to utilizing the vitality contained in the repository, when it is first found, as the sole wellspring of vitality for creation of oil and gas from a supply Recovery from oil repositories under essential exhaustion have diverse range anyplace from basically nil to in overabundance of 60%. there is often a large volume of oil remaining in an oil reservoir after the completion of the primary recovery stage, there can be a large beneficial impact of imp lamenting an enhanced recovery process in an oil reservoir also in the other hand primary recovery refers to the amount of hydrocarbons that can be recovered by naturally

occurring energy in the reservoir. When a new reservoir is first discovered, the reservoir rock and fluids are under considerable pressure caused by: Hydrostatic weight, Solution gas drive, Gas top development, Natural water (spring) drive, Gravity waste and Compaction. The inexact oil recuperation run is organized underneath for different driving instruments, Table(1).

**Table ( 1): The approximate oil recovery for various driving mechanism.**

| Driving Mechanism         | Oil Recovery Ranges |
|---------------------------|---------------------|
| Rock and liquid expansion | 3-7                 |
| Solution gap              | 5-30                |
| Gas cap                   | 20-40               |
| Water drive               | 35-75               |
| Gravity drainage          | <80                 |
| Combination drive         | 30-60               |

### 1.2 Water injection

In the oil business, water flooding or water infusion is the place water is infused into the oil field, for the

most part to expand pressure and along these lines invigorate creation. Water infusion wells can be discovered both on- and seaward, to build oil recuperation from a current repository.

### **1.2.1 water infusion may likewise be utilized so as to:**

- Reservoir pressure Maintenance
- Dispose of brackish water as well as delivered development water
- As a water drive to dislodge oil from the injector wells to the maker wells.

### **1.2.2 Injection water source :**

- Produced arrangement water(s)
- Surface water sources (lakes, waterways, sea, and so on.)
- Shallow groundwater (consumable)
- Deeper 'wet' arrangements which go about as water sources

### **1.2.3 Common water quality issues :**

Water quality issues can be partitioned into various classes for assessment purposes:

- Ionic creation
- Chemical contaminants
- Suspended solids
- Scale and encourage potential
- Oil/oil/hydrocarbon content
- Non-condensable gas content
- Bacterial substance

### **1.3 Aims and Objectives:**

1. Building a 3D geological and Petrophysical models

2. Calculation of oil in-place for Mishrif formation using petrel software

3. Build dynamic model and see the reservoir behavior with time.

4. Make history matching for reservoir production and pressure.

5. Make some development planning for the reservoir

### **1.4 Area of study**

Name: Maysan Oil Fields (see figure 1).

Controlled by: Ministry of Oil (Baghdad).

Location: A complex of fields located around 175 kilometers (km) north of Basra city, close to the border with Iran, including the Abu Ghirab, Jabal Fauqi (Fakka) and Buzurgan oil fields.

Reserves: 2.5 billion barrels of oil

Developed by: China National Offshore Oil Corporation (CNOOC) (63.75%), Türkiye Petrolleri Anonim Ortaklığı (TPAO) (11.25%), Iraq Drilling Company (25%)

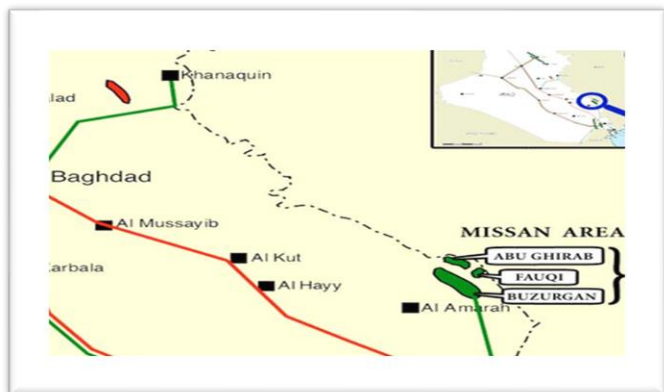
Contract granted: May 2010

Remuneration: \$2.30 per barrel of oil

Production started: 1976.

Plateau production target: 450,000 bpd.

A full list of oil and gas fields controlled by the Ministry of Oil in Baghdad can be found here.



**Fig (1):The Study Area**

## II. SIMULATION

### 2.1 Geological model

A static supply concentrate normally includes three fundamental stages, did by specialists in the different orders, fig,(2).

**Structural Modeling:** Reconstructing the geometrical and basic properties of the supply, by characterizing a guide with auxiliary tops and the arrangement of existing deficiencies. This phase of the work is completed by coordinating translations of geophysical studies with the accessible well information.

**Stratigraphic Modeling:** Defining a stratigraphic conspire utilizing admirably information shapes the reason for well-to-well relationships. The information utilized in this stage regularly comprise of electrical, acoustic and radioactive logs recorded in the wells, and accessible centers, coordinated where conceivable with data from experts' investigations and creation information.

**Petro physical Modeling:** Defining a quantitative translation of well logs to decide a portion of the primary petro physical attributes of the supply rock, for example, porosity, penetrability, and water immersion.

The aftereffects of these stages are incorporated in a two-dimensional (2D) or three-dimensional (3D) setting, to construct what we may call a coordinated land model of the supply. This model spoke to the

reference outline for figuring the amount of hydrocarbons set up, and shapes the reason for the instatement of the dynamic model. In this investigation, it shapes the reason for the introduction of the dynamic model and estimating oil set up.

### 2.2 Structural Model

The development of a basic store model fundamentally includes the meaning of the guide of the structure top, and deciphering the arrangement of issues going through the repository assuming any. The meaning of the store's top includes distinguishing the essential geometrical structure of the hydrocarbon trap. The structure of Buzergan Oil Field is associated to the shape guide of Mishrif Formation highest points of wells (bU-1, bU-2, bU-3, bU-4, bU-5, bU-6, bU-7, bU-8, bU-9, bU-10, bU-11, bU-12, bU-13, bU-14, and bU-16) . The 3D structural reservoir model and the structural contour maps for each unit (B-1, B-2, B-3, B-4, B-5, B-6, A-1, A-2, A-3, and A-4) of top of Mishrif Formation which have been plotted using Petrel software, Fig(2). These structural contour maps show that the Mishrif Formation is composed of two anticlines as in the previous studies. The age of the auxiliary model is done in the process called Pillar Gridding. A few choices are accessible to tweak the 3D matrix for geo-demonstrating. A 3D lattice development is the initial step to fabricate the 3D model. In straightforward terms, a 3D framework splits a model into boxes. Each crate is known as a matrix cell and will have a solitary stone sort, one estimation of porosity, one estimation of water immersion, and so forth. These are alluded to as the cell's ProPellies. This is a rearrangements of the genuine case, however permits us to create a portrayal of reality that can be utilized in estimations.

#### 2.1.1 Gridding

The geological model makes by redistribute the properties of limited region surrounding the wells, which covered by core treatment and logging, to

cover all reservoir regions with the greatest possible precision, figs.(2and 3).

The first step divides the reservoir into volumetric units to increase distribution efficiency and average values become more actualy.Buzerganfield was spoken to by three dimensional network frameworks of cells along the x-hub and along the y-pivot and 12 layers along the z-hub. The spans of frameworks were 200 m in width and 200 m long, all out number of cells is 300546 cells. The extents of networks were picked relying upon the region of the field and to determine the variety of the petrophysical properties.

### 2.1.2 Make horizons

Make skylines process step was utilized in characterizing the vertical layering of the 3D lattice in petrel. This introduced a genuine 3D approach in the age of 2D surfaces which were gridded in a similar procedure, considering the connections between the surfaces .Figure (3) speak to skyline of Mishrif developments.

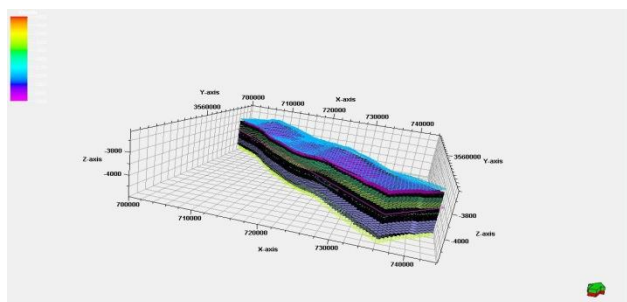


Fig. (2):Geological model.

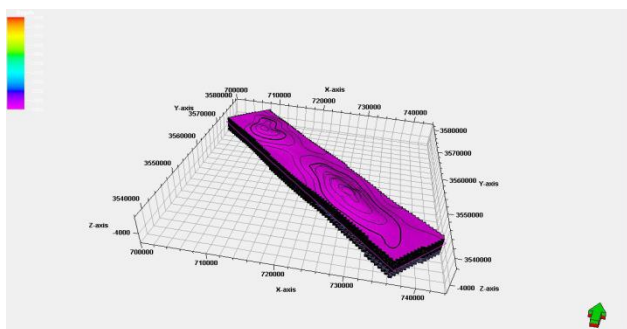


Fig (3): Horizon of Mishrif Formation

### 2.1.3 Layering

Current geography requires precise portrayal of layered volumes. Three-dimensional (3-D) geologic models are progressively the best technique to compel geography at profundity. Every repository unit has been separated into numerous layers relying upon petrophysical properties. Just the primary zones have been partitioned into layers as in the table (2).

Table (2): layer number of Mishrifformation units in Buzerganoil field

| Zone name | No.layers |
|-----------|-----------|
| Zone 1    | 10        |
| Zone 2    | 5         |
| Zone 3    | 5         |
| Zone 4    | 40        |
| Zone 5    | 30        |
| Zone 6    | 5         |
| Zone 7    | 5         |

### 2.2 Stratigraphic Model

The improvement of the stratigraphic model is, without question, one of the most conventional undertakings of the repository geologist, who must play out a well-to-well relationship with the point of characterizing the stratigraphic skylines bouncing the fundamental topographical successions inside the hydrocarbon arrangement .

#### 2.2.1 Property Modeling

Property Modeling is the way toward filling the cells of the lattice with property estimations. One of the most significant devices in store demonstrating is to protect the major geographical highlights and heterogeneities inside the supply.

#### 2.2.2Petrophysical Model

Liquid stream in a store happens in an interconnected framework of permeable spaces inside the repository rock. The attributes of this lattice decide the amount of liquids present, their relative dispersion, and the straightforwardness with which they can stream towards creation wells. The quantitative investigation of the permeable space in supply rock shapes a piece of petrophysics,

adiscipline which assumes a principal job in store examinations. This speaks to the reason for the dynamic depiction of liquid stream, and in this manner of the conduct (watched or anticipated) of creation wells. Therefore it is basic to give adequate time and assets to this stage, both as far as information assortment and investigation (counting lab tests on centers), and as far as translation, so as to create an agent of the repository.

### 2.3. Net to net store estimation

Net compensation is a key parameter in store assessment, since it recognizes the entered land segments that have adequate repository quality and interstitial hydrocarbon volume to work as huge delivering interims. It adds to the estimation of the hydrocarbon set up volume. Net Pay is evaluated using petrophysical shorts that are applied to well logs translation information. Shorts is restricting estimations of development parameters that expel non-contributing interims.

### 2.4 Determination of porosity cut off

The 'porosity cut off' is characterized as the base porosity thought about suitable from a monetary viewpoint. Porosity cut-off was found by plotting center porosity versus Logarithm center porousness, at that point build the best fit line through these focuses. Appeared in Figure (4).

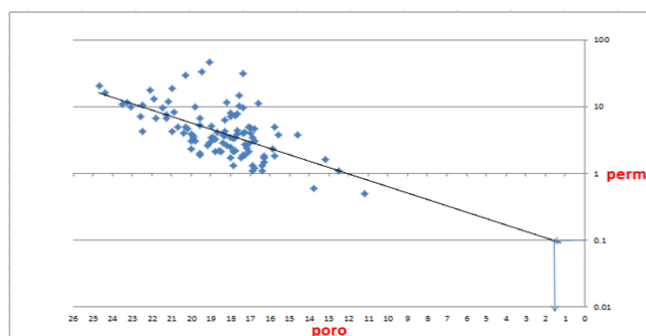


Fig (4): The Porosity Model.

#### 2.4.1 Oil Water contact

Water contact is a term utilized in numerous repository studies, messages and references to depict the height above which liquids other than water can

be found in the pores of a stone. Much of the time in the hydrocarbon business the term is qualified similar to an oil-water contact (OWC).

Oil — water contact investigation is significant stage in supply portrayal and hydrocarbon hold estimation, since it's required for limit depiction among water and oil zone.

### 2.5. The volumetric count.

The volumetric technique was applied to process the hydrocarbon at first set up (HIIP). It was determined for every unit of the supply by utilizing the condition underneath:  $OIIP = (VB \times \phi \times (1 - Swi) \times NET / GROSS) / BOi$

OIIP: Original oil set up, sm<sup>3</sup>. VB: mass volume, m<sup>3</sup>.  $\phi$ : Porosity, part.

Swi: Initial water immersion communicated as a small amount of the pore volume. Boi: arrangement volume factor, under beginning conditions, (Boi=1.2 rm<sup>3</sup>/sm<sup>3</sup>), Volume figuring procedure will precisely compute the different volumes (mass, pore and liquid) in a 3D framework. During the way toward displaying of the repository, a few 3D frameworks may make with various medicines of the shortcomings and skylines. Inside those frameworks, there might be a few renditions of a property model and contacts and there might be a few portrayals of the liquids inside the model. What's more, the underlying oil set up in every unit that was determined as in the table 3.

Table (3) :Oil Initial in Place by the Petrel software for Individual zones of Mishrif Formation /Buzergan Field.

| Unit   | OIIP (STB) |
|--------|------------|
| Zone 1 | 0          |
| Zone 2 | 200        |
| Zone 3 | 435        |
| Zone 4 | 507        |
| Zone 5 | 200        |
| Zone 6 | 1          |
| Zone 7 | 0          |

### III.DYNAMIC MODEL

### 3.1 Grid Section (GRID)

#### 3.1.1 Grid Properties:

This section contains rock properties like permeability in (X,Y,Z) direction, porosity and net thickness... etc., which are exported from petrel program.

#### 3.1.2 Grid Geometry:

Grid geometry concerns the depth of grids and the geometry of the block .In our study the number of model grid cells are (121\*207\*12) 300564 while the active cells 128040.

### 3.2 The properties section (PROPS)

The PROP Section contains both PVT data and SCAL data.

#### 3.2.1 PVT Section

The crude oil of BU field is black oil. Therefore the data needed to be input into the simulator is given in

tables (4 and 5) and taken from pvt samples analysis where PVT sample is available from the field. The initial pressure (Pi) =439.43(Kg/Cm<sup>2</sup>)

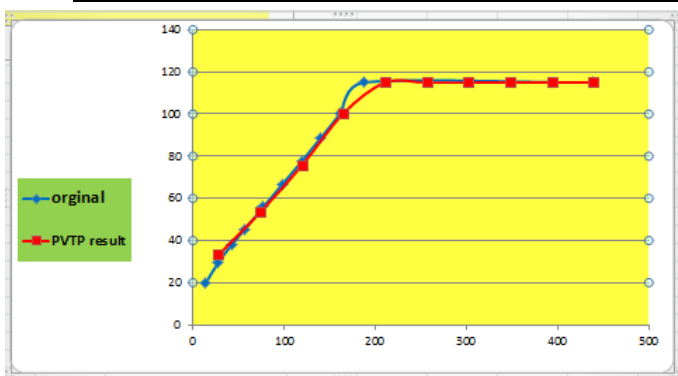
The reservoir temperature =111.5 coand API gravity=28.8o (you can see figs (5-7).

**Table (4): PVT data from well sample.**

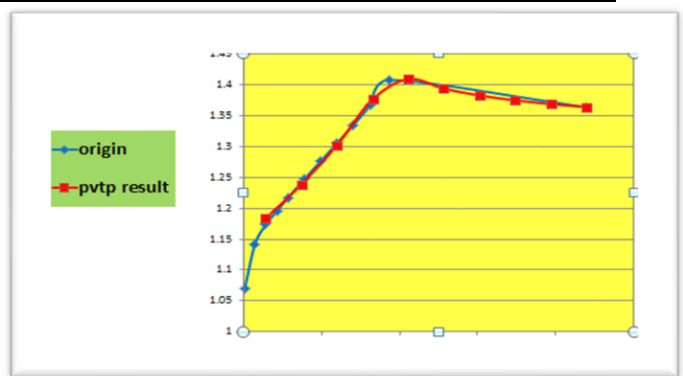
| P(kg/C m <sup>2</sup> ) | RS(m <sup>3</sup> / m <sup>3</sup> ) | Bo(bbl/s tb) | Mu(C p) |
|-------------------------|--------------------------------------|--------------|---------|
| 439.43                  | 114.9                                | 1.3641       | 0.94    |
| 187.02                  | 114.9                                | 1.4083       | 0.73    |
| 161.71                  | 100.37                               | 1.3667       | 0.84    |
| 140.62                  | 88.92                                | 1.3355       | 0.96    |
| 119.52                  | 77.69                                | 1.3057       | 1.08    |
| 98.43                   | 66.86                                | 1.2764       | 1.23    |
| 77.34                   | 55.92                                | 1.2471       | 1.4     |
| 56.25                   | 45.08                                | 1.217        | 1.6     |
| 42.19                   | 37.73                                | 1.1956       | 1.72    |
| 28.12                   | 29.73                                | 1.1735       | 1.98    |
| 14.06                   | 19.94                                | 1.1415       | 2.65    |
| 1                       | 0                                    | 1.0697       | 2.99    |

**Table(5):calculated data from pvt program**

| Temperature (deg C) | Pressure (Kg/cm <sup>2</sup> a) | Bubble Point (Kg/cm <sup>2</sup> a) | Gas Oil Ratio(m <sup>3</sup> /m <sup>3</sup> ) | Oil FVF(RB/STB) | Oil Viscosity (centipoise) | Oil Denssity(Kg/m <sup>3</sup> ) |
|---------------------|---------------------------------|-------------------------------------|--|-----------------|----------------------------|----------------------------------|
| 111.5               | 28.12                           | 187.02                              | 33.2877  | 1.18359         | 1.9113                     | 802.709                          |
| 111.5               | 73.8211                         | 187.02                              | 53.4708  | 1.2386          | 1.43676                    | 782.922                          |
| 111.5               | 119.522                         | 187.02                              | 75.673   | 1.30251         | 1.08666                    | 761.106                          |
| 111.5               | 165.223                         | 187.02                              | 100.474  | 1.37664         | 0.820496                   | 737.656                          |
| 111.5               | 210.924                         | 187.02                              | 114.9  | 1.40931         | 0.724641                   | 730.525                          |
| 111.5               | 256.626                         | 187.02                              | 114.9  | 1.39362         | 0.761365                   | 738.745                          |
| 111.5               | 302.327                         | 187.02                              | 114.9  | 1.38279         | 0.79809                    | 744.535                          |
| 111.5               | 348.028                         | 187.02                              | 114.9  | 1.37485         | 0.834814                   | 748.833                          |
| 111.5               | 393.729                         | 187.02                              | 114.9  | 1.36879         | 0.871538                   | 752.15                           |
| 111.5               | 439.43                          | 187.02                              | 114.9  | 1.364           | 0.908262                   | 754.788                          |

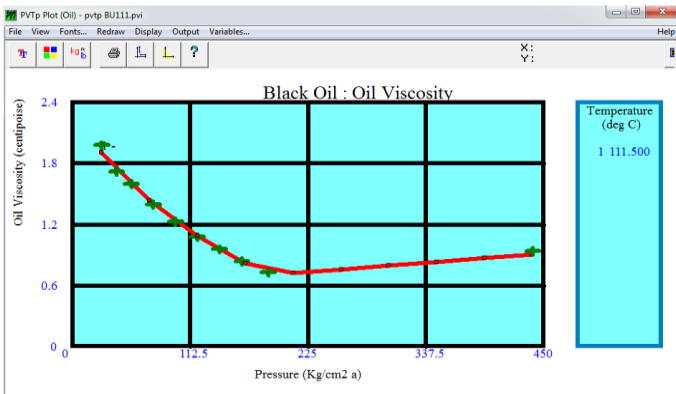


**Fig(5): Original & calculated Bo data**



**Fig(6):Original & calculated Rs data**

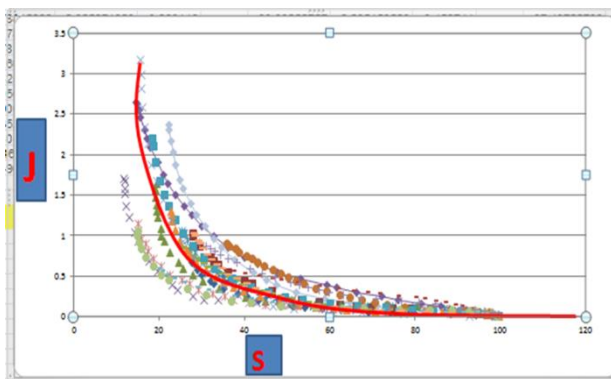
We made a PVT in the PVTP program. A good match was obtained between the calculated and observed results.



**Fig(7): original & calculated viscosity data**

### 3.2.2 SCAL Section

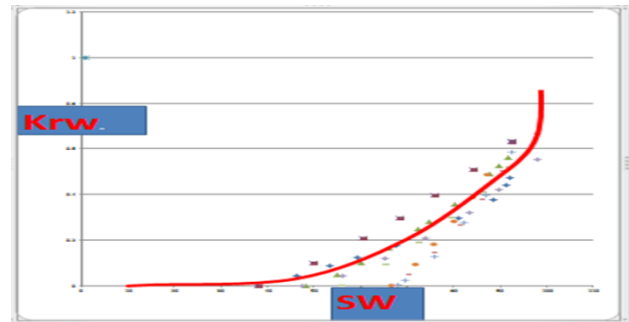
Capillary Pressure: There are nine capillary pressure curves available in fig. (8)



**Fig. (8): Capillary pressure curves for all samples**

### Relative Permeability Curve

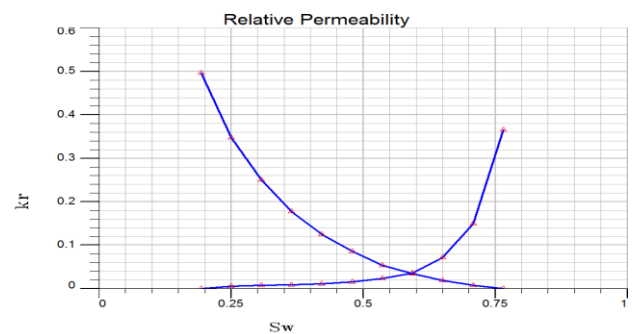
The primary source for relative permeability is from laboratory measurements performed on core plugs selected from the reservoir of interest. Special core analysis (SCAL) is required to determine capillary pressure curves and the relative permeability curves through a sequence of standard measurements and calculations, as shown in the fig. (9).



**Fig.**

**(9): Measured Oil & Water Relative Permeability curves, for Well BU-4**

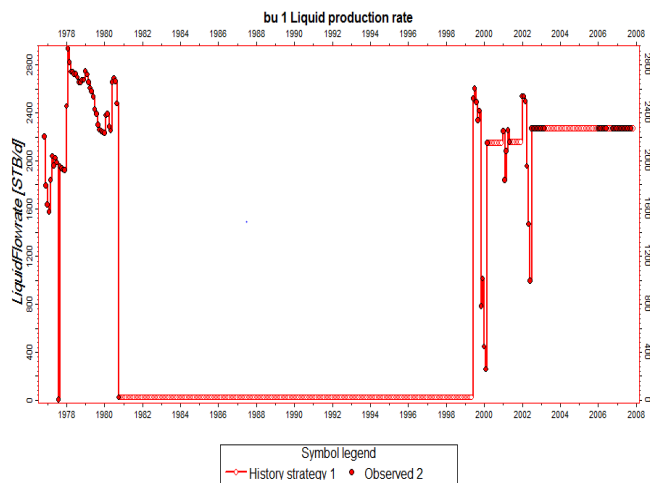
These curves were averaged to get an average relationship as shown in fig. (10)



**Fig. (10): Measured Oil & Water Relative Permeability average**

### History matching:

By and large, history coordinating is a high issue that includes altering model parameters (like porosity and other stream properties) until the reenactment results from the repository model fit the watched (or dynamic) information, for example, weight and creation information. Choosing the fitting parameterization is useful to get solid creation gauging for store improvement arranging and enhancement-verifiable creation is accessible as a stream rate where there is an authentic creation for seven months starting in the February in 1978 until August in 2008 as appeared in the fig.(11).



**Fig(11).Historical production from 1978 to 2008.**

#### IV. RESULTS AND DISCUSSIONS

The results include original oil in place (OOIP) of the field; well block pressure matching and future reservoir performance. The predicted future results are obtained with different production scenarios over the period 2015 to 2045. The results from this study are compared with the available measured data.

##### 4.1. Initialization Results

The initial conditions presented in the previous chapters have been fed to the constructed model. The initialization results of fluids saturation are used to calculate OOIP. Table 6 shows the values of total pore volume, hydrocarbon pore volume and initial oil in place.

**Table 6: Initial Fluid in Place and Hydrocarbon Pore Volume in the Current Model**

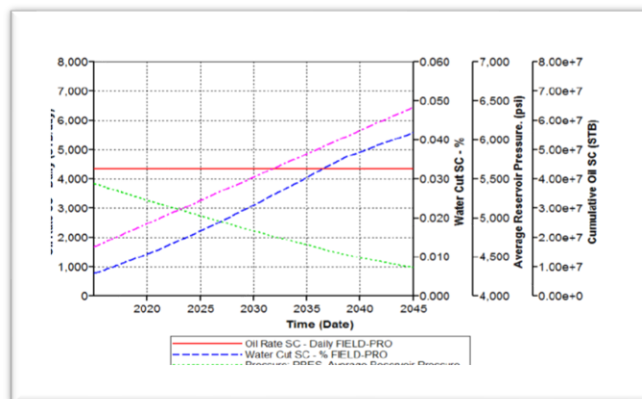
| Variables                   | Value     |
|-----------------------------|-----------|
| Total oil in place, MMSTB   | 1342.4    |
| Total water in place, MMSTB | 3610.89   |
| Total gas in place, MMMSCF  | 146.59659 |
| HC. Pore Volume, MMrbbl     | 3767.0426 |

##### 4.2. Prediction Cases Results

The reservoir production performances under various production strategies have been assumed as:

###### 5.2.1. Case -1: Do Nothing:

In the base scenario, the production rate of the reservoir begins with 4,358 STB/Day in 2015 and remains constant to the end of prediction period (2045). The cumulative production was 64 MM STB with pressure drop equal to 1075.87 psi from 5445.79 psi to 4369.92 psi, recovery factor 4.8% for the reservoir at the case end. The water cut at this case reach to 0.0419 % at end of the prediction period because low production rate of most wells according to data of the last month (October/2013). All the results of this case are shown in fig. 12.

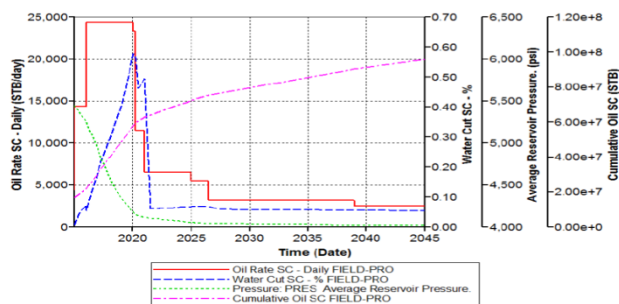


**Fig. (12): Variation of Production, Water Cut, Avg. Reservoir Pressure, Cumulative Oil Produced for Case 1**

###### 4.2.2. Case 2: Adding (20) Production Wells.

The production rate increase to reach the plateau 24,356 STB/Day in 2016 and continue at this rate for four years and then decrease because some wells closed due to decrease in pressure. The average reservoir pressure in this case was decreasing from 5445.78 psi to 4021.71 psi at end of prediction period. The water cut in this case increase to 0.57 % in 2021 and then decrease to 0.06 % at end of prediction period and in this period cumulative oil production 95.75 MM STB with a recovery factor

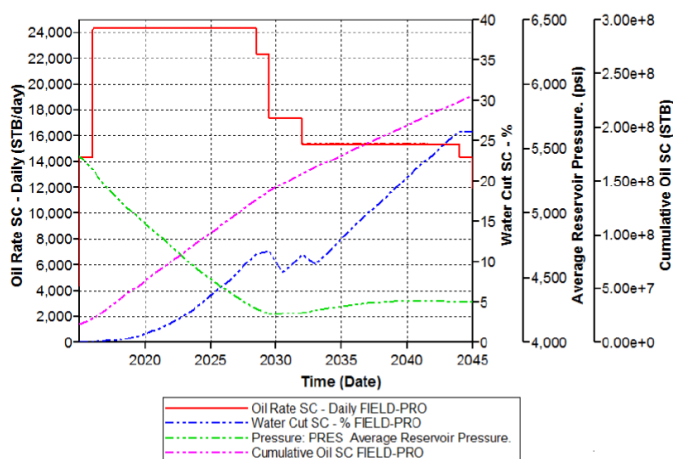
7.08% for the reservoir. All the results of this case are shown in fig. 13.



**Fig.(13): Variation of Production, Water Cut, Avg. Reservoir Pressure, Cumulative Oil Produced for Case 2**

#### 4.2.3. Case 3: Adding (20) Production Wells and (10) Injection Wells.

The production rate of the reservoir increase to 24,360 STB/Day and continued at this rate from 2016 to mid-2028. The plateau of oil production was extended to 12 years and half. The average reservoir pressure in this case decreasing to 4220.62 psi in mid-2029 and then rise slightly due to the closing some of wells and the presence of reservoir pressure support from by injection wells. The water cut in this case increase to 11.36 % in 2029 and then decrease, rise and decrease due to group of wells have been closed to reach 26.2 % at end of prediction period. Cumulative oil production in this case is 229.78 MM STB at end of the prediction period and the recovery factor is 16.7 %. All the results of this case are shown in fig.14.



**Fig.(14): Variation of Production, Water Cut, Avg. Reservoir Pressure, Cumulative Oil Produced for Case 3**

## V.CONCLUSIONS

1. Acceptable history matching results have been obtained from the current reservoir model as compared with the field measured data.
2. The volume of Initial oil in place (OIIP) or (STOIP) in the Mishriff formation of the field equal to (1342.4) million barrels.
3. The field can continue producing oil at production rate of 4358 STB/Day until 2045 under certain conditions.
4. The best case is the third case due to increase the oil production period.

## VI. RECOMMENDATIONS

1. Trying to build a geological model using seismic data then building a reservoir model for the field depending on it.
2. More pressure data to be measured for all the wells in the field.
3. Water-Cut measurements of the producing wells must be exist.

## REFERENCES

1. Gulraiz Khan "Experimental studies of carbon dioxide injection for enhanced oil recovery technique" m.sc oil and gas technology at 1997.
2. Shunhua Liu "Alkaline Surfactant Polymer Enhanced Oil Recovery Process" at 1993.
3. Khalid Abdulla Elraies and Isa M. Tan University Technology PETRONAS, Ipoh Malaysia "The Application of a New Polymeric Surfactant for Chemical EOR" in 1992.
4. Hawar Abdul-Khaliq "Introduction to Enhanced Oil Recovery (EOR) Processes".

5. Wan Rosli Wan Sulaiman and Euy Soo Lee "Simulation of Surfactant Based Enhanced Oil Recovery" at 2001.
6. Sumit Kumar Rai , AchintaBera and Ajay Mandal "Modeling of surfactant and surfactant–polymer flooding for enhanced oil recovery using STARS (CMG) software" at 2003.
7. AlirezaMollaei ,MojdehDelshad and Zhitao Li "A Novel Forecasting Model for Chemical Flooding Enhanced Oil Recovery", The University of Texas at Austin, SPE ;paper 144586 in 2014.
8. ArildLohne , EkoPurwanto , IngebretFjelde " Gravity Segregated Flow in Surfactant Flooding" SPE paper 154495 presented at 2012 SPE Europec/EAGE Annual Conference, 4-7 June, Copenhagen, Denmark .