A Preliminary Study to Evaluate Mishrif Carbonate Reservoir of Nasiriya Oil Field

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Abstract— Oil and gas field development becomes the main purpose of the E and P companies to increase the field productivity and reservoir pressure maintenance through their strategy plans and technical innovation. In addition to the discovery and exploitation jobs for new production areas. The present work categorises under the development reservoir studies headlines, which concerning with Mishrif oil reservoir of Nasiriya oil field. It presents a preliminary field development point of view for the present and near future to increase the oil and gas production from the field.

A simulation study was carried out by developing a 3 D fluid flow model to simulate the concerning reservoir under solution gas drive with a moderate bottom water drive. The necessary petrophysical and PVT information data for the building model acquired from the available field reports and literatures of wells (NS1 – NS5). Good response and results were obtained from the model through a matching phase. The calculated OOIP was 4355 MMSTB through initialization, while the dynamic stage of simulation has been pointed well results about OWC and wells production matching according to the available data. This was covered the period from 2009 to 2013, while the prediction period extended from 2013 to 2020.

The obtained results indicate very well production capacity of the field can be continue up to 2020 with 50 000 STB/D within 15 drilled wells, more field development plans can be applied in future to increase its production and pressure maintenance.

Index Term— Reservoir development, simulation study, increasing production, Mishrif, Nasiriya oil field.

I. INTRODUCTION
Nasiriya oil field is one of the important southern oil fields in Iraq. It was located in the province of Dhi Qar 38 km almost away northwest of Nasiriya. The field was discovered by seismic surveys carried out from 1973 up to 1988. The dimensions of the field about 34 km long and 17km a wide which shows the presence of subsurface un faulted fold structure toward the northwest – southeast general trend in direction with tilted angle (1 – 2)°. Figure (1) show the geographical location of the field, while figure (2) detect the location of the field by satellite picture.

Scope and limitation
The main objective of the present work is to suggest a development plane by modelling of fluid flow behaviour of Mishrif reservoir - Nasiriya oil field, which is one of the most important southern oil fields in Iraq, as well as to predict the possibility of field production from the concerning reservoir under study.

Geological description
Geologically, Iraq [1] is a part of the Zagros and Arabian sedimentary provinces and structural geology of the area is the foreland of Zagros, outside the Zagros belt and on the Arabian sedimentary province. Zagros is a folded belt due to Arabian plate subduction. The general structure of the southern Iraq is a North-South trending anticlines. That has two lower cretaceous deltaic sequences, which are interrupted by a carbonate deposition along the northern margin of the Arabian pserlate.

Amna, H.M [2] presented that Mishrif Formation represents high degree of heterogeneity formation (Porosity of the formation is up to 22%, and permeability ranges from 23 to 775 md, which reflects), originally described as organic detrital limestones with beds of algal, rudist, and coral-reef limestones, capped by limonitic fresh water limestones. The abundant fauna listed by Bellen et al. indicates that the formation is of Cenomanian- Early Turonian age. The formation was deposited as rudist shoals and patch reefs over growing subtle structural highs developing in an otherwise relatively deeper shelf on which marine sediments of the Rumaila Formation were deposited. The lower boundary of the formation is conformable. The underlying unit is usually the Rumaila Formation. The upper contact is unconformable and this unit overlay the Muddud Formation.

Also, Amna H.M [3], states that Geological analysis proved the initial porosity is sovereignty and there is scarcity of secondary porosity due to the lack of digenesis process acting on the rocks configuration like dilution and dolomitization process, and this is very clear in regards to Lack of dolomite while calcite sovereignty as well as the lack of secondary porosity, due to the lack of effect of dolomitization process on reservoir configuration.

Reservoir description
The importance of Carbonate (Limestone and dolomite) reservoirs constitutes one of the largest sources of crude oil supply in the world. Approximately 65% of the present world production comes from carbonate reservoirs mostly located in the Middle East, Mexico, and Canada[4].

Augilera, R,[5] stated that Mc Naughton and Garb state that the ultimate recovery from currently producing fractured reservoirs will surpass 40 billion STB of oil and in spite of this
very attractive figure, fractured reservoirs had not received the attention they deserve until recently. The concerning reservoir (Mishrif Formation) of the present work belong to the carbonate reservoirs which is considered one of the important formation in Iraq and the Middle East oil fields.

Since all the evidences from exploratory tests, and productivity of wells as well as the availability of logs and tests of the wells drilled in the common fields of southern Iraq which were producing from the same formation turned out to be an important economic reservoir in terms of productivity and senior high producing well potential.

Alaa M A and Amna H[6] give a brief description about Nasiriya Oil field reservoir in their work, three reservoir formation units were discovered in the field, these are Yamama, Nuher Umar and Mishrif formations, and from those formation units, Mishrif is the main reservoir of the field that has a heterogeneity and complex in nature which is described as organic detrital limestone, with beds of algal, rudist, and coral-reef limestone, capped by limonitic fresh water limestone, because it consisting a complex structure of calcareous rocks, as fare that the lithofacies and the depositional environments grew up and ranging from the open / shallow outer shelf with the depositional environmental of organic materials to open lagon environment / inner shelf with limited movement. The abundant fauna within the formation indicates that the formation is Cenomanian- Early Turonian age.

Mishrif formation is divided into two main production units upper Mashrif and lower Mashrif denoted (MA and MB) respectively, according to different porosity and permeability which are classified under fracture reservoirs, they were separated by shale unit, the second one also divided into two subdivision units with barrier rocks in some areas of the field. Figure (3) [3], shows the stratigraphic column in Nasiriyah oil field from five drilled wells.

The stratigraphic column of southern Iraq is characterized by thick Cretaceous succession of important hydrocarbon accumulations within many formations. Mishrif Formation is considered as an important middle Cretaceous carbonate formation deposited during the Cenomanian-Early Turonian [7], many geological studies and reports viewed that Mashrif formation acquires special importance because its petrographic and petrophysical characteristics make it an oil reservoir. Figure (4) shows the stratigraphic column in southern of Iraq.

**Reservoir modeling**

The goal of the present study can be achieved by adopting of reservoir modeling which is in general means, a conventional method of mapping reservoir parameters in two or three dimensions; it could include any of the geological, fluid or other characteristics of the reservoir. Nowadays mathematical modeling is done by simulator packages made by many credited companies with wide reputation of their software’s.

Simbest II is a black oil simulator of the reservoir simulation software made by Intercomp Company, for more details about the Simbest II principles, practicing and user’s manual one can refer to the ref.[8]-[9]. These software's model the fluid flow in the porous media with all reservoir activities to perform the history matching and predictions modes. In the following section, the essential information required for the model construction will be presented.

**Behavior of the Reservoir**

The overall reservoir behavior can be describe and observe by the following items:-

1. Average reservoir pressure, well pressure versus time.
2. Investigation of water and gas saturation changes with the time.
3. Checking and verifying the production rates according to the yearly planes. These planes depend on the results of the technical field reports.

**Grid System**

For as long as the purpose of imposing a grid on the reservoir is to allow us to solve the nonlinear flow equations that predict the response of the reservoir to change at wells or other boundaries. This representation technique of reservoir to achieve the solution of flow equation on a discrete grid that is choosing by simulator to predict the reservoir performance with different future point of view, Khalid Aziz [10] presented eight considerations for grid selection. The general idea of grid system of the reservoir was taken in this study to cover all the Nasiriya oil field, with consideration of the main axis of the structure in the field [11]-[12]. The grids in Y - direction goes parallel to the main dome orientation (NW – SE) axis while the X - axis is perpendicular to Y – direction. Z – Direction is orthogonal on the (x-y) plane, both of X & Y direction grids are constant in their dimensions and uniform rectangular grids were applied, while the Z-direction is variable according the gross thickness of each layer. The reservoir in the vertical direction is divided into 5 layers, therefore the three dimensional calculation is performed over (33 * 22 * 5). The grid model contains 3630 cells, 111 cells of them are not active, and the remaining is active. Figure (5) shows the gridding map of the present study.

**Important Data.**

Some times E and P data acquired from oil and gas fields through different activities may be little in one side rather than another, this is depend on the policy of the companies which manage the field and their plans to obtain them. For our case of Nasiriya oil field – Mishrif reservoir, the important data for the builded model comes from reports and literatures even published data on many technical sites concerning with this field. Unfortunately, only few wells from any field is coring due to the fact that the coring is an expensive process and sometimes impossible. In concerning with the Mishrif...
formation of the present work, those cores were taken from the five wells (NS1, NS2, NS3, NS4, and NS5) [3]. And because of the lack of data that have been obtained from the first exploratory wells drilled in the field, so the field was divided five regions so that made the properties of each well is representative of the allocated area.

Porosity & permeability are important petrophysical properties in the simulation studies. Those properties are taken from laboratory measurements of core samples were brought from drilled wells in the field, capillary pressure & relative permeability of the concerning formation were examined from the available core analysis also according to the measurements of throat pores size and displacement pressure results [3]. The main reservoir in Nasiriya oil field was initially under saturated and still up to the date of the current study. The experimental of PVT investigation measurements and technical reports were published in order to get a general idea about the fluid properties for fluid samples taken from different well locations and depths in the field. Table (1) presents the physical and thermodynamic properties of the reservoir oil of Nasiriya Oil field (Mishrif reservoir) that was adopted in the present study, which is taken from ref.[13]. As well as the average petrophysical properties of the formation [3].

Production wells distributions and development plan. The reservoir management methodologies allowed freely proposal and thinking according to engineering roles which are compatible with realism and field results, on this basis the point of view for the present study states that, the wells locations and the suggested development plan goes in parallel lines from the crest of the reservoir structure toward the flank of anticline, with previous production wells of the field (NS1 – NS5). In order to avoid many of the production problems and followers of the primary production ways, this criterion was adopted in the present study, so that it is identical to what opinion stated previously in similar production situations. Figure (6) shows the old and new wells locations.

Production history Schedule. The production history of Nasiriya oil field that was adopted by the present study coverage the period from jun 30 2009 to December 31 2012, according to the available field data and reports. The production rate for each well is available and provided according to the production program adopted by the Dhi qar fields authority – SOC that was coincidental with increasing of oil well drilling in the field by SOC article [14] . These data are used as production schedules which are plug in the constructed reservoir model, 15 wells are drilled in the field. Locations of new 10 wells are suggested as a development plan point of view in the present work, their locations were shown in figure (6), and the production rates data accuracy play a significant role in the matching phase of the study. Reservoir simulation software does matching on production rather than on pressure and this means that re-distributes the well production according to the production unit’s pressure in each well. The cumulative production with average reservoir pressure was plotted vs. time for the overall field. These plots are shown in figures (7-8) which reflects a general overview for the reservoir behavior and wells potential.

A boundary condition criteria was taken into account when constructing the simulation model, including no flow boundary from neighboring areas, the reservoir is volumetric under solution gas drive with such water influx from local bottom aquifer.

Prediction Scenario. The prediction scenario was suggested to checking the production possibility for the concerning field, by running the simulator up to 2020 concerning the daily production from 15 production wells under production limitations . The obtained results revealed that the field can continue with 450 000 STB/D up to the end of 2020. Figures (9-10) show those results.

Results and discussions. In general, all the obtained results from the present research are coming from simulation model runs concerning the Mishrif carbonate reservoir under study, results can be classify as:-

1.1 Initialization stage results, which are concerned with simulation of the static reservoir status to get the first glance about the initial reservoir pressure and fluid saturation distributions for the whole reservoir without any field activity in terms of production and injection. Another important result has been gotten in this stage which is the original fluids in place. Table (2) summarized the calculated OOIP for the concerning reservoir formation with differences between the present work and the previous studies.

1.2 The OOIP by the present study and the previous studies are different from each other with difference of - 23.45% to -37.7% and this is due to:-

- The cut off values of porosity and permeability
- The net and gross thickness of the reservoir (Upper and lower Mishrif reservoir).
- Calculation of water saturation cut off for both reservoir units.
- Calculation of included porous rock volume.

In addition to that, the previous methods used volumetric reserve estimation method using of contour maps technique, while the method of the present work used a reservoir modeling and Simulations technique. Therefore, the calculated reserve is compatible with the announced by the Reserve estimation by SOC articles [15]-[16].
2. Results comes from the dynamic stage of the reservoir status that occurs along the reservoir production life, multiple runs were carried out those results can be categorize as:-

2.1. Matching phase, that is adapted or appropriate in accordance with the available field reservoir data. Figure (8) represents previously the final step of the average reservoir pressure due to production matching. Also this stage of matching includes the matching of static well pressure for many production wells whenever field measured data are available. Figures (11-15) are showing samples of them.

From those results, one can notice that:-

- Second matching process was done in regard to the available water saturation data (oil water contact) for the wells NS1-NS5. Results of this step shows in table (3). Acceptable agreements between the observed and calculated OWC in those points of reservoir during dynamic match step. It is obvious that, a good match of saturation indicates correct fluid movements through the reservoir and makes the prediction of future performance more acceptable. The fluid saturation changes in the field with time due to fluids encroachments or fluids production from the field.

- Water saturation changes along the time period of production, pointed that upper mashrif reservoir unite its saturation was changed with little value but cover all of the unit, while the another units (lower Mishrif A and B), have saturation changes in some place, also in this case that water saturation of unit B is more than unitA, of course this is due to water advancement from bottom of reservoir to the formation during well productions as well as its production with oil and gas.

II. CONCLUSIONS
The main conclusions of the current study can be summarized as below:-

1. A three-dimensional two phase (oil and water) flow model has been constructed using Simbest II simulation package, to predict the performance of the Nasiriya oil Field under depletion drive and moderate bottom water drive. The model has the following specifications:-
   a. Reliable and acceptable matching results have been obtained by the simulation model according to the correct trends of matching results as compared with the available field measured data and the available results in Ref. [3].
   b. Good response of the simulator model to the system properties changes makes the results going into correct side and easily to improve.

2. The concerning reservoir (Mishrif Formation) has a moderate bottom water influx, which reflects the variation of measured OWC at the wells (NS1-NS5) due to its homogeneity. This became partially support the reservoir pressure declining during the production period.

3. It seems from reservoir pressure maps by layers resulting from the simulation runs, there was a low pressure region in the second layer of Mashrif reservoir (MA) moves a long side of reservoir, this is due to the fact that the reservoir depends mainly on the dissolved gas drive developed by moderate bottom water drive as production mechanism of reservoir. While the reservoir layers MB1 and MB2 still keeps the reservoir pressure drop rates at low averages, especially in the suggested developing area in the field, which is considering as the main productivity area along the longitudinal axis of the reservoir fold structure, as well as it is closest to the supporting effect of water derive. Figures (16-18) reveals this phenomenon.

4. The field can be continuing with production at least 50000STB/D until 2020 at certain conditions.

5. From the petrophysical properties and saturation distribution maps (quality maps), it seems that the good and promising environment for production development, that can be done toward the north west of the field rather than north east, also this is provided by geological analysis and depositional facies.

REFERENCES


[13] الخواص الفيزيائية والثروة الحيوية لنفط حقل ناصرية في حقل ناصرية، برر ناصرية 1191، تقرير مشرف عادل الكرم وجمعه لام محلك، تقرير فني رقم (432)، 1979


Fig. 1. Geographical location of Nasiriya oil field

Fig. 2. Satellite pictures of Nasiriya oil field
Fig. 3. Stratigraphic column in Nasiriya oil field after Ref.[2].

Fig. 4. Stratigraphic column in southern Iraq.
**Active Cell**  **Non active Cell**

Fig. 5. Gridding map of Mishrif Reservoir under study

<table>
<thead>
<tr>
<th>Table I</th>
<th>The physical and thermodynamic properties of the reservoir oil of Nasiriya Oil field (Mishrif reservoir) and the petrophysical properties of the Mishrif formation.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reservoir oil, PVT properties</strong></td>
<td><strong>Mishrif formation, petrophysical properties</strong></td>
</tr>
<tr>
<td>API Gravity</td>
<td>Average porosity – upper Mashrif $^{11}$</td>
</tr>
<tr>
<td>36.6</td>
<td>23.6%</td>
</tr>
<tr>
<td>Oil density (gm/CC)</td>
<td>Average porosity – lower Mashrif $^{11}$</td>
</tr>
<tr>
<td>0.89</td>
<td>24.1%</td>
</tr>
<tr>
<td>Oil formation volume (bbl/STB)</td>
<td>Average water saturation – Upper Mashrif $^{11}$</td>
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<tr>
<td>1.3139</td>
<td>28.6%</td>
</tr>
<tr>
<td>Oil compressibility – (1/Psia)</td>
<td>Average water saturation – lower Mashrif $^{11}$</td>
</tr>
<tr>
<td></td>
<td>35.5%</td>
</tr>
<tr>
<td>GOR – gas oil ratio (SCF/STB)</td>
<td>Average Permeability</td>
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<tr>
<td></td>
<td>23 md</td>
</tr>
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</table>

**Original Wells**  **New suggested wells**

Fig. 6. Nasiriya oil field Mishrif formation – location of the production wells
Fig. 7. Shows the cumulative Production Vs. time.

Fig. 8. Shows the production rate and reservoir pressure Vs. time.
Fig. 9. Presents the cumulative productions for prediction period (2013-2020).

Fig. 10. Presents the reservoir pressure for prediction period (2013-2020).
Fig. (11-15). Pressure and production rate Vs. Time for wells (NS1-NS5) respectively.
Table II
OOIP for Mashrif carbonate reservoir - Nasriyah Field.

<table>
<thead>
<tr>
<th></th>
<th>The present study</th>
<th>Amna study II</th>
<th>2001 study II</th>
<th>1989 study II</th>
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<tr>
<td>Original oil in place</td>
<td>4355.033528</td>
<td>6989.463878</td>
<td>7130.807941</td>
<td>5689.098505</td>
</tr>
<tr>
<td>MMSTBO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences</td>
<td>-------</td>
<td>-37.7%</td>
<td>- 38.93%</td>
<td>- 23.45%</td>
</tr>
<tr>
<td>Original gas in place</td>
<td>1406.972764</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMMSCF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original water in place</td>
<td>556.351891 E06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STBW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field matrix pore volumes</td>
<td>6882.129376 E06</td>
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<td></td>
<td></td>
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</table>

Table III
Matching of OWC

<table>
<thead>
<tr>
<th>Well</th>
<th>Observed OWC, m</th>
<th>Calculated OWC, m</th>
<th>Error %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS1</td>
<td>2080</td>
<td>2074.351</td>
<td>0.272316</td>
</tr>
<tr>
<td>NS2</td>
<td>2054</td>
<td>2050.966</td>
<td>0.147908</td>
</tr>
<tr>
<td>NS3</td>
<td>2071</td>
<td>2085.432</td>
<td>0.692048</td>
</tr>
<tr>
<td>NS4</td>
<td>2065</td>
<td>2070.433</td>
<td>0.262408</td>
</tr>
<tr>
<td>NS5</td>
<td>2059</td>
<td>2066.766</td>
<td>0.375745</td>
</tr>
</tbody>
</table>

Average OWC = 2065.8 m

Fig. 16. Pressure map of upper Mashrif MA layer at the end of 2013
Fig. 17. Pressure map of Lower Mashrif MB1 layer at the end of 2013.

Fig. 18. Pressure map of Lower Mashrif MB2 layer at the end of 2013.