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Table Of Content

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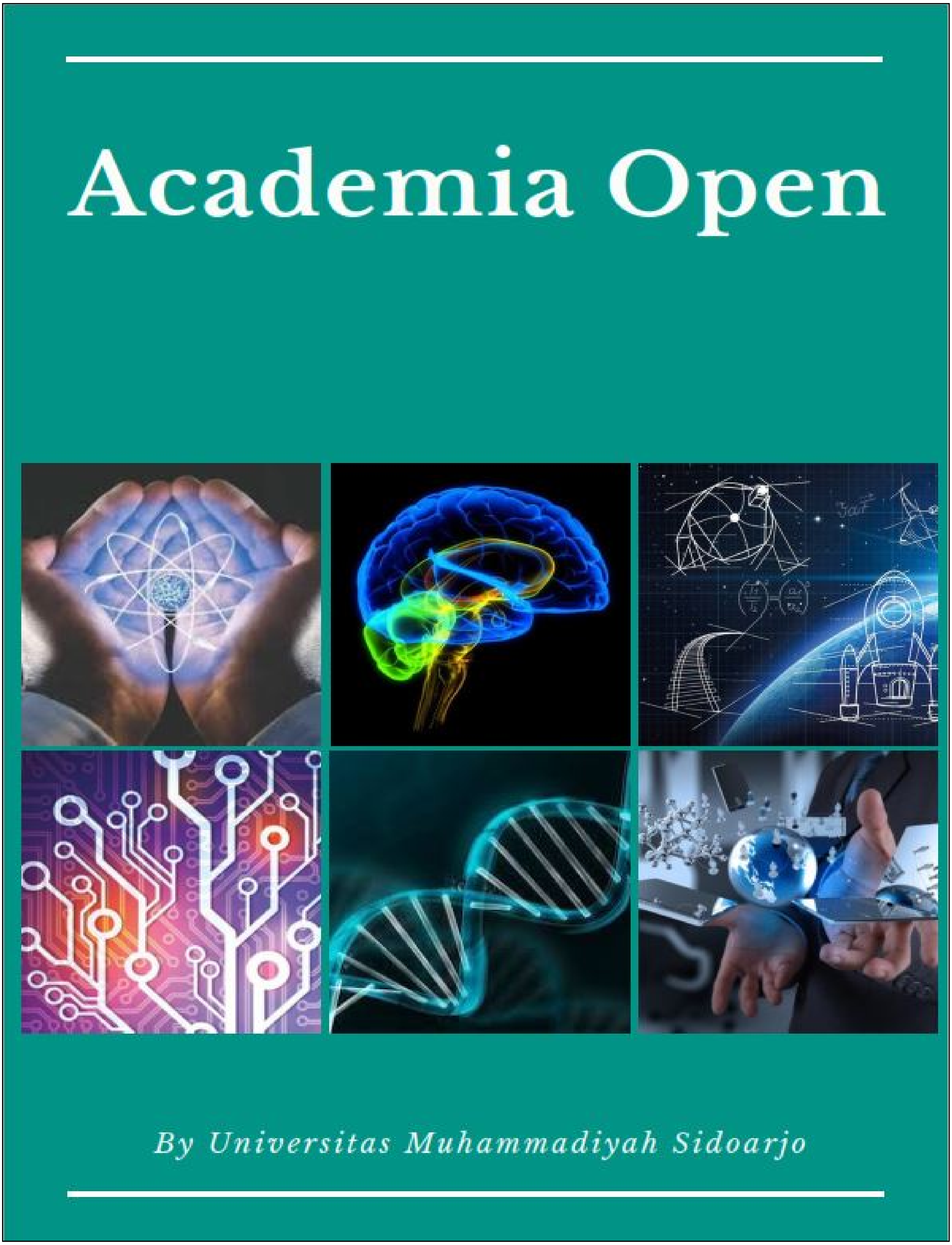

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Water injection in single well model case study

Injeksi air dalam studi kasus model sumur tunggal

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Abstract

This study compares two water injection patterns (line drive and five-spot) using CMG software in a cubic reservoir model based on Buzergan field data. Line drive injection showed higher water cut rates due to direct water flow, while the five-spot pattern distributes water flow across the area, resulting in lower water cuts. Economic analysis favors the line drive pattern for its lower setup cost and reduced water injection requirements. These findings offer insights for optimizing injection patterns and maximizing oil production in reservoir management.

Highligt:

1. Injection Pattern Comparison: Direct vs. Distributed Water Flow Analysis.
2. CMG Software Simulation: Accurate Reservoir Modeling and Analysis Tool.
3. Cost-Effective Optimization: Maximizing Oil Production with Economical Injection Strategies.

Keyword: Water Injection Patterns, CMG Software, Reservoir Management, Oil Production Optimization, Economic Analysis

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Introduction

1.1 Preface Field development planning stands as one of the pivotal tasks in reservoir engineering, requiring the careful consideration of predefined objectives and the project's physical, operational, and economic constraints. During the initial phases of field development, access to reservoir information is severely limited, making it challenging to construct an accurate reservoir model. Consequently, the utilization of simplified simulation models becomes essential, offering more dependable production and injection forecasts that yield superior outcomes. This study introduces a methodology that incorporates a robust optimization procedure utilizing reservoir simulation forecasts to assess an objective function (Net Present Value, NPV). This approach aids in the decision-making process, with a focus on maximizing profits and minimizing the investment-associated risks. [1]

1.2 Reservoir simulation involves the surface management of a hydrocarbon reservoir, encompassing the utilization of evidence and techniques relevant to reservoir engineering.[2]

The simulation of petroleum reservoir performance involves creating and operating a model that emulates the behavior observed in an actual reservoir. Such models can take the form of either physical representations, like laboratory sand packs, or mathematical constructs consisting of equations that, under specific assumptions, depict the physical processes occurring within the reservoir. While the model itself may not replicate the exact reality of the reservoir, the behavior of a valid model closely mimics the behavior of the actual reservoir .[3]

The objective of simulation is to estimate field performance, such as oil recovery, for one or more production strategies. While the field itself can only be produced once, incurring significant costs, a model can be generated and run multiple times at a relatively low cost and within a short timeframe. [4]

Reservoir simulation relies on established reservoir engineering equations and methodologies—those familiar tools and techniques employed by reservoir engineers over many years. In essence, simulation involves depicting a particular process through the use of either a theoretical or physical model. [5]

CMG (Computer Modeling Group Ltd.) stands as a prominent independent provider of reservoir simulation technologies designed to enhance oil recovery. CMG's primary emphasis is on the development of user-friendly simulation solutions that deliver the highest level of accuracy for a wide range of processes, including compositional, conventional, unconventional, and advanced IOR/EOR methods. [6]

1.3 Aim of the Study The objective of the research is to know the behavior of injection with using different patterns of injection by CMG software.

1.4 Improved Oil Recovery Iraq seeks to raise its production to 7 to 8 million barrels of oil per day by 2025- 2027. Most of the Iraqi production is from the southern regions, which are old reservoirs. Production began in the middle of the previous century. it suffers from low pressure as a result of production. Therefore, it is necessary to maintain the reservoir pressure and raise production, which began in Secondary recovery & Tertiary recovery techniques. In Iraq the use of Secondary recovery. In southern Iraq, most of the fields contain water injections, the Buzergan field, there are injections, but very few wells. As is known, the Buzergan field have non active drive & API reduced. This requires starting to study the feasibility of injecting the reservoir with water by preparing a simulation model and obtaining the results and knowing the economic feasibility [8][9].

Improved Oil Recovery (IOR) and Enhanced Oil Recovery (EOR) Methods are strategies employed to target hydrocarbon resources that cannot be effectively extracted using conventional production techniques. IOR encompasses any method aimed at augmenting oil recovery beyond what can be achieved with naturally-flowing vertical production wells, with the understanding that each reservoir's baseline varies due to its unique response to such techniques. When primary oil recovery methods no longer yield additional oil, water injection emerges as a viable approach to enhance reservoir oil production. This is not only due to its cost-effectiveness but also because of water's inherent properties, which efficiently displace trapped oil. One primary challenge associated with this process is the limited volume of effectively controlled water, particularly in reservoirs with heterogeneous characteristics. [10]

While natural oil recovery from a producing well is known as primary production, Enhanced Oil Recovery (EOR) enhances the amount of oil recovered from a well by employing additional engineering techniques. Water injection, also referred to as water flood, is an example of a secondary EOR production process.

1.5 Area of Case study The Buzergan oil field is situated in the South-Eastern region of the Republic of IRAQ, near the Iran border, approximately 40 Km North East of Amara. The oil field was found in 1970, and its development commenced in November 1976. The development of the oil field was undertaken by the general organization of south oil – Missan Oil field.

1.6 Water Injection Water injection, also known as water flooding, represents a secondary method for the recovery of hydrocarbons. This technique involves the injection of treated or demineralized water, produced water, or freshwater into a well's formation, applying high pressure and temperature conditions to enhance the recovery of the initially in-place oil (OIIP). During the water injection process, the water injected directed into the reservoir aquifer by a network of injection wells located around the production well. This water injected initiates a drive called bottom water within the oil zone, propelling upwards the oil.

Two reasons lead to water injection:

1) support the pressure of the reservoir (voidage replacement).

2) To displace or sweep the oil from the reservoir, pushing it to the oil production well.

Disadvantages

1) Reaction of injected water (ion-exchange) with the formation water can cause formation damage.

2) Corrosion of surface and sub-surface equipment.

1.7Water-flooding As part of water injection, a commonly employed technique is water flooding. Water flooding involves the injection of water into the reservoir via dedicated injection wells, which drives the oil within the reservoir rocks toward the production wells. Different between water injection and water flooding in figure (3).

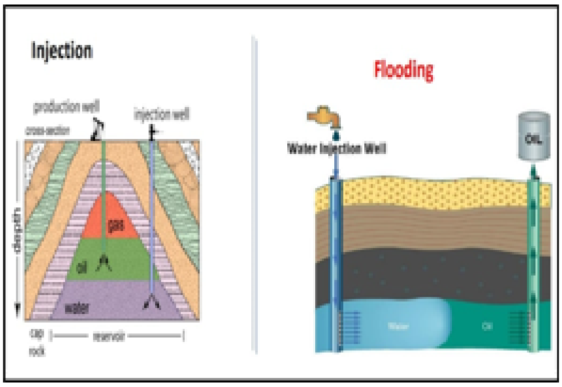

Figure (3): Water injection VS Water flooding

Figure 1. *Water injection VS Water flooding*

1.8 Water injection pattern

The specific arrangement of production and injection wells depends on various factors. These factors include the positioning of existing wells, the size and shape of the reservoir, the cost associated with drilling new wells, and the expected increase in recovery linked to different injection patterns. Over the lifespan of a field, adjustments can be made to the flood pattern in order to alter the flow direction within the reservoir with the goal of contacting untapped oil reserves. Often, the pattern size is reduced through infill drilling, that enhances oil recovery by improving reservoir connectivity between injector and producer wells. Typical patterns of injection include staggered line drive, direct line drive, two, three, four, five, seven, and nine-spot. The patterns of two and three-spot are commonly used for the purpose of pilot testing. these patterns are termed 'regular` or 'normal' if they have only one production well in the pattern and 'inverted' when they consist of only one injection well per pattern.[24] Selection of injection patterns One of the first

When designing a single-well water injection model, an initial step involves choosing the injection pattern. The aim is to select the most suitable pattern that ensures the injection fluid makes maximum contact with the crude oil system.

This selection can be achieved by

1) transforming current production wells into injectors or

2) excavating infill injection wells.

When deciding, the subsequent aspects should be taken into account:

1. Reservoir heterogeneity and directional permeability

2. Direction of formation fractures

3. Availability of the injection fluid (gas or water)

4. Desired and anticipated flood life

5. Maximum oil recovery

6. Well spacing, productivity, and injectivity.

Typically, the choice of an appropriate flooding pattern for the reservoir is contingent upon the quantity and placement of current wells. In certain instances, production wells can be repurposed as injection wells, while in other scenarios, the drilling of new injection wells may be essential or advantageous.[25]

1.9Disadvantages of water injection technique Water injection may increase oil volume recovered from any reservoir; but sometimes it is not the right solution because some disadvantages and complications may occur. Evaluation of the best procedure to use helping an oil reservoir to produce, the Engineer responsible must analyze the injection of water economically and applicably. The analyzation must study the complication factors like the list below;

1. Planned water injection compatibility with the connate water of the reservoir.

2. Injected water interaction with the rocks of the reservoir (rock dissolution, clay sensitivities, and rock framework weakening).

3. Treatment of Injected water to remove bacteria, Oxygen, and unwanted chemicals.

4. handling and separating produced water that contain oil traces, various scale-forming minerals and radioactive materials that occurs naturally (NORMs). Increasing the production rate and maintaining the formation pressure through water injection.[16]

1.10 Factors to be considered in Water injection

1. Economics; (Movable Oil after Primary)

2. Vertical Flood Front

3. Lab & Field Models

4. Mobility Ratio: Oil Ko/mo, Water Kw / mw

5. Sweep Efficiency; Vertical & Horizontal

6. Five Spot, Line Drive

7. Producing Water Cut (Initial & after)

8. Inject into Water Zone

9. Reservoir Pressure Maintenance

Methodology

3-**The first case**, as we mentioned in the second chapter, is line drive:

The original well and the injection well added. we will study the effects that will happen to water from the injection well to the production, the effect on the recovery Victor, the form of the injection and sw during the layers.

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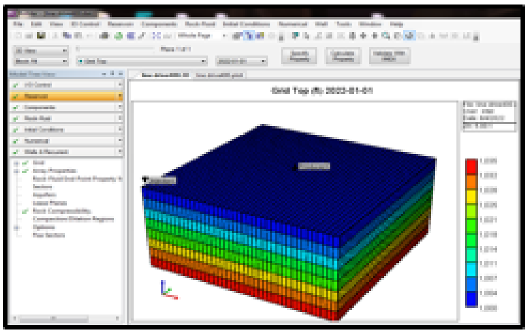

Figure (7): Line drive model (3D)

Figure 2. *Line drive model (3D)*

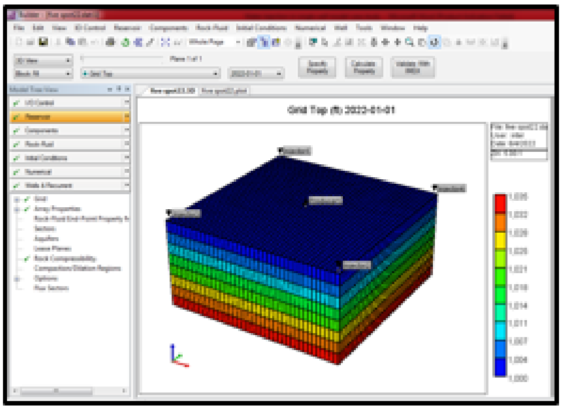

Figure (8): Five spot model (3D)

Figure 3. *Line drive model (3D)*

1. We decided to conduct a comparative study of two injection cases of the same reservoir model. We decided to make the reservoir model in a cubic shape for ease of using the data of the Buzergan field because it is available and available back. The reservoir model will consist of a reservoir grid model with dimensions 41*41*8. The reason for choosing a cube is so that the differences between the layers are clear.

2. The organized part is not to convert the reservoir into a cube shape Rather, it is a truncation of the part of the field in the form of a cube containing the same data as the Buzergan field. This cube must contain well oil Details of the place and the coordinates of the site will be discussed later.

3. **The second case**, is five spot: The well production that was selected will be in the middle and we will drill 4 wells in the form of a square around it , and inject a quarter of the quantity .we will study the effects that will happen to water from the injection well to the production , the effect on the recovery Victor ,the form of the injection and sw during the layers.

4. Then we conduct a comparative study between the two results, which is better.

2 .1 Water injection modeling

Reservoir properties After examining all the wells, the first well, which is located in the northern dome, and the sixth well, which is located in the middle of the southern dome, was selected, In order to cover all the characteristics of the Buzergan field and transfer them to the cmg program, Our first step was to collect the necessary data for the Buzergan field in order to enter it into the program and it will be displayed as follows:

2 .3 Model details

We will work on making two models that are similar in terms of dimensions and features. But the injection method is different.

2.3.2 Line drive

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A direct line drive pattern involves situating the injection wells in a straight line parallel to the production wells. In this pattern, the injected fluid, typically water, steam, or gas, creates a nearly linear frontal movement. The direct line drive pattern is also referred to as a line drive pattern, as depicted in figure (7).

2.3 . 3 Five spot

A square-shaped injection pattern involves situating four input or injection wells at the corners, with the production well positioned at the center. The injection fluid, typically water, is simultaneously injected through the four injection wells to displace the oil towards the central production well. This configuration is illustrated in figure (8).

2 .4 Procedures

We have prepared two models for water injection with different modes using the CMG system; we entered the injection information for the Shulmberger field regarding reservoir and well properties, production information, fluid and petro physical properties, assuming that no injection data is available in Buzergan field.

The first model (line drive pattern) is one injection well and one production well with a constant injection rate, and the second model (five spot pattern) has four injection wells and one production well, and the injection rate is divided by four injection wells.

2 .5 Water cut

The measurement of water cut is a crucial factor in crude oil analysis as it provides a clear indication of the water content present in reservoir fluids. It can be calculated using the following formula: Water cut = (Mass of water in a sample / (mass of water + mass of oil in the same sample)) x 100. Water cut represents the proportion of water produced in a well relative to the total volume of liquids produced. As the reservoir becomes saturated with water, a combination of oil and water is extracted from the well. The water cut refers to the percentage of water present in these wells.

Results and discussion

3 . 1 Results of line drive model

3. 1.1 Water cut

Relationship of the percentage of water cuts with the passage of time in line drive model showing in figure (9).

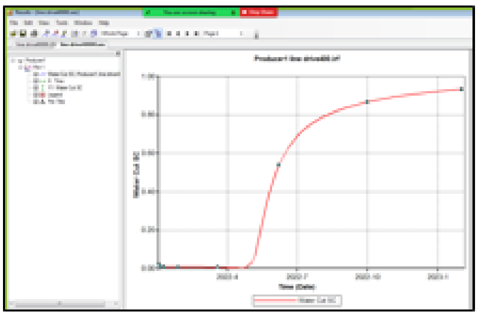

Figure (9): Water cut Vs Time –line drive.

Figure 4. *Water cut Vs Time –line drive*

3 .1.2 Water saturation with time

Relationship of water saturation in the injection pattern with different times for the production well in line drive model:

In the middle of the injection period, that is, after half a year has passed, figure (10).

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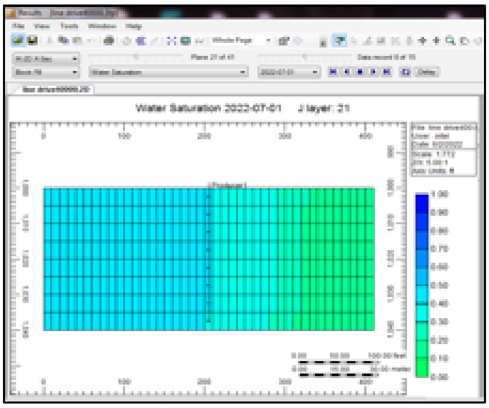

Figure (10): Water saturation at 6 month –line drive.

Figure 5. *Water saturation at 6 month –line drive*

3 .2 Results of five spot model

3 .2.1 Water cut

Relationship of the percentage of water cuts with the passage of time in five spot model showing in figure (11).

Figure (11): Water cut Vs Time –five spot-

3.2.2 Water saturation with time

Relationship of water saturation in the injection pattern with different times for the production well in five spot model:

In the middle of the injection period, that is, after half a year has passed, figure (12).

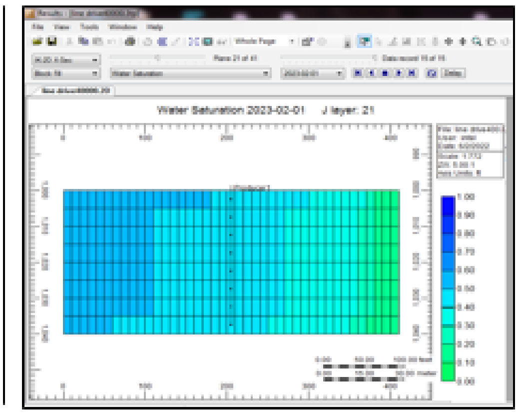

Figure (12): Water saturation at 6 month – five spot.

Figure 6. *Water saturation at 6 month – five spot*

Discussion and Conclussion

1. In the first days of the injection, we notice that the saturation around the well is also constant but over time, we find that water saturation infiltrates from injection wells to production wells in the form of a single wave, and this leads to reducing the saturation of the remaining oil, which leads to the washing of oil towards production wells. In this mode, the amount of injection should be reduced.

2. When the water saturation increases around the well from the side of the injection well, this leads to an increase in water cuts and thus an increase in the water produced.

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3. In the first days of the injection, we notice that the saturation around the well is constant as for the water saturation, we note that it creeps from the injection wells to the production wells, and this leads to reducing the saturation of the remaining oil, which leads to sweeping the oil towards the production wells.

4. When the water saturation increases around the well, this leads to an increase in water cuts and thus an increase in the water produced

5. We note that the water cut is less due to the overlap of the flood waves resulting from the injection wells, and also the water injection is less

6. Economic perspective for injection pattern selection one of the most important things to consider before choosing any style. It is the cost of completing the pattern and the financial return. The process of choice pattern depend the amount of oil produced from the injection process and the cost of constructing a well and providing water for these wells line drive pattern it is cheaper to set up a well. Starting with drilling, cement and completion, and also the cost can be reduced, and this converts production into injections, in five spot the cost is high because the method requires drilling four injection wells.

7. Over time, we notice that the percentage of water cuts is higher in the line drive than it is in the five spot. The reason for this is that the solution of the equations in the simulation software is in a straight line. The flow of water in the five-spot moves from each injection well to another, passing through the entire area and grids between them until it reaches the production well, while in the line drive the direction of water flow is directly from the injection well to the production well, that is solving the equation is straight so the water cutoff is higher. so, we need to inject less water into the line drive than it is in the five-spot.

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