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Analysis of Enhanced Oil Recovery Methods Like Gas Injection in the Fractured Reservoirs and Optimize Its Efficiency

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Abstract

Hydrocarbon reservoir is a porous and permeable structure in underground that are placed natural accumulation hydrocarbons in a liquid or gas forms and they are isolated by non-permeable rocks from the surrounding environment. Petroleum industry has used a wide variety of methodologies for stimulating the reservoir fluids to obtain the maximum amount of production rate in the surface; this method entails CO_2 injection by transporting to the preferred layers which had the most recovery factor over a period of 35 years. Besides, in terms of fractured reservoirs enhanced oil recovery of these formations were poorly considerable candidates due to the complexity of predicting the productivity of these reservoirs. Oil and injected fluids tend to produce oil through gaps or cracks in the matrix block and cannot be moved easily. The purpose of this research is to gradually increase the extent of recovery by injecting carbon dioxide, methane and water. PVT modules of Eclipse software were being used. By injecting carbon dioxide into the reservoir, Injected Gas due to its gravity drainage move through the fracture of block matrix.

Keywords: Gas injection scenarios; Fracture carbonated reservoir; Eclipse software

Nomenclature

WOC: Water Oil Contact, ft;

GOC: Gas Oil Contact, ft;

RF: Recovery Factor %.

Introduction

When a reservoir was being drilled, firstly it was produced by the natural mechanisms. Natural mechanisms provided the substantial energy to push the fluid mainly included oil and gas to the surface. Oil expansion is a very important part among those mechanisms if without availability of other artificial introduced energy. The rock and fluids expand due to their individual compressibility [1-4]. Since the fluid was expanded and the matrix pore volume was imbibed by the surrounding fluid, the reservoir pressure was plunged. As a result, the crude oil and water will be forced out of the pore space to the wellbore. If the natural energies couldn't provide appropriate power to transfer the oil and gas to the surface, we should use enhanced oil recovery methods like gas injection, water injection and etc. Due to population growth and increasing energy demands in different situations of life especially, in major industries and manufacturing operations seem that this Good-given and non-renewable resources should be used correctly and in optimum condition, improper usage and mismanagement of these energy sources is not only causing problems at the present time but also the survival of future generations will face a serious crisis. Fossil energy such as oil, gas and coal at first glance, look gigantic and endless, generally they are not completely recoverable and reversible. Fractured carbonated reservoirs are the most type of reservoirs in Iran [5-7]. One of the chief aims of optimizing the maximum amount of oil production is to opt the appropriate method of Enhanced oil recovery techniques. The percentage of crude oil is shown statistically in Figure 1. As can be seen in the pie chart, the vast majority of crude oil included into two sections; remaining of heavy ultra-heavy oil and non-recoverable natural oil.

Iranian reservoirs have decline in natural reservoir pressure and production rate for the wells about 8-10 percent annually (Production rate for wells with low reservoir pressure drop is directly related) [8-12]. Production rate gradually reduce with the continuous drop in reservoir pressure, until the normal production of the reservoir will not be profitable. This procedure occurs when the reservoir oil recovery is relatively low. The recovery for reservoir is about 15-20 percent; in other words, 80 to 85 percent of oil remains in reservoir. So new advanced methods and techniques require producing remained oil in reservoirs. As a result, we can divide the production process of a well into two categories (without that, this classification refers to method of reservoir production) [13-15]:

- IOR or improved oil recovery
- Enhanced oil recovery

Primary recovery

Primary recovery or natural production is applied for oil extraction under natural driving mechanisms in reservoir without the use of external energy such as gas and water. As it mentioned before, a reservoir has economic production for a short period. In the natural production of reservoir, oil drift is run due to certain mechanisms; we will express them as below [16-18]:

- Rock and Fluid expansion
- Solution Gas Drive
- Gas Cap Drive
- Water table Drive

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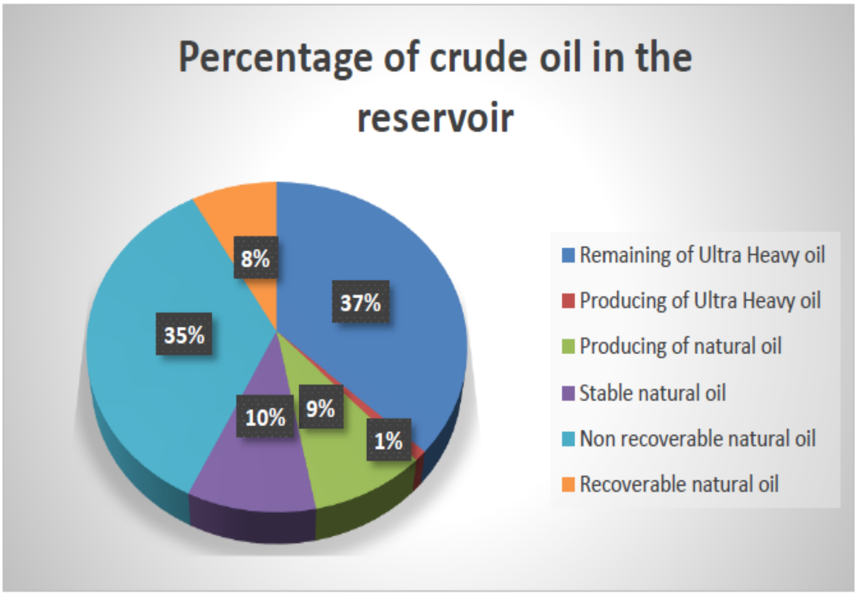

Figure 1: Percentage of crude oil in the reservoir.

- Gravity Drive

Enhanced oil recovery

In some cases that the fluid (oil) enter in the bottom of the well and the fluid pressure in the bottom of the well is not capable to bring them to wellhead, other techniques such as gas lift (gas is injected from the surface into the well and this gas with well oil creates mixed miscibility that the density is less than primary oil density and can be transmitted oil to wellhead with that bottom pressure) or down-hole pumps (the oil is pumped from the bottom to wellhead by this device) is used. But, this technique is not mentioned as one of EOR methods [19-22]. Certainly, enhanced oil recovery (EOR) methods are named as techniques that the fluid inject into the reservoir and this process energize the fluid so, the aim of these methods, is reducing amount of waste oil reservoir.

Gas flooding

Gas can inject in moderate reservoir pressure and immiscible form. Moreover, it will contribute to pressure surge but this method is used less than water for some reason in secondary injection mode. Gas compares with water have a bit height from hydrostatic head prospective. So, the compression operation and pressure surge should be done with high expenditure. The ability of gas movement is higher than water and it can quickly pass to higher permeability area and reach to production wells without required performance. Furthermore, gas viscosity is much lower than water and oil. So, the movement and washing oil does not perform well in tiny pores and gas due to low weight tends to migrate to upper part of reservoir [23-25].

In such a system an injected fluid does not sweep out oil from the matrix block. Production from the matrix blocks can be associated with various physical mechanisms including: The mechanisms behind gas cyclic injection for increasing fractured oil recovery include [26-28]:

1. The injected gas helps to provide energy for the reservoir.

2. The injected gas dissolves in the crude oil by decreasing oil viscosity and oil expansion.

3. Gas miscible flooding helps reduce gas and oil capillary pressure.

Production properties of fractured reservoirs [29]:

- Due to high conduction capabilities throughout the fractures network, pressure drop among the production well was very low. Production was being done by the complex mechanisms between fractures network and matrixes.
- In the fractured reservoir with limited matrix permeability, the pressure drop was extremely low. Fluid expansion, Drainage and Imbibition are the processes of transferring the mobility fluid through the matrix into the fractures.
- If the reservoirs are managed properly, Gas-oil ratio (GOR) remains very low. Released gas is usually moved vertically to the top of the reservoirs. Thereby, this released gas makes gas cap or gas cap expansion and the dissolved gas through the oil was decreased.
- In production wells, Water cut is the function of productivity rate. Petro-physics properties of reservoir rocks and PVT had less impact on the water production.
- Because of convection flow took place among the fractured reservoir, PVT properties approximately reached plateau throughout the reservoir.

Microscopic and macroscopic displacement: Total displacement recovery factor could be divided into two parts [30].

To begin, microscopic displacement was defined as the movement through the pores and cracks. In the other hand, microscopic displacement efficiency was a scale of amount of influential fluid in oil displacement in which sections moveable fluid connected with the oil.

By contrast, macroscopic displacement efficiency related to displacement fluid in a volumetric overview, macroscopic displacement efficiency was a scale of displacement fluid in the oil production as the vertical and surficial occasions.

Appropriate planning: The real priority of EOR projects was greatly depended on the appropriate planning of management procedures. It needs to schedule a timetable flowchart progress as mentioned below [31]:

- Recognize the best injection scenarios throughout the wellbore
- Describe and analyze the reservoir and fluid properties.
- Investigate engineering parameters
- Operate well-test and well-logging processes for analyzing the properties of wellbore appropriately.
- Implementing the comprehensive reservoir model to prospect the future of a production well.

To consider a reservoir model, a process of five steps must be applied as below [25-27]:

- The proper simulator must be chosen due to the reservoir properties.
- Gathering mountains of data which was variable and reliable.
- Data collection must be matched due to historical events of productivity rates.
- Future estimation of production operations.
- Final reservoir model must be designed.

Before commencing a project, economic statistical evaluation and necessary reservoir stimulation must be done properly. It should be noted that by administered these analysis the non-reasonable expenses of production operations due to lack of required explanations of a well have been decreased moderately.

Methodology of Work

Field description

The studied oil field is located in the west of Iran. It was discovered in 1919. The field was an asymmetric anticline which its reservoir located in the carbonated Asmari layer with Gachsaran cap rock. Reservoir fluid has API, 43 and it was considered as a light crude oil (Tables 1-4).

Conclusions

There is a variety of EOR technologies currently in use all over the world. Many of them have been used for decades; some of them were developed during the last few years. These results are being delivered by analysis the procedures of scenario injections from Table 5 as below:

1. Between water injection and continuous gas injection, continuous gas injection is the best method of injecting.

2. CO_2 has the highest amount of recovery factor among those compounds which are injected to the reservoir. Therefore, it is considered as the best efficiency through all injection scenarios.

3. Drainage is one of the most important driving mechanisms in the fractured reservoir but it is extremely time dependence.

4. In high permeability reservoirs with high depth, gravity diffusion was negative factors that decrease the efficiency of displacement procedure dramatically (Table 5).

Year	Average WOC depth (ft)	Average GOC depth (ft)
Initial condition	3100	1800
1968	2800	2200
1972	2774.6	-
1973	2832	2260
1978	2802.3	2320
1991	2777	2405
1998	2640	2436.7
2002	2623.5	2485.2

Table 1: Contact depths.

Rock compressibility	8.6E007psi^{-1} @558psia
Bubble point pressure	1939.7 psia
Initial reservoir pressure	2459.7 psia
Current pressure	1678 psia

Table 2: Fluid properties.

Initial reservoir pressure	2421 psia
Reservoir temperature	125 .F
Primary WOC	3100 ft
Primary GOC	1800 ft
Average oil gradient	0.35 psi/ft
Average water gradient	0.48 psi/ft
Average gas gradient	0.05 psi/ft

Table 3: Primary Data.

Component	Mole percent%
C1	37.38
C2	8.34
C3	5.48
IC4	1.94
NC4	4.89
IC5	1.44
NC5	1.12
C6+	37.87
MW(C6+)	199
SG(C6+)	0.8181
H2S	0.6
CO_2	0.94

Table 4: Oil reservoir component.

Scenario	Inj. Rate (SCFD)	Inj. Rate (SCFD)	RF1 %	RF1 %	Inj. Time (Day)	Inj. Time (Day)
Natural depletion	-	-	15.26	-	-	-
N_2 injection	1500	2000	18.51	23.54	1410	1409.2
CO_2 injection	1500	2000	49.01	58.67	1442	1764.5
C1 injection	1500	2000	46.12	51.89	1440.3	1762.8
TB injection	1500	2000	40.19	52.34	1439.5	1533.7
Water injection	1500	-	19.05	18.71	1404	1437

Table 5: Oil reservoir component.

Recommendations for Future Works

We have to consider the required reservoir pressure, temperature and reservoir fluids compositions when we want to use this technique. It would be more practically applicable and meaningful to optimize what fraction of primary slug, what fraction of secondary slug of solvent is and if some other extra gas supplement like nitrogen will acquire the more oil recovery.

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