

Evaluation of Gas Injection in the Horizontal Wells and Optimizing Oil Recovery Factor by Eclipse Software

Afshin Davarpanah*

Department of Petroleum, Science and Research Branch, Islamic Azad University, Tehran, Iran

Abstract

During the life of a producing oil field, several production stages are encountered. Initially, when a field is brought into production, oil flows naturally to the surface due to existing reservoir pressure in the primary phase. As reservoir pressure drops, water is typically injected to boost the pressure to displace the oil in the secondary phase. Lastly, the remaining oil can be recovered by a variety of means such as CO₂ injection, natural gas miscible injection, and steam recovery in the final tertiary or enhanced oil recovery (EOR) phase. Nowadays, despite of new technologies in petroleum industries, the volume of oil and gas production in many oil fields are plummeted because most of the wells in Iran and other countries were being produced for several years. Hence, recovery factor was a reduction trend. Petroleum engineers due to their field studies and experimental evaluation wrapped up and showed that drilling wells in forms of horizontal, the contact of reservoir formation and production facilities were merely increased. Therefore, the recovery factor was rose gradually. In most of scenario's injection, CO₂ is the best gas compound that should be injected to the model. Thereby, the results that was received from the injection methods for taking appropriate results were be compromised. This comparison included gas continuous injection and using horizontal wells impact.

Keywords: Gas continuous injection; Horizontal wells; CO₂ injection; Scenario's injection

Abbreviations: C1: Methane gas (Condensate form); N₂: Nitrogen gas; TB: Combination of some gases such as methane, ethane.

Introduction

Horizontal drilling

Horizontal drilling is a drilling process in which the well is turned horizontally at depth. It is normally used to extract energy from a source that it runs horizontally, such as a layer of shale rock. Horizontal drilling is a common way of extracting gas from the Marcellus Shale Formation.

Since the horizontal section of a well is at great depth, it must include a vertical part as well. Thus, a horizontal well resembles. When examining the differences between vertical wells and horizontal wells, it is easy to see that a horizontal well is able to reach a much wider area of rock and the natural gas that is trapped within the rock. Thus, a drilling company using the horizontal technique can reach more energy with fewer wells [1].

In this Figure 1, well B represents a vertically drilled well and well A represents a horizontally drilled well. Vertically drilled wells are only able to access the natural gas that immediately surrounds the end of the well. Horizontal wells are able to access the natural gas surrounding the entire portion of the horizontally drilled section.

As you can imagine, drilling a horizontal well is a more complicated process than drilling a conventional vertical well. The driller must first determine the depth of the energy-rich layer. That is done by drilling a conventional vertical well, and analyzing the rock fragments that appear at the surface from each depth.

Once the depth of the shale is determined, the driller withdraws the drilling assembly, and then inserts a special bit assembly into the ground that allows the driller to keep track of its vertical and horizontal location.

The driller calculates an appropriate spot above the shale in which the drill must start to turn horizontally. That spot is known as the 'kickoff point.' From there, the drill bit is progressively angles so that

it creates a borehole that curves horizontally. If done properly, the well reaches the 'entry point' and makes its way into the rock where the natural gas is trapped. The horizontal portion of the well is drilled, and provides much more contact with the rock than a vertical well.

Technology of drilling the well in a Horizontal way to achieve more volume of oil and gas widespread dramatically. In this method the contact between the reservoir and the well will be increased and the production engineers and companies try to drill most of those wells that produced for many years and their recovery factor are far less by horizontal wells to produce more volume of oil and gas. Drilling horizontal wells require much more facilities and equipment than drilling the vertical wells but this method economically due to the recovery factors increases and optimize the well efficiency will be preferred. It can be seen a sample of drilling horizontal well in Figure 2.

The use of horizontal drilling technology in oil exploration, development, and production operations has grown rapidly over the past 5 years. This report reviews the technology, its history, and its current domestic application [2]. It also considers related technologies that will increasingly affect horizontal drilling's future.

Drilling horizontal wells were more difficult than vertical wells. It needed more proper equipment and the procedure of drilling must be controlled in every hole change angle due to its high sensitivity of wellbore inefficiencies and in some cases it can be possible that facilities and equipment stocked in the borehole and provided fishing operation

*Corresponding author: Afshin Davarpanah, Department of Petroleum, Science and Research Branch, Islamic Azad University, Tehran, Iran, Tel: +989178546466; E-mail: Afshindpe@gmail.com

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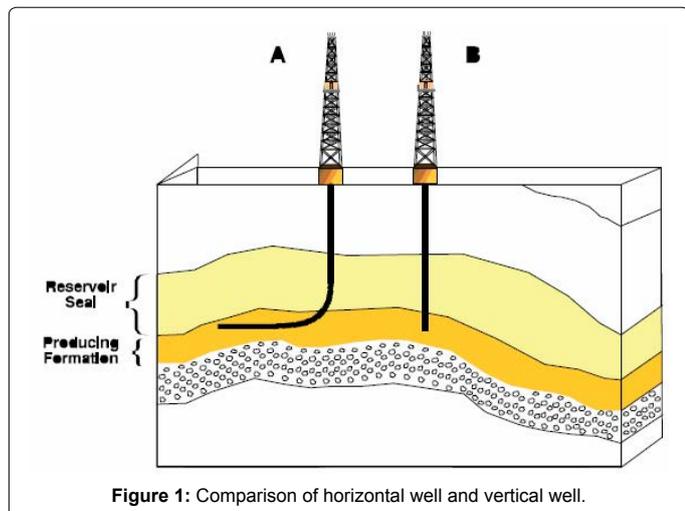


Figure 1: Comparison of horizontal well and vertical well.

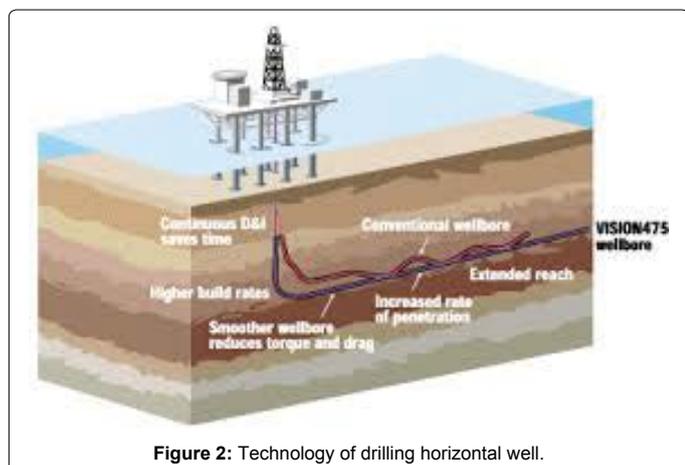


Figure 2: Technology of drilling horizontal well.

to recover the fallen facilities and reopen the way of drilling. If the drilling operation with less accuracy, it may be imposed extravagant expenditures to the government or in the worth cases we will lose the well in terms of high spending.

Some of the applications of drilled well in a horizontal well listed below. So, we can identify the procedure of enhanced oil recovery and optimizes its efficiencies [3-5].

- When the production oil and gas decreased, horizontal well helped us to increase the production rate.
- when we lost a well caused by many occasions like fish, horizontal wells will be drilled to assess the reservoir.
- If we have a reservoir beneath the sea or shallow water, we used this method of drilling.

Types of horizontal wells and their application favorability

Short-Radius horizontal wells: Short-radius horizontal wells are commonly used when re-entering existing vertical wells in order to use the latter as the physical base for the drilling of add-on arc and horizontal whole sections [6].

Medium-Radius horizontal wells: Medium-radius horizontal wells allow the use of larger hole diameters, near-conventional bottom hole (production) assemblies, and more sophisticated and complex completion methods [7].

Long-Radius horizontal wells: Long-radius holes can be drilled using either conventional drilling tools and methods, or the newer steerable systems. Long-radius wells, in the form of deviated wells (not, however, deviated to the horizontal), have been around quite a while. They are not suited to leases of less than 160 acres due to their low build rates [7].

Recovery mechanisms

When a reservoir were 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 [8]. 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 [9]. 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. to alter the dead well to a productive well with high efficiency.

Injection of organic and inorganic gases into the reservoir is used during secondary and tertiary recovery of oil in order to maintain the balance of the reservoir energy. Gas methods involve blocking the action of capillary forces due to partial or complete mixing of the gas with oil. Process stability is achieved by alternating injection of bursts of gas, gas and water or a gas - water mixture. Pure gas treatment is applied in the case of vertical oil displacement or formations with low permeability where flooding is not applicable. Gas methods enable to increase the production of oil by 5-19% comparing to ordinary flooding applied during secondary recovery [10,11]. There are following gas methods:

Hydrocarbon gas drive, CO₂ drive, Inert and flue gas drive, High pressure gas drive, Water-gas drive.

Application of CO₂ injection: Carbon dioxide (CO₂) flooding is a process whereby carbon dioxide is injected into an oil reservoir in order to increase output when extracting oil.

When a reservoir's pressure is depleted through primary and secondary production, Carbon Dioxide flooding can be an ideal tertiary recovery method. It is particularly effective in reservoirs deeper than 2,500 ft., where CO₂ will be in a supercritical state, with API oil gravity greater than 22-25°C and remaining oil saturations greater than 20%. It should also be noted that Carbon dioxide flooding is not affected by the lithology of the reservoir area, but simply by the reservoir porosity and permeability, so that it is viable in both sandstone and carbonate reservoirs. Carbon dioxide flooding works on the physical phenomenon that by injecting CO₂ into the reservoir, the viscosity of any hydrocarbon will be reduced and hence will be easier to sweep to the production well [12,13].

As an oil field matures and production rates decline, there is growing incentive to intervene and attempt to increase oil output, via tertiary recovery techniques (also called improved or enhanced oil recovery). Petroleum Engineers will assess the available options-generally chemical injection, thermal/steam injection, or CO₂ injection. After gathering information and running simulations, the engineers will determine whether CO₂ is the optimal solution to increase oil production rates. To increase the rate of oil production, engineers must increase the amount of pressure within the reservoir.

In the case of CO₂ flooding, the first step is to inject water into the reservoir, which will cause the reservoir pressure to increase. Once the reservoir has sufficient pressure, the next step is to pump the CO₂ down through the same injection wells. The CO₂ gas is forced into the reservoir and is required to come into contact with the oil. This creates this miscible zone that can be moved more easily to the production well. Normally the CO₂ injection is alternated with more water injection and the water acts to sweep the oil towards the production zone [14].

Field Evaluation

Introduce eclipse software

Eclipse software that was used for this evaluation was an integrated development environment (IDE) used in computer programming, and is the most widely used Java IDE. It contains a base workspace and an extensible plug-in system for customizing the environment. Eclipse is written mostly in Java and its primary use is for developing Java applications, but it may also be used to develop applications in other programming languages through the use of plugins. Eclipse software is a powerful software for simulating the stages above.

Evaluation

Successful management of enhanced oil recovery projects was depended on proper planning. Even though, the primary planning was completed it was prevented from the poor project assessment. Appropriate planning has been divided as below:

- Determine proper process of enhanced oil recovery
- Determine reservoir properties include rock and fluid properties
- Determine engineering design parameters
- Doing field tests or experimental operations
- Assess to the comprehensive model for managing the project to what will be expected.

For developing a reservoir model, five-stage procedures must be considered as below:

- Select appropriate simulator
- Collect variable data
- History match
- Anticipate project operation
- Comprehensive Reservoir studies

It should be considered noticeably that before starting a project, economic studies and reservoir simulation had been analyzed. Therefore, the extra costs of lacking knowledge about the reservoir could be decreased dramatically. For investigating the effects of horizontal wells on the recovery processes, horizontal sample was only be preplanned for injection wells. One model from horizontal wells with network length of 10 and network width was received. For this model two injection rate of 500 MSCFD and 1000 MSCFD was used. In the second model, horizontal well was drilled in the middle of area for comprising the results with the first sample. The results are being shown in the Figures 3 and 4.

As it can be seen in Figure 4, 4 types of gases like CO₂, C1 (methane gas), N₂ (nitrogen gas) and TB gas are injected to the bottom and middle layer of the reservoir in the rate of 500 MSCFD and 1000 MSCFD. The

recovery factor in the rate of 1000 MSCFD for all gases are reached the peak. In Figure 5, 4 types of gas are compared together. The Figure 3 demonstrated that CO₂ gas has the largest impact on the ultimate recovery factor. After that C1 (methane gas) is the second gas that has more effect on ultimate recovery factor. The results of this evaluation are illustrated in Tables 1 and 2.

As it can be seen in the Figure 6 pressure differences are being decreased by the time of production. The Figure 6 shows that CO₂ injection has the least pressure loss during the period of time until it approximately reached plateau during the 3000 to 4000 days after production.

Bottom horizontal wells			
Scenario	Gas type	Inj. rate (SCFD)	RF (%)
GI	CO ₂	500	60.69
GI	C1	500	61.22
GI	N ₂	500	18.97
GI	TB	500	55.92
GI	CO ₂	1000	63.79
GI	C1	1000	62.33
GI	N ₂	1000	26.06
GI	TB	1000	59.03

Table 1: Recovery factor on the Bottom horizontal wells.

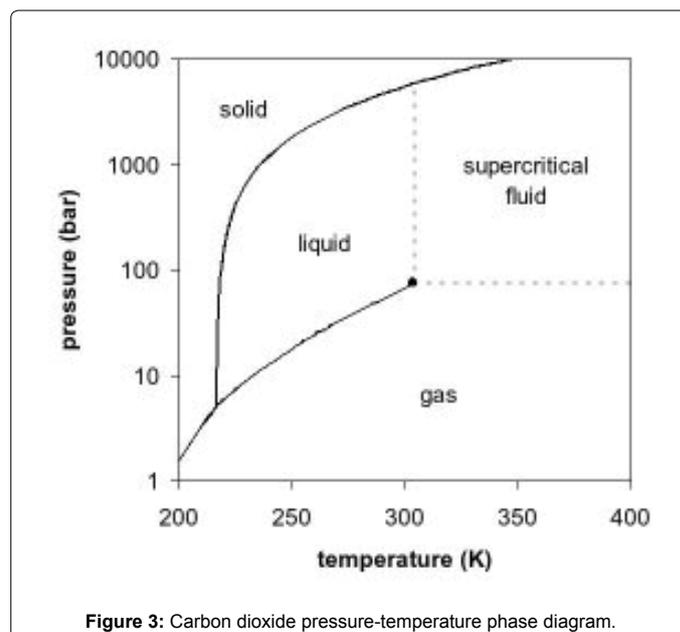


Figure 3: Carbon dioxide pressure-temperature phase diagram.

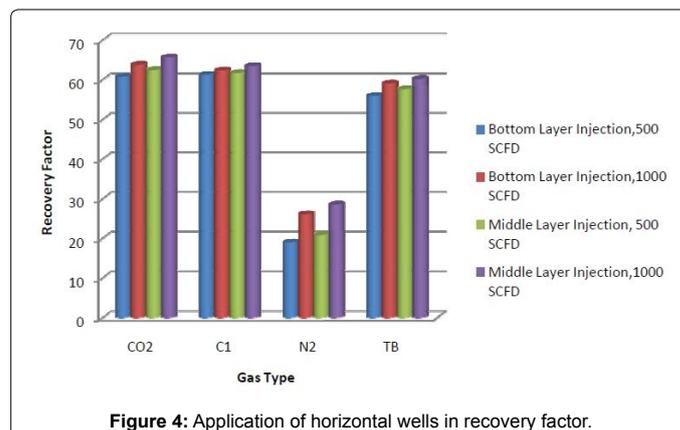


Figure 4: Application of horizontal wells in recovery factor.

Results

As you can see in the Tables 1 and 2, CO₂ injection is the most effective method in optimizing the recovery factor.

Conclusions

Drilling horizontal wells instead of vertical wells due to the high contact of reservoir formation helped the production engineer to produce more volume of oil from the reservoir. Thereby, the oil recovery factor will be dramatically increased. It also considers related technologies that will increasingly affect horizontal drilling's future. In most of scenario's injection, CO₂ is the best gas compound that should be injected to the model. Thereby, the results that was received from the injection methods for taking appropriate results were be compromised. This comparison included gas continuous injection and using horizontal wells impact. Among the oil compounds, CO₂ has the most recovery Factor. Thereby, it has the best efficiency up to all. The

Middle horizontal wells			
Scenario	Gas type	Inj. rate (SCFD)	RF (%)
GI	CO ₂	500	62.43
GI	C1	500	61.68
GI	N2	500	20.83
GI	TB	500	57.6
GI	CO ₂	1000	65.62
GI	C1	1000	63.42
GI	N2	1000	28.53
GI	TB	1000	60.22

Table 2: Recovery factor on the Middle horizontal wells.

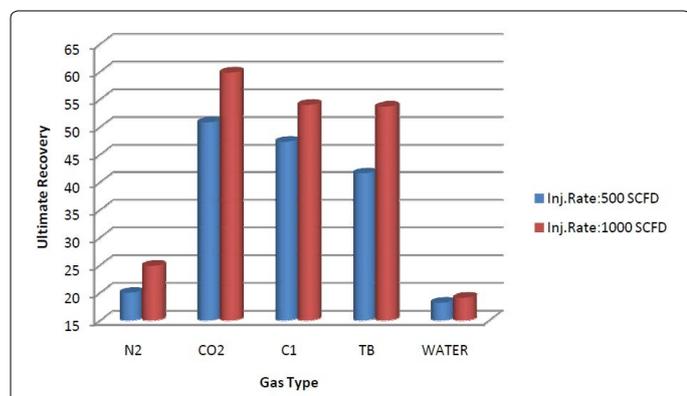


Figure 5: Comparison of different injection gases and its effect on ultimate recovery factor.

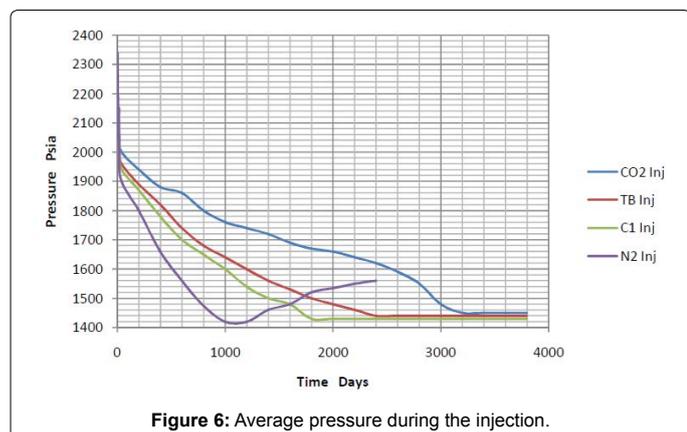


Figure 6: Average pressure during the injection.

most completion that was used in the horizontal wells that fluid should be injected through the middle layers. Furthermore, the Figure 6 shows that CO₂ injection has the least pressure loss during the period of time.

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