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Journal of Petroleum & Chemical Engineering

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Vol: 2 & Iss: 2

Impact of the Horizontal Well Section Length to Well Drainage Zone

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Citation: Eyvazov J, Guliyeva M, Rahimli A, Ahmadov S. Impact of the Horizontal Well Section Length to Well Drainage Zone. *J Petro Chem Eng* 2024;2(2): 24-26.

Received: 20 April, 2024; **Accepted:** 09 October, 2024; **Published:** 11 October, 2024

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ABSTRACT

Horizontal wells offer several advantages over their vertical counterparts and they have become more prevalent in today's oil and gas industry. One significant factor contributing to their widespread use is the broader coverage of drainage zones by horizontal wells, leading to increased daily oil and gas extraction. This article primarily explores the alterations in drainage zone dynamics through adjustments in the effective length of horizontal wells within oil-saturated areas. The impact of these length modifications on overall oil and gas production has been quantified. Furthermore, the article investigates the production of diverse types of horizontal wells under varying conditions of water cut and tubing head pressure. Compared to vertical wells, horizontal wells necessitate less pressure reduction, which, in turn, decreases the likelihood of encountering issues such as water and gas coning, salinity problems and sand production.

Keywords: Well drainage area; Horizontal well; Horizontal well section; Tubing diameter

Introduction

Horizontal well technology has significantly impacted the oil industry over the past few decades and it is now a widely adopted technique globally. It has proven successful in various geological layers, including both conventional and non-conventional formations with natural fractures. The primary objective of employing horizontal wells is to enhance and expedite oil extraction, resulting in higher oil yields compared to traditional vertical wells. This advantage stems from the fact that horizontal wells yield oil and gas in larger volumes and cover more extensive geological layers. Consequently, the drainage area of horizontal wells is notably greater than that of vertical wells, making them more efficient.

Horizontal wells require less pressure reduction to produce an equivalent volume of hydrocarbons compared to vertical wells, reducing the risk of issues like water and gas coning, salinity and sand production. However, it’s crucial to assess optimal conditions, taking into account geological characteristics and economic factors to determine the best well placement. The development of horizontal wells, especially, hinges on accurately defining the drainage zone. The results of this estimation play a vital role in enhancing oil extraction and shaping economic evaluation programs.

To determine the drainage area of vertical wells, pressure transient tests and decline curve analysis are commonly employed methods. These approaches are also applicable to horizontal wells.

Joshi has outlined three methods for calculating the drainage zone of horizontal wells drilled in both isotropic and anisotropic geological layers. He has discussed the relationship between vertical and horizontal wells and their respective drainage zones. Joshi also emphasized the importance of determining the drainage area of vertical wells when assessing horizontal well performance. Additionally, he noted that the boundary anisotropy has a significant impact on the drainage area, with higher permeable areas having longer drainage lengths than lower permeable regions.

In this model, the system is characterized as a dual-phase system, consisting of both oil and water. It is based on a black oil model, which adheres to Newtonian fluid properties. The wells used in this system are primarily production wells and there are no artificial lift methods integrated into this production setup.

Experimental Part

This project was executed using Prosper software, which involved the integration of PVT (Pressure-Volume-Temperature), petrophysical parameters, as well as data related to surface and subsurface equipment (**Figure 1**). The focus of this well model was on horizontal wells and the trajectory of the horizontal well was also incorporated into the system. With all these input parameters in place, the project aimed to calculate the Inflow Performance Relationship (IPR) (**Figure 2**).

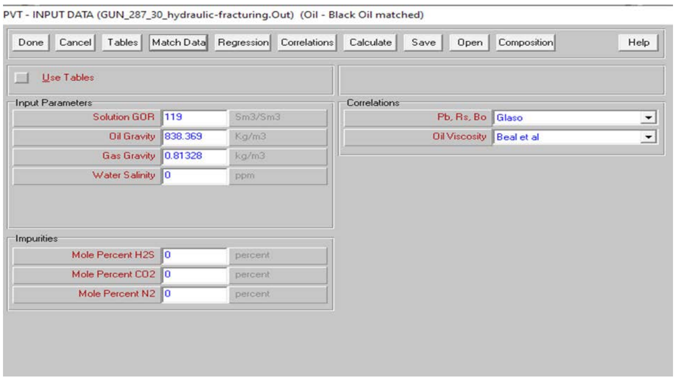
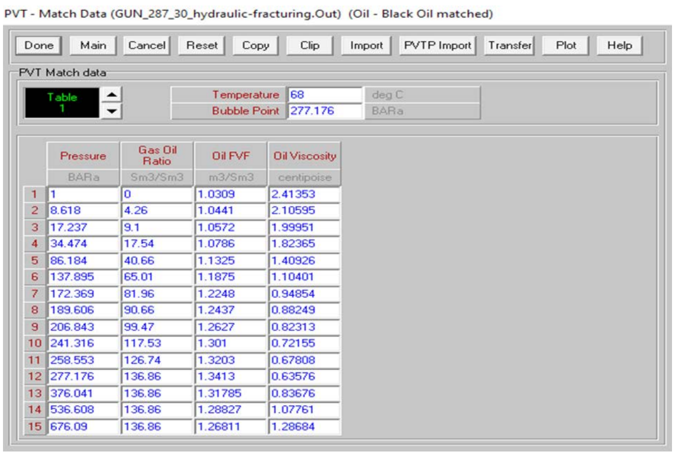


Figure 1: PVT parameters for the well-reservoir model.



	Pressure (BARa)	Gas Oil Ratio (Sm3/Sm3)	Oil FVF (m3/Sm3)	Oil Viscosity (centipoise)
1	1	0	1.0309	2.41353
2	8.618	4.26	1.0441	2.10595
3	17.237	9.1	1.0572	1.99951
4	34.474	17.54	1.0786	1.82365
5	86.184	40.66	1.1325	1.40926
6	137.895	65.01	1.1875	1.10401
7	172.369	81.96	1.2248	0.94854
8	189.606	90.66	1.2437	0.88249
9	206.843	99.47	1.2627	0.82313
10	241.316	117.53	1.301	0.72155
11	258.553	126.74	1.3203	0.67808
12	277.176	136.86	1.3413	0.63576
13	376.041	136.86	1.31785	0.83676
14	536.608	136.86	1.28827	1.07761
15	676.09	136.86	1.26811	1.28684

Figure 2: PVT test results for the well-reservoir model.

The initial reservoir conditions for this well are as follows:

Reservoir pressure: 350 bar

Reservoir temperature: 68°C

To enhance the permeability in the vicinity of the wellbore, hydraulic fracturing has been employed. The key reservoir and technical parameters for hydraulic fracturing will be important in optimizing this process. If you have specific details or parameters related to hydraulic fracturing that you would like to discuss or analyze, please provide them and I'd be happy to assist you further (**Figures 3 and 4**).

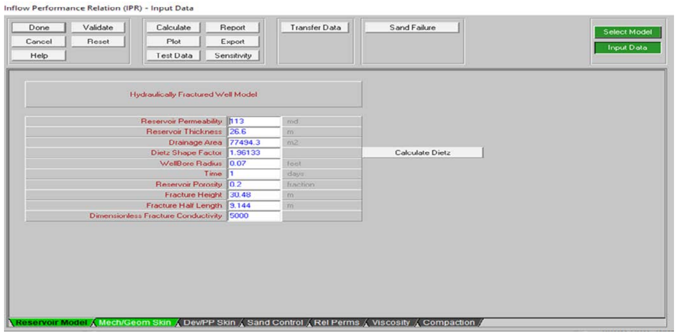


Figure 3: Input reservoir parameters for the hydraulic fracturing model.

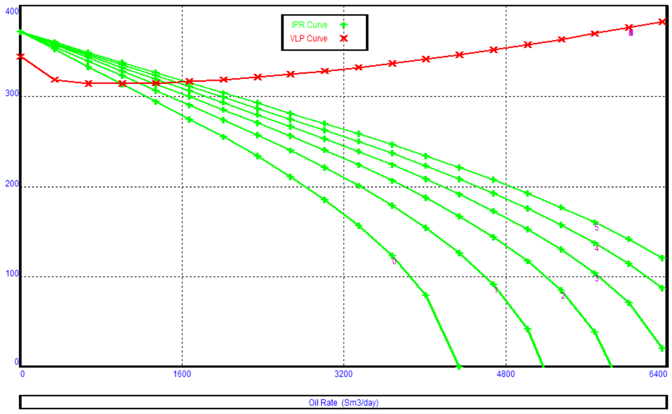


Figure 4: Variation of oil production rates based on the length of horizontal well section.

Table 1: Variation of oil production rates in different values of the horizontal well section.

Length of the horizontal section,m	200	300	400	500	600	700
Gas production,m3/day	137.59	162.48	182.3	198.7	213.2	226.5
Oil Production,m3/day	995.4	1175.5	1319	1438	1542	1639

In the graph, a sensitivity analysis was conducted while keeping the tubing head pressure constant at 100 bar, the total gas-oil ratio at 0.13822 ksm3/cm3 and a water cut of 0%. The length of the horizontal segment of the well was varied between 200, 300, 400, 500, 600 and 700 meters. The curves labeled from 0 to 5 correspond to the horizontal well sections of these respective lengths (**Table 1**).

The graph illustrates that with a 200-meter horizontal well section, the minimum daily production is approximately 968 cubic meters per day. On the other hand, when the length of the horizontal section extends to 700 meters, the daily production increases significantly to around 1632 cubic meters (**Figure 5**).

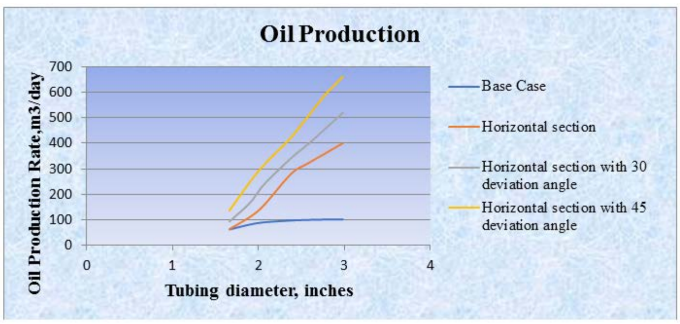


Figure 5: Daily oil production rates in different production tubing diameters.

This figure shows that, when we choose tubing diameter with 2.98 inches, daily oil production rate reaches to 662.2 m3/day by using 500 meters of horizontal section in case of 45 deviation angle. But, in base case it was 101.4 m3/day (**Figure 6**).

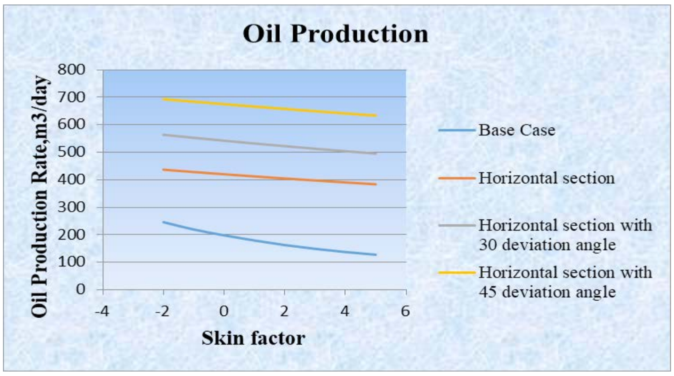


Figure 6: Daily oil production rates in different skin factors.

This figure demonstrates a substantial increase in daily oil production rates when specific parameters are adjusted. When a skin factor of -2 is selected and a horizontal section of 500 meters with a 45-degree deviation angle is used, the daily oil production rate surges to 693.4 m^3 per day. In comparison, the base case, which presumably involves different parameters, yields a considerably lower daily oil production rate of 245.8 m^3 per day. This significant improvement in oil production can be attributed to the modifications made, particularly the reduction in skin factor and the use of an extended horizontal section with a deviation angle of 45 degrees.

Conclusion

Through this research, all PVT (Pressure-Volume-Temperature), Petrophysics and reservoir parameters remain consistent for both vertical and horizontal wells. These well models serve as a basis for the primary objective, which is to compare the production of oil and gas between these two types of wells. As it is well-known, horizontal wells possess a broader drainage area compared to their vertical counterparts. The study has provided insights into how altering the length of the horizontal section impacts the overall production of oil and gas.

In this investigation, the wellhead pressure of horizontal wells, with identical drainage areas, has been identified as a crucial factor for production management. Notably, for horizontal wells with a 500-meter horizontal section and deviation angles of 30 and 45 degrees, the oil and gas production significantly exceeded that of vertical wells. The choice of the appropriate development approach has the potential to yield substantially higher quantities of oil and gas from the well.

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