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Study of the cyclic injection of CO2 in unconventional tight oil reservoirs

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Abstract

An experimental-work was conducted for Cyclic CO2 Injection Process (CCIP) in low-permeable tight coresamples. CCIP is an EOR method involving of huff, shut-in and puff periods. The work of CCIP and oil-production in unconventional-formations is generally a task of fluid, rock and operating constraints. Laboratory-work was performed to evaluate numerous designing parameters of CCIP to differentiate the parameters with highly influence on the hydrocarbon-production and to understand the influence of CCIP in tight-reservoirs. The consequences of the above unreliable parameters as well as the water-saturation with different salinity-concentrations on the procedure of CO2 EOR have not been fully comprehended. Therefore, it's definitely indispensable to evaluate the more important parameters which influence the operation. The principal aim of this work is to ameliorate procedures for designing CCIP in order to optimize CO2-injection and maximize well-production. The outcome shows that the presence of brine will have an adverse impact on oil-production, demonstrating that increasing fracturing-fluid flow back will increase production. This can be used for a better understanding of optimization design of fracturing-fluids. Furthermore, the results show that water-saturation has an effect on the oil-production during CCIP for production period of 15 minutes at the end of the fourth cycle, the oil-recovery for the core that is only saturated with oil (C-1) was 77.74%, compared with 30.40% for core that initially was saturated with water and then with oil (C-2). Finally, it is concluded that in both cases C-1 and C-2, CCIP has potential to produce an incremental oil-recovery from unconventional-reservoirs.

Introduction

The depletion of petroleum reservoirs globally has been progressively increasing hydrocarbon production from low-permeable formations is one of the essential energy treasures that could confront the rising need of the world's energy. Exploration of the resources and production of hydrocarbons from ultra-low permeable formations has attracted observations as its accessible in immense extents worldwide. Associated with advanced technologies utilized in shale gas evolution, developing tight oil resources derive into a new stage. Tight oil reservoirs are the common resources that comprise light crude oils in unconventional reservoirs that are in competent to recover at inexpensive production rates with the implementation of traditional procedures. Consequently, the advancement in horizontal drilling with multilateral hydraulic fracturing techniques are ordinary exercised to puncture ultra-low permeable formations such as shale gas, tight oil, shale oil and coal bed methane; those capitals considered high substantial to supply sufficient energy to equalize the deficiency of traditional resources. Nevertheless, the natural production of unconventional resources remains depressed to only 5-10% of the initial oil in place, although immensely fractures associated along with the horizontal wells.

Water flooding is an extremely applied secondary recovery procedure in traditional reservoirs, however, it's not an appropriate choice in tight oil formations, mostly because of poor injectivity, indigent sweep efficiency and clay swelling concern. Many researches have revealed that gas-injection might be a suitable choice. The main objectives for conducting such studies is due to lack of effectual and economic procedures for enhancing oil production in tight oil formations, inadequacy of traditional techniques such as water-flooding and the complex nature of tight resources such as low permeability. Alternatively, gas injection approach is commonly injected for unlocking unconventional reservoirs. Cyclic CO2-injection procedure is start to have accomplished a better well performance in ultra-low permeable formations and a favorable EOR method that could dominate some major issues related with incessant CO2- flooding, such as need for CO2 source, high processing costs, and early CO2-breakthrough. Consequently, it is ultimately significant to assess effectiveness of cyclic CO2-injection procedure, which can reduce early CO2 breakthrough along with the recovered reservoir fluid. Recent researches demonstrated the requirement for optimizing cyclic CO2- injection process.

Discussion

Gamedi conducted laboratory test for unconventional shale-oil and noted that CO2-injection as huff-n-puff is efficient of producing oil from low-permeable shale formations. Furthermore, Chen assessed the impact of heterogeneity on the cyclic CO2-injection production in a shale formation performing numerical simulation and the capability of CO2 to infiltrate vicinity-fractured zones. Correspondingly, Song and Yang showed an experimental as well reservoir simulation to evaluate the efficiency of miscible and immiscible cyclic CO2-injection in low-permeable shale reservoirs. Yu and Sheng also did a laboratory work to study the impact of pressure depletion rate on shale oil production by cyclic N2 injection process and also examined the effect of production time and shut-in time. Nevertheless, it is significant to study the supreme parameters controlling the cyclic v-injection process in the existence of reservoir aquifer water in the core sample.

This work helps in comprehensive understanding the performance of injection practice in unconventional oil formations. An experimental work has been conducted to assess some parameters of the cyclic injection design and investigate the effect of water saturation on the oil recovery, in order to advance procedures for planning cyclic injection treatments.

Conclusion

The effect of number of cycles on the oil recovery for the cores saturated with/without water for the core sample that only saturated with oil, one can observe that the highest oil recover was at the first two cycles at average of 21.66% (the recovery factor was 37.43% and 59.09% respectively) for the 15 minutes of production. However, the oil recovery factor then slightly increased after the second cycle until it reached the value of 77.74% at the end of the fourth cycle. For the production time of 30, 60, 90 and 120 minutes, the oil recovery factor was 41.24, 43.86, 46.37 and 49.18% respectively, and it increased at the average of 8.41, 8.37, 8.57 and 8.69% at each cycle correspondingly. Similarly, for the core sample that initially saturated with water and then saturated with oil, one can observe that increasing the number of cycles increases oil production recovery. For instance, the oil recover at the first cycle was of 11.64% for the 15 minutes of production and the second cycle, the oil recovery was of 22.47% which means that is nearly the twice recovery of the first cycle (10.83%). However, the oil recovery while considering water saturation was then slightly increased after the second cycle until it reached the value of 30.40% at the end of the fourth cycle. After the second cycle, the oil recovery factor keeps increasing at average of 4.35% at every cycle. For the production time of 30, 60, 90 and 120 minutes of C-2, the oil recovery factor while considering water saturation was 14.57, 16.95, 18.86 and 21.75% respectively, and it increased at the average of 4.38, 4.54, 4.92 and 4.97% at each cycle correspondingly. Furthermore, the comparison between them, the cumulative oil recovery factor of the fourth cycle for production period of 15 minutes was 77.74% for 30.40% for which means that the oil recovery factor of the core saturated with water and oil dropped to almost 47.34% of the recovery factor of the core that only saturated with oil. Similarly, for the production period of 30, 60, 90 and 120 minutes were dropped 46.81, 46.10, 45.74 and 46.04% respectively.