Energies, 2021, vol.14, N22

Feasibility of gas injection efficiency for low-permeability sandstone reservoir in western siberia: Experiments and numerical simulation

Sorokin A., Bolotov A., Varfolomeev M., Minkhanov I., Gimazov A., Sergeyev E., Balionis A.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

Gas injection is one of the prospective methods in the development of unconventional oil reserves. Before implementation in the field, it is necessary to justify the effectiveness of using gas agents in specific object conditions. Experiments of oil displacement on physical models with subsequent numerical modeling can provide the information necessary to justify the feasibility of using gas injection in specific reservoir conditions. This work is devoted to a series of experiments determining the minimum miscibility pressure (MMP) on a slim tube model and the analysis of oil displacement dynamics for various gas compositions, as well as numerical modeling. Displacement experiments were carried out using a recombined oil sample from one of the fields in Western Siberia. The MMP was determined by the classical method of inflection point on the displacement efficiency versus injection pressure curve, which was 34.6 MPa for associated petroleum gas (APG) and 49.9 MPa for methane. The dysnamics of oil displacement for different gas compositions at the same injection pressure showed that APG and carbon dioxide (CO2) are the most effective in the conditions of the studied field. The influence of the gas composition on the gas breakthrough point was also shown. It is revealed that the change in the concentration of the displacing agent in the outgoing separation gas helps define in more detail the process of displacement and the processes implemented in this case for various displacing gas agents. Similarly, it is shown that the displacing efficiency of a gas agent in a miscibility injection mode is affected by the configuration of wells when it is necessary to achieve MMP in reservoir conditions. For the immiscible gas injection mode, no influence of the well configuration was observed.

http://dx.doi.org/10.3390/en14227718

Keywords

APG, Gas injection, Methane, MMP, Physical and numerical modeling, Slim tube

References

[1] Arshad, A.; Al-Majed, A.A.; Menouar, H.; Muhammadain, A.M.; Mtawaa, B. Carbon dioxide (CO) miscible flooding in tight oil reservoirs: A case study. In Proceedings of the Kuwait International Petroleum Conference and Exhibition, Kuwait City, Kuwait, 14–16 December 2009.

[2] Zhang, L.; Ren, B.; Huang, H.; Li, Y.; Ren, S.; Chen, G.; Zhang, H. CO EOR and storage in Jilin oilfield China: Monitoring program and preliminary results. J. Pet. Sci. Eng. 2015, 125, 1–12. [CrossRef]

[3] Yu, H.; Lu, X.; Fu, W.; Wang, Y.; Xu, H.; Xie, Q.; Qu, X.; Lu, J. Determination of minimum near miscible pressure region during CO and associated gas injection for tight oil reservoir in Ordos Basin, China. Fuel 2019, 263, 116737. [CrossRef]

[4] Zhang, L.; Geng, S.; Yang, L.; Hao, Y.; Yang, H.; Dong, Z.; Shi, X. Technical and Economic Evaluation of CO Capture and Reinjection Process in the CO EOR and Storage Project of Xinjiang Oilfield. Energies 2021, 14, 5076. [CrossRef]

[5] Cao, C.; Liu, H.; Hou, Z.; Mehmood, F.; Liao, J.; Feng, W. A Review of CO Storage in View of Safety and Cost-Effectiveness. Energies 2020, 13, 600. [CrossRef]

[6] Larry, W. Lake. In Petroleum Engineering Handbook, V.5. Reservoir Engineering and Petrophysics; Society of Petroleum Engineers: Austin, TX, USA, 2007; p. 1640.

[7] Dindoruk, B.; Johns, R.; Orr, F.M. Measurement of Minimum Miscibility Pressure: A State of the Art Review. In Proceedings of the SPE Improved Oil Recovery Conference, Virtual, 31 August–4 September 2020. [CrossRef]

[8] Al Wahaibi, Y.M.; Al Hadhrami, A.K. First-Contact-Miscible, Vaporizing-and Condensing-Gas Drive Processes in a Channeling Heterogeneity System. In Proceedings of the SPE Middle East Oil and Gas Show and Conference, Manama, Bahrain, 25–28 September 2011. [CrossRef]

[9] Johns, R.T.; Dindoruk, B. Chapter 1-Gas Flooding. In Enhanced Oil Recovery Field Case Studies; Sheng, J., Ed.; Elsevier: Houston, TX, USA, 2013.

[10] Zick, A.A. A combined condensing/vaporizing mechanism in the displacement of oil by enriched gas. In Proceedings of the SPE Annual Technical Conference and Exhibition, New Orleans, LA, USA, 6–8 October 1986.

[11] Johns, R.T.; Dindoruk, B.; Orr, F.M. Analytical Theory of Combined Condensing/Vaporizing Gas Drives. SPE Adv. Technol. Ser. 1993, 1, 7–16. [CrossRef]

[12] Zhang, K.; Jia, N.; Zeng, F.; Li, S.; Liu, L. A review of experimental methods for determining the Oil-Gas minimum miscibility pressures. J. Pet. Sci. Eng. 2019, 183, 106366. [CrossRef]

[13] Zhang, J.; Liao, X.; Cai, M.J.; Liu, M.; Li, R. Characteristic Analysis of Miscible ZONE of Slim Tube Experiment of CO Flooding. In Proceedings of the International Petroleum and Petrochemical Technology Conference, Beijing, China, 27–29 March 2019; Lin, J., Ed.; Springer: Berlin/Heidelberg, Germany, 2020. [CrossRef]

[14] Hudgins, D.A.; Llave, F.M.; Chung, F.T.H. Nitrogen Miscible Displacement of Light Crude Oil: A Laboratory Study. SPE Reserv. Eng. 1990, 5, 100–106. [CrossRef]

[15] Flock, D.L.; Nouar, A. Parametric analysis on the determination of the minimum miscibility pressure in slim tube displacements. J. Can. Pet. Technol. 1984, 23, 80–88. [CrossRef]

[16] Glaso, O. Miscible Displacement: Recovery Tests With Nitrogen. SPE Reserv. Eng. 1990, 5, 61–68. [CrossRef]

[17] Khlebnikov, V.N.; Polishchuk, A.M.; Gubanov, V.B. Use of slim-tube models for physical modeling of oil displacement processes by miscible agents. Part 3. Features of mass transfer in oil displacement by carbon dioxide. Pet. Eng. 2014, 9, 43–47.

[18] Sabanchin, I.V.; Titov, R.V.; Petrakov, A.M.; Egorov, Y.A.; Lebedev, I.A.; Nenartovich, T.L.; Starkovskiy, V.A. Physical simulation of gas injection at oil-gas-condensate fields of Eastern Siberia. Neft. Khozyaystvo-Oil Ind. 2017, 2017, 92–97. [CrossRef]

[19] Mogensen, K. A novel protocol for estimation of minimum miscibility pressure from slimtube experiments. J. Pet. Sci. Eng. 2016, 146, 545–551. [CrossRef]

[20] Jin, F.; Li, D.; Pu, W.; Li, Y.; Li, B.; Yuan, C.; Wang, N. Utilisation of multiple gas injection to enhance oil recovery for fractured-cavity carbonate heavy oil reservoir. Int. J. Oil Gas Coal Technol. 2017, 15, 77. [CrossRef]

[21] Du, D.; Pu, W.; Jin, F.; Liu, R. Experimental study on EOR by CO huff-n-puff and CO flooding in tight conglomerate reservoirs with pore scale. Chem. Eng. Res. Des. 2020, 156, 425–432. [CrossRef]

[22] Suicmez, V.S. Feasibility study for carbon capture utilization and storage (CCUS) in the Danish North Sea. J. Nat. Gas Sci. Eng. 2019, 68, 102924. [CrossRef]

[23] Al-Mudhafar, W.J.; Rao, D.N.; Nasab, S.H. Optimization of Cyclic CO Flooding through the Gas Assisted Gravity Drainage Process under Geological Uncertainties. In Proceedings of the ECMOR XV-15th European Conference on the Mathematics of Oil Recovery, Amsterdam, The Netherlands, 29 August–1 September 2016. [CrossRef]