Research Article

URF PUBLISHERS
connect with research world

Journal of Petroleum & Chemical Engineering

https://urfpublishers.com/journal/petrochemical-engineering

Vol: 3 & Iss: 1

The Process of Identifying the Ideal Hot Water Injection volume to Enhance Oil Recovery in a particular Heavy Oil Reservoir

Jabrayil Eyvazov* and Mehri Guliyeva

Azerbaijan State Oil and Industry University, Azerbaijan

Citation: Eyvazov J and Guliyeva M. The Process of Identifying the Ideal Hot Water Injection volume to Enhance Oil Recovery in a particular Heavy Oil Reservoir. *J Petro Chem Eng* 2025;3(1): 60-62.

Received: 29 January, 2025; **Accepted:** 09 February, 2025; **Published:** 11 February, 2025

***Corresponding author:** Jabrayil Eyvazov, Azerbaijan State Oil and Industry University, Azerbaijan, E-mail: Jabrayil.eyvazov88@gmail.com

A B S T R A C T

The recovery of heavy oil reserves has become a significant challenge for the oil industry, driven by the increasing global demand for oil and current oil prices. Recent efforts have focused on addressing the complexities involved in producing these deposits, which often remain unrecovered due to their high viscosity. Thermal recovery technologies, by introducing heat into the reservoirs, can lower oil viscosity and enhance oil recovery.

One such method is hot water injection, a thermal recovery process in which water is pumped into hydrocarbon reservoirs. This hot water injection not only reduces the viscosity of heavy oil but also propels it toward production wells. This study investigates the application of hot water injection in a reservoir rich in heavy oil reserves located in the Middle East. The heavy oil within this reservoir initially had an oil saturation of 75% and a viscosity of 500 centipoise (cp).

The study involved conducting experiments on two-phase fluid flow displacement to determine the optimal design parameters for injection temperature and the size of the hot water slug that would yield the highest performance. The results display the outcomes of various design configurations, including hot water floods with different slug sizes and timing. These findings can be valuable in the construction of hot water injection systems designed to efficiently recover heavy oil from such reservoirs. Furthermore, they provide insights into the conditions under which a particular design can lead to improved recovery performance.

Keywords: Hot water injection; Heavy oil; Oil viscosity; Enhanced oil recovery methods; Thermal recovery methods

Introduction

After exhausting the primary oil recovery methods, a significant portion of hydrocarbons remains unrecovered in depleted reservoirs. The primary objective of Enhanced Oil Recovery (EOR) is to enhance hydrocarbon recovery in such reservoirs and EOR processes fall into three fundamental categories: thermal, chemical and miscible methods. Each category targets distinct aspects of hydrocarbon displacement[1].

Thermal recovery technologies play a significant role in improving the recovery of heavy oil reservoirs. These technologies harness heat to extract oil from underground formations[2]. Heat can be generated internally through in-situ combustion, where the reservoir's oil serves as the fuel and oxidants like air or oxygen-containing fluids are injected into the formation. Alternatively, external heat can be supplied by injecting hot fluids such as steam or hot water into the reservoir[3]. Among the various heat injection methods, in-situ combustion is less commonly employed. The primary heat injection techniques include steam stimulation, steam displacement, hot gas injection and hot water injection[4].

Hot water injection is one of the simplest heat injection methods, resembling a standard waterflood in terms of simplicity. The concept behind hot water injection is straightforward: heated water is produced at the surface and injected through designated injection wells into the reservoir[5,6]. The combination of the water's displacement mechanism and the added heat reduces the oil's viscosity, enabling it to flow more readily towards production wells. As the temperature rises, heavy oil's viscosity decreases more rapidly than that of water, leading to increased oil mobility compared to water[7]. Consequently, hot water injection results in higher oil recovery compared to cold-water injection.

Steam injection into a well is a process used in enhanced oil recovery (EOR) to extract heavy or viscous crude oil from underground reservoirs. This technique involves injecting high-temperature steam into the wellbore, which then travels into the reservoir. Here's an explanation of the process:

Objective: The primary goal of steam injection is to reduce the viscosity of heavy crude oil, making it easier to flow and extract from the reservoir. This method is particularly effective in heavy oil reservoirs where conventional extraction methods may not be efficient[8].

Steam Generation: High-pressure steam is generated on the surface using boilers or steam generators. This steam is typically superheated to ensure it remains in a gaseous state as it travels down the wellbore and into the reservoir.

Injection Well: A dedicated injection well is used for the steam injection process[9]. This well is equipped with downhole tools and equipment designed to handle the high-temperature and high-pressure steam[10].

Steam Injection: Superheated steam is injected into the wellbore at a predetermined pressure and temperature. As the steam enters the reservoir, it heats the surrounding heavy crude oil. The heat reduces the oil's viscosity, allowing it to flow more easily[11].

Oil Mobility: The heat from the injected steam reduces the heavy oil's viscosity and increases its mobility. This enables the oil to flow towards production wells more effectively[12].

Production Wells: Production wells are strategically located near the injection well. These wells are used to collect the mobilized oil, which has become less viscous due to the heat from the injected steam[13].

Continuous Cycle: Steam injection is often performed as part of a continuous cycle. Steam is injected into the reservoir, which mobilizes the oil. The oil is then produced and the process repeats[14]. This continuous injection and production cycle helps maximize oil recovery from the reservoir.

Monitoring and Control: The injection process is carefully monitored and controlled to ensure that the right pressure and temperature conditions are maintained for effective oil mobilization. This involves using surface facilities and instrumentation to adjust the steam injection as needed.

Steam injection is a well-established EOR method for heavy oil reservoirs and has proven to be effective in enhancing oil recovery. It is especially valuable in reservoirs with high-viscosity crude oil, as it significantly improves the oil's flow properties, ultimately increasing production rates.

Generally, saturated steam carries significantly more energy than hot water below 423°F, hot-water injection generally has lower maximum energy injection rates than steam injection. In laboratory tests, steam injection was found to recover more oil compared to hot water injection. Steam tends to follow the pathways created by hot water flooding, thus encountering more oil, while hot water falls and moves through the swept zone. Transitioning from a steam flood project to a hot water flood project typically yields little additional oil recovery.

The experimental part

In the experimental part of this research project, the West (Qarbi) Absheron field, a heavy oil field with oil viscosity ranging from 20-28 centipoise (cP), was used as the study site. Thermal enhanced oil recovery methods were deemed the most suitable for heavy oil fields. The focus of the study was on determining the optimal daily hot water injection volume, mainly from the QA and QD horizons **(Table 1)**. Presently, there are 59 production wells extracting oil from the reservoir and plans are in place to drill 14 hot water injection wells. The primary research goal is to identify the optimal daily hot water injection volume, leading to a sensitivity analysis based on this injection volume **(Figure 1)**.

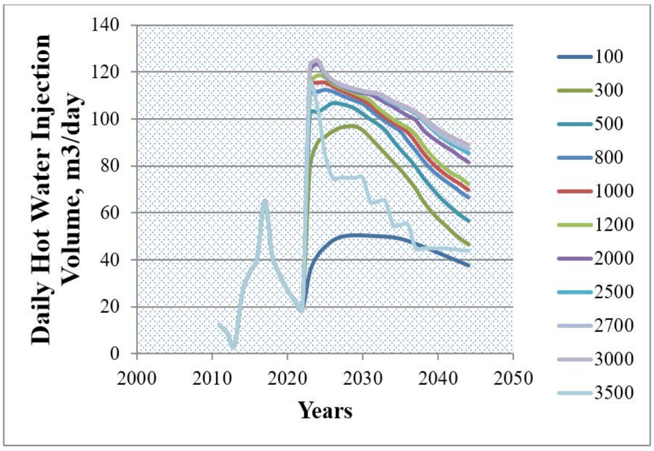

Figure 1: The varying oil production rates in relation to different levels of hot water injection volumes.

The search for the most effective volume of hot water injection, which maximizes the recovery of heavy oil, is a critical aspect of our research. This endeavor is driven by the need to enhance oil recovery from depleted reservoirs and the unique challenges posed by heavy oil. Our focus centers on determining the ideal daily hot water injection volume for the West (Qarbi) Absheron field, characterized by heavy oil with viscosities ranging between 20-28 centipoise (cP).

This study acknowledges the preference for thermal enhanced oil recovery methods in heavy oil fields due to their proven effectiveness. The primary oil extraction efforts within this reservoir currently involve 59 production wells. Additionally, there are plans to introduce 14 hot water injection wells as part of our research[15].

The central aim of our investigation is to identify the daily hot water injection volume that optimizes oil recovery. To accomplish this, we have conducted a thorough sensitivity analysis based on variations in hot water injection volume. This analysis is crucial in ensuring the efficient and effective recovery of heavy oil from the QA and QD horizons within the West (Qarbi) Absheron field.

Table 1: The rates of oil production at various levels of hot water injection volume.

Years	Hot Water Injection Volume, m3/day										
	100	***300***	***500***	***800***	***1000***	***1200***	***2000***	***2500***	***2700***	***3000***	***3500***
2023	135.20	146.06	152.90	157.43	158.85	159.18	160.08	160.23	160.24	160.24	158.78
2024	149.59	177.66	190.78	197.73	200.56	201.97	205.13	205.79	205.84	205.84	198.51
2025	165.60	211.03	228.52	238.71	242.76	245.13	249.19	250.02	250.12	250.18	235.25
2026	182.82	245.20	267.28	279.67	284.61	287.53	291.89	292.83	292.99	293.15	264.99
2027	200.74	280.15	306.16	320.20	325.84	329.18	333.83	334.86	335.04	335.28	292.31
2028	219.08	315.56	344.94	360.32	366.63	370.43	375.32	376.42	376.66	377.04	319.70
2029	237.50	350.96	383.26	399.87	406.81	411.14	416.22	417.51	417.83	418.30	347.02
2030	255.93	386.10	420.85	438.95	446.46	451.32	456.83	458.30	458.68	459.25	374.33
2031	274.32	420.24	457.63	477.35	485.54	490.94	497.21	498.84	499.29	499.96	400.73
2032	292.69	453.27	493.72	514.85	523.72	529.73	537.35	539.30	539.82	540.59	424.46
2033	310.95	484.96	528.92	551.36	560.83	567.41	576.66	579.11	579.85	580.84	448.13
2034	329.13	515.39	562.74	587.06	597.11	604.22	615.34	618.25	619.16	620.39	469.35
2035	347.13	544.58	595.09	622.03	632.65	640.24	653.31	656.87	657.94	659.35	489.36
2036	364.90	572.57	626.18	655.84	667.55	675.69	690.67	695.14	696.35	697.95	509.43
2037	382.23	598.98	655.93	688.07	701.16	710.22	727.30	732.77	734.17	735.78	528.84
2038	399.11	623.58	684.00	718.89	733.22	743.42	762.68	769.48	771.13	772.98	545.21
2039	415.52	646.48	710.57	748.22	763.71	774.98	796.86	805.03	806.92	809.28	561.57
2040	431.50	668.07	735.82	776.47	793.05	805.33	830.24	839.59	841.76	844.68	577.98
2041	446.94	688.45	759.74	803.68	821.27	834.50	862.73	873.09	875.61	879.15	594.35
2042	461.88	707.74	782.59	830.08	848.64	862.76	894.49	905.80	908.72	912.96	610.63
2043	476.33	725.98	804.45	855.58	875.28	890.30	925.38	937.85	941.22	946.18	626.77
2044	490.33	743.38	825.50	880.30	901.17	917.13	955.56	969.39	973.29	978.95	642.86

Our research is driven by the recognition that understanding the optimal hot water injection volume is a key factor in maximizing oil recovery and ensuring the sustainability of oil production in this challenging reservoir.

Conclusion

Thermal enhanced oil recovery methods play a crucial role in mitigating high oil viscosity, thereby improving oil mobility within reservoirs. Hot water injection is a method that effectively increases the overall oil recovery factor. In our study, determining the critical threshold for hot water injection volume has been a significant focus. Based on a comprehensive sensitivity analysis, it has been established that the optimal range for hot water injection lies at 3000 cubic meters per day (m3/day). Beyond this threshold, the injection of hot water does not yield any further increase in the oil recovery factor. This finding underscores the importance of precise volume control to maximize the benefits of thermal enhanced oil recovery techniques.

References

1. Al-Hadhrami HS, Blune JM. Thermally Induced Wettability Alteration to Improve Oil recovery in Fractured reservoir. SPEREE 2001: 179-186.
2. Jabrayil Eyvazov. Sensitivity analysis of oil and gas production as a result of increasing the drainage area with changing in well parameters during different completion of wells.SOCAR Proceedings 2022;2:19-22.
3. Bhat SK and Kovscek AR. Permeability Modification of Diatomite during Hot Fluid Injection. paper SPE 46210, SPE Western region Meeting, Bakersfield, California 1998:10-13.
4. Eyvazov J, Hamidov NN. The effect of hydraulic fracturing length to the well production. J Physics Conference Series 2594:012022.
5. Bousaid IS. Hot-Water and Steam flood Studies Using Kern River Oil. SPE 21543, SPE International 1991.
6. Eyvazov J, Hamidov NN. The Effect of Different Hydraulic Fracturing Width to the Well Production. Int J Oil Gas Coal Engineering 2023;11:74-78.
7. Thermal Operations Symposium, Bakersfield, California 1991:7-8.
8. Eyvazov J. The Effect of Sand Production to the Well Drainage Area. Proceedings of the 2022 Int Petrol Petrochemical Technol Conf 2022:141-146
9. Cassinat JC, Payette MC, Taylor DB. Optimizing Water Flood Performance by Utilizing Hot water injection.
10. In a High Paraffin Content Reservoir. SPE 75141, SPE/DOE Improved Oil Recovery Symposium, Tulsa, Oklahoma 2002:13-17.
11. Jabrayil Eyvazov. How the Oil Recovery Factor Changes in Different Polymer Concentrations on in the Basis of Increasing Well Drainage Area. Proceedings of the 2022 Intern Petrol and Petrochemical Technol Conf 2022:133-140.
12. Goodyear SG, Reynolds CB, Townsley PH and Woods CL. Hot water flooding for high permeability viscous oil fields. SPE 35373, SPE/DOE Improved Oil Recovery Symposium, Tulsa Oklahoma 1996:21-24.
13. Hong KC. Steam flood reservoir management. PennWell Books 1994.
14. Eyvazov J, Guliyeva M. Increase Oil Recovery in Different Surfactant Concentrations on the Basis of Increasing Well Drainage Area. Progress in Petrochemical Science 2023;5:463-467.
15. Hong KC. Guidelines for Converting Steam Flood to Water Flood. SPERE 1987:67-76.