

# Annotated bibliography on enhanced oil recovery



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## Introduction:

Oil, one of the endowments of the nature. At the point when the wells are bored on land and in ocean beds for extracting Crude Oil, it achieves the surface by its own because of high borehole pressure in the beginning for a limited time span.

As the Crude Oil quits achieving the surface by its own after some degree of time due to decrease in borehole pressure, there will be gigantic measure of Crude Oil left in the wells bored. Specialists say 70% of unrefined petroleum will be left in the wells. Artificial methods are applied to extricate the unrefined petroleum left.

Methods are Primary, Secondary and Tertiary Techniques. Primary method incorporates the utilization of Pump Jacks, secondary methods incorporate the utilization of Sucker Rod Pumps and tertiary methods incorporate Enhanced Oil Recovery. There are these different strategies for effectively pumping the raw petroleum to the surface, however the most productive and one of the least costly methods is Enhanced Oil Recovery Technique. The principle explanation behind utilizing Enhanced Oil Recovery is it increases the permeability and porosity of unrefined petroleum which will enable the oil to stream to the surface.

Use of this strategy will result in 40% - 60% more extraction of the oil left.

There are different processes in this procedure, for example,

- (i) Gas Injection.

(ii) Thermal Injection.

(iii) Chemical Injection.

Chen, B. and Reynolds, A. (2018). CO<sub>2</sub> water-alternating-gas injection for enhanced oil recovery: Optimal well controls and half-cycle lengths.

Computers & Chemical Engineering, 113, pp. 44-56.

CO<sub>2</sub> of required quantity is injected in the fractures made in the reservoir which will prompt increment in the permeability of Oil and the oil will achieve the surface. Sometimes CO<sub>2</sub> and Water are alternately injected in a cyclic process for periods of time and this process is known as CO<sub>2</sub> water-alternating-gas (WAG) process and once in a while CO<sub>2</sub> and water are injected at the same time (CO<sub>2</sub> – WAG) and this techniques of injecting both the components at the same time is more effective Enhanced Oil Recovery technique in low permeability reservoirs as this method increases microscopic miscible displacement efficiency.

Jin, L., Pekot, L., Hawthorne, S., Salako, O., Peterson, K., Bosshart, N., Jiang, T., Hamling, J. and Gorecki, C. (2018). Evaluation of recycle gas injection on CO<sub>2</sub> enhanced oil recovery and associated storage performance.

International Journal of Greenhouse Gas Control, 75, pp. 151-161.

When CO<sub>2</sub> and water are injected combined or alternately they will promote more oil recovery, but when these components are injected there are some impurities which gets injected with CO<sub>2</sub> and will have astonishing effects on the oil recovery. CH<sub>4</sub> is the dominant impurity when compared to other impurities.

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Different impurities like N<sub>2</sub>, NO<sub>2</sub>, H<sub>2</sub>S and SO<sub>2</sub> have different effects on CO<sub>2</sub> enhanced oil recovery but overall there will be negligible effect on CO<sub>2</sub> enhanced oil recovery performance. The presence of impurities also have an effect on CO<sub>2</sub> storage due to the change in phase behaviour. The main impurity CH<sub>4</sub> has effects on density, viscosity and compressibility factor. When even 10 mol% of CH<sub>4</sub> is present in CO<sub>2</sub> it reduces the gas density, viscosity and compressibility factor. Impurities like N<sub>2</sub>, O<sub>2</sub>, and CH<sub>4</sub> increase the MMP (Minimum Pressure) and impurities like H<sub>2</sub>S and C<sub>2</sub>-C<sub>5</sub> reduce it.

Sheng, J. (2015). Enhanced oil recovery in shale reservoirs by gas injection. *Journal of Natural Gas Science and Engineering*, 22, pp. 252-259.

Gas injection is more feasible in shale reservoirs than water flooding and any other EOR methods as the water viscosity is much higher than gas viscosity. In shale reservoirs three different gas injection methods are used such as huff and puff gas injection, gas flooding and cyclic gas injection.

In the huff and puff gas infusion, the isolated gas created from a well amid the puff time frame is infused back to the reservoir through a similar well amid the huff period. At the point when the isolated gas delivered from producers is infused in cycle rotation once again into a similar field through injectors in the flooding mode, this procedure is called gas flooding. Cyclic gas could mean both gas flooding and huff-and-puff. For whatever length of time that the created gas is infused back to the reservoir through either the huff- and-puff mode or gas flooding mode, and this procedure is repeated, it is known as cyclic gas injection.

CO<sub>2</sub> flooding is viewed as a superior alternative than CO<sub>2</sub> huff and puff, the huff and puff process is not ideal as both injection time and soaking time are too long. Oil production from CO<sub>2</sub> injection is higher than that from water flooding. Relative permeability additionally appears to be a vital system in the gas huff and puff process.

Wan, T. and Liu, H. (2018). Exploitation of fractured shale oil resources by cyclic CO<sub>2</sub> injection. *Petroleum Science*, 15(3), pp. 552-563.

More shale oil can be recovered by nitrogen huff and puff when compared to water huff-n-puff under the same conditions. The oil recovery by water huff and puff using 24 h of soaking time after 12 cycles will be half of the oil recovery done by nitrogen huff and puff. Soaking time influences the oil recovery. When huff and puff and water flooding are compared huff and puff results in a superior recovery performance. There are several factors which have effects on CO<sub>2</sub>- Enhanced Oil Recovery (EOR) such as molecular diffusion. The factors which get influenced by CO<sub>2</sub> molecular diffusion are the contact area and the exposure time within the reservoir fluid and CO<sub>2</sub>. If the molecular diffusion is considered its effect results in a decline of reservoir pressure, which is caused by the reduction of interfacial tension. The effect of molecular diffusion on oil mobilization depends heavily on system size.

The CO<sub>2</sub>-EOR performance also gets affected by proppant distribution in the secondary fractures. Proppant settles very quickly near the wellbore due to the low viscosity of slick water. Proppant does not get settled evenly and easily in the fractures. When injection rate is low it has a greater chance of

increasing the complexity of fracture networks and interconnecting more natural fractures.

A huge worry about breaking low permeability reservoirs is the fracture conductivity necessities in nano-darcy developments. The nearness of proppant in the crack system significantly affects well creation execution if the un-propped break conductivity is deficient.

Amrollahi Biyouki, A., Hosseinpour, N., Bahramian, A. and Vatani, A. (2017). In-situ upgrading of reservoir oils by in-situ preparation of NiO nanoparticles in thermal enhanced oil recovery processes. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 520, pp. 289-300.

One of the best technique in thermal injection enhanced oil recovery is Insitu combustion. In-situ burning (ISC) within the sight of reactant metal oxide nanoparticles is a promising improved oil recuperation process for overwhelming oil stores. An appropriate strategy for uniform dissemination of the nanoparticles in the store liquids is in-situ combination of the nanomaterials. After warming, the nanoparticles are framed, on which asphaltenes are adsorbed and pyrolyzed to give the fuel to a stable Insitu Combustion front.

The accomplishment of an Insitu Combustion process is mainly subject to building up a stable spreading burning front. The principle parameters controlling ignition front solidness are observed to be the sum and reactivity of the fuel (coke) and the rate and consistency of the fuel testimony in front of the burning front. Likewise, the burning front temperature should be controlled at alluring qualities since it might offer ascent to cap rock cracking

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issues and consequently disappointment of the Insitu Combustion EOR process.

Egboga, N., Mohanty, K. and Balhoff, M. (2017). A feasibility study of thermal stimulation in unconventional shale reservoirs. *Journal of Petroleum Science and Engineering*, 154, pp. 576-588.

Kerogen is a complex fossilized organic material, which is found in shale oil and other sedimentary rock, which is insoluble in common organic solvents and yields petroleum products on distillation. Kerogen also plays vital role in shale rocks during thermal injection enhanced oil recovery techniques.

Kerogen response rate is contrarily corresponding to initiation vitality and specifically relative to recurrence factor. Amid the heating time, higher recurrence factor prompts more prominent kerogen deterioration and bigger increment in oil set up. Higher recurrence factors and lower actuation energies, which both infer quicker kerogen deterioration, result in higher recuperation yet not altogether.

At the point when there is increment in oil set up from kerogen decomposition at hoisted temperatures this will fundamentally prompt enhance recovery. The recovery which will be gotten amid thermal stimulation will be comparable for both a kerogen-containing supply and a repository with no kerogen. Kerogen decay will assume a more critical job in recovery if the warmed region is better associated with the crack system, permitting the oil produced from kerogen deterioration to progress to the wellbore through the fractures.

Kapadia, P., Kallos, M. and Gates, I. (2015). A review of pyrolysis, aquathermolysis, and oxidation of Athabasca bitumen. *Fuel Processing Technology*, 131, pp. 270-289.

Pyrolysis (likewise referred to as thermolysis or warm splitting) is thermochemical decay of oil sands at hoisted temperatures without oxygen. Aquathermolysis (likewise referred to as hydrous pyrolysis) is a synthetic connection of oil sands with water within the sight of warmth and nonappearance of oxygen. The term aquathermolysis implies (water = water; bottle = hot; lysis = slackening, disintegration).

Aquathermolysis responses are moderately non-damaging, when contrasted with the higher temperature warm splitting procedure. Oxidation of bitumen is very difficult and for Athabasca bitumen it is comprehensively arranged into Low temperature oxidation(LTO) and High temperature oxidation(HTO). LTO responses are predominant in temperature go from 150 to 300 °C and items framed amid LTO responses are water, carbon oxides and oxygen-containing mixes, for example, carboxylic acids, aldehydes, ketones, alcohols, hydroperoxides. Littler atoms shaped amid pyrolysis are oxidized. HTO responses essentially supply the greater part of the warmth to support arrangement of different responses amid in situ ignition of bitumen.

Pei, H., Zhang, G., Ge, J., Jiang, P., Zhang, J. and Zhong, Y. (2017). Study of polymer-enhanced emulsion flooding to improve viscous oil recovery in waterflooded heavy oil reservoirs. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 529, pp. 409-416.



Polymer flooding is one of the strategies utilized under Chemical Injection procedure. Polymer flooding is a viable improved oil recovery (EOR) process for waterflooded substantial oil reservoirs, which isn't appropriate for the utilization of thermal recovery strategies due to monetary issues or specialized obstructions. Polymer flooding is a promising upgraded oil recovery (EOR) procedure to enhance the scope proficiency for reasonably viscous oil, which can likewise be connected to enhance clear effectiveness of waterflooded overwhelming oil reservoir. For the strategy for shaping emulsion in situ, the salt or surfactant is by and large infused, which can lessen the oil/water interfacial strain. Lower interfacial pressure can not just diminish the capillary force of the residual oil, yet in addition create oil-in-water (O/W) emulsion to enhance to improve the mobility ratio, and then improve the sweep efficiency.

Brown, L. (2010). Microbial enhanced oil recovery (MEOR). *Current Opinion in Microbiology*, 13(3), pp. 316-320.

In this procedure microorganisms are utilized to deliver the improved oil recovery. One of those life forms is microscopic organisms. It can create acids from oil and other natural mixes which will break up carbonates, along these lines expanding porousness . They can likewise deliver gases that expansion weight in the store and lessening the consistency of the oil by dissolving in it. Biosurfactants, emulsifiers, and solvents diminish the consistency of oil making it simpler to create, or they can deliver biopolymers that expansion the thickness of the water in waterflooding activities, making the task more compelling. By expanding in number, the microorganisms will specifically plug the oil-bearing development and adjust

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the water infusion profile in a waterflooding task. MEOR could considerably build the world's supply of oil, but then it has not picked up acknowledgment by the oil business.

Dopffel, N., Kögler, F., Hartmann, H., Costea, P., Mahler, E., Herold, A. and Alkan, H. (2018). Microbial induced mineral precipitations caused by nitrate treatment for souring control during microbial enhanced oil recovery (MEOR). *International Biodeterioration & Biodegradation*, 135, pp. 71-79.

Nitrate is ordinarily utilized as an inhibitor of microbial sulphate decrease. Microbiologically dynamic conditions, similar to oil reservoirs, can endure a scope of issues because of the nearness of sulphate-diminishing microorganisms. They are H<sub>2</sub>S development, souring and erosion. To counteract biogenic sulphate decrease, nitrate can be utilized as an earth inviting option to biocides.

Symptoms of nitrate infusion are once in a while watched. Nitrate expansion can be a compelling H<sub>2</sub>S relief operator in supply water if nitrate is ceaselessly infused and nitrate-decreasing microscopic organisms are available and dynamic. Permeability estimations gets diminished . Initial Permeability could just mostly be re-established by HCl flushing.