INVESTIGATION OF STEAM FLOODING TECHNIQUE IN ENHANCE OIL RECOVERY OF HYDROCARBON FROM MATURE OIL FIELDS: A REVIEW

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Abstract

Any oil field which exhibits heavy oil, poor permeability and irregular fault lines results in a rapid production decline where conventional oil recovery methods become ineffective. To improve production from such fields, favorable and emerging technologies should be implemented. Steam injection is one such effective thermal enhanced oil recovery technique, which involves the process of injecting steam from surface facilities, into the depleted reservoir, through its distribution from the injector wells accordingly to the well patterns as arranged and decided in the field. When the injected steam enters the reservoir it heats the crude oil, resulting in a reduction of viscosity and eventually the steam condenses due to change in temperature, thereby promoting the heat transfer in the payzone. The condensed steam gets transformed into hot water. The steam and hot water combinedly generates an artificial drive that sweeps the now mobilized oil towards the producer well. Extensive review has been put forward on the field tests conducted on Issaran Oil Field (Egypt), Iranian Fractured Light Oil Reservoir (Iran), and Daqing Oil Field (China). Based on these research studies the paper has come to a conclusive feasibility of steam injection.

Keywords: *Steam Injection, Enhanced oil Recovery, Heavy oil Reservoir,* Steam assisted gravity drainage, Cyclic Group Steaming of the Well

Introduction

Enhanced oil recovery (EOR) techniques are needed when unfavorable conditions such as heavy-oil reservoir, high-medium viscous, low matrix permeability, oil-wet matrix, and poorly connected fracture network exist in an oil reservoir.Extraction of oil can be divided into three phases primary,secondary and tertiary. The primary phase include the extraction of oil by its own potential hydrocarbon rises to the surface, secondary phase include by injection of oil and water through the injection even after the secondary phase 80% of hydrocarbon will remain there . Tertiary phase is the EOR method used for the oil recovery up to 30% original oil in place(OOIP).Steam flooding is a subdivision Thermal EOR. Steam flooding is the most common method used in thermal EOR rather than in-situ combustion. In steam flooding steam is injected to the heavy oil. The temperature present in the steam heats the crude oil as a result viscosity of the heavy oil will decrease, the decreased viscosity helps to reduce the surface tension ,mobility of oil increases and improve reservoir seepage condition[2].Two main types of steam flooding are cyclic steam stimulation and steam flooding. In cyclic steam stimulation injection and production well is same. Stem is injected to the well to a limited period of time couple of weeks or month the steam thus injected to the well heats the oil.The process continuous till the it reaches the target viscosity. When it reaches the target the steam injection stops. There will be a recovery of maximum crude oil after this stage until the temperature decreases and the viscosity regains. In the second method steam flooding there are two wells injection and production. Steam is injected through the injection well is driven toward the oil which heats the oil and decrease the viscosity this oil drive toward the production well. Steam flooding is costlier than cyclic stimulation because it needs more amount of steam.[1][2]

Steam Injection Mechanism

In a steam flood some wells are used as steam injection wells and other wells are used for boring ..Boring is to done to enlarge or modify the existing diameter of the well. In boring, only the diameter of an existing hole can be increased. Likewise, a cylindrical hole can be converted into a tapered hole by using boring process. Boring cannot increase or decrease the length of a well; it can only increase the diameter of the well.There are two types of mechanisms which is used in steam flooding .The first mechanism is to reduce the viscosity by heating the oil in to higher temperature that the flow of oil becomes smooth through the formation towards the well.Second method is Steam huff and puff is also called steam stimulation or cyclic steam injection. Using this technique,wet saturated steam is first injected into a well under reservoir condition of high temperature and pressure. After the injection of enough steam, the steam is left to soak by keeping the well shut for a couple of days to heat the oil . The whole process is conducted within the same well

A form of steam flooding that has become popular in the Alberta tar sands which is located in northeastern part of Canada, is steam assisted gravity drainage (SAGD), in which two horizontal wells are drilled, One well is located above the other one and the steam is injected to the well which is in the upper position it is to reduce the viscosity of the bitumen to point where gravity will pull it down the producing well[3]

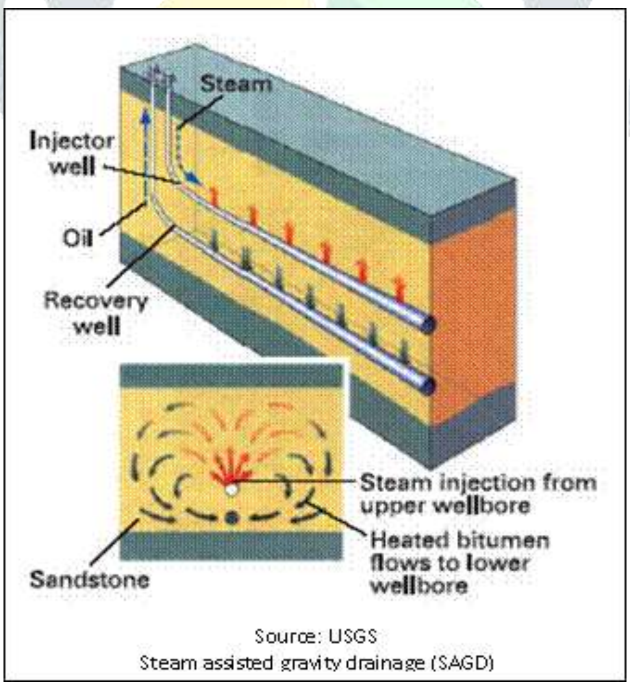

Fig 1.Steam assisted gravity drainage (after USGS, 2003)

- Steam-assisted gravity drainage (SAGD), is a drilling technique used to extract heavy crude oil which is buried too deep or otherwise burdensome to access.

- The process was created by the Alberta Oil Sands Technology and Research Authority (AOSTRA) as an efficient means of recovering difficult-to-access oil reserves.

Discussion on the implementations of steam flooding in few prominent fields

Issaran Oil Field

Issaran oil field is located 290 km southeast of Cairo and 3 km inland from the western shore of gulf of Suez , covering area of 20000 acres. Cyclic Group Steaming of the Well (CGSW) was the technique used for the recovery of 10-12 °API heavy oil from the fields of Egypt. The first re-completed well in Gharandal(I-064) was produced for 1.5 years from cold production and for 10 months by zonal isolation (Figure 2)

The steam injection started in the first well after the re-completion of the surrounding wells cyclic steam injection started in all well six wells in selected pilot (Figure 2). By the continuous monitoring of the field it is observed that there are some negative and positive effects. Negative effects like oil loss from the well when cyclic steam injection is done in the adjacent well and positive effect in the nearby well oil production nearly increasing the slug volume.[4][5]

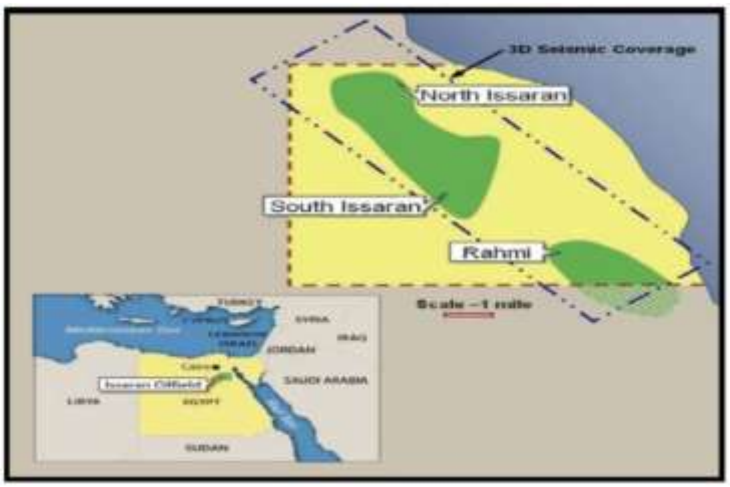

Figure 2. Issaran Field Location (after S.K. Komany, 2015)

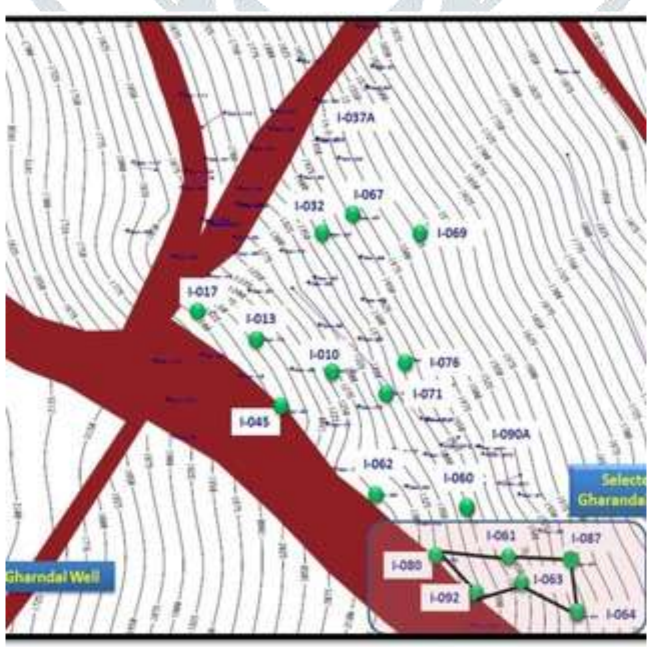

Figure 3. Formation Contour Map showing the location of the Selected Pilot

(after S.K. Komany, 2015)

From this observation it was decided to do the cyclic steam injection simultaneously in all wells by increasing the slug volume and produce them all. As a result of CGSW , initially the average oil production was X bopd then after application of CGSW the average oil production was 3.2X and it lasted for 2 months. In the 2nd CGSW the average daily production was 4.6X and it lasted for 3 months , in the 3rd CGSW it was 1.8X. from the results we can observe that by applying CGSW there is a high oil recovery in short period of time.[5]

Iranian Fractured Light Oil Reservoir

The Iranian wet carbonated field is a giant and highly fractured reservoir and was named “reservoir A” that is located in south western Iran It has been producing for more than 40 years and has a huge amount of oil in place.

Table 1.Characteristics of reservoir A (after Bagheripour, 2010)

Property	Value
Area of reservoir (acre)	3036
Original oil in place (barrel)	1×10^{9}
Solution of gas density (lbm/ m³)	16.49
Dead oil density (lbm/ m³)	2.21×10^{-6}
Water oil contact (ft)	8796.6
Initial pressure at 7546 ft (psi)	4350
Initial temperature (°F)	172.2
Gas oil contact (ft)	4642.5
Water compressibility (psi^{-1})	2.21×10^{-6}
Oil compressibility (psi^{-1})	2.099×10^{-5}

After comparing the nine spot patterns production efficiency with five spot pattern it was observed that the five spot pattern has ultimate oil recover. when comparing with steam injection with water injection middle east field the matrix rocks are commonly oil wet or mixed so in that condition water injection is not possible ,steam injection is appropriate for this field this is an alternative technique and by steam injection the heat also increases the permeability of the region.Steam injection rate was improved in match with steam oil ratio, water and gas oil ratio.[6]

As the steam injection increases cumulative oil production also increases. While reviewing the paper it was also understood that in injection well perforation top four layers were perforated because the gravity of steam is less as compared to water oil and gas so when the steam is injected it moves upward and pushes the oil down to the bottom layer. Also if the bottom layers are perforated the steam that we inject condensate and form water it move towards upward and reaches the producer well which results to large amount of reservoir area kept unswept. So in this case top four layers were perforated. When talking about the quality of steam unlike from heavy oil here treating with lighter oil so any quality of steam can be used . So for economic purpose the quality of steam was fixed low. It can be justified because lighter oil have low viscosity so we need only less amount of latent heat for the recovery.[6]

Daqing Oil Field

SaBei is a transition zone in the Daqing oil field which has been water flooded for 30 years. The region is under high water saturation and because of its worst condition of the reservoir and rock conventional methods are not applicable there so the field should undergo thermal recovery method.

Porosity has a crucial role in determining steam flood performance. As the porosity increases the oil in place increases. The base case assumes the porosity as 30% and runs are also made with porosity of 20 and 40%. When there is a change in the porosity the water and steam injection also changes so that to maintain the PV constant.when the porosity decreases from 30 to 20% the life get shortened and the SOR become an uneconomical level.when the porosity is equal to or greater than 30% is the better condition for steam injection. permeability for base case is assumed to be 1000md as uniform permeability and runs were made 200md,500md and 3000md. When the permeability is less than 500md the oil recover reduces. So the permeability less than 200md is not suitable for steam flooding. Residual oil saturation is also important like porosity as .residual oil saturation in base case is summed to be 40% and runs were made 30% and 50%. When the residual oil saturation increases there will be a increase in oil recovery and decrease in SOR. Reservoir base case thickness is assumed to be 20ft. runs were made with 30,40 and 60ft. here we are avoiding the case of 10ft because with the decrease in the thickness of reservoir SOR increases which lead the reservoir to a unlikely candidate of steam flooding.and the water and steam injection should be arranged proportionally with the reservoir thickness so that to maintain the PV constant.

Table 2.Characteristics of SaBei Transition zone (after Zeng Xuemei, 2011)

	Criteria for steam flood [6]	**Actual oil and rock property in SaBei area[6]**
Oil property	>26 °API	26.1-34.2 °API
Reservoir thickness (m)	>6.1	10-15
Porosity (%)	>30%	27.4%
SOR (%)	>40%	36.65%
Permeability (md)	>200 md	274 md
Permeability variation	Increasing downward	Increasing downward

Since the field was highly saturated with water because of the lower recovery after water flooding, several pilot test has been introduced for improving the recovery. In 2005-2008 period four production wells were chosen and 3 cycle steam soak had conducted in SaBei transition area. As a result of this the average oil production get increased to 6.4 tonnes and at the end of July 2008 the increased output reached to 5277 tonnes.

While comparing water flood and steam flood in SaBei transition zone the efficiency increases by 11% in the same temperature and exceeding nearly 25% than water flood in 50(°C) temperature. After reviewing this paper we can conclude that steam flooding decreases the SOR at the same time increases the oil recovery.[7]

Conclusion

The demand for hydrocarbons continues to be increasing to cope up with demand, the Oil industry is challenged to enhance current recovery mechanisms and being compelled to invent new means of techniques to meet the demand.There fore there are positive rays of scope in the field of EOR .This opens vast opportunities of implementing steam flooding in different reservoirs across the world. Steam flooding helps manufacture up to 30% of the original oil in place .It can be implemented in a reservoir which exhibit heavy oil, poor permeability, irregular fault lines.All the fields which has been reviewed shows more positive sign towards steam flooding.Most of the pilot tests and simulation which carried out in the fields were successful and as a result implementation of steam flooding become favourable. Apart from the success side there are some misfortunes in the field analysis the engineers were able to modify the issue with a positive approach and thus leading to a better way of Enhanced Oil Recovery..The main advantage of steam flooding from other EOR methods is it does not results in major environmental risks.Well construction, injection operations (injection of fluids into the subsurface), production operations (recovery of oil), waste disposal, and secondary impacts resulting from chemical manufacturing and refining related to oil recovery have the potential to cause multiple types of pollution and adversely affect land and water resources.But the main issue that determines whether this technique should be implemented in the field or not is economy, as the steam injection process is an expensive technique.By the growth of technologies day by day there are inventions going on the scope of steam flooding to implement this technique in a cost effective manner.There fore there will be better ways of recovery techniques of EOR from current techniques in the future.

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