APPLICATION CRITERIA OF MICROBIAL ENHANCED OIL RECOVERY

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Abstract

The need of enhancing and propelling the enhanced oil recovery (EOR) procedures to make them more productive has pulled in the consideration of specialists and oil field administrators. at present the worldwide average oil recovery rate is about 30%, where in the USAthe average oil recovery factor is 39%. In any case, numerous specialists that within a reasonable time-frame the recovery factor may well achieve 50-60% and even 70-80%.

The microbial-enhanced oil recovery method strategy depends on microorganisms and their metabolic products to mobilize residual oil. It is ecologically amicable and simple to work. In the previous ten years, the microbial-enhanced oil strategy has pulled in a lot of consideration in both research and field applications. This article outlines the all around recorded field cases in the previous ten years. The targets are to investigate the microbial-enhanced oil recovery mechanisms and application criteria dependent on field information. The present achievement rate for the enhanced oil recovery method stands at about 80%. With a superior comprehension microbial-enhanced oil recovery mechanisms and field encounters, the microbial-enhanced oil recovery mechanism is relied upon to flourish and the achievement rate will move forward.

1. INTRODUCTION

In the world today, we rely greatly on crude oil as a major source of energy. A huge percentage of this precious non-renewable resource is inaccessible and therefore left behind in the reservoir after the conventional Oil extraction methods have been applied. However, we really do need to produce more crude oil in order to be able to match up to the ever rising world demand for energy and this explains the importance of having positive improvement in the Enhanced Oil Recovery (EOR) activities.

We have mainly three types of recovery of oil process that are Primary recovery, Secondary recovery and Tertiary recovery (EOR) methods.

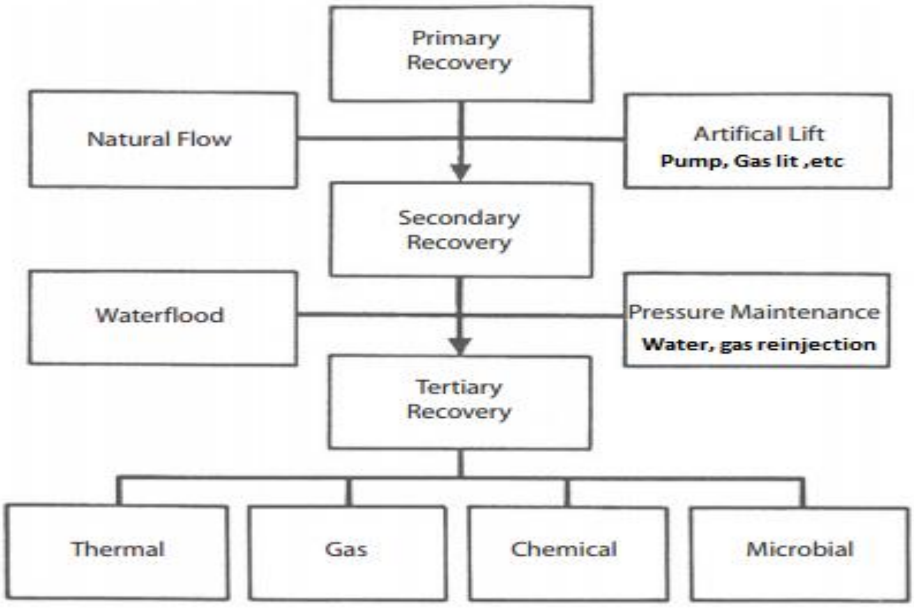

Figure 1.1: Oil recovery mechanism

1.1 Microbial Enhanced Oil Recovery (MEOR)

MEOR is one of the many Enhanced Oil Recovery techniques utilized in the industry and it needs to do with microorganisms and their by-products being used for mobilization of oil in a reservoir. We can define MEOR as a procedure that increases oil recovery by inoculating micro-organisms in a reservoir, their by-products and projecting bacteria causes some positive effects such as the formation stable oil-water emulsions, reduced interfacial tension due to the residual oil being mobilized and diverting of injection fluids through upswept areas of the reservoir by clogging high permeable zones. MEOR exercises are getting progressively acknowledged the world over on the grounds because it is cost effective and also environmental friendly in its process to increase the volume of crude oil being produced.

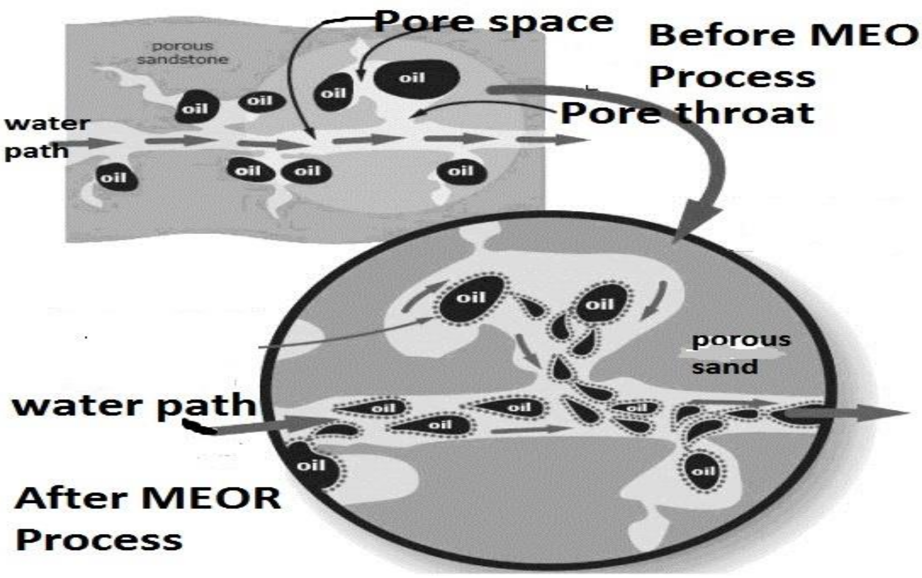

Figure1.1: Efficiency of MEOR

Family	Respiration Type	Products
Clostridium	Anaerobic	Gases, acids, alcohol and surfactants
Bacillus	Facultative	Acids and surfactants
Pseudomonas	Aerobic	Surfactants and polymers, can degrade hydrocarbons
Xanthomonas	Aerobic	Polymers
Leuconostoc	Facultative	Polymers
Desulfovibrio	Anaerobic	Gases and acids, sulfatereducing
Arthrobacter	Facultative	Surfactants and alcohols
Corynebacterium	Aerobic	Surfactants
Enterobacter	Facultative	Gases and acids

Table1.1: Bacteria that are used in MEOR and their products

Possible MOER applications of different micro organisms:

MEOR agents	Possible MEOR application
Biomass(flocks or bio-films)	Selective plugging and to change the wettability angle
Surfactants	It decrease the interfacial tension
Biopolymers	Change the viscosity and injectivity process, Selective plugging
Solvents	Dissolves the rock to increase permeability, reduce oil viscosity
Acids	Increase Permeability, emulsification process
Gases	oil swelling, lessen the interfacial forces and thickness; increment in permeability of the stone

Table1.2: Microbes applications

1.3. Possible mechanism of oil release

1. Modification of reservoir permeability by acids
2. Repressurization by production of carbon dioxide, hydrogen, methane, nitrogen
3. Solution of gases in oil resulting in swelling and decreased viscosity
4. By degradation of large molecules viscosity reduction
5. To increase oil water contact by surfactants
6. Dissolution of oil by solvents e.g. Alcohols and Ketones
7. Sulphonation of oil by bacteria
8. Displacement of oil from rock surfaces by bacterial growth
9. By using bacterial polymers increasing the viscosity
10. Selective plugging of regions of high permeability

2. LITERATURE REVIEW

MEOR as a science is relatively young. Although the first suggestion that microorganisms might be used to increase oil production was made in 1926, and laboratory investigations were conducted by Claude ZoBell in the 1940s, the majority of the MEOR work leading to field trials has been completed in about the past 15 years. Researchers are still sorting out the characteristics of various organisms, and determining what they require to flourish in the subsurface environment. To many in the oil industry, the MEOR approach still looks like a "hit or miss" proposition.

In the initial couple of many years of penetrating, geologists' suggestions were respected in all respects incredulously by drillers. Designers frequently, with cleverness, propose they should at present be respected with distrust today; the science and routine with regards to MEOR is respected in a similar way by most of the oil business.

The DOE has funded several field demonstrations using, if not prolific producers, at least sound wells and fields. Financial support for MEOR research in the last six years started in Fiscal Year 1986 with $600K, (Table 2.1). It peaked in Fiscal Year 1990 at $3,60OK and dropped to $2,20OK in Fiscal Year 1991. By 1992, support for the MEOR projects had decreased to $1,10OK. Reduction in FY 1991 was mainly due to the termination of several MEOR contracts with no new MEOR

3. RESERVOIR SELECTION FOR MEOR

The first thing comes to one's mind when hearing the MEOR is, what is the role of microbes? Only microorganisms are consider in MEOR process for best results. Yeast, protozoa, molds and green growth not used because of their physical structures and insecurity to develop under the high pressure and temperatures.

To an exceptionally huge degree, the accomplishment of MEOR transfers on the utilization of fitting microorganisms. . Most importantly, there are two critical models that must be met. Above all else the microorganism ought not be pathogenic to people or creatures. Second, development of the microorganisms does not have any antagonistic impacts on the nature of the oil or produce any unwanted metabolic items.

Reservoirs suitable for MEOR should typically be at temperatures lower than 80°C with salinities less than10%.. The reservoir pressure is not normally a limiting factor because the growth of most microorganisms is unaffected by pressureosfupto300atm

For all practical purposes the reservoir should be considered to be an anaerobic environment. Only strict anaerobic and facultative organisms should be considered for injection. They are poisoned by oxygen and therefore require some care in handling and for growth of the inoculums. No MEOR field connects in high-weight and high-temperature stores have been spoken to. The normal characteristic prerequisite for temperature is about 158° F (70° C), and the weight constrainment is around 20,000 psi. All most MEOR field endeavors have been driven with light foul oils having API gravities around 30 ° to 40 °, triumphs have been represented with overpowering crudes having gravities around 20 ° API.

4. RESEARCH METHODOLOGY

ONGC Ahmedabad asset (Cambay Basin)

Ageing of oil fields is a perpetual and crucial concern facing the global oil industry. Thousands of oil wells in such fields fall in the category of stripper wells producing small to insignificant quantities of oil.

To enhance oil production from these stripper wells, joint research of ONGC, IRS & TERI lead to improved Microbial technology of cultured set of microbes that could survive temperatures as high as 90ºC, air pressure up to 140 kilograms per square centimeter, and strong salinity with concentration levels ranging from 4% to 8%. These microbes were successfully field tested in oil wells of Gujarat and Assam and the application of this technology is through Huff & Puff method where microbial injection & oil production is done through the same well.

OTBL has executed 50 MEOR jobs in oil wells of 5 fields of ONGC, Ahmedabad Asset. The tabulated field wise execution status of these jobs as follows:

Field Name	No of MEOR job executed
Field – A	23
Field – B	10
Field – G	5
Field – I	4
Field – L	8
Total	50

Some Assumptions made

- The reservoir is assumed to be related to PVT cell
- The thermodynamics of fluids are independent of the wall properties of the reservoir, and provided that these walls are not so closely spaced as to affect the thermodynamics properties of the bulk fluid
- Mass of the dissolved gas released considered.
- Gas flow is in 1 dimension, from the point of injection to the reservoir extent.
- Metabolite production mostly biogenic gases.
- Gas solubility considered

4.1 RESULTS AND DISCUSSION

Field B parameters for model validation:

η_L (cp)	η_g (cp)	K_g (md)	V_f	P_o (Psi)	T (^{0} C)
1.100	0.0250	0.001	0.8	3,600	50
1.105	0.0234	0.004	0.7	3200	70
1.114	0.0220	0.033	0.6	2900	80
1.123	0.0217	0.102	0.5	2700	90
1.196	0.0201	0.222	0.4	1800	110
1.337	0.0184	0.395	0.3	1600	130
1.497	0.0139	0.614	0.2	900	150
2.100	0.0128	0.867	0.1	500	180

Table 4.1: Field- B parameters for model validation

The calculations of the general effect of microbial activities on these parameters are shown below:

When $A=600ft^2$, $\eta_L = 1.100$, $\eta_g=0.25$, $V_f=0.8$, $K_{rg} = 0.004$ then

Permeability of gas in oil after microbial application can be obtained from

$$\left(\frac{K_L}{K_g}\nabla\right)_{MA} = \left(\frac{(1-V_f)}{V_f}\frac{\eta_L}{\eta_g}\right)_{MA}$$

$$K_{LMA} = \left(Kg\frac{(1-V_f)}{Vf}\frac{\eta_L}{\eta_g}\right)_{MA}$$

$$K_{LMA} = \left(0.004\frac{(1-0.8)}{0.8}\frac{1.1}{0.025}\right)_{MA}$$

=0.004(11)

=0.044md

For oil viscosity is given as

$$\mu_{LMA} = \left(\frac{\eta_L}{K_L}\right)_{MA}$$

$$\mu_{LMA} = \left(\frac{1.1}{0.044}\right)_{MA}$$

μ_{LMA} = 25cp

The oil viscosity due to microbial application is calculated as:

Solubility of gas in oil due to MEOR activities is calculated from equation (23) above as;

$$Bg_{MA} = \left|\frac{\overline{Tref}}{T}\frac{(\bar{P_b})}{p_{ref}\bar{R_{sb}}}\right|_{MA}$$

P_{ref} = 4044 P_{si} P=3600 P_{si}

B_g = 0.89

$$Q_{MA} = \left[A\frac{K_L}{\mu_L}(1-V_f)\frac{dp}{dx}\right]_{MA}$$

Q_{MA} =0.019 bbl/day

When A=600ft^2 , η_L = 1.1050 , η_g =0.0234 , V_f=0.8 , K_{rg} = 0.004 then

V_f= 0.7, T=70°C

$$\left(\frac{K_L}{K_g}\nabla\right)_{MA} = \left(\frac{(1-V_f)}{V_f}\frac{\eta_L}{\eta_g}\right)_{MA}$$

$$\left(\frac{K_L}{0.004}\right)_{MA} = \left(\frac{(1-0.7)}{0.7}\frac{1.105}{0.0234}\right)$$

K_{Lma} = 0.081 md

The oil viscosity due to microbial application is calculated as

$$\mu_{LMA} = \left(\frac{\eta_L}{K_L}\right)_{MA}$$

$$= \left(\frac{1.105}{0.081}\right)$$

=13.64 cp

Solubility of gas in oil after microbial activities is;

$$B_{gMA} = \left|\frac{\overline{Tref}}{T}\frac{(\bar{P_b})}{p_{ref}\bar{R_{sb}}}\right|_{MA}$$

$$B_{gMA} = \frac{15.6}{70}\ln 14.7$$

B_{gMA} = 0.599

$$Q_{MA} = \left[A\frac{K_L}{\mu_L}(1-V_f)\frac{dp}{dx}\right]_{MA}$$

Q_{MA} = 4.5 bbl/day

μ_L (Cp)	Q (bbl / day)	Krl(md)
27.500	0.018	0.044
13.600	4.9	0.084
1.000	23.4	1.144
0.210	34.9	5.280
0.060	41.2	19.800
0.020	48.6	55.970
0.006	52.6	264.500
0.002	63.6	1280.000

Table 4.2: Deduced parameters after MEOR application for field B

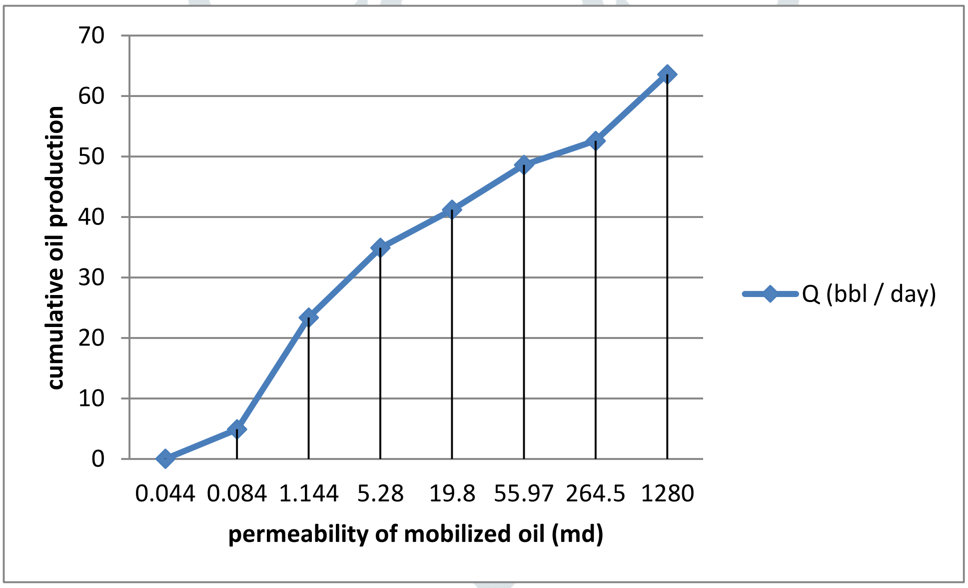

Fig 4.1 Plot of cumulative production against permeability of mobilized oil

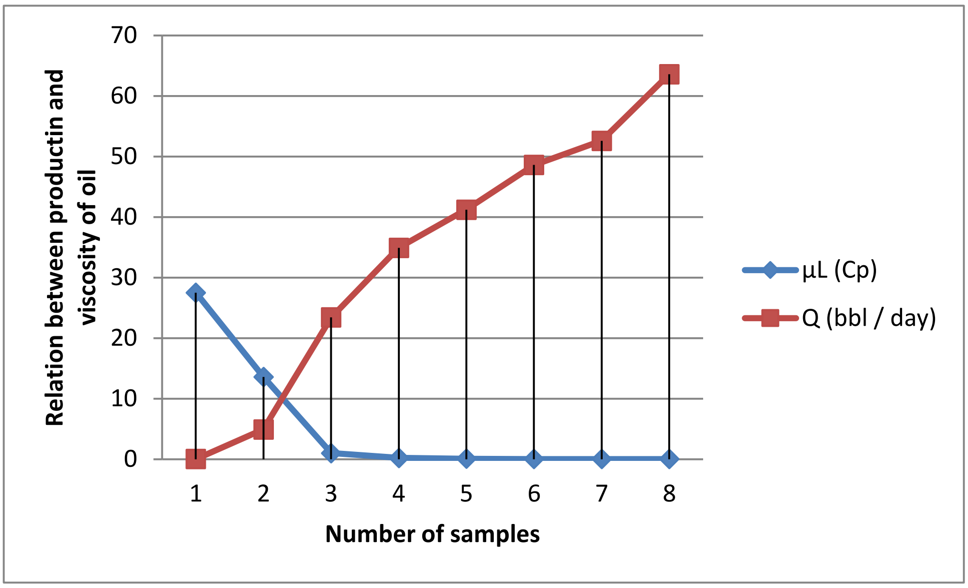

Fig 4.2 Plot of cumulative production against oil viscosity

Fig 4.3 Plot of oil viscosity against effective permeability of mobilized oil

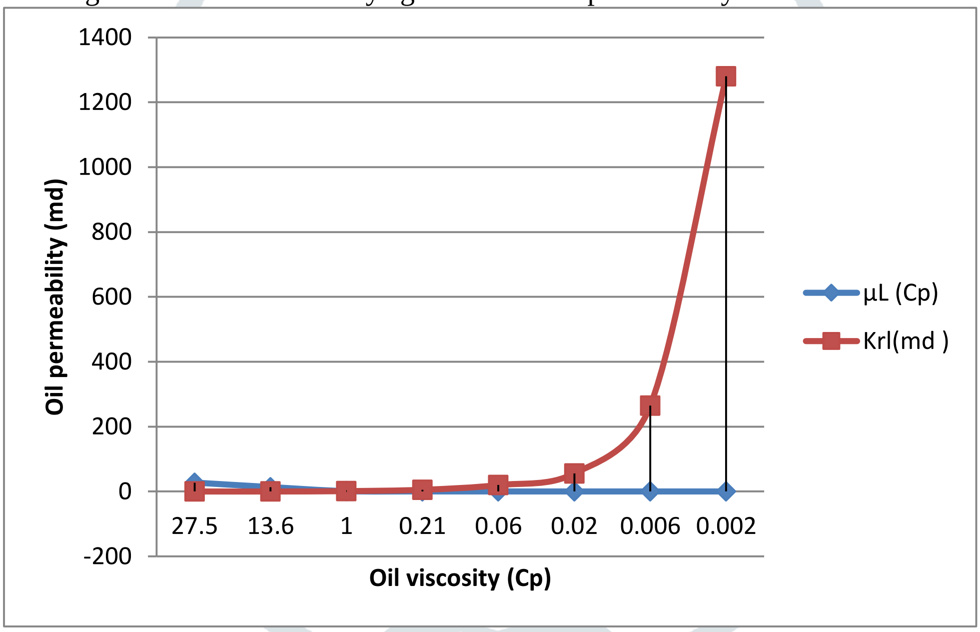

Fig 4.3 Plot of oil viscosity against effective permeability of mobilized oil

5. DISCUSSION

Figure 1 shows the plot of cumulative production against the altered viscosity of oil. The plot shows that as the viscosity of crude oil decreases, cumulative production increases. This improved production is traceable mechanism of improved mobility of oil as a result of the dissolved biogenic gases in the oil. On the other hand, if more gases are evolved from the oil, the oil becomes more viscous resulting to a reduction in cumulative production. The Crude becomes very heavy at this point and is difficult to produce. Figure 2 shows the relationship between cumulative production and oil permeability. The plot shows that production of oil increases with an increased permeability of oil in the microbe-subjected reservoir. Injected microbes tend to plug thief zones, diverting flow towards the production points in the reservoir, plugging these high permeable zones in the reservoir increases sweep efficiency during production. Permeability of a rock is the measure to which the rock can transmit fluid through itself. Once oil viscosity drops in magnitude, the permeability of the oil in the reservoir increases instantly. The inverse relationship between viscosity and permeability is shown in figure 3

6. CONCLUSION

MEOR is a verified technology to improve oil recovery particularly in mature oil wells. MEOR is eco-friendly and cost effective and it is a technique that also indicates various benefits over the other EOR processes. Most microorganisms cannot survive high temperatures. It is thus believed that temperature has the most significant effect on the success of MEOR applications. Based on the field data, one should apply MEOR methods to formations under 85° C., preferably below 55° C. Bacteria also are sensitive to water salinity. Based on limited information, salinity less than 100,000 ppm seems a reasonable criterion. MEOR projects do not seem to depend on reservoir permeabilities. The dominant MEOR mechanisms may be interfacial tension reduction and selective plugging. The reduction in interfacial tension may not be less effective than selective plugging in improving recovery.

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