A Comparative Study of Locally designed and Imported Alkaline-Surfactant-Polymer Flooding for Enhanced Oil Recovery

[1] Oluwashina Olaniyan Peter, [2] Prof Mike Onyekonwu
[1,2] Department of Petroleum and Gas Engineering,
University of Port Harcourt, Nigeria

Abstract - The production of hydrocarbons from a known reservoir undergo some stages of recovery and about 35 – 50% of the hydrocarbon content in the reservoir are able to be recovered from the primary and secondary recovery stage leaving a significant amount of oil trapped or bypassed in the reservoir. During water flooding process, an unstable displacement usually occur in the reservoir as a result of the oil viscosity being higher than water. This implies that the viscosity of the injected fluid needs to be improved upon by adding a polymer or a combination of alkaline- polymer solution to improve sweep efficiency during water flooding process. In this study, an appropriate composition of a locally made Alkaline-Surfactant-Polyme (ASP) slug such as burning of palm bunch, plantain back, archi and a solution of foreign polyanoic cellulose polymer were designed. Several core flooding experiments were carried out in the laboratory, varying the compositions of the slugs to determine the compositions that would perform optimally. Result obtained showed that highest recovery of oil 3.5ml was observed when the ASP slug composition was 60% Alkaline and 40% Polymer. Displacement 64.07% as against 4.0ml (78.13%) by the foreign polymer. The residual oil saturation after flooding with the local alkaline-polymer slug was about 24%.

Introduction

The recovery of hydrocarbon from the reservoir usually undergoes several stage. At the beginning of production, the primary energy comes from the natural drive of the reservoir such as depletion, gas cap, gravity drainage, water, rock compaction and a combination drive which help to push the hydrocarbon towards the perforation. In some cases, the wells may require some form of artificial lift such as gas lift and pumping system. The hydrocarbon fluids are actually trapped in the pore space of the reservoir. Thus, some of the question that are frequently asked are how much oil and gas can be recovered, how much has been produced, how much is remaining in the reservoir and what is the best way to technically and econimically recover the remaining oil? During the primary and other recovery techniques.

Therefore, when the reservoir can no longer perform very well under the primary recovery, a secondary recovery techniques is employed such as water or gas injection to increase hydrocarbon recovery from the reservoir beyond primary recovery. During the injection of water or gas, there are sometimes some bypassed oil left unswept in the reservoir called residual oil saturation that is current a challenge to the oil and gas industry. This requires an enhanced oil recovery technique to increase oil recovery beyond primary or secondary recovery processes.

Enhanced oil recovery is also called tertiary recovery processes. These are further classified under four main groups: miscible gas injection processes, chemical processes, microbial and thermal processes.

A method to improve oil recovery often referred to as tertiary recovery scheme in the form of polymer, surfactant, alkaline or a combination of two or more flooding has proved to be effective in reducing the residual oil saturation in laboratory experiments and field projects through the reduction of interfacial tension and mobility ratio between the oil and water phases. In this study, a combination of Nigeria locally source and foreign alkaline -polymer (AP) solution will be used in conducting the experiment to investigate it efficacy in enhanced oil recovery. From literatures, it has been widely reported that the viscoelasticity of polymer solutions plays an important role in polymer flood operations. These polymer solutions are used in many operations in the petroleum industry, and their viscoelastic effects are generally recognized (Smith, 1970, Achaya, 1986). Protein is a natural polymer, made of amino acid monomers joined together by peptide bonds (Jenkins et al, 1982).

Polymer flooding technique is an enhanced oil recovery method in which polymer solutions are enhanced oil by increasing the viscosity of the injecting fluid to decrease the water/oil mobility ratio. The mobility ratio is lowered as a result of the increase in viscosity and also decrease in aqueous phase permeability. This in turn helps in increasing the volumetric sweep efficiency and lower swept zone oil saturation. The polymer flooding method is considered favorable when the waterflood mobility ratio is high, the reservoir heterogeneity is serious, or a combination of these two happens (Lake Harry W, 1989)

The most important factors to be considered for polymer flooding are mainly the temperature of the reservoir and the chemical properties of reservoir water. When the reservoir temperature is high or when the salinity content reservoir water is high, the polymer cannot be kept stable and polymer concentration will lose the strength of its viscosity (Farid, 2011).

The purpose of surfactant flooding is to recover the capillary trapped oil after water flooding. When a surfactant solution has been injected, the trapped oil droplets are mobilized due to a reduction in the interfacial tension between oil and water. The coalescence of these drops leads to a local increase in oil saturation and oil bank is generated. The oil bank will start to flow, mobilizing any residual oil in front of the bank. Behind the flowing oil bank, the surfactant will prevent the mobilized oil to be re-trapped. The interfacial tension, the viscosity, and the volume of the surfactant solution behind the oil bank will therefore be of importance for the final residual oil saturation. (Kleppe, Jon et al, 1992).

The major goal of surfactant flooding is to recover the capillary-trapped residual oil after water flooding is exhausted. By the injection of surfactant solution, the residual oil can be pushed or mobilized through a strong lowered interfacial tension (IFT) between oil and water. (Zolotukhin, A.B. et al 2000). The ability to lower the surface tension between aqueous solutions and other phases is one of the most significant aspects of surfactants that raise their applicability in industries. The critical micelle concentration (CMC), one of the main parameters for surfactants, is the concentration at which the surfactant solutions begin to form micelles in large amount (Hoff et al. 2001). Presence of polymer and alkali in a solution of surfactant significantly influences the surface tensions (Nedjhioui et al. 2005; Horváth-Szabó et al. (2002). For evaluating the effect of polymer on the surface properties, surface tension measurements of SDS surfactants have been performed in the presence and absence of polymer.

In the past, different authors, such as Christopher and Middleman (1965); Willhite and Uhl (1986); van Poollen and Jargun (1969); Hirasaki and Pope (1974); Abou-Kassem and Ali (1986); Pruess and Witherspoon (1991), have proposed several models to account for the flow behavior of polymer solutions under different conditions and some other authors have also suggested simple empirical models to account for non-linear relationship between flow rate and the pressure drop for non-Newtonian fluid flow. But these models fall short in accounting for the elastic phenomena manifested by polymer flow in porous media. Carreau model gives a better representation of flow behavior in these shear regimes (Carreau et al. 1979, Bird et al. 1987) while Maxwell came up with a model that accounted for both viscous and elastic components.

Factors Affecting ASP Flooding

ASP flooding is depended on the concepts expressed below:

- Interfacial tension force between the injected fluid and the residual oil after primary recovery process,
- Capillary number of the displacing fluid
- Mobility ratio between the displacing fluid and the displaced fluid
- Microscopic displacement efficiency,
- Macroscopic sweep efficiency.

Therefore that oil recovery can greatly be improved or enhanced when interfacial tension force (IFT) is lowered and capillary number increased also, reduction in mobility ratio to enhance microscopic displacement efficiency, and macroscopic sweeping efficiency of residual oil trapped in sand-oil-water reservoir system.

Challenges

The cost of the polymers, the permeability of the reservoir, and the temperature of the reservoir are some of the challenges which deter the application of polymer in enhanced oil recovery scheme. The cost of polymers limits the concentration and slug size of the polymers that can be used to achieve higher oil recovery. Low rock permeability can limit the use of more viscous polymers to improve mobility control, and can cause low injectivity. Polymers are not stable at reservoir temperatures higher than 175 F

It has been observed that most oil fields are in the later production stage and the water production level increases tremendously even as high or more than 80%. As a results water flooding no longer meets the expected needs of oilfield production. Therefore, it is pertinent that a new recovery technique would be considered in place water flooding. This new technique of ASP flooding was developed in the 1980s on the basic concepts of synergy effect of alkali- surfactant and polymer-flooding. This concept considered the benefits of the three flooding methods simultaneously, and oil recovery is significantly improved by reducing interfacial tension (IFT), improving the capillary number, enhancing microscopic displacing efficiency, improving the mobility ratio, and increasing macroscopic sweeping efficiency. Also, this technique is of necessity since oil and water are immiscible and none of these can completely displace the other from a reservoir.

Objectives of Study

- To experimentally determine the appropriate composition of locally derived ASP slug (Alkaline-Surfactant-Polymer) that would optimally enhance oil recovery from a reservoir.
- Comparative analysis of locally designed and conventionally designed ASP slug.

Materials and Apparatus

Apparatus or equipment used to carry out this experimental work is as shown in Fig. 3 which consists among others; weighing balance, beaker, measuring cylinder, PH meter, pump, filter paper, sieve or mesh, viscometer, hose, thermometer, sand pack holder and crude oil.

The materials for this research work are locally sourced due to its availability and affordability. This is one of the objectives of this research work, to make use of what we have locally, improve on them and reduce or eliminate the importation of oil field chemicals. These materials are palm bunch ash, plantain bark ash and palm oil (the surfactant source), and archi (the polymer source) and sodium hydroxide as the alkaline source.

Preparation of sand samples

For the purpose of this of this experiment, a cylindrical sand packed core samples were built. Core samples were designed using unconsolidated sand. The following procedures were used in preparing the core samples (Figure 1).

i. A sample of sand was collected, washed and dried.
ii. A 40/80 sieve plate was used to separate the sand samples into various particle sizes.
iii. Aluminum foils of known weights were improvised into cylindrical shaped body of (5cm and 2cm) in length and diameter respectively. Wire mesh sizes (200/120) were used to wrap the bottom of the cylindrical shaped body.
iv. Sand samples were poured into the cylindrical shaped aluminum foils and the top also covered/wrapped with a mesh sizes wire (200/120).
v. The cylindrical core samples formed were oven-dried for it to be more compacted.
vi. The weight, length and diameter of each of the core samples were recorded after been dried with oven.

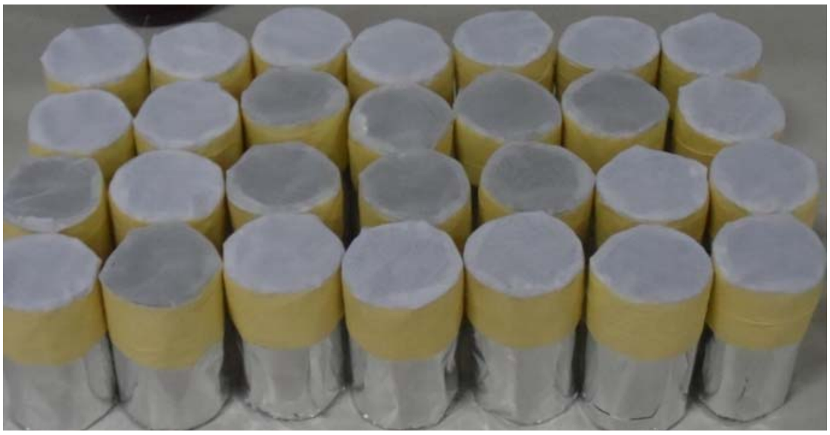

Figure 1: Prepared sand samples

Preparation of Brine

The concentration of the brine used was 20000ppm and was prepared as follows.

- 20g of common salt (Nacl) was measured using the electronic weighing balance.
- The salt was placed in a beaker and 30ml of distilled water was added and stirred with magnetic stirrer until the salt dissolved completely to have a uniform solution.
- Introduce the salt solution into 1000ml measuring cylinder.
- Distilled water was added up to the 1000ml mark of the cylinder.

Preparation of Alkaline (NaOH)

The concentration of the NaOH used was 20000ppm and was prepared as follows.

- 20g of (NaOH) pellet was measured using the electronic weighing balance.
- The salt was placed in a beaker and 30ml of distilled water was added and stirred with magnetic stirrer until the salt dissolved completely to have a uniform solution.
- Introduce the salt solution into 1000ml measuring cylinder.
- Distilled water was added up to the 1000ml mark of the cylinder.

Local Polymer

The local polymer source is local archi, sourced from a local market. While the foreign polymer is polyanoic cellulose polymer. The concentration of the local archi polymer used was 12500ppm and prepared as follows:

- The archi was grinded to powdery form.
- 12.5g of the grinded archi was weighed using electronic weighing balance.
- The 12.5g of grinded archi was introduced into a beaker and dissolved with about 30mls of hot distilled water, stirred continually with a magnetic stirrer until the archi dissolved completely, forming a uniform solution.
- The archi solution was introduced into a 1000ml measuring cylinder and distilled water added up to the 1000ml mark of the cylinder.

Foreign Polymer

The foreign polymer used here was polyanoic cellulose polymer. The polymer was also already in powdered form.

- Also same procedure was repeated for the foreign polymer. However, in this case, 6.5g of foreign polymer was used to generate a concentration of 6500ppm.

It was observed that at these concentrations (12500ppm and 6500ppm) for both the local and foreign polymer, same viscosity was attained.

Local Surfactant

The local surfactant was sourced from burning of palm bunch and plantain back. The ashes generated was poured into water and filtered to get a potassium hydroxide solution.100ml of palm oil was then introduced into 300ml of the potassium hydroxide solution and mixed thoroughly until there was a complete blend of the mixture. This mixture was allowed to sit for four days, solidifying to form a black soap.

- The solid black soap was grinded into powdery form.
- 5g of the powdered black soap was weighed using electronic weighing balance.
- The measured quantity of the powdered black soap was introduced into a beaker and dissolved in 50ml of hot distilled water, stirred continually with a magnetic stirrer until the black soap dissolved completely forming a uniform blended surfactant solution.
- The surfactant solution was introduced into a 1000ml measuring cylinder and distilled water added up to the 1000ml mark of the cylinder

Foreign Surfactant

The foreign Surfactant used was Alkyl aryl Sodium Sulfonate, Anionic. The concentration of the surfactant used was 5000ppm.

Experimental Procedure

Step 1: Brine solution with measured concentration was formulated in the laboratory and used to perform core flooding experiment until residual oil is obtained.

Step 2: Alkaline Polymer (AP) slug of varying compositions and concentration was prepared in the laboratory using local materials.

Step 3: Enhanced oil recovery was carried out by injecting the formulated AP (local and foreign) slug solution of varying composition.

Step 4: The procedure was repeated using different core samples and different compositions of AP slug (both for the locally designed slug and the foreign slug).

Step 5: Comparative analysis of recovery performance was carried out between a local slug and also foreign slug.

Step 6: Slug compositions with the highest recovery of noted for both AP slugs.

Step 7: Measured quantity of locally designed surfactant (black soap) was added to the slug compositions with highest recovery forming slugs of Alkaline-polymer (AP). Same repeated for the conventional (foreign) AP slug using a measured quantity of conventional surfactant.

Step 8: Recovery performances were noted for both slugs.

Flooding Process

Step 1: The formation is saturated with 100% brine

Step 2: The brine in the saturated solution is then flushed out with crude oil until no more is produced.

Step 3: The sand packs were then water flooded until the residual oil saturation is obtained by injecting water at a constant rate until very small quantity of oil is produced. This is done after an initial flooding using the same volume of brine for all samples (with a particular pore volume of the sample).

Step 4: AP slug solutions at varying compositions were injected into the core to recover residual oil trapped in the core by injecting at a constant rate until or no oil is produced.

Step 5: Calculation of percentage recovery of the residual oil in place by measuring the amount of oil separated from the recovery.

The Figure 2 represents a schematic set up of the flooding process as carried out in the laboratory.

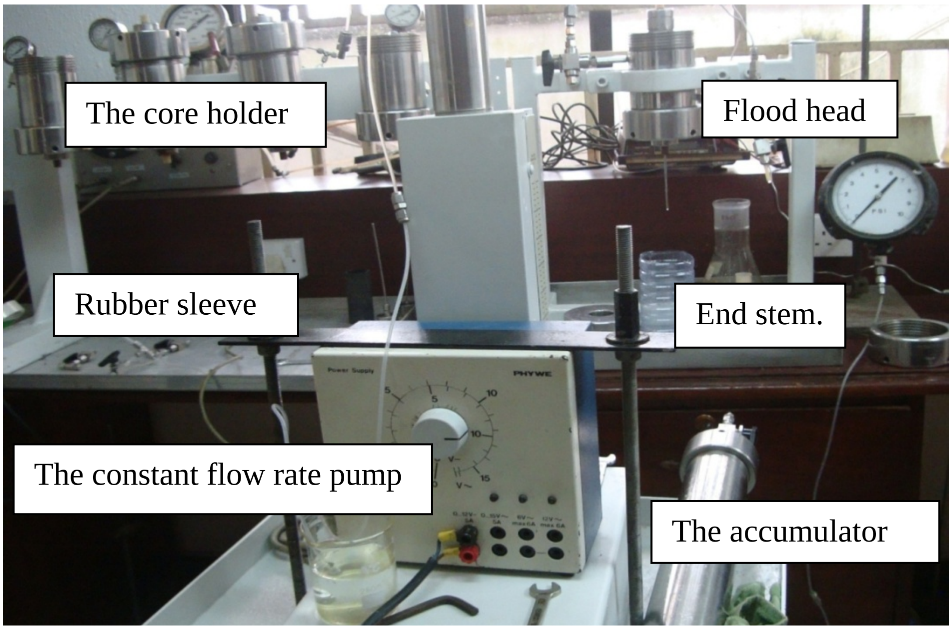

Figure 2: Equipment setup for core flooding experiment

Result and Discussion

The experimental results for the sand samples used in the flooding with varying compositions of foreign Alkaline, Surfactant and Polymer (ASP) slugs are represented in Table 1 & 2 in appendix.We should note that samples A represent sand packs for the foreign ASP slug while samples B represent the local ASP slug.

Observation 1:

- Approximate volume of oil injected at 60% pore volume was 13ml (on average).
- Approximate volume of oil recovered by brine was 8ml (on average).
- Highest recovery of oil (4ml) was observed when the AP slug composition was 40% Alkaline and 60% Polymer. Recovery factor at this point was also observed to be about 78% and residual oil saturation after flooding was about 5%. The slug compositions were a combination of sodium Hydroxide and a foreign polymer (See Table 1).
- Highest recovery of oil (3.5ml) was observed when the AP slug composition was (50% Alkaline and 50% Polymer)and (60% Alkaline and 40% Polymer) Recovery factor at these point was also observed to be about 63.7% and 64.07% .Residual oil saturation after flooding was about 24%.The slug compositions were a combination of sodium Hydroxide and a local polymer(See Table 2).

Observation 2:

The result in Table 1 & 2 is an analysis of recovery per volume of injected ASP slug within a time interval. The maximum recovery from water flooding was observed to be about 8ml,it was observed that at a given point, further water flooding do not yield further recovery of the oil. Recovery remained at a marginal despite flooding. At this point it was not economical to continue flooding since recovery remained marginal.

To further recover oil, it was necessary to introduce the foreign ASP slug as the displacing/flooding fluid. Incremental recovery as a result of the ASP slug injection was observed in relation to the oil unrecovered after water flooding. The maximum cumulative recovery achieved by flooding with the foreign ASP slug was about 88.6% (4.52ml)while that of local ASP slug was about 77% (4.2ml). These were amount of the unrecovered oil after water flooding**.**

Performance and Economic Evaluation

NPV compares the value of a dollar today to the value of the same dollar in the future, taking inflation and returns into account. If the NPV of a project is positive, it should be accepted. However, if the NPV is negative, the project should probably be rejected because cash flow will also be negative. It is defined by the formula

$$NPV = \frac{Revenue - Expenditure}{(1+r)^t} \quad \text{.........} 2.12$$

Where r = discount rate

t = time (years)

Assumptions:

The following assumptions were made to effectively analyze and compare the NPV of the project for flooding with foreign ASP slug as against local ASP slug.

- 1ml of crude oil in the laboratory represents 1000bbl in the field
- 1 ml of other fluids (water, chemicals) represents 1000,000bbl in the field
- $ 1(USD) represents N165
- 1g in the laboratory represents 1000 kg in the field
- 2minutes in the laboratory represents 2 weeks in the field.
- Prevailing price of crude oil as $93/ bbl (N15,345/bbl)
- Foreign Alkaline $2.5/Kg (N412.5/Kg)
- Foreign Surfactant $10.5/Kg (N1732.5/Kg)
- Foreign Polymer $9.0/Kg (N1485/Kg)
- Importation of the foreign alkaline, surfactant and polymer $2.0/Kg
- Local Surfactant $3.0/Kg (N495.0/Kg)
- Local Polymer $2.5/Kg (N412.5/Kg)

Analysis of the foreign slug

Cumulative Volume of ASP slug injected was 58.29 ml which is equivalent to 58,290,000bbls.

Cost of foreign polymer

Concentration of the Polymer used was 6500ppm (6.5g/1000ml of water) and at a proportion of (60/125)*100% =48%

Thus, 48% of 58,290,000bbls equals 27,979,200bbl. This would require 181,864kg of powdered polymer.

This would eventually cost $9.0*181,864Kg = $1,636,776 (N270,068,040)

Importation cost equals $2.0*181,864Kg = $363,728 (N60,015,120)

Total cost of the foreign Polymer =$2,000,504 (N330,083,160)

Cost of foreign Surfactant

Concentration of the Surfactant used was 5000ppm (5.0g/1000ml of water) and at a proportion of (25/125)*100% = 20%

20% of 58,290,000bbls equals 11,658,000bbls. This would require 58,290kg of surfactant.

This would eventually cost $10.5*58,290kg = $612,045 (N100,987,425)

Importation cost equals $2.0*58,290kg =$116,580 (N19,235,700)

Total cost of the foreign Surfactant = $728,625 (N120,223,125)

Cost of foreign Alkaline

Concentration of the Alkaline used was 20ppm (20.0g/1000ml of water) and at a proportion of (40/125)*100% = 32%

32% of 58,290,000bbls equals 18,652,800bbls. This would require 373,056.00kg of NaOH pellet.

This would eventually cost $2.5*373,056kg =$932,640 (N153,885,600)

Importation cost equals $2.0*373,056Kg = $746,112 (N123,108,480)

Total cost of NaOH =$1,678,752 (N276,994,080)

Total Expenditure on the foreign ASP slug = 1,678,752 + 728,625 +2,000,504 **=$4,425,368**(N730,185,720)

Assume facilities expense and other operations to be $15,000,000

Overall expenditure $19,425,368

Revenue =($93*Volume of oil Recovered in bbls)

Volume Recovered in ml (4.527459) =4,527,459bbl*$93 **=$421,053,687**

Injection time 22 weeks (154days)

Therefore time (in years) = 154/365 =0.4219years.

Recall from NPV = $\frac{Revenue - Expenditure}{(1+r)^t}$

Revenue-Expenditure =421,053,687-19,425,368=401,628,319

$(1+0.8)^t = (1.8)^{0.4219} = 1.28$

NPV =401,628,319 /1.28

Therefore the NPV when foreign ASP was used =$**313,772,124** (excluding overhead cost for the period of 22 weeks and Royalty where the need arises).

Analysis of the local slug

Applying the same principle as in case of the foreign slug would give a total expenditure of the local slug as (**$521,623.12)**

Alsoassuming facilities cost operation cost to be same as in case of foreignslug **($15,000,000)**.

Total expenditure =$**15,521,623.12**

Oil recovery by flooding with local slug was about 4.2ml. This equals 4,200,000bbls.

Revenue from oil recovery $93*4,200,000 =**389,637,915**

Therefore NPV = (390,600,000-15,521,632.12)/1.25

=$300,062,694

NPV comparison analysis of the foreign and local slug

NPV of foreign slug ($**313,772,124)**

NPV of local slug (**$300,062,694)**

Conclusion

- From the experimental results obtained, applications of both the foreign and local ASP were very effective. Though flooding cost was intensive, the ASP flooding project was worthwhile. This could be observed from the incremental oil Recovery after water flooding failed to yield further recovery.
- Result obtained shows clearly that the local slugs performed competitively well against the foreign slug which justifies the aim of study is to compare both the foreign and the local slugs in terms of recovery performance and economic value.
- A recovery of 4.189ml was obtained by the local slug as against 4.59ml by the foreign polymer. Also from the NPV analysis of both cases the local slug competed favorably. With further research work, the local chemicals could yield improved performance as we gradually eliminate the importation of oil field chemicals and also reducing cost in Oil and gas operations.

Recommendations

- Nigeria as a nation is endowed with adequate resources which could be profitable as Oil field Chemical**.** More research should be geared towards maximizing these potentials which would also go a long way to eliminate cost of importation of oil field chemicals. This would also go a long way to boost local participation in the Oil and gas sphere.
- ASP flooding can be applicable in oil fields where water flooding could not recover further fluids.

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Table 1: Experiment result of flooding with Foreign ASP slug

samples	Alkaline (NaoH) (Composition by %)	Polymer (Composition by %)	VOLUME OF OIL INJECTED (60% OF PORE VOLUME)	VOLUME OIL RECOVERED BY BRINE. (ml)	VOLUME OIL RECOVERED BY NAOH & FORIEGN POLYMER. (ml)	Water Saturation. (sw) (%)	Recovery Factor. (%) by brine	Residual oil Saturation. (%) after Brine flooding	Recovery Factor. (%) by (Naoh & Foriegn Polymer)	Residual oil Saturation. (%) after (Akaline & Polymer) flooding	Pore volume injection of ASP slug at 2mins time interval (ml)	Recovery after flooding with ASP flug at various injection volume (%)
A1	0	0	13.38589	7.8	0.0	8.923925	58.27033	25.03780	0.00000	25.03780	25.00	37.50
A2	0	100	13.03000	8.0	3.0	8.686668	61.39677	23.16194	59.64213	9.34767	27.00	41.25
A3	10	90	13.12988	8.0	2.8	8.753253	60.92973	23.44216	54.58218	10.64692	29.16	45.38
A4	20	80	13.23320	8.0	3.0	8.822134	60.45401	23.72760	57.32629	10.12544	31.49	49.91
A5	30	70	13.24927	7.6	3.8	8.832849	57.36164	25.58302	67.26529	8.37453	34.01	54.90
A6	40	60	13.11955	8.0	4.0	8.746365	60.97772	23.41337	78.13191	5.12006	36.73	60.39
A7	50	50	13.28429	7.9	3.5	8.856192	59.46875	24.31875	65.00396	8.51060	39.67	66.43
A8	60	40	13.08051	7.8	3.2	8.720343	59.63068	24.22159	60.60016	9.54327	42.85	73.08
A9	70	30	13.54144	8.0	3.0	9.027629	59.07790	24.55326	54.13752	11.26074	46.27	80.38
A10	80	20	13.21655	8.0	2.8	8.811036	60.53015	23.68191	53.67528	10.97058	49.98	88.42
A11	90	10	13.41516	7.9	2.6	8.943441	58.88859	24.66684	47.14277	13.03821	53.97	88.51
A12	100	0	13.25731	8.0	2.4	8.838206	60.34407	23.79356	45.65073	12.93162	58.29	88.60

Table 2: Experiment result of flooding with Local ASP slug

Samples	**Alkaline (NaoH) (% Composition)**	**Polymer (% Composition)**	**VOLUME OF OIL INJECTED (60% OF PORE VOLUME)**	**VOLUME OF OIL RECOVERED BY BRINE. (ml)**	**VOLUME OF OIL RECOVERED BY NAOH & FORIEGN POLYMER. (ml)**	**Recovery Factor.(%) using brine**	**Recovery Factor. (%) using (Naoh & local Polymer)**	**Residual oil Saturation. (%) after Brine flooding**	**Residual oil Saturation. (%) after (Akaline & Polymer) flooding**	**Pore volume injection of ASP slug at 2mins time interval (ml)**	**Recovery after flooding with ASP flug at various injection volume (%)**	**Volume of oil recovered by flooding with ASP slug (ml)**
B1	0	100	13.14366	8.00	2.00	60.8659	38.8829	23.4805	14.3506	29.50	32.55	1.77723
B2	10	90	13.03517	8.50	2.20	65.2082	48.5098	20.8751	10.7486	31.86	35.81	1.954953
B3	20	80	13.52365	7.80	2.50	57.6767	43.6784	25.3940	14.3023	34.41	39.39	2.150448
B4	30	70	13.11553	8.00	3.00	60.9964	58.6450	23.4022	9.6780	37.16	43.32	2.365493
B5	40	60	13.42377	8.00	3.00	59.5958	55.3121	24.2425	10.8335	40.13	47.22	2.578388
B6	50	50	13.49323	8.00	3.50	59.2890	63.7148	24.4266	8.8632	43.35	51.47	2.810442
B7	60	40	13.46223	8.00	3.50	59.4255	64.0764	24.3447	8.7455	46.81	56.11	3.063382
B8	70	30	13.50184	8.00	2.50	59.2512	45.4394	24.4493	13.3397	50.56	62.28	3.400354
B9	80	20	13.58335	8.00	2.00	58.8957	35.8208	24.6626	15.8283	54.60	68.51	3.74039
B10	90	10	13.6815	8.20	2.00	59.9349	36.4864	24.0390	15.2681	58.97	76.73	4.189236
B11	100	0	13.19819	8.00	1.80	60.6144	34.6275	23.6314	15.4484	63.69	76.73	4.189655