ASP / SP

Alkaline Surfactant Polymer / Surfactant Polymer Technologies

The Science of Enhanced Oil Recovery

OVERVIEW

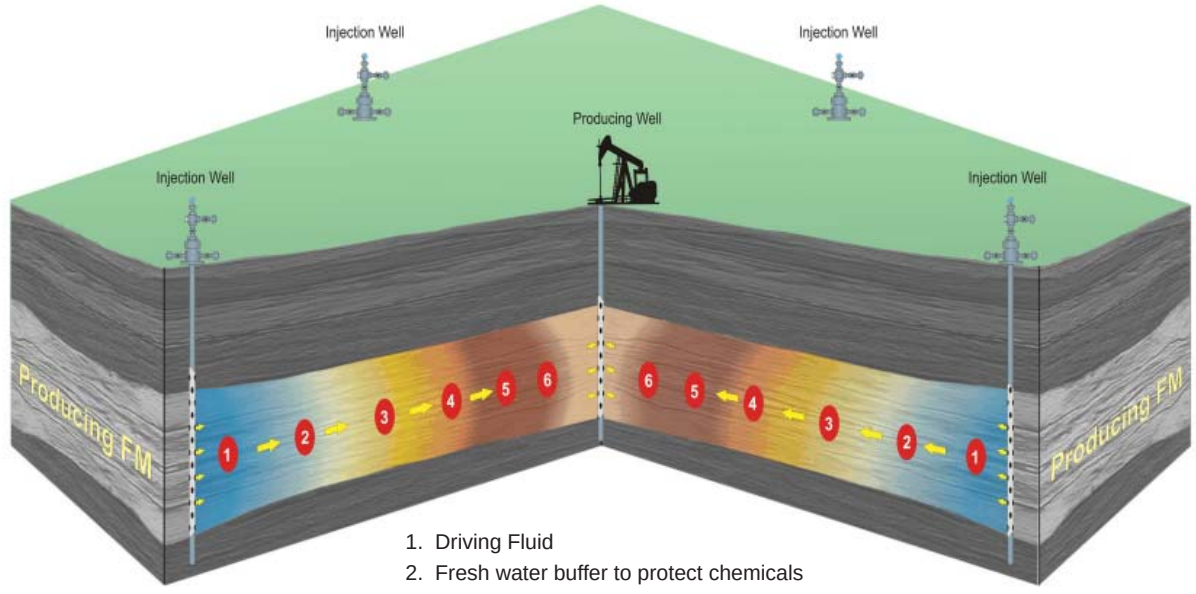
Primary and Secondary Recovery techniques together are able to recover only about 35-50% of oil form the reservoir. This leaves a significant amount of oil remaining in the reservoir. Chemical flooding (using surfactants) is one of the available technologies that can be used to recover up to an additional 35%.

Surfactant flooding is a well known concept that has been practiced in the field for many decades. Current technology is a progressive and gradual development of technologies and ideas that have existed for a long time. The key difference is the amount of surfactant used in projects today is much lower due to high purity.

SURFACTANT FLOODING

Surfactant flooding is usually carried out after a waterflood. There are two main types of surfactant flooding – Alkaline Surfactant Polymer or Surfactant Polymer Flooding. All components are injected together into the reservoir as an ASP "slug" and it is not a sequential injection. Typically, the (A)SP slug is injected at about 0.3-0.4 PV for effective performance. The alkaline component reacts with the acidic moieties that exist in the oil creating natural soap and also helps with reducing the adsorption of the surfactant on the rock. Surfactant component helps in releasing the oil from the rock and reducing the interfacial tension between water and oil, while the polymer (typically, partially hydrolyzed polyacrylamide or HPAM) acts as the viscosity modifier and helps mobilize the oil. Typically, a (A)SP flood is followed up with an equivalent pore volume injection of a polymer "push" solution. This helps reduce the slope of oil recovery decline and helps extend the production for a longer period of time.

The diagram (from: NETL) depicts a surfactant flooding process in a 5-spot well pattern. In an ideal situation, the ASP slug creates an oil bank as it moves through the reservoir.



1. Driving Fluid
2. Fresh water buffer to protect chemicals
3. Chemicals for mobility control
4. Chemicals for releasing oil
5. Additional oil recovery (oil bank)
6. Pre-flush to condition reservoir

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Pre-work for (A)SP

Today, typical implementation of (A)SP in the field (pilot scale) take about 3-4 years. This is mainly because of the lab developmental work that goes into the choice of the various components. Additionally, implementation requires significant capital expenditure for polymer hydration equipment, blending equipment and specialty injection pumps.

The lab work that goes into designing a surfactant flooding project is as follows:

- Fluid analysis (water and oil analysis)
- Fluid-Fluid Work (phase behavior work) to identify alkali and surfactants
  - Alkali identification
  - Alkali concentration
  - Surfactant concentration
  - Static adsorption of surfactant on reservoir rock
- Core flood Work
  - Oil displacement efficiency
  - Adsorption studies
- Simulation or modeling work

The various aspects of implementation of a chemical EOR project is summarized below.

Field Screening & Identification	Develop EOR Chemicals	Flood Design	Implement Flood	Oil Recovery
• Field history and status	• Feedstock supply	• Flood pattern	• Install capital	• Demulsify oil/water
• Field geology	• Capacity	• Injection plan	• Train operators	• Treat water
• Oil type	• Prove chemicals	• Equipment design	• Contract services	
• Available water / CO_2	• IFT / Phase behavior	• Water TX plan	• Purchase chemical	
• Polymer, SP, ASP	• Core floods	• Develop capital cost	• Manage chemical inventory	
• Existing equipment	• Water TX plan	• Refine economics	• Monitor flood	
• Economic modeling		• Modeling		

ASP vs. SP

ASP formulation typically consists of about 0.5-1% alkali, 0.1% surfactant and 0.1% polymer, while a SP formulation consist of 1% surfactant and 0.1% polymer. The choice between ASP or SP depends on a number of factors.

- Acid value of the oil
- Quality of water – if divalent ion concentration is high, >100 ppm, SP may have to be used
- Economics of project
- Ability to carry out water softening or desalination (geographic location)

OTHER TYPES OF SURFACTANT PROJECTS

Imbibition / Wettability Alteration

Surfactants can be used in chemical EOR to change the wettability of the reservoir rock –in this approach, reservoir rock that is predominantly oil wet can be altered to become water wet, which releases the oil from the rock.

Insitu Foam

In this approach, which is suitable for immiscible gas injection projects such as Nitrogen, surfactant solution in water is pumped into the reservoir followed by the immiscible gas injection. This causes formation of foam that blocks of high permeability zones and forces the nitrogen/CO2 to sweep the low permeability zones. This approach is feasible with nitrogen, steam or CO2 at low pressure. This approach is called Surfactant Alternating Gas (SAG) and variations of this are also know - Foam alternating Gas (FAG) and Foam alternating water alternating Gas (FAWAG).

Foam for Mobility Control

In situations where polymer usage is not suitable, foam can also be used as a mobility control agent to replace polymer in a surfactant project.