EOR Techniques Smart Screening for Selected Reservoir

An Advisory System

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Presentation Outline

- Global Oil Production Costs
- Lifecycle of EOR Practices
- New Screening Advisory System
- Recent Examples – Aberdeen
- Conclusion
Oil Production - Today and Tomorrow

- By 2050, energy demand will double or even triple.
- The “Easy Oil” era is over; fields entering the production decline phase

- State of the art technologies which make it possible oil to produce where it was impossible before are costly. Government incentives and support are required
Lifecycle of EOR Practices
Industry Average Trend - EOR Techniques

- Preliminary Screening
- Laboratory Testing & Studies
- Pilot Design
- Pilot Tendering
- Pilot Construction and Installation
- Pilot Operation & Evaluation
- Full Field EOR Development Planning

Industry Average

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EOR Reserves Quantified
Proof of Concept >

Steam injection
Hot water
In-situ combustion
Other incl. Microbial, electrical, chem. leaching...
An Advisory System
New EOR Techniques Screening Approach

Bridging the Gap between Analytical and Numerical Evaluation

Industry Guidance on Screening

1. First Stage Screening Analytical Modeling
2. Second Stage Screening Numerical Modeling

Expert System
Guided System

Bayesian Belief Network Statistical Approach
EOR Global Projects Database

Qualitative Screening
Quantitative Screening
Expert System

Qualitative Screening; EOR Projects Database

Active EOR Projects

- SAGD
- Microlbial
- CSS
- WAG immiscible
- WAG miscible
- N2 miscible
- N2 immiscible
- HC immiscible
- CO2 immiscible
- Foam
- ASP
- Surfactant
- Alkaline
- Hot Water
- HC miscible
- Combustion
- CO2 miscible
- Polymer
- Oil price($/bbl)

YEAR

Active project count

Oil price($/bbl)
Expert System
Qualitative Screening; Key Parameters

- Thermal/chemical projects selected for higher end viscosity
- Miscible/immiscible projects selected for lower end viscosity

Dependencies between API Gravity, Viscosity
Expert System
Qualitative Screening; Key Parameters

- Oil API Gravity
- Oil viscosity
- Reservoir temperature
- Reservoir depth
- Porosity
- Permeability
Expert System
Qualitative Screening ; Bayesian Networks

- Total of ~6700 projects data collected
- Data streamlined to ~2800 successful projects
  
  6 key parameters baseline

- BBNs added; Data uncertainty and Incompleteness
- For each EOR Method BBNs defined with:

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<table>
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<th>BBN</th>
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Guided System
Quantitative Screening

- Quantify the Potential increase displacement at pore level-LDE
- Complements the ranking of Expert System
- Staged approach
  - Reservoir architecture
  - Rock and fluid quality
  - Drive mechanism
  - Unswept area
  - Reservoir forces balance
  - Saturation distribution
- Analytical approach-BL Theory
- Numerical approach-Forecasting
Guided System
First Level Quantitative Screening

Analytical Approach
Buckley Leveret Theory
Guided System
Second Level Quantitative Screening

Numerical Approach
Representative Reservoir Element

Better understanding
Pore, Vertical and Areal Sweep Efficiency

Two RREs
Region with Good rock quality & More remaining oil
Region with Fair rock quality & Average remaining oil

Flow unit potential area indicator (PAI)
divide cells into three HCIP regions
(good, medium, poor).

\[ PAI = \left[ S_{oil}(T) - S_{OWCR} \right] \times \frac{PORO}{PORO_{MAX}} \times \frac{PERM}{PERM_{MAX}} \times NTG \times D_z \]
Guided System
Second Level Quantitative Screening

Simple Economic Analysis
Methodology Considers Economics
EOR Agent used
Injection, Production costs
Oil & Gas Prices

Net Present Values
Unit Total Costs
Recent Examples from the Aberdeen Technical Center
Screening to identify EOR methods for a carbonate field
The Dykstra-Parsons coefficient of heterogeneity VDP was calculated for each of the reservoirs based on RCAL.

Also, the proportion of rock below 20 mD was estimated from core.
Core Analysis: Rock Heterogeneity and Low Permeability

- VDP (per layer) varies between 0.70 and 0.94, and is generally quite high. This is to be expected with carbonate reservoirs, and the actual heterogeneity will be higher due to features not represented in simple RCAL permeability.

- A rule of thumb often used with Polymer / Surfactant is that heterogeneity greater than 0.6 is not suitable.

- The proportion of rock with permeability less than 20 mD is 60% overall, which is quite significant. There is a general guideline that rock with permeability < 20 mD does not respond well to Polymer EOR due to mobility issues.
EORt Screening Results for a Carbonate Reservoir

CO2 and WAG miscible are the two best proven methods.

Salinity of the reservoirs is above limits for chemical methods applicability.
Conclusion

- Advisory system helps in quick initial screening
- Provides both qualitative and quantitative screening
- Uses both analytical and numerical approaches
- Considers industry guidance; past experiences and in-house EOR screening expertise
- Global projects database; continues addition
- Screens EOR mostly used methods; Thermal, Chemical, Miscible and Immiscible
- Used for different real-recent cases; time saving in optimum selection
Thanks