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Improved Oil & Gas Recovery by Polymer Technology: EOR, Water Shutoff and Sand Control

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Outline

1. EOR Challenges

2. Polymer Flooding
   - General aspects
   - Field case in heavy oil reservoir

3. Water Shut-Off
   - Fundamentals of WSO by RPMs
   - WSO gas well field case

4. Sand Control
   - Principle of sand control by polymers
   - Sand control in gas storage wells

5. Conclusions
EOR Challenges

- Peak oil occurring soon, oil slow decline expected
- EOR enables increase in Recovery Factor
- Teams mobilized in Major Oil companies to implement EOR
- Chemical EOR attractive, major focus on polymers
- Low capital cost, low risk, waterflood improvement
Malaysia Scenario

Focus areas for oil:
• IOR
• Small field development
• Deepwater development
• Exploration

• Increasing domestic consumption
• Forecasted decline from 2007
• Net crude importer by ~2010?
EOR by Polymers

Polymer Flood improves Mobility Control, thus reservoir sweep efficiency
Polymer Flood:
Heavy-Oil Application (Canada)
Pelican Lake heavy oil field

- High-permeability sand reservoir
- Thin continuous pay layer (4 m thick)
- Heavy oil – 14° API – 2000 cP
- Shallow, low temperature, fresh water
- Horizontal well primary production
- Low recovery factor (around 5%)
- RF expected to jump to 25% with polymer flood
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<th>ENVIRONMENT</th>
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Typical stratigraphy in area around pilot site. Section is repeated three times except that no bar complex is present in the Wabiskaw B and C units.
Pelican Lake Polymer Flood Pilot

1400 m

200 m
Oil rate in Central Producer 00-15-PRO
Max Injection & Production Rates 150 m³/d

Simulation of Polymer Injection Scenarios
Pelican Lake Polymer Pilot Response

Oil Production (bbl/d)
Wells 14-34, 15-34, 16-34

Initiate Polymer Injection

Jan-05 Feb-05 Mar-05 Apr-05 May-05 Jun-05 Jul-05 Aug-05 Sep-05 Oct-05 Nov-05 Dec-05 Jan-06 Feb-06 Mar-06 Apr-06 May-06 Jun-06

Implementing New Opportunities
Main outcomes of Polymer Flood pilot

• Polymer Flood has potential in heavy-oil reservoir
• In combination with Horizontal Wells
• Integrated Lab & Simulation studies help designing pilot
• Polymer injectivity is an essential issue
• First pilot results very positive, field extension implemented by operator (270 injection wells in 2009)
Water Shutoff
Water Shutoff by Polymer/Gels

- Two strategies: (1) Sealing gels and (2) RPM
- Sealing gels block a water producing interval
- Sealing gels compete with cements or packers
- Relative Permeability Modifiers are weak polymer/gels
- Usually “bullhead” injected into the whole open interval = cost effective
- Maintain oil/gas permeability while reducing strongly water permeability
Principle of WSO by RPM Polymers

Two-layer model

(a) Before treatment

(b) After treatment

Low k

High K

Swollen or weakly X-linked polymer
Modification of Relative Permeability by Polymer Adsorption

**Principle of RPM treatments**

- **(Sor)**: Adsorbed polymer or microgels
- **(Swi)**: Adsorbed polymer or microgels

![Graph showing modification of relative permeability](chart.png)

- $RRF=10$
- $k_r$
- $k_{ro}$
- $k_{rw}$

- **before polymer**
- **after polymer**
Example of successful WSO treatment
Pelican Lake Horizontal Well 11-15A (Canada)
Successful WSO treatment in horizontal well (Canada)
New Microgel Technology

SMG are calibrated microgels larger and more stable than conventional polymers
Several Microgel products proposed today

- “Brightwater” (Popping microgel)
- “Colloidal Dispersion Gels” (CDG)
- “SMG” (Small calibrated microgels)
- “PPG” (Preformed Particle Gels to plug thief zones)
- More used for Conformance Injection well treatments
Example of integrated study:
Water Shutoff in a
Gas storage well
Cerville (GDF)
(SPE 106042)
Model construction

- Well
- Reservoir
- Low k
- Aquifer

Diagram showing layers and permeability.
Simulation forecasts

![Graph showing simulation forecasts](image)
Effect of Microgel WSO treatment on gas well
Drop in water production
Effect of Microgel WSO treatment on gas well
Increase in Gas Production rate
Sand Control by Polymers
Principle of action:

Stabilization of rock cement by "coating" with adsorbed polymer/micogel layer.
Chemical sand consolidation

- Two types of products; (1) Oil-based, (2) Water based
- Oil-based product: resins and organo-silanes
- Resins form hard solid compounds
- Formulations have to re-establish oil/gas permeability
- Water-based polymers are environmentally friendly
- Lower consistency than resins, deeper penetration
- Low costs compared to sand control completions
Advantages of water-based RPM polymer products

- Treatment has little impact on oil or gas permeability
- Thus, can be injected into existing completion with no risk of well plugging
- Deeper penetration possible than with resins or cement, also much thicker intervals
- Environmentally friendly water based RPM products
Microgel treatment: effect on sand production

Sand monitoring device
Effect of Microgel Treatment on Sand Production

Sand production *before* treatment

Sand production *after* treatment

Sand impacts at wellhead
Conclusions

- Polymer Technology has great potential
- Easier and cheaper than other IOR methods
- Both EOR (reservoir) & WSO/Sand Control (near-wellbore) applications
- New products available (microgels)
- Environmentally friendly (water based)
Conclusions (II)

• Broadening field of applications: Sand Control & EOR in Heavy Oil fields

• New products in WSO and Conformance, more stable than conventional polymers (microgels)

• Lab/Simulations integrated studies improve process control & success rate