The Plugging Mechanisms of Sand Control Media in Thermal Heavy Oil and Bitumen Recovery Operations

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At the end of this presentation you will have a better understanding of plugging mechanisms in thermal sand control media

- One size does NOT fit all
- Plugging: when and why?
- What can we do about it
Sand Control: What Do We Know?

• Sand production: not necessarily a problem, increases productivity
• Sand production increases operating costs
• Settled sand or bridges severely inhibits or prevents production

• Depends on:
  – Upper tolerance level for volume and size of allowable sand production
  – Required mechanical strength
  – WE DO NOT WANT TO STOP ALL SAND
Sand Control Media for Thermal Production Operations

- Slotted liners
- Pre-packed screens
- Wire wrapped screens
- Premium screens
One Size Does NOT Fit All

✓ Reservoir Specific

- **CHOPS**: sand production is required
- **Bluesky**: semi-consolidated sand
- **McMurray**: unconsolidated, quartz-rich sand – sand control needed, more issues with shoreface McMurray (high fines content)
- **Grand Rapids**: feldspar (thermal formation damage)
- **Heavy oil in carbonates**: “dolofudge”, formation collapse
One Size Does NOT Fit All

✓ Project Specific
  - Thermal stability
  - Mechanical strength
  - Corrosion and erosion resistance
  - Life of the well

A NEED TO UNDERSTAND LINER FAILURE MECHANISMS, IN PARTICULAR PLUGGING
What is “Plugging”?

✓ **Conventional reservoirs**: installation issues, filter cake, formation collapse

✓ **Heavy oil**: reduction in the open flow area of the sand control media due to trapped sand and fines and different type of scale leading to production decline and an increase in drawdown pressure

*excludes slot closure/opening and pipe collapse due to installation loads, thermal cycle loading and external pressure or screen deformation and erosion*
What Do We Know?

✓ **Goal:** maximize production rates while providing optimal sand retention, e.g. no excessive sand production or pressure build up

✓ **“Arches” / “Bridges”**

✓ **“Rules of Thumb”**

- Particle size distribution (PSD): D10, D50, UC = D40/D90, etc.
- $1.5D_{50} < \text{SLOT} \leq 2 \times D_{10}$
- Finer slots used in uniform sands
Work in Progress

✓ Amount of Fines in Oil Sand
  > 10% of fines - need to choose screen
  < 2% of fines - no bridges, sand pouring through

✓ Roundness and Sphericity – grain shape
  - elongated particles pass through easily
  - smooth surface of particles – difficult to form bridges

✓ Reservoir Mineralogy

✓ “Geochemistry of SAGD”
Slotted Liners
Nexen Well 07P05, Long Lake, McMurray

0.0135” x 0.018” Rolled Top

SPE Paper 165111-MS
Over 90% of the open area of the slots on the provided liner sections were occluded (filled with material)
Epoxy Impregnated Liner
Slot Aperture

- Average aperture top – 0.012” (< original 0.0135”)
- Average aperture base – 0.015” (< original 0.018”)

- Possible reasons for changes in the slot geometry:
  1. Corrosion
  2. Plugging
  3. Poor liner quality
  4. Wrong specification
Plugging Material in Slots

(a) Clean slot  
(b) Semi-plugged slot  
(c) Plugged slot
Plugging Material in Slots

Sand grains

Film of clay and corrosion products
Plugging Material in Slots

- Scanning Electron Microscope (SEM) with Backscattered Electron Detector: mosaic images

- Energy Dispersive Spectroscopy (EDS): compositional analysis of the plugging material
Analysis of Plugging Material

Silica (clay)

Iron oxide

Iron sulphide

Oxygen (clay)
Plugged Slots Analysis: Test Results

- Analysis of the composition of the plugging material shows:

  1. Large amount of corrosion products, iron oxide - FeOOH.
  2. Significant amount of iron sulphide (FeS).
  3. Clay fines, mostly kaolinite - Al₂Si₂O₅(OH)₄.
  4. Some quartz grains (SiO₂).

- The examination of the slots shows that films of the plugging material, predominantly corrosion products and clay, are gradually choking slots.
Wire Wrapped Screens

Sand Control Media Top Delta P vs. Rate

- Oil
- Oil + Water
- Oil + Water + Gas
- Oil

Delta P - psi

Injection Rate – cc/hr

- 0.018” SC
- 0.012 x 0.018” RT
- 0.018” WWS

5 psi
Wire Wrapped Screens

Produced Solids vs. Rate

- 0.018" WWS
- 0.012 x 0.018" RT
- 0.018" SC

Solids Weight - grams

Injection Rate – cc/hr

0.1 grams

Oil
Oil + Water
Oil + Water + Gas
Oil
Wire Wrapped Screens

Epoxy Impregnation

Arrows: yellow – quartz, purple - iron
Wire Wrapped Screens

A. 85% of screen – clean
B. 15% of screen entries showing bridging and clay retention; arrows: purple – iron, red – epoxy, yellow – quartz, green – iron oxide
Wire Wrapped Screens

Epoxy Impregnated 0.018” WWS: Produced Fine Solids
Liner Plugging in Thermal Projects: Industry Shared Knowledge

✓ SPE Thermal Sand Control Workshop, Banff, May 2012
  1. A.Keller, Suncor, MacKay River, SAGD
     - Slotted liner: scale (silica with organics (!), fine sand grains held in organic matric)
     - Xylene and HF acid wash

  2. S.Brand, Husky Energy, Colony, Lloydminster, SAGD
     - Calcium carbonate scale
     - Acid wash, 5% HCl – most successful

✓ SPE Thermal Well Design Workshop, Banff, November 2014
Summary

• Plugging mechanisms in sand control media used in thermal production operations are related to the reservoir characteristics, type of sand control media and operational practices.

• Future success of thermal projects depends on:
  - collecting and analyzing field data
  - running appropriate lab tests
  - pilot testing
  - learning from the experience
  - sharing knowledge