Effects of Shearing and Shearing Time on Dewatering and Yield Characteristics of Oil Sands Flocculated Fine Tailings

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Reserves: Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves.

Resources: Our use of the term “resources” in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers (SPE) 2P + 2C definitions.

Resources and potential: Our use of the term “resources and potential” are consistent with SPE 2P + 2C + 2U definitions.

Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

Shales: Our use of the term ‘shales’ refers to tight, shale and coal bed methane oil and gas acreage.

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With respect to operating costs synergies indicated, such savings and efficiencies in procurement spend include economies of scale, specification standardisation and operating efficiencies across operating, capital and raw material cost areas.

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Introduction

• Pipeline flow of flocculated MFT

(a) Symmetric-lubricated

(b) Stratified-lubricated

(c) Symmetric-non-lubricated

(d) Stratified-non-lubricated
Approach

• A primarily empirical approach was developed to model the most intensive shearing conditions in a typical pipe at laminar flow regime

Why most intensive??

➢ If the effect of shearing under such intensive conditions is negligible then shearing in the pipeline is not a design constraint

What is the most intensive shearing condition??

➢ When the lubricated layer and the non-yielded core of the pipe are disrupted

➢ At these conditions, assuming flow of a Newtonian fluid in laminar regime, shear rate is:

\[ \dot{\gamma} = \frac{8U}{D} \]

\( U \) = Bulk velocity in the pipe
\( D \) = Pipe internal diameter
Need to accommodate large flocs.
Need to have a uniform shear rate distribution in the gap

\[ \dot{\gamma} = \frac{N \times \overline{R}}{R_o - R_i} \]

\[ \overline{R} = \frac{R_o + R_i}{2} \]

$N =$ Bob rotational rate in rad/s

$R_o$ and $R_i =$ The cup and the bob inner and outer radii including baffles

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Materials

• Shell raw MFT:
  – ~30 wt% solids
  – MBI of ~7.3-7.6 meq/100 g solids

• Flocculants:
  • A (a partially hydrolyzed polyacrylamide)
  • B (a polyethylene oxide)
  • C (a Ca-polyacrylamide)

• Flocculated MFT:
  • Produced by mixing the raw MFT with a flocculant by a 5” (3.8” impeller) in-line dynamic mixer at various mixing conditions
  • Only well flocculated materials were selected
Experimental Procedure

- The field-scale pipeline transport system:

\[
\begin{align*}
Q &= 662 \text{ m}^3/\text{hr} & D &= 24" \text{ or } 30" \\
Q &= 662 \text{ m}^3/\text{hr} & Q &= 2648 \text{ m}^3/\text{hr} \\
Q &= 662 \text{ m}^3/\text{hr} \\
Q &= 662 \text{ m}^3/\text{hr}
\end{align*}
\]

<table>
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<th>Flow Rate, Q</th>
<th>Pipe Nominal Diameter, D_n</th>
<th>Nominal Shear Rate, 8U/D</th>
<th>Pipe Length</th>
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- Parameters measured before and after shearing in the Couette:
  - Yield stress
  - Capillary Suction Time (CST)
  - Permeability Index (PI)
  - 7-day water release in graduated cylinders.(for 1 km transport distance)
Experimental Procedure

• Prolonged Shearing:
  • The highest shear rate chosen (63 s⁻¹)
  • Applied the highest shear rate for residence times corresponding to 5 and 10 km transport distance

• The following parameters were measured on the sheared flocculated MFT:
  • Yield stress
  • Capillary Suction Time (CST)
  • Permeability Index (PI)
  • 7-day water release in graduated cylinders
Variation of Dewaterability with Shear

- CST increases with the shear rate and duration of shear
- A higher CST value indicates poorer immediate dewaterability
- Generally, the trends are similar with all polymer types
- Pipeline transportation of well-flocculated MFT samples will not affect the immediate dewaterability significantly
Effects of Prolonged Shearing on Short-Term Dewatering

- $8U/D=63 \text{ s}^{-1}$ for residence times corresponding to 1, 5, and 10 km transport.
Effects of Prolonged Shearing on Dewatering

- 7-day water release in graduated cylinders
Variation of Yield Stress with Shear

- Yield stress decreased *significantly* with shearing at all shearing conditions, even the mildest
- Yield stress change in actual pipeline can be significantly less than those measured in this study due to the protection provided by the lubricated layers and formation of non-yielded cores
Conclusions

• Pipeline shearing has only a *slightly* negative impact on the short-term dewatering of flocculated MFT (measured by CST)
• The dewatering of flocculated MFT can be accelerated by shearing
• Yield stress of the MFT decreases significantly by shearing
• Pipeline transportation can produce a slightly less dewatered deposit with significantly reduced strength immediately following deposition, which is predicted to release more water volume over time compared to unsheared flocculated MFT