A Comprehensive Control Scheme for Dynamic Inline Flocculation of Oil Sands 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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Inline Flocculation

- Mix flocculant with tailings and transport to deposit
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- Need appropriate instruments
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- Plus control scheme
Optimal Flocculation

- Mixing state
- Polymer dosage
- Varying conditions
Inline Flocculation

- Challenges:
  - Dosage
  - Mixing
- Dynamic mixing gives control, but still need to find optimum
Flocculation Apparatus

- 5” inline mixer
- Polymer injected upstream of hydrofoil impellers
- 10 m³/h but applicable to larger scales
Control Strategy

- Appropriate instruments
- Feed-forward and feedback control
Control Elements

• Feed standardization
• Polymer delivery
• Mixing
Polymer Delivery

- \( Q_{poly} = f(Q_{FFT}, \rho_{FFT}, \beta, \phi_{poly}) \)
- Optimal dosage in g/tonne depends on clay content and density of feed
- Required polymer flow rate depends on FFT flow rate and dosage, as well as FFT and polymer properties
- Feed-forward control
FFT Clay Content

- Used Bruker NIR spectrometer to measure online
- 4200 – 7500 cm\(^{-1}\) (1.3 – 2.4 µm)
- Emission head mounted on custom pipe spool with sapphire window
- Chemometric analysis to build calibration curve for MBI
Optimal Polymer Dosage

- Performed ~150 flocculation experiments.
- Selected optimal dosage for each feed material
- $\beta = f(\rho, \text{MBI})$
- Fitted to create feed-forward map
Mixer Speed

• Similar approach to develop feed-forward scheme

\[ N = f(K, Q_{FFT}, Q_{poly}, D) \]

• \( K = f(\rho, MBI) \) feed-forward map from experimental results

• Added feedback trim

Flocculation State

- Challenging to measure
- Desire good dewatering and material strength
- Defined mixing states
- Investigated instruments:
  - PVM
  - FBRM
Flocculated FFT Image Analysis

• Particle Vision and Measurement (PVM) instrument from Mettler Toledo
• Process microscope

Focussed Beam Reflectance Measurement (FBRM)

- Probe inserted into process similar to PVM
- Instrument provides chord length distribution, similar to particle size distribution
- Associated large particles with presence of flocs
Mixing State Transmitter

• Analyzes PVM images using modified facial recognition techniques
• Combines image data with other results, e.g. FBRM
• Estimates mixing state for feedback trim using maximum likelihood classifier

Mixing State Transmitter

Undermixed | Dewatering | Strength

1 2 3 4

Coanda
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Laboratory Results

- Used feed-forward
- Feedback data collected but not used online
- Disabled control, switched tanks, then re-enabled

- Sample results:
  1. CST 8 s, Yield 96 Pa
  2. CST 20 s, Yield 38 Pa
  3. CST 14 s, Yield 125 Pa

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Future Work

• Test the different elements of the scheme and identify the optimum configuration
• Field testing at larger scale