Effect of Demulsifier and Mixing Parameters on Bitumen Froth Clarification

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Introduction

Bitumen is mined in the oil sands through open-pit mining where the lumps are broken and mixed with hot water. This slurry is sent through pipelines where bitumen is recovered as froth. (Rao and Liu, 2013) [1]

Bitumen froth, coming from Athabasca Oil Sands contains 60% bitumen, 30% water, 10% solids by mass. The water containing salts and solids cause a multitude of problems during downstream upgrading. (Masliyah, Xu, Czarnecki, & Dabros, 2011) [2]

There are two solvent extraction methods to remove the undissolved salts, water and solids: Naphtha (higher bitumen recovery using less solvent but higher water/solids) or Paraffinic (lower bitumen recovery using more solvent but less water/solids).

Purpose

The purpose of this study is to examine the settling of water and solids in bitumen using naphtha-based froth treatment. The aim is to enhance the understanding of water and solid removal and possibly improve it further for downstream upgrading. In order for bitumen to be transported through the pipeline, the combined percent of water and solids must be less than 0.5% by mass.

Methods

After pre-mixing (for 15 mins) and heating the bitumen and naphtha to 80° C, the naphtha and bitumen are poured into a Confined Impeller Stirred Tank, (CIST), which is surrounded with ethylene glycol, in order to maintain the temperature at 80° C.

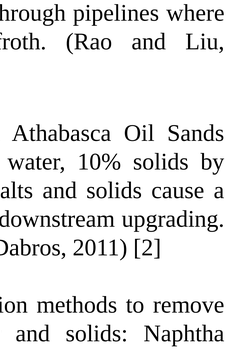

Figure 1: CIST used in experiments. Height 1 (Z1) top; Height 4 (Z4) bottom

The naphtha and bitumen are blended together (at a certain time and speed) using either a Rushton, A310 or Intermig impellers that determine the mixing energy, J, (variable).

After naphtha blending, demulsifier is added at a certain bulk (variable) and injection (variable) concentration. The impellers are stopped and solids/water are allowed to settle. Samples are taken at 2 heights (Z1 (52mm) and Z4 (184mm)) or 4 heights (Z1, Z2 (96mm), Z3 (140mm) and Z4) after the mixing at 3, 5, 7, 10, 30 and 60 minutes. Samples are also taken for Focused Beam Reflectance Measurement (FBRM) analysis to determine particle size and distribution. Microscope slides are prepared from the samples to analyze the aggregates such as water-water, water-solid and solid-solid clusters in the sample. Images are taken with 10x and 40x objective lens. The left over samples are kept for Karl Fischer Analysis to determine the percent water in the sample.

Results

Sample taken at:	The sample displayed signs of:			
	Height	Run 3	Run 4	Run 5
3 mins	Z1	W-W W-S S-S	W-W S-S	W-W S-S
	Z4	W-W	W-W W-S	W-W W-S
5 mins	Z1	W-W W-S S-S	W-W W-S S-S	W-W W-S S-S
	Z4	W-W W-S S-S	W-W W-S S-S	W-W
7 mins	Z1	W-W S-S	W-W W-S S-S	W-W W-S
	Z4	W-W	W-W	W-W S-S
10mins	Z1	W-W W-S S-S	W-W W-S	W-W W-S S-S
	Z4	W-W W-S	W-W W-S	W-W
30 mins	Z1	W-W W-S	W-W W-S	W-W S-S
	Z4	W-W	W-W	W-W
60 mins	Z1	W-W	W-W	W-W
	Z4	W-W	W-W	W-W

Legend (Type of Aggregate)
W-W = Water-Water
W-S = Water-Solid
S-S = Solid-Solid

Table 1: Compares Runs 3, 4 & 5; The types of aggregates (W-W, W-S, S-S) present when analyzed under the microscope

When analyzed, aggregates occur in three forms: water-water (W-W), water-solid (W-S) and solid-solid (S-S).

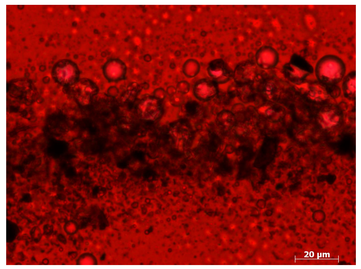

Figure 2: 40x, Water-Solid Chain

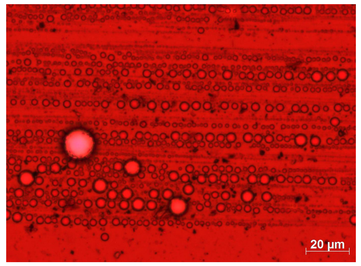

Figure 3: 40x, Water-Water Chain

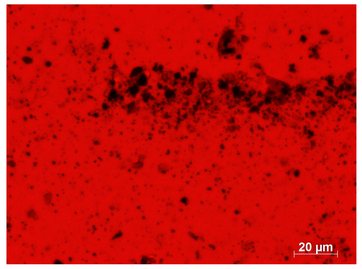

Figure 4: 40x, Solid-Solid Aggregate. Aggregation is when particles stick together but do not fuse into each other (Coalescence).

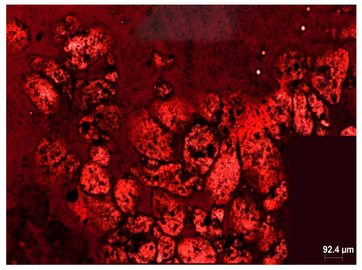

Figure 5: Multiple images of 10x, 7 mins at Z4. Free Water Aggregate. The surface of free water aggregates are covered in water drops and small solids.

Experimental Variables:

Runs 3 & 4; Impeller: A310; Naphtha Blending: 1250 rpm for 2 mins; Demulsifier Dispersion: 1000 rpm for 9 mins, Bulk concentration = 150 ppm, Injection concentration=16.5 % by mass.

Run 5; Impeller: Rushton; Naphtha Blending: 600 rpm for 2 mins; No demulsifier, but still mixed at 600 rpm for 10 mins

Conclusion

During the first 10 minutes of settling at both heights, water and solids formed chains and aggregates. At 30 and 60 minutes of settling, a clean slide is observed for height Z1, some aggregates for height Z2 and Z3 and huge aggregates (to the scale of the slide) on height Z4. This observation also agreed with low water content at heights Z1, Z2, Z3 and high water content at height Z4 obtained from Karl Fischer Analysis.

A clean slide refers to clean bitumen that can be sent for downstream upgrading and refining plants in order to convert bitumen into synthetic crude oil.

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Literature Cited

[1] Rao,F., & Liu, Q. (2013). Froth treatment in Athabasca oil sands bitumen recovery process: A review. *Energy and Fuels, 27*(12), 7199-7207

[2] Masliyah, J. H., Xu, Z., Czarnecki, J. A., & Dabros, M. (2011). *Handbook on theory and practice of bitumen recovery from Athabasca Oil Sands.* Cochrane, Alta. : Kingsley Knowledge Pub., c2011-2013. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat03710a&AN=alb.5428621&site=eds-live&scope=site