Methods for Controlling Mixing in a Deposit Formed through Co-deposition

Background

Oil sands mining typically produces multiple and characteristically different tailings streams. This may include "whole tailings" and froth treatment tailings but depending on the specific details and history of the extraction process and tailings management strategy, may also include other streams containing specific fractions of the whole tailings stream and chemical additives (flocculants and coagulants). These streams are then often strategically deposited back into tailings storage facilities to meet various objectives. Coarser untreated streams may form components of the containing structure, while the treated higher fines streams are typically deposited in specific and isolated areas to support various reclamation objectives. Depending on the pour strategy, some streams may be deposited close to each other without explicit isolation using constructed dykes. Mixing of these streams can occur and form a composite material that behaves differently from the original tailings streams. Reclamation objectives may require minimizing the formation of any mixed materials to ensure that reclamation strategies predetermined for the two original tailings streams are not undermined. Conversely, other deposition strategies may rely on this mixing to meet specific reclamation objectives for a deposit.

Some existing tailings strategies include the technique of forming an intermediate fines deposit that relies on this mixing behaviour. Froth treatment tailings, thickened tailings (TT) resulting from thickening the hydrocyclone overflow in a conventional thickener with a polymeric flocculant, and coarse sand tailings (CST) resulting from the hydrocyclone underflow can be deposited next to each other on a beach. The resultant composite material has shown an elevated sand to fines ratio (SFR) averaging around 2.5 while still achieving the target solids contents averaging above 70 wt.% [1]. Other mixing strategies, including centrifuge product and CST (e.g., Canadian Natural's Albian), can consistently achieve SFRs as low as 2 and average solids contents above 75 wt.%.

Beach below water deposits can be relatively well mixed resulting in a desirable homogeneous material bearing a composition that is not similar to either component stream. However, they can also be poorly mixed, resulting in undesirable heterogeneous interbedded layers whose composition indicates that one or the other component stream was the primary contributor at the time of deposition. For both scenarios, a better understanding of the potential methods for controlling the extent of mixing and homogeneity of the resulting mixture can contribute to more effective deposition planning and reduced risk profiles for the resultant deposits.

Statement of Research Opportunity

Some practical considerations can influence the degree of mixing between multiple streams. Previous work conducted across the industry and specifically on a mixed deposit at Muskeg River mine [2], proposes that the fines capture (driven, in this case, by mixing between the higher fines streams and CST) can be influenced by practical modifications to the deposition strategy. This list includes, but is not limited to:

- Modifying the deposition location (the flow state that each stream is in at the point that they are merged);
- Modifying the deposition velocity (via diffusers or nozzle) or deposition energy (spoons/spigots);
- Earthworks to modify the overland flow paths (e.g., jetties perpendicular the beach, controlled beaching/polders);
- Controlling the pond elevation/beach length to influence the potential distance over which mixing can occur, as well as the proportion of "beach-above-water" and "beach-below-water" deposit being formed; and
- Modifying the solids content of the streams.

An assessment of some of these factors and their predicted impact on the area and homogeneity of the resultant mixed deposits can help inform and optimize deposition strategies in the future. Both computer modelling ([3], [4]) and larger scale laboratory studies have been informative in understanding the drivers and processes that influence mixing. Extensions of this work may provide practical guidance that can be implemented at a field level for further validation.

The various streams potentially subject to mixing possess varying compositions and rheological properties. A project assessing the mixing potential of a low SFR (<0.5) stream and a high SFR (>4.0) stream, as well as a low bitumen (<3 wt.%) and high bitumen (>9 wt.%) content may provide insight that can be readily applied to many of the mixing scenarios relevant in the industry. Variability in mixing behaviour has also been observed between centrifuged fluid fine tailings (CFFT) and polymer-amended FFT at similar solids contents (45-50 wt. % and SFR >0.2); so assessing the influence of the modified rheological properties imposed by centrifugation may also provide valuable insight.

Desired Results

The desired outcome of this research will be a set of recommendations that presents the best pour strategies to drive mixing over a large or small footprint, and how to best encourage homogenous or heterogeneous interbedded deposits so these strategies can be implemented as required, depending on the specific deposition objectives. It is however acknowledged that the desired broad practical recommendations may be unrealistic, and that more focused recommendations evaluating the impact of one or two critical variables on "mixing potential" may be more appropriate.

Though qualitative recommendations are the expectation, recommended deposition strategies with critical measurements, such as spigot spacing or critical flow rates, would ideally be presented with quantitative outputs for future validation.

Works Cited

[1] Ansah-Sam, M., and Rudolf, K. 2016. MRM ETF North Pool Deposit Performance, Proceedings of the Fifth International Oil sands Tailings Conference, Lake Louise, Alberta,

[2] COSIA. 2013. Potential Methods for Enhancing Fines Capture, COSIA Tailings EPA 2013 Beach Fines Capture Study, (pp. 55).

[3] Ansah-Sam, M., Sheets, B., Langseth, J., Sittoni, L., and Hanssen, J. 2017. Delft3D modeling of sand placement on an Oil Sands treated tailings deposit, Proceedings of Tailings and Mine Waste Conference, Banff, Alberta.

[4] Ansah-Sam, M., Sheets, B., Langseth, J., Sittoni, L., and Hanssen, L. 2018. Delft3D modeling of sand placement on an Oil Sands treated tailings deposit. COSIA Oil Sands Innovation Summit, Calgary, AB.