Simplified Rheological Model to Predict Impact of In-situ Variability on Dredging

Background

The current mine plan requires several transfers of fluid tailings (FT) dredged from existing tailings ponds. These transfers include moving fluid tailings from ex-pit structures to in-pit cells, and from their current storage facilities to treatment facilities. In some ponds, currently operating transfers maintain consistent feed solids content with relative ease and infrequent dredge moves, while in other ponds, it is challenging to consistently maintain a uniform feed at the required solids content. Inconsistent feed solids content can lead to schedule delays in subsequent activities and bottlenecking in any tailings treatment process. Currently some oil sands operators relying on operational experience and a "reactive" approach to manage dredging operations, as oil sands operations mature and the requirement to transfer larger amounts of partially treated FT from one location to another becomes more common, this approach may be problematic.

This variability in dredging behavior should be largely characterized by the rheology of the fluid tailings, however two critical gaps exist. The first gap is in understanding the best practice for sampling and characterizing the in situ rheology of a tailings pond. In the industry much work has been done to understand the rheology of fluid tailings slurries to support process engineering; however, once the tailings have been placed in a pond, often segregated, aged, and exposed to residual polymers from treated tailings the rheology can change significantly. Ideally, in situ testing would allow for a characterization of the rheology that accounts for all these effects (which are lost once a sample is disturbed during collection), however there are several issues surrounding this. Currently, in situ measurements would be limited to a determination of yield strength. This can be collected through shear vane, ball CPT, or other specialty equipment such as a 'RheoTune', but it is unclear if characterization of yield stress alone is sufficient to provide useful insight into dredging. Also this testing is a relatively costly addition to any tailings investigation. More sophisticated rheological testing can be performed on samples collected throughout the pond, however, the sample is disturbed on collection and so the impacts of some of the specific in situ effects are lost. The most practical solution may include work to develop a correlation between in situ yield strength measurements, and rheological measurements on samples collected for routine characterization for regulatory reporting. The useful gap to fill, would be determining the minimum testing regime (whether in situ, lab or a combination of both) required to build a simple model that would be useful to predict dredging efficiency throughout a FT transfer.

The second related gap is the application of this model. Once a basic rheological model is established for a given pond, how can we use it to answer two basic questions? What is the theoretical maximum recharge of solids to a dredge? Will that change as the program continues and our feed characteristics change? These two answers will then support planning specific infrastructure requirements (number of dredges and pumps) and durations for current and future transfers. Some computational fluid dynamics (CFD) modeling has been performed in the industry already to assess the impact of various changes to dredging operations, however, the complexity of this modeling makes it prohibitive as a tool for routine planning and frequent updating based on the results of periodic investigations. For critical dredging operations CFD modelling may be a useful tool which may be able to provide insight into other optimizations related to dredging operations such as optimal ladder depths, theoretical dredge move frequency/required distance or the influence of neighboring dredges on each other to determine optimal dredge spacing.

Any modelling done as an output from a rheological characterization of a pond will however require calibration, to correlate the variable fluid properties of dredged tailings to dredging efficiency. Any effective calibration of this "tool"/model will require that it be calibrated based on multiple dredging operations, moving fluids with varying rheological properties, using a standardized input. To achieve this, it is likely only possible with multiple operators providing data on their active transfers, which is why this issue is well suited for a COSIA project.

The dredging of muds and specifically systems with muds possessing a range of rheological properties has been researched in the context of harbour dredging and determination of nautical bottoms [1]. In a similar context, the work here has been attempted for dredging in harbors such as Port Rotterdam [2], however the scope, scale and application of this work will likely require some modification to apply to oil sands mining.

Statement of Research Opportunity

The problem facing the industry is that planning and optimizing dredging operations is being performed "reactively" or based on previous experience (which will likely not apply to many future dredging operations) and so mid to long range plans are bearing excessive uncertainty. This significantly impairs our ability to make informed decisions, and can have significant cost implications.

A new solution/approach should allow for prediction of dredging efficiencies for future operations, to a level of detail that gives a rough understanding of the infrastructure requirements and duration of future transfers based on the observed characteristics of the specific ponds in question.

Desired Results

The desired outcome of this work would be the development of both a "best practice" guideline for testing methods and data requirements to develop a simple rheological model of a tailings pond, and a tool to then predict the maximum solids recharge as a function of that model. The rheological model should also be developed with the expectation that it may be used to support CFD modeling for critical dredging operations.

Works Cited

[1] P. T. Rewert Wurpts, "15 Years Experience with Fluid Mud: Definition of the Nautical Bottom with Rheological Parameters," Terra et Aqua, vol. June 2005, pp. 22-30, 2005.

[2] K. Geirnaert, "TESTS ON NEW MAINTENANCE CONCEPT IN THE PORT OF ROTTERDAM," in CEDA Dredging Days 2015, Rotterdam, Netherlands, 2015.