Technology Development

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Abstract

Technological innovation has been a primary factor in the successes achieved in tailings handling within the oil sands industry in north-eastern Alberta. As a key driver of innovation for Suncor Energy, Inc., The author has been part of the team that stewarded several developments from conception through to full-scale implementation. This paper will present the conceptual shift in thinking which allowed for the introduction of key technologies including Tailings Reduction Operations (TRO).

Technology Development Discussion

The pace of technological innovation in oil sands tailings has accelerated greatly over the past few years. It has been stated that this area of scientific and engineering development is not “rocket science”, and many individuals and groups who may be new to the industry often ask why wide-spread, successful solutions are not yet fully realised. Is it that appropriate efforts to define the challenges and seek solutions have not occurred, or are there some other drivers?

Let me be clear - first and foremost, the science is well known. Decades of collaborative efforts have resulted in the material properties and laboratory tailings behaviours being well known and clearly documented, so much so that there may not be much room here for major leaps based on additional investigations into the fundamentals. So again, why the apparent lack of significant industry-wide solutions?

Two primary areas of science and applied science have dominated the work thus far: the science pertaining to slurries, and the science pertaining to earth materials. The science pertaining to slurries is predominated by mineral process engineering while those in the science of earth materials by geotechnical engineering. These two pursuits, while describing very different aspects of tailings behaviour, are both required considerations if one is to develop field scale, successful technologies. However, it is the material transition from the slurry-dominated description to the geotechnical-dominated ones that can pose the biggest issues.

In other industries, and for most applications in those industries where slurries are converted to solids, this transition occurs under either very clear conditions or within short timeframes. This allows the impact of this transition to be, for all intents and purposes, disregarded as only a minor component of the overall process. If we understand the science and if demonstrated, successful technologies and practices exist in other areas of industry, why do oil sands tailings solutions remain an outstanding objective on large scale, collaborative investigations? Two possible explanations come to mind, and involve two very different considerations.

The first involves the tailings material itself. The suspension of silts and clays in process affected water, which is one output from the Clark Hot Water Extraction process, falls within the gap between process and geotechnical engineering practice. While a detailed description of the science behind this are beyond the scope of this paper it is clear that these materials have some unique characteristics. For one, the settling particles do not entirely obey the simplest forms of Stokes’ Law. Past a certain point in the settlement curve some force works to keep the suspended particles apart. Whether this is due to surface charges on the clays, pore water chemistry, zeta potential, or some combination of these or other characteristics is widely described but not commonly understood by the public. This suspension represents the transition zone between the behaviours described by the two sciences, and is an example of where neither the conditions under which this occurs is clear nor is the timeframe sufficiently short such that this transition can be disregarded. It may be that the transition process for these slurries of fine particles, under settlement and self-weight consolidation effects alone, will be unable to reach to the point where inter-particle contact occurs. If this proves to be the case, how might this confuse things in the pursuit of solutions?

One potential point of confusion may have to do with the conditions within the testing apparatus used to evaluate these tailings, along with the interpretation of the results of those tests. In general, equipment like tri-axial cells and centrifuges subject tailings samples to controlled conditions designed to provide insight into how these materials will behave in the field. Consolidation curves, an example of a typical output from these types of equipment, are assumed to be applicable to conditions found at various depths within a column of earth materials. But what if the simulated conditions are only applicable to predictions of how that material will behave in the test equipment itself? A centrifuge, used in a laboratory to reduce the observed timescales for gravity-based behaviours, alters the physical conditions under which the material responds. The simple change in the particle weights due to changes in acceleration can alter more than just the timeframes for settlement, it has impacts on the relationships between surface charge interactions (unaffected by the centrifuge) and the increased effective weight of the particles. This sets up a condition that is not replicable in the field, and hence predictions based on the results of these tests require careful consideration. The same can be said for the drainage conditions induced within tri-axial cells and other consolidation equipment. We must ask ourselves whether the results of any particular test can be applied to specific field conditions, especially when the tests originate from one of the two end-member areas of the science.

So how do we address this gap? One potentially important resource option could be the in the services of a science and engineering “translator” of sorts. Tailings Engineers, whether they are cognisant of it or not, are earth materials transition specialists. The most successful are capable of discussing technical topics ranging from pump curves, turbulent flows, segregation boundaries and pipeline wear with the process engineering teams, all the way to discussions on beach angles, consolidation curves, and groundwater flow regimes with the geotechnical engineers. However they are often specialists in neither area of engineering. While very few specific educational programmes exist for this field, many of the practitioners come from the Geological Engineering areas. It may be that the training in earth sciences, fundamental mineralogy and water chemistry as well as the necessity in dealing with varying degrees of uncertainty associated with geological interpretation are among the skill sets that make this training well suited to tailings. I have often referred to tailings as the practice of man-made geology, and this seems an apt description. Tailings must be viewed as more than a product of a mineral processing system or a pre-cursor to a geotechnical material. It is a material in flux that requires a combined model to accurately describe its behaviour. Even beyond these considerations, the volumes of material produced also require it to be utilised as a landform construction material and must be included as part of the design process for the long-term reclamation of the mining areas. Once again, this is another area that requires additional input not typically integrated at the start of the technology development process.

So where does that leave the technology development efforts? Several technologies in development today focus on replicating those laboratory techniques that have successfully transitioned these slurry materials at the bench and pilot scale, and are now being scaled up to full operations. Suncor’s Tailings Reduction Operations utilises breakthroughs in flocculation techniques applied to undiluted MFT, producing a dewatering effect not demonstrated previously. The focus is now on determining how best to take advantage of this effect applied to millions of tonnes of fines on an annual basis.

Syncrude's work on centrifuges is probably one of the clearest examples of a technology focusing on replicating laboratory transition processes at scale. While it faces many of the same scale challenges as does TRO, the development work is less about achieving the transition of state and more about achieving it at rates sufficient to meet production and cost targets. Scale-up challenges are not to be underestimated, but the technology can focus on these issues alone without also attempting to deal with translation of the fundamental techniques. This reduction of variables in the development process may result in improved results over previous efforts.

Conclusion

In general, three items are necessary:

1. Access to the right experts – find and understand the previous work for what it is (an excellent description of the fundamentals of this material behaviour) as well as for what it is not (a complete set of field design parameters). Ensure all areas of expertise for an operation are included, as every area will have an impact on the technology.

2. Engage those positioned to produce end-to-end solutions. Experienced generalists capable of translating between the various specialities and focused on tailings as a full operating life cycle technology are the necessary leaders in developing these areas. No single specialty should predominate.

3. Identify and focus on the transition gaps in the technology development areas. An understanding as to how to apply techniques from the lab to field conditions is critical to developing new and successful technologies. This may also point towards more active manipulation techniques.

Of the many technical directions that may be taken to produce successful tailings technologies, there are two that come from this discussion of advancing the understanding of how to apply the results of laboratory characteristics, such as consolidation curves, to field conditions, or on focusing on replicating successful laboratory transition conditions at full scale. Regardless of the directions taken in the ongoing technology development effort in oil sands tailings, there is little doubt that the new focus and interest in this area of science and engineering will produce the solutions necessary to support ongoing success and responsible development of this world class resource.