MFT Drying — Case Study in the Use of Rheological Modification and Dewatering of Fine Tailings Through Thin Lift Deposition in the Oil Sands of Alberta

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ABSTRACT

Mining and processing operations in the Athabasca Oil Sands of north-eastern Alberta, Canada have resulted in significant volumes of stored mature fine tailings (MFT). This material is characterised by high fines content and very slow consolidation rates, and represents a major challenge to tailings management in the industry. Based on grass-roots research completed in the 1980s and 1990s as well as deposition work conducted in the thickened tailings industry, Suncor Energy has developed a rheological treatment and deposition system for MFT that allows the dewatering of the material utilising both evaporation and freeze/thaw effects. This process could result in the reduction or elimination of MFT inventories currently stored in ponds, with associated water recovery for reuse. A general review of previous work is discussed, along with a detailed discussion on the phased research and testing work, pilot construction and operation, deposit behaviour, and the final requirements for scale up to full production.

1 INTRODUCTION

Suncor Energy Inc. operates an oil sands mining, extraction and upgrading facility in the Fort McMurray area of north-eastern Alberta, Canada. In forty years of oil sand operations, mining and processing have resulted in volumes of stored mature fine tailings. This fluid like material is characterised by high fines content and very slow consolidation rates. These fines are typically defined as particles of a size less than 44 microns, or passing a 325 mesh. Of this material, approximately half by weight are clay sized particles less than 2 microns.

On site MFT accumulations to date are in excess of 180 million cubic metres of stored material, and pose a major challenge to tailings management. Several methods of dealing with these inventories have been developed within the industry including a technology known as consolidated tailings (CT) which involves mixing the MFT with sand or coarse tails produced from cyclone underflow and gypsum in order to produce a non-segregating mixture. This mixture is then deposited into the tailings ponds and allowed to consolidate. This method, while effective, relies on continuous extraction operations for a supply of sand. Complimentary methods that are independent of plant production could provide opportunities to reduce existing MFT inventories at a rate greater than current systems allow.

Several alternate methods of dealing with MFT have been examined by a variety of research groups, but none have emerged as a successful, accepted operation. The MFT drying process has been developed as an extension of a large body of previous works, “standing on the shoulders of giants” as it were. Research into oil sands tailings issues has been combined with basic principles for thickened tailings deposition resulting in a simple and effective method of converting MFT inventories into a reclaimable landscape at a predictable rate independent of extraction operations. While this method has yet to be proven to be a “silver bullet” solution, it does hold the promise of greatly increasing the ability of operators to better handle current and future MFT inventories.

2 BACKGROUND

The history of the oil sands deposits in the Fort McMurray area of Alberta, Canada has been discussed in various documents, so only a quick review is presented here. Parties interested in more detail about oil sands tailings are referred to the publication: FTFC (Fine Tailings Fundamentals Consortium), 1995, Advances in Oil Sand Tailings Research, Alberta Department of Energy, Oil Sands and Research Division, Publisher.

Early explorers noted the presence of a black tar pitch flowing from deposits along the shoreline of the Athabasca River as far back as the 1760s. These deposits, known early on as tar sands and more recently as oil sands, were used by the area inhabitants to water proof and repair their canoes. Serious efforts to extract the bitumen from the oil sands began in the 1920s, with construction of the first major commercial venture to successfully extract bitumen from the deposits completed in 1967. That company, now known as Suncor Energy Inc., has produced a billion barrels of oil as of 2006 from the Athabasca oil sands, with current production averaging approximately 260,000 barrels per day.

2.1 Tailings Generation

While mined ore from the Suncor oil sands site varies in material makeup, Table 1 shows what can be considered a typical set of properties for Suncor ore. Table 2 outlines the typical mineral constituents which form the primary tailings material. This table does not include the waste material that must be taken and processed due to its proximity to the ore. The waste material that is of primary concern to tailings storage is the shale bed lenses, which are up to 50% clays. Table 3 shows the products produced during processing of the total ore and waste lenses.

Table 1 Typical oil sand properties by weight

Ore Material	Mineral	Bitumen	Water
Percent by Weight	85%	11%	4%

Table 2 Typical mineral constituents by weight

Material	Quartz	Feldspars	Micas and Clays	Carbonates and Heavy Minerals
% of Mineral by Wt	95%	2-3%	2-3%	Trace

(Clays are typically <1% of oil sands, but up to 50 % of shale beds in deposit)

Table 3 Average material produced from 1 tonne of ore

Product	**Constituent Material**	**Wt/Volume**
Bitumen (11% in ore)		0.6 barrels
Fines	Total wt <44um	0.10 t
	Total clays @ 50% clay	0.05 t
	Fines released to water	0.047 t
Beach	Total volume	0.5 m^3
	Water	0.208 m^3
	Fines	0.053 t
	Sand	0.75 t
MFT @ 30% w/w	Total volume	0.13 m^3
	Water	0.11 t
	Fines in MFT	0.047 t
Total water	Total in MFT & beach	0.318 m^3

The process of extracting the bitumen from the deposit used by Suncor Energy is known as the Clark Hot Water Extraction Process. In this method, processing begins with the oil sand ore being crushed then conditioned in long hydrotransport pipelines with the addition of hot water. The resulting slurry is transported to primary separation vessels where the coarse sand settles to the bottom, and with the bitumen forming a froth and floating to the top of the vessel to be removed for further upgrading. In order to produce bitumen of high enough quality for upgrading, significant quantities of fine solids must be removed from the streams along with the coarse sand. The water used in conditioning together with the fines, sand, and residual bitumen now form the tailings stream. Once this remaining material is discharged into the tailings ponds, sand deposits consume the major portion of available tailings storage. The fines, however, travel with the water stream and a large portion remains suspended. This column of settling fines is the major challenge in oil sands tailings management.

2.2 Mature Fine Tails (MFT)

The fines that remain in suspension within the water column consist of approximately 50% clay-sized particles and consolidate very slowly. Starting at around 5% w/w, consolidation to 30% w/w can take 3 years or longer depending on water chemistry, after which there is a general reduction in consolidation rates. Once the suspended fines have reached this point, the material is known as MFT. It is commonly stated that consolidation of MFT to form a trafficable deposit would take centuries. The MFT generation volume for any particular year is small averaging about 22 Mm^3/year under current production rates, but over the course of 40 years of operations the total stored volume has exceeded 180 Mm^3 and now represents a major challenge to pond management and reclamation. The classification of MFT is determined by a point on the consolidation curve for oil sand fines suspended in water, and as such the material properties for MFT as a whole vary fairly widely. In terms of MFT definitions within Suncor ponds, Table 4 can be used as a "typical" characterisation of the physical properties, while the values displayed in Table 5 are the result of fitting the laboratory flow curves to the Bingham viscosity model.

Table 4 MFT physical properties

Property	Low Range	High Range	Model Value
% mineral by weight	25%	50%	30%
% minus 325 mesh (<44um) by weight	95%	99.9%	100%
% Clay/fines by weight[1]	30%	100%	50%
% Clay/water by weight[1]	20%	50%	n/a

Table 5 Dependence of rheology on the MFT solids content (Omotoso and Mikula, 2006)

Wt% solids of MFT (no additive)	Viscosity (mPa·s)	Yield Stress (Pa)
10	4.1	0.2
15	4.9	0.3
20	5.6	0.4
25	6.4	1.1
30	8.7	1.7
40	22.6	23.0
50	120.7	138.5
60	999.1	499.2

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[1] Clay content based on clay activity as measured by Methylene Blue testing

Depending on the method of removal, these in situ properties may be altered when the material reports to processing. This is primarily due to dilution of the material with pond water during removal by dredging or pumping. The yield stress of the material has been shown to be constant with temperature, whereas the viscosity decreases with temperature. The viscosity has also shown to be insensitive to agitation time.

3 DEVELOPMENT OF MFT DRYING AT SUNCOR

3.1 Historical Work

The MFT drying process is not a new technology entirely. The development of the current system started with a review of previous research work into methods of dewatering fine tailings conducted during the 1970s and through into the 1990s. While promising, many of the processes discussed in this early research were discounted by industry as not practically applicable.

In the case of research work into freeze/thaw dewatering of MFT, several field trials were conducted at Suncor and other oil sands sites with the MFT deposited into small, shallow ponds that were allowed to freeze over the winter followed by thaw and evaporative dewatering the following summer (Dawson, et al., 1999). In order to scale this process up to production levels, enormous surface areas would be required as these pits could only be two to four metres deep. The primary restrictions under this scenario were the collection of release water and precipitation on the surface of the dewatering MFT resulting in only partial utilisation of the evaporative effects.

Evaluations of this dewatering process, as well as other early research works, were published by the Fine Tailings Fundamentals Consortium which noted that "…these approaches were not practically applicable, because of either high capital costs, high operating costs, or the results were not satisfactory" (Fine Tailings Fundamentals Consortium, 1995). This statement defined the industry response to the technology, as shown by the lack of implementation of such systems. There remained opportunity for improvement.

3.2 Revival of Bench Testing

During the summer of 2003, Suncor Tailings Engineering began bench scale testing on the evaporative limits of MFT drying. Trays of MFT placed in varying thicknesses between 1 cm and 30 cm were placed on outside racks against a building facing approximately east, which exposed the samples to morning sunlight. In addition, the samples were placed under a clear plastic cover that allowed exposure to sunlight but shielded the samples from rain to avoid pooling. The plastic covering was open at the sides to allow airflow.

Initial results indicated a practical limit to the thickness of MFT that would be subject to evaporation, due likely to surface crust formation.

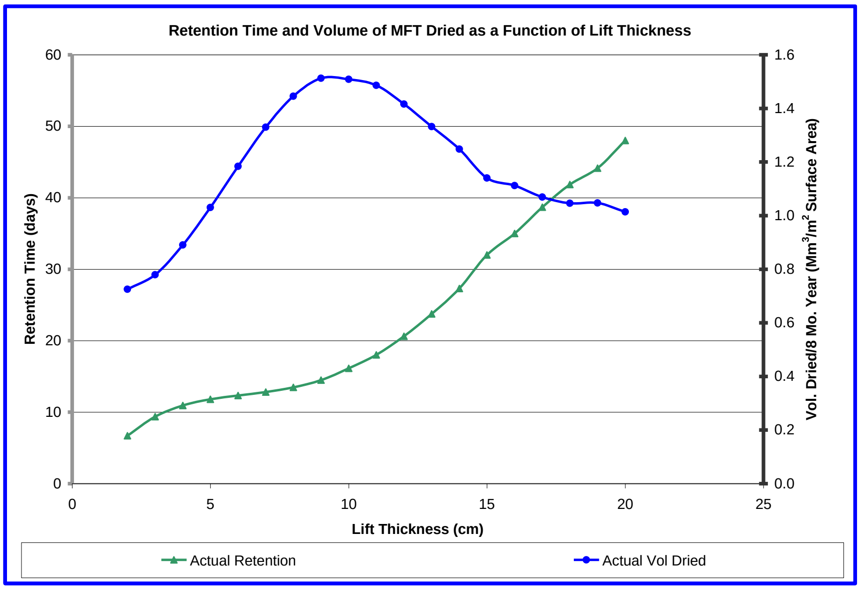

Figure 1 **2003 MFT evaporation bench test results**

The final dewatered fine tailings was well below the plastic limit and displayed penetrometer test values in excess of 500 kPa occurring within 16 days. Figure 1 shows the results of analysis of the evaporative test data, and indicates that an MFT lift thickness of approximately 9 cm provides optimal volumetric dewatering in a given time. This results in a maximum MFT disposal volume of 1.55 m^3 of MFT for each square metre of available surface area, given an evaporation period of April 1 to November 1. However, this did not solve the problem of how to avoid the slowed evaporation from the deposit due to water cover under pit deposition scenarios.

3.3 Towards Field Testing

Reviews of field deposition techniques began during the Paste and Thickened Tailings Workshop held in 2003 in the city of Edmonton, Alberta. If the MFT material could be given sufficient shear strength to hold a slope, thin lift deposition and desiccation was a possibility. Lab work conducted through CANMET in 2002 focused on the use of various chemical species to increase the strength of MFT (Omotoso et al., 2002). A range of chemicals were identified, but the strength gains were not monitored on the time scales required to manage an active deposition system. Further testing was required.

In the fall of 2003, bench scale tests were conducted by a team consisting of Suncor staff and consulting experts. Tests were conducted with the objective of determining which of a series of additives would produce sufficient strength within a few minutes such that stable 10-20 cm layers could be formed on a 4% slope. Figure 2 shows the results of depositing untreated MFT on the test slope. Figure 3 shows the additives used and their dosages relative to the 20 L volume of 30% w/w MFT, as well as the physical behaviour after treatment. Each of these treatments were mixed in a 20 L pail for 20 minutes prior to deposition on a plastic covered sheet of plywood placed at a 4% slope.

Figure 2 Untreated MFT on 4% slope

The tested materials produced distinct results. The addition of gypsum produced a release of small volumes of clear water from each of the mixtures, with very little colour change. Gypsum addition alone did not, however, result in any apparent improvement to the stacking capabilities of the deposit.

Hydrated lime initially resulted in a visible reduction in the viscosity of the MFT during mixing, but “set-up” after approximately 10 minutes. After this mixing period, the treated MFT exhibited sufficient strength to maintain an 8-10 cm thickness on the sloped surface. The colour of the deposit was lighter, but no release water was visible. These results were very similar to those from the Portland cement addition.

It was then decided to trial a mixture of the gypsum and hydrated lime together. A successful 8 cm thick deposit was formed with a dosage of 100 g of hydrated lime and 30 g of gypsum, was dark in colour, and exhibited clear water release. This mixture was to be used in a larger scale field deposit. This first field trial was conducted in September, 2003 utilising a 5 m^3 cement truck depositing on a 4% sloped sand bed contained on three sides. This initial deposit is shown in Figure 4, with evident dewatering eight days later shown in Figure 5.

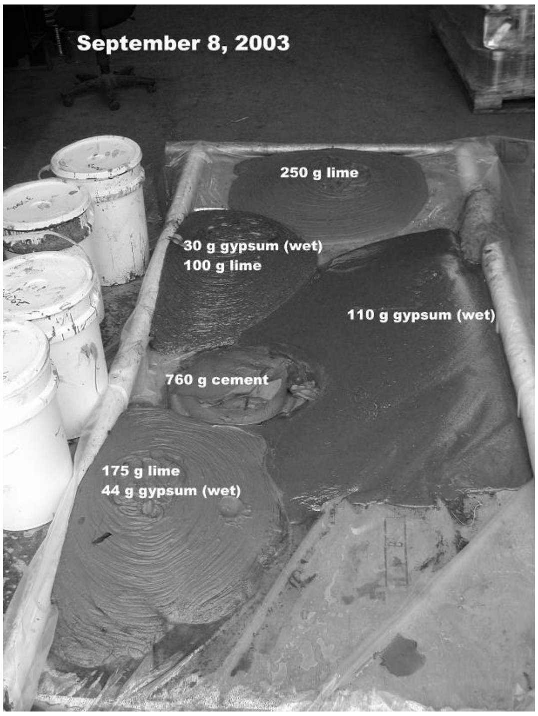

Figure 3 Treated MFT (sludge) on 4% slope

Once this preliminary field trial had been conducted, evaluation of the flow behaviour of the treated and untreated MFT samples was undertaken with a variety of standard techniques by staff at the CANMET Energy Technology Centre in Devon. The results of this testing are shown in Table 6. The small scale slump test was very consistent in matching the slopes from the flume tests, as was the conventional rheometer in a vane configuration (with the exception of the highest gypsum and lime combination). As a result of the experimental difficulties with laboratory based equipment for field applications, there is an interest in small scale slump tests using whatever cylindrical container might be available (Pashias et al., 1996; Gawu and Fourie, 2004). For field evaluation of consistency in the MFT mixture recipe (the combination of MFT solids content, chemical addition, and mixing), it is difficult to match the ease of use and ruggedness of the small scale slump test.

Figure 4 MFT drying field trial — initial deposit

Figure 5 MFT drying field trial — 8 days

Table 6 Comparison of rheology data with flume test slopes (Omotoso and Mikula, 2006)

	Viscosity (mPa·s)		Yield Strength (Pa)			Small Scale Slump Test (13 cm initial diameter)	Flume Test Slope (%)
Sample	Rheometer Cup and Bob	Rheometer Vane	Rheometer Cup and Bob	Rheometer Vane	Field Geotech Vane		
MFT (35.8% solids)	12.2	22.2	5.4	2.3	40.5	45	1.1
0.125% Gypsum	17.4	37.5	12.7	26.9		40.5	1.8
0.5% Gypsum	29.9	48.7	33.1	26.2	44.6	36.5	1.9
0.125% Lime and Gypsum	18.2	11.2	31.8	40.9		27	2.1
0.5% Lime	19.5	241.7	10.4	103.1	77	21	2.6

The laboratory data gave an indication of the additive requirements for this type of deposition system, while the field trial provided a simple, effective demonstration of the technology in a site that could be reviewed by management. Seeing is believing, and this provided sufficient proof of concept to propose moving to a pilot system.

4 FIELD TESTING AND RESULTS

4.1 2004 Pilot Testing

A phase 1 pilot plant was constructed and operated in the fall and winter of 2004. This pilot consisted of an oil field tank which was filled with MFT and then dry lime and gypsum was added. The batch was allowed to mix for a minimum of ten minutes, after which it was pumped out onto the beach through a series of spigots. The depositional area was 150 m wide by 300 m long. The base material was the pre-existing silica sand which had been graded to a 4% slope. The MFT was deposited through a series of 50 mm spigots spaced every 6 m along a 200 mm diameter header pipe as shown in Figure 6.

The batch mixing allowed for multiple lime and gypsum addition ratios to be tested within a limited beach deposition area. Field rheological testing combined with visual observations, confirmed the dosage rates which were identified in previous testing. A ratio of 2.5 g of dry lime per kg MFT slurry and 2.5 g of dry gypsum per kg of MFT slurry was found to provide the desired lift thickness on the slope. Figure 7 shows a view of the gypsum being added to the feed conveyor.

Advancements in knowledge obtained during this phase of testing centred on equipment selection. Mixing the MFT in a tank with dry lime and gypsum was not found to be practical. The power required to mix a high viscosity slurry was not available from the oil field tanks. From this, it was determined that a more practical approach would be to slurry the lime and gypsum separately and then inject the slurry into an MFT pipe. Injecting at the suction of a booster pump would allow the pump to act as the mixer. This design was carried forward to the next phase of testing.

Reagent addition requirements are inversely dependant on the density of the source MFT. As the solids content increased, the amount of lime required decreased dramatically.

Figure 6 View of spigot pipe for deposition

Figure 7 Loading of gypsum onto conveyor belt

Once the phase 1 pilot plant was operational, compositional and rheological testing of the material were conducted to allow for comparisons between bench scale tests and field operations. These tests included on-site vane shear tests, 50 cent Rheometer slump tests, as well as laboratory shear and material composition tests. The primary focus was to determine a functional additive dosage for both the lime and the gypsum through an attempt to correlate the field and lab tests to actual field deposit behaviour. For field testing operations, it appears that a simple slump test is more effective and dependable than vane shear tests.

The single largest factor in achieving desired viscosity and yield strength values is the density of the MFT. Any material that is less than 30% w/w cannot be treated with reasonable additive volumes. However, if the source MFT exceeds 40% solids, it is likely that lime addition is not actually required. In this case, gypsum alone would be used in order to reduce the total drying time of the deposit. A focus on reducing the total amount of dilution during the MFT removal process has the potential to greatly reduce the cost associated with rheological amendment.

Once the deposition is complete, daily samples of the deposit were taken and analysed for percent solids. When plotted on a graph, as in Figure 8 along with the bench scale testing, the conclusion is that the field drying rates were easily comparable to those in the bench scale testing despite precipitation effects.

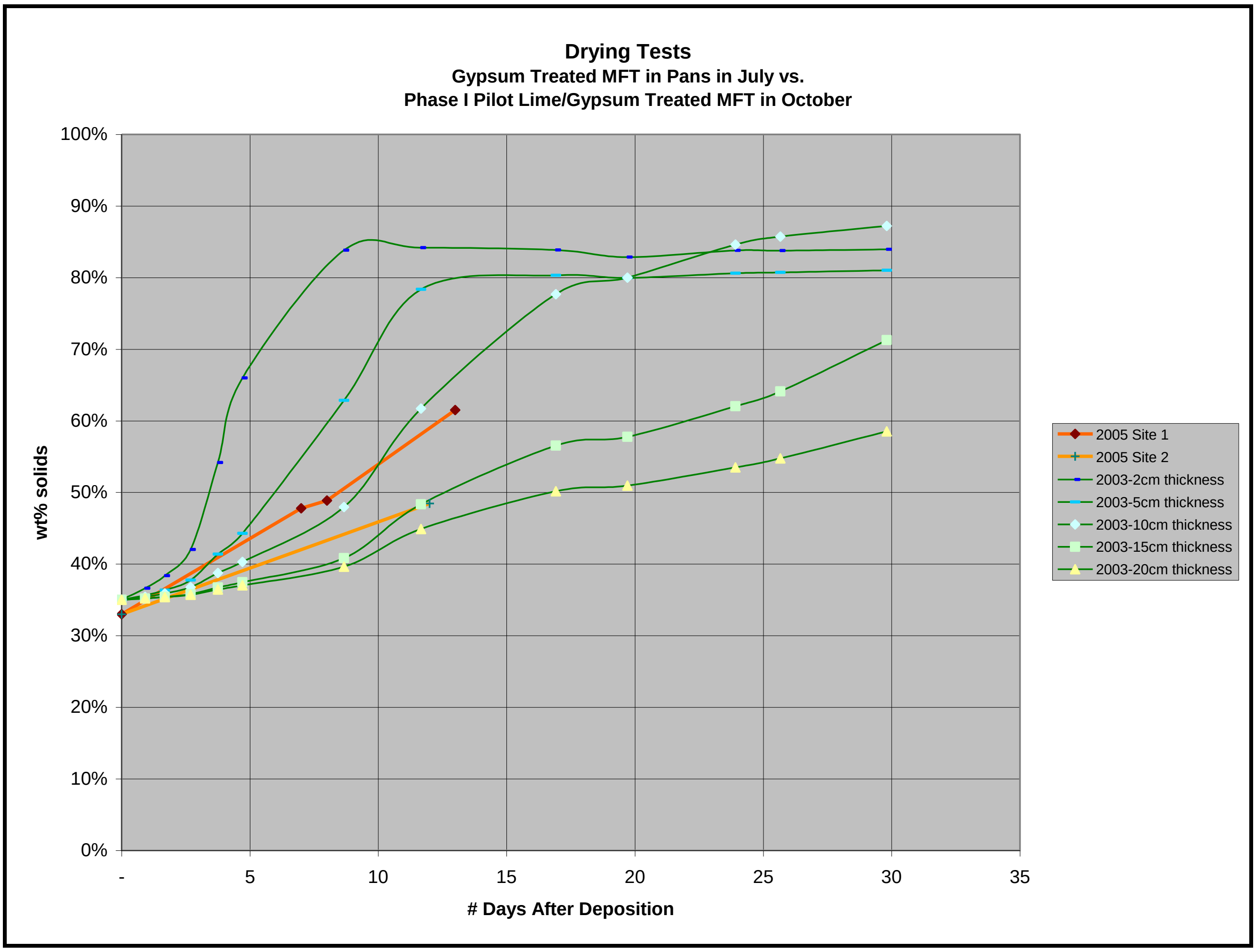

Figure 8 Pilot deposit to bench test comparison

4.2 2005/2006 Field Trials

Building on the knowledge gained from the previous trial, a second trial was performed between the fall of 2005 and the spring of 2006. In this trial, the beach deposition area was expanded to provide four distinct cells onto which the MFT could be poured. The original cell from the previous trial was re-utilised. The remaining cells were rough graded to 2% rather than the 4% of the original cell. This was largely due to the pre-existing topography, but gave an opportunity to assess the impact of cell grading on the deposition.

To one side of the first cell, two berms were pushed up with 2.5 m spacing between them. A weather station, thermistors, and soil moisture diviners were installed to assist with monitoring for reclamation testing once the berms are filled with sufficient dried MFT. The mechanical equipment used in this trial was designed based on the experience of the previous trial. A 20 m^3 tank was filled with water and dry lime and gypsum were added to the tank initially with a Gradall loader and later through a hopper and auger. The tank was agitated with an air bubbling ring. The air agitation was required due to the lack of availability of a mechanical agitator in the time frame required by the project. The presence of the air, lead to a very stable foam layer being formed on the top of the tank. This foam layer was largely controlled though the use of a de-foaming surfactant.

The MFT supply was from a slipstream off of a production transfer line. A flow of 63 l/s was taken off the main line and with a booster pump and was pumped out to the spigots on the depositional area. The lime and gypsum slurry was injected into the suction of the booster pump. This trial operated in a semi-continuous mode. A batch of lime and gypsum would be made up in the morning; it would then be continuously injected into the MFT stream. The lime / gypsum batch tank is shown in Figure 9. The batch tank was sized such that only one batch per day was required. The facility was operated 10 hours per day and 4 days per week.

At the end of each day, all lines had to be drained and flushed to prevent over night freezing. Due to the high viscosity of the amended MFT, it would not drain from the pipeline by gravity. A water flush followed by an air blow was required to ensure that the pipes were clear and would not freeze. Allowing this flush water to be deposited through the spigots would result in channels being cut in the deposit and the day’s deposit being washed away. At the end of each of the 150 m long spigot sections, a 200 mm drain valve was installed. By closing the valves on each of the spigots and opening the drain valve, the header could be flushed without water ending up on the deposit.

Each depositional cell was poured onto until it was covered to a depth of 8 to 10 cm and the entire sloped area was covered. Figure 10 and Figure 11 show the deposition. Once this was accomplished, the depositional activities moved to the next cell. In the summer months, each cell is allowed to dry for 14 days prior to another lift being deposited. At this point, the material has dried to ~80% w/w and can support a person walking across it. In the winter time, the cell need only freeze solid before another lift can be applied. While deposition of the lift onto the snow covered cell surface prevented visual assessment of the amount of slope coverage, it was apparent during the spring melt that the winter deposits had adequately covered the slopes.

As with the previous trial, the largest restriction was a consistent supply of MFT at a high enough density. MFT is removed from the pond with a suction cutter dredge. The dredge by its nature tends to dilute the MFT as it is removed. Also due to the viscosity and yield strength of the MFT, the dredge digs a hole which then collapses and re-fills. These issues result in difficulty in maintaining the flow at the required density. In addition the mechanical reliability of the dredge, especially in the winter months when the pond is frozen, made for a reduced amount of operating time. Work is ongoing outside the scope of this project to improve the MFT supply year round.

The lime and gypsum dosage required continued to be in line with previous lab and field work. As would be expected, the lime and gypsum dosage decreased as the slope of the depositional area decreased. A 2% slope would appear to be optimal in terms of minimising reagent requirements while still maintaining enough slope for positive water run-off.

This trial showed that the process is feasible on a continuous basis. The basic design from this trial would be applied to a commercial scale operation. Based on field observations and lab testing, a target minimum of 68-75% w/w allows sufficient deposit strength to allow placement of further lifts.

Figure 9 **Lime / gypsum mix tank and MFT booster pump**

Figure 10 View of the deposition from the spigot header

Figure 11 View of the depositional area from downslope

4.2.1 Effects of freezing

Due to the location of the test site, evaporation is only effective for about half of the year. Dewatering by freeze/thaw processes has the potential to be the major mechanism in the treatment of MFT, with a single freeze/thaw cycle dewatering a 30%w/w material to 50%. During spring and fall, night time temperatures often fall below freezing, with daytime temperatures above. This allows for rapid dewatering of the placed MFT, along with associated release of water for recycling back into the system. Once temperatures fall below zero Celsius for the season, thin lifts may be placed on the deposition slopes and allowed to freeze. Successive lifts up to a total frozen thickness of between one and two metres is possible, with this deposit dewatering in spring. The chemical composition of release water from thawing deposits in fall, 2005 is shown in Table 7, and is contrasted to a typical Suncor process effected water chemistry that is produced during normal tailings process. The higher calcium and magnesium levels are comparable to other gypsum dosed tailings on site, so a comparison of the chemistries indicates that the release water from MFT freeze/thaw processes fall within the ranges of current water quality standards and can be reused as part of the recycling process. Based on work previously conducted, there is some indication that the total winter deposit could be made as thick as 3 to 4.5 metres (Dawson et al., 1999). However, such a deposit would likely require the entire summer to dewater sufficiently for additional lifts. One optimisation for this process would be moving to a winter only system, which could increase the total volume treated per unit surface area from the current projections of 2m^3 MFT / 1m^2 surface area to 3 to 4.5m^3. In addition, winter only deposition would maximise the total volume of water returned to the system.

Table 7 Release water quality

Sample Description	Cond	pH	CO_3 (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)
Average Process Water	2339	8.33	22.5	837.3	205.2	268.2	12.2	66.1	556.9	11.3
MFT Drying Release	2810	8.17	0.0	617	91.7	901.4	41.2	33.4	570.0	20.3
Pond/CT Release	2100	8.25		900	100	300	40	20	500	25

Freezing within the deposit occurs at a number of scales with lenses of clear ice forming at thickness ranging from the millimetre scale up to 2-3 cm wide. Orientations range from sub-horizontal to sub-vertical, with surface expressions taking a fan or fern-like appearance. Evaporative processes, if allowed to proceed well past the plastic limit, produce hard, polygonal crusts while the freeze/thaw process results in ped structures with particle sizes typically below 2mm in diameter as shown in Figure 12.

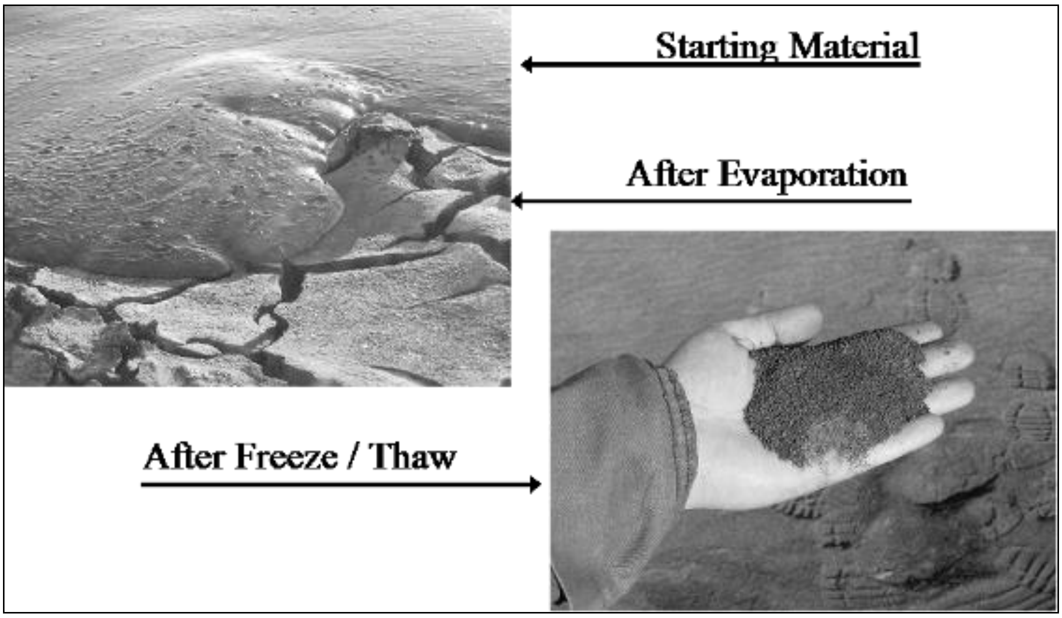

Figure 12 Comparison of fresh MFT versus evaporative dying versus freeze / thaw

4.3 Winter 2006 Operations

In order to capitalise on the benefits of winter deposition, a full scale plant has been built and will be operated through the winter of 2006. This plant was designed based on the lessons learned in previous testing. The gypsum is slurried within an agitated tank. Once the slurry is mixed, it is transferred to a gypsum run tank. Similarly, the lime is stored in a silo and is slurried with water in an agitated tank, then transferred to a lime run tank. From the two run tanks, the lime and gypsum slurries are metered into the suction of an MFT booster pump which transfers the mix out to the depositional area. Using separate mix tanks and run tanks permit a new batch of lime or gypsum to be made without interrupting the injection into the MFT. This will permit 24 hour operation, 7 days per week. Photos of the facility are shown in Figure 13 and Figure 14.

Figure 13 Exterior view of full scale plant

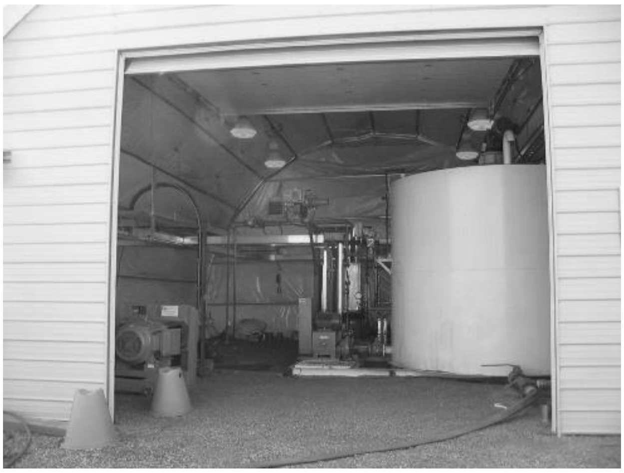

Figure 14 Interior view of full scale plant

5 FUTURE OPPORTUNITIES

5.1 Lime Replacement

Rheological modification through the use of hydrated lime is likely not an optimal solution. Now that the principals of deposition and dewatering of MFT have been demonstrated, the opportunity exists to investigate alternate additives to increase effectiveness and reduce costs. Several variations have been examined, including fly ash from the flue gas desulphurisation (FGD) operation on site, but none have proven to be an effective replacement for hydrated lime. The next phase of testing will focus on polymer addition to achieve sufficient shear strength to allow for sloped deposition, but this trial phase has not been fully defined. Partners will be sought to conduct laboratory testing, with a focus on yield stress modifications with pipeline and deposition shear resistance. Full scale operations at Suncor site could begin as early as 2007.

5.2 Mechanical Optimisations

Mechanical optimisations are scheduled to be made to the existing plant and will be incorporated in future designs. The agitators for the gypsum slurry have proven to be less than ideal for maintaining the gypsum in suspension. A revised agitator design will be required.

In order to prevent flush water from being deposited on the cell, a ball valve has been installed on each of the spigots. This requires an operator to manually close each valve for the flush and then re-open them. An optimisation would see the spigot pipes coming off the top portion of the header pipe through a vertical rise prior to discharging on the beach. This vertical rise would provide enough head to prevent water from coming out of the spigots once the drain valve at the end of the header was opened.

A further optimisation on the depositional area would be to use a central pillar discharge, rather than a linear discharge with spigots. This would produce a conical deposit rather than the rectangular one currently being used. The natural topography of the area prior to deposition would likely dictate which method was more suited.

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