Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 3026731 C 2019/11/26

(11)(21) **3 026 731**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(22) Date de dépôt/Filing Date: 2018/12/07
(41) Mise à la disp. pub./Open to Public Insp.: 2019/02/08
(45) Date de délivrance/Issue Date: 2019/11/26
(30) Priorités/Priorities: 2017/12/19 (US62/607,717); 2017/12/19 (US62/607,713); 2017/12/19 (US62/607,712)

(51) Cl.Int./Int.Cl. *B03B 9/02* (2006.01), *B03B 5/00* (2006.01), *B03D 1/00* (2006.01)

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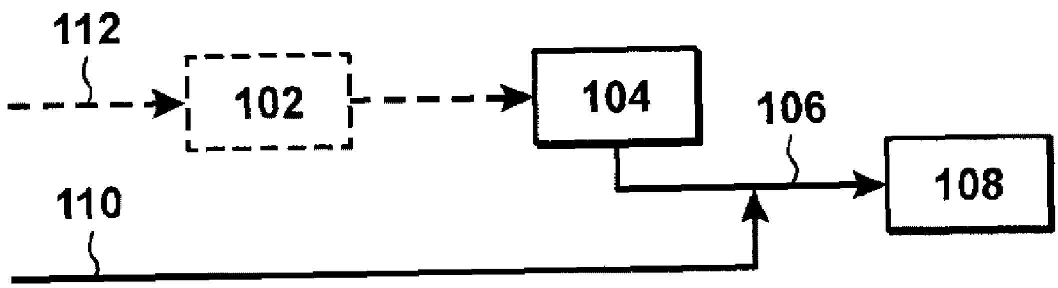
(54) Titre : DEPOT CONTROLE DE RESIDUS DE SABLES BITUMINEUX
(54) Title: CONTROLLED OIL SAND TAILINGS DEPOSITION



(57) Abrégé/Abstract:
A method of controlled deposition for increasing deposition rate, the method comprising providing a first fines dominated stream having a first sand to fines ratio (SFR) of less than 0.6 and having first solids content; providing a second fines dominated stream having a second SFR of between 0.6 and 3.0 and having a second solids content; wherein the first solids content and the second solids content differ by at least 5%, by mass; and depositing the first and second dominated streams into a common deposition cell.

ABSTRACT

A method of controlled deposition for increasing deposition rate, the method comprising providing a first fines dominated stream having a first sand to fines ratio (SFR) of less than 0.6 and having first solids content; providing a second fines dominated stream having a second SFR of between 0.6 and 3.0 and having a second solids content; wherein the first solids content and the second solids content differ by at least 5%, by mass; and depositing the first and second dominated streams into a common deposition cell.

CONTROLLED OIL SAND TAILINGS DEPOSITION

BACKGROUND

Field of Disclosure

[0001] The disclosure relates generally to the field of oil sand processing. More particularly, the disclosure relates to oil sand tailings processing.

Description of Related Art

[0002] This section is intended to introduce various aspects of the art, which may be associated with the present disclosure. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present disclosure. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0003] Modern society is greatly dependent on the use of hydrocarbon resources for fuels and chemical feedstocks. Hydrocarbons are generally found in subsurface formations that can be termed “reservoirs”. Removing hydrocarbons from the reservoirs depends on numerous physical properties of the subsurface formations, such as the permeability of the rock containing the hydrocarbons, the ability of the hydrocarbons to flow through the subsurface formations, and the proportion of hydrocarbons present, among other things. Easily harvested sources of hydrocarbons are dwindling, leaving less accessible sources to satisfy future energy needs. As the costs of hydrocarbons increase, the less accessible sources become more economically attractive.

[0004] Hydrocarbon removal from oil sand may be performed by several techniques. For example, a well can be drilled to an oil sand reservoir and steam, hot air, solvents, or a combination thereof, can be injected to release the hydrocarbons. The released hydrocarbons may be collected by wells and brought to the surface. In another technique, strip or surface mining may be performed to access the oil sand, which can be treated with water, steam or solvents to extract the heavy oil.

[0005] Oil sand extraction processes are used to liberate and separate bitumen from oil sand so that the bitumen can be further processed to produce synthetic crude oil or mixed with diluent

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to form "dilbit" and be transported to a refinery plant. Numerous oil sand extraction processes have been developed and commercialized, many of which involve the use of water as a processing medium. Where the oil sand is treated with water, the technique may be referred to as water-based extraction (WBE). WBE is a commonly used process to extract bitumen from mined oil sand. Other processes are non-aqueous solvent-based processes. An example of a solvent-based process is described in Canadian Patent Application No. 2,724,806 (Adeyinka *et al*, published June 30, 2011 and entitled "Process and Systems for Solvent Extraction of Bitumen from Oil Sands"). Solvent may be used in both aqueous and non-aqueous processes.

[0006] One WBE process is the Clark hot water extraction process (the "Clark Process"). This process typically requires that mined oil sand be conditioned for extraction by being crushed to a desired lump size and then combined with hot water and perhaps other agents to form a conditioned slurry of water and crushed oil sand. In the Clark Process, an amount of sodium hydroxide (caustic) may be added to the slurry to increase the slurry pH, which enhances the liberation and separation of bitumen from the oil sand. Other WBE processes may use other temperatures and may include other conditioning agents, which are added to the oil sand slurry, or may operate without conditioning agents. This slurry is first processed in a Primary Separation Cell (PSC), also known as a Primary Separation Vessel (PSV), to extract the bitumen from the slurry.

[0007] In one bitumen extraction process, a water and oil sand slurry is separated into three major streams in the PSC: bitumen froth, middlings, and a PSC underflow (also known as coarse tailings or primary separation tailings).

[0008] Regardless of the type of WBE process employed, the process will typically result in the production of a bitumen froth that requires treatment with a solvent. For example, in the Clark Process, a bitumen froth stream comprises bitumen, solids, and water. Certain processes use naphtha to dilute bitumen froth before separating the product bitumen by centrifugation. These processes are called naphthenic froth treatment (NFT) processes. Other processes use paraffinic solvent, and are called paraffinic froth treatment (PFT) processes, to produce pipelineable bitumen with low levels of solids and water. In the PFT process, a paraffinic solvent (for example, a mixture of iso-pentane and n-pentane) is used to dilute the froth before separating the product, diluted bitumen, by gravity. A portion of the asphaltenes in the bitumen is also rejected by design in the PFT process and this rejection is used to achieve reduced solids and water levels. In both the NFT and the PFT processes, the diluted tailings (comprising water, solids and some hydrocarbon) are separated from the diluted product bitumen.

[0009] Solvent is typically recovered from the diluted product bitumen component before the bitumen is delivered to a refining facility for further processing.

[0010] The PFT process may comprise at least three units: Froth Separation Unit (FSU), Solvent Recovery Unit (SRU) and Tailings Solvent Recovery Unit (TSRU). Mixing of the solvent with the feed bitumen froth may be carried out counter-currently in two stages in separate froth separation units. The bitumen froth comprises bitumen, water, and solids. A typical composition of bitumen froth is about 60 wt. % bitumen, 30 wt. % water, and 10 wt. % solids. The paraffinic solvent is used to dilute the froth before separating the product bitumen by gravity. The foregoing is only an example of a PFT process and the values are provided by way of example only. An example of a PFT process is described in Canadian Patent No. 2,587,166 to Sury.

[0011] From the PSC, the middlings, comprising bitumen and about 10-30 wt. % solids, or about 20-25 wt. % solids, based on the total wt. % of the middlings, is withdrawn and sent to the flotation cells to further recover bitumen. The middlings are processed by bubbling air through the slurry and creating a bitumen froth, which is recycled back to the PSC. Flotation tailings (FT) from the flotation cells, comprising mostly solids and water, are sent for further treatment or disposed in an external tailings area (ETA).

[0012] In ETA tailings ponds, a liquid suspension of oil sand fines in water with a solids content greater than 5 wt. %, but less than the solids content corresponding to the Liquid Limit are called Fluid Fine Tailings (FFT). FFT settle over time to produce Mature Fine Tailings (MFT), having above about 30 wt. % solids.

[0013] It would be desirable to have an alternative or improved method of processing oil sand tailings.

SUMMARY

[0014] It is an object of the present disclosure to provide a method of processing oil sand tailings.

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[0015] According to one aspect, there is provided a method of controlled deposition for increasing deposition rate, the method comprising:

a) providing a first fines dominated stream having a first sand to fines ratio (SFR) of less than 0.6 and having first solids content;

b) providing a second fines dominated stream having a second SFR of between 0.6 and 3.0 and having a second solids content; wherein the first solids content and the second solids content differ by at least 5%, by mass; and

c) depositing the first and second dominated streams into a common deposition cell.

[0016] The foregoing has broadly outlined the features of the present disclosure so that the detailed description that follows may be better understood. Additional features will also be described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and other features, aspects and advantages of the disclosure will become apparent from the following description, appending claims and the accompanying drawings, which are briefly described below.

[0018] Fig. 1 is a schematic of a method of processing oil sand tailings.

[0019] Fig. 2 is a schematic of a method of processing oil sand tailings.

[0020] Fig. 3 is a schematic of a method of processing oil sand tailings.

[0021] Fig. 4A is a graph of void ratio versus effective stress for oil sand tailings.

[0022] Fig. 4B is a graph of void ratio versus hydraulic conductivity for oil sand tailings.

[0023] Fig. 4C is a graph of void ratio versus effective stress for oil sand tailings.

[0024] Fig. 4D is a graph of void ratio versus hydraulic conductivity for oil sand tailings.

[0025] Fig. 4E is a graph of void ratio versus effective stress for oil sand tailings.

[0026] Fig. 4F is a graph of void ratio versus hydraulic conductivity for oil sand tailings.

[0027] Fig. 5 is a graph showing dewatering results from a model.

[0028] Fig. 6 is a graph showing additional dewatering results from a model.

[0029] Fig. 7 is a graph showing deposition results.

[0030] Fig. 8 is a graph showing deposition results

[0031] Fig. 9 is a graph showing deposition results.

[0032] It should be noted that the figures are merely examples and no limitations on the scope of the present disclosure are intended thereby. Further, the figures are generally not drawn to scale, but are drafted for purposes of convenience and clarity in illustrating various aspects of the disclosure.

DETAILED DESCRIPTION

[0033] For the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the features illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Any alterations and further modifications, and any further applications of the principles of the disclosure as described herein are contemplated as would normally occur to one skilled in the art to which the disclosure relates. It will be apparent to those skilled in the relevant art that some features that are not relevant to the present disclosure may not be shown in the drawings for the sake of clarity.

[0034] At the outset, for ease of reference, certain terms used in this application and their meaning as used in this context are set forth below. To the extent a term used herein is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Further, the present processes are not limited by the usage of the terms shown below, as all equivalents, synonyms, new developments and terms or processes that serve the same or a similar purpose are considered to be within the scope of the present disclosure.

[0035] Throughout this disclosure, where a range is used, any number between or inclusive of the range is implied.

[0036] A “hydrocarbon” is an organic compound that primarily includes the elements of hydrogen and carbon, although nitrogen, sulfur, oxygen, metals, or any number of other elements may be present in small amounts. Hydrocarbons generally refer to components found in heavy oil or in oil sand. However, the techniques described are not limited to heavy oils but may also be used with any number of other reservoirs to improve gravity drainage of liquids.

Hydrocarbon compounds may be aliphatic or aromatic, and may be straight chained, branched, or partially or fully cyclic.

[0037] “Bitumen” is a naturally occurring heavy oil material. Generally, it is the hydrocarbon component found in oil sand. Bitumen can vary in composition depending upon the degree of loss of more volatile components. It can vary from a very viscous, tar-like, semi-solid material to solid forms. The hydrocarbon types found in bitumen can include aliphatics, aromatics, resins, and asphaltenes. A typical bitumen might be composed of:

19 weight (wt.) % aliphatics (which can range from 5 wt. % - 30 wt. %, or higher);

19 wt. % asphaltenes (which can range from 5 wt. % - 30 wt. %, or higher);

30 wt. % aromatics (which can range from 15 wt. % - 50 wt. %, or higher);

32 wt. % resins (which can range from 15 wt. % - 50 wt. %, or higher); and

some amount of sulfur (which can range in excess of 7 wt. %), the weight % based upon total weight of the bitumen.

In addition, bitumen can contain some water and nitrogen compounds ranging from less than 0.4 wt. % to in excess of 0.7 wt. %. The percentage of the hydrocarbon found in bitumen can vary. The term “heavy oil” includes bitumen as well as lighter materials that may be found in a sand or carbonate reservoir.

[0038] “Heavy oil” includes oils which are classified by the American Petroleum Institute (“API”), as heavy oils, extra heavy oils, or bitumens. The term “heavy oil” includes bitumen. Heavy oil may have a viscosity of about 1,000 centipoise (cP) or more, 10,000 cP or more, 100,000 cP or more, or 1,000,000 cP or more. In general, a heavy oil has an API gravity between 22.3° API (density of 920 kilograms per meter cubed (kg/m^3) or 0.920 grams per centimeter cubed (g/cm^3)) and 10.0° API (density of 1,000 kg/m^3 or 1 g/cm^3). An extra heavy oil, in general, has an API gravity of less than 10.0° API (density greater than 1,000 kg/m^3 or 1 g/cm^3). For example, a source of heavy oil includes oil sand or bituminous sand, which is a combination of clay, sand, water and bitumen.

[0039] The term “bituminous feed” refers to a stream derived from oil sand that requires downstream processing in order to realize valuable bitumen products or fractions. The bituminous feed is one that comprises bitumen along with undesirable components. Undesirable components may include but are not limited to clay, minerals, coal, debris and water. The bituminous feed may be derived directly from oil sand, and may be, for example, raw oil sand ore. Further, the bituminous feed may be a feed that has already realized some initial processing but nevertheless requires further processing. Also, recycled streams that comprise bitumen in combination with other components for removal as described herein can be included in the bituminous feed. A bituminous feed need not be derived directly from oil sand, but may arise from other processes. For example, a waste product from other extraction processes which comprises bitumen that would otherwise not have been recovered may be used as a bituminous feed.

[0040] "Fine particles" or "fines" are generally defined as those solids having a size (i.e diameter) of less than 44 microns (μm), as determined by laser diffraction particle size measurement.

[0041] "Coarse particles" are generally defined as those solids having a size (i.e. diameter) of greater than 44 microns (μm).

[0042] The term "solvent" as used in the present disclosure should be understood to mean either a single solvent, or a combination of solvents.

[0043] The terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numeral ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and are considered to be within the scope of the disclosure.

[0044] The articles "the", "a" and "an" are not necessarily limited to mean only one, but rather are inclusive and open ended so as to include, optionally, multiple such elements.

[0045] The term "paraffinic solvent" (also known as aliphatic) as used herein means solvents comprising normal paraffins, isoparaffins or blends thereof in amounts greater than 50 wt. %. Presence of other components such as olefins, aromatics or naphthenes may counteract the function of the paraffinic solvent and hence may be present in an amount of only 1 to 20 wt. % combined, for instance no more than 3 wt. %. The paraffinic solvent may be a C_4 to C_{20}

or C_4 to C_6 paraffinic hydrocarbon solvent or a combination of iso and normal components thereof. The paraffinic solvent may comprise pentane, iso-pentane, or a combination thereof. The paraffinic solvent may comprise about 60 wt. % pentane and about 40 wt. % iso-pentane, with none or less than 20 wt. % of the counteracting components referred above.

[0046] An "oil sand tailings stream" is any suitable stream stemming from oil sand. Examples include, but are not limited to, coarse tailings (also known as primary separation tailings), middlings, flotation tailings, froth separation tailings, tailings solvent recovery unit (TSRU) tailings, fluid fine tailings (FFT), mature fine tailings (MFT), thickened tailings, centrifuged tailings, hydrocycloned tailings, or a combination thereof. The oil sand tailings stream may stem from aqueous based extraction. The oil sand tailings stream may stem from solvent based extraction. An oil sand tailings stream may comprise coarse tailings stream, middlings, flotation tailings, froth separation tailings, tailings solvent recovery unit (TSRU) tailings, fluid fine tailings (FFT), mature fine tailings (MFT), thickened tailings (TT), thickener overflow, centrifuged tailings, hydrocycloned tailings, or a combination thereof.

[0047] An "oil sand tailings treatment process" means a process used to treat an oil sand tailings stream. Examples of treatment are vast and may include removing bitumen, solvent, or water.

[0048] Fluid fine tailings (FFT) treatment and volume reduction are important for tailings management. Presently, fluid fine tailings (FFT) are treated by a thickener followed by chemical injection. The amount of FFT that can be blended in and treated is based on the amount of Flotation Tailings (FT) from the plant. A drawback of this process is that FFT treatment is highly dependent on upstream facility availability and the amount of FFT depends on flotation tailings (FT) solids rate. By introducing a FFT by-pass line, FFT treatment can be increased. When FT are available, the FFT may be treated along with FT, and when FT are not available, the FFT may be treated through tailings lines. Since FFT and process water may be stored in the same pond, the process water volume can be reserved.

Oil Sand Tailings Processing

[0049] With reference to Fig. 1, a first method may comprise: a) providing a gravity distributor (GD) (102), a thickener (104), an underflow pipeline (106), and a deposition cell (108), arranged in series, such that flotation tailings (FT) (112) can be introduced into the GD (102), sent to the thickener (104), formed into thickened tailings, and introduced into the deposition cell (108); b) introducing fluid fine tailings (FFT) (110) downstream of the thickener (104) as a bypass; and c) settling out at least a portion of the FFT in the deposition cell (108).

[0050] The first method may further comprise introducing flotation tailings (FT) into the GD, sending the FT from the GD to the thickener, forming thickened tailings in the thickener, and introducing the thickened tailings into the deposition cell. FFT may be introduced into the GD. FFT may be introduced into the thickener, bypassing the GD.

[0051] With reference to Fig. 2, a second method may comprise: a) providing a gravity distributor (GD) (202), a thickener (204), an underflow pipeline (206), and a deposition cell (208), arranged in series, such that flotation tailings (FT) (212) can be introduced into the GD (202), sent to the thickener (204), formed into thickened tailings, and introduced into the deposition cell (208); b) introducing fluid fine tailings (FFT) (210) into the GD (202); c) sending the FFT from the GD (202) to the thickener (204); d) sending thickened tailings from the thickener (204) to the deposition cell (208); and settling out at least a portion of the FFT in the deposition cell (208).

[0052] The second method may further comprise introducing FFT downstream of the thickener as a bypass. The second method may further comprise introducing FT into the GD, sending the FT from the GD to the thickener, forming thickened tailings in the thickener, and introducing the thickened tailings into the deposition cell.

[0053] With reference to Fig. 3, a third method may comprise: a) providing a gravity distributor (GD) (302), a thickener (304), an underflow pipeline (306), and a deposition cell (308), arranged in series, such that flotation tailings (FT) (312) can be introduced into the GD (302), sent to the thickener (304), formed into thickened tailings, and introduced into the deposition cell (308); b) introducing fluid fine tailings (FFT) (310) into the thickener (304), bypassing the GD (302); c) sending thickened tailings from the thickener (304) to the deposition cell (308); and settling out at least a portion of the FFT in the deposition cell (308).

[0054] The third method may further comprise introducing FFT downstream of the thickener as a bypass. The third method may further comprise introducing FT into the GD), sending the FT from the GD to the thickener, forming thickened tailings in the thickener, and introducing the thickened tailings into the deposition cell. FFT may be introduced into the GD.

[0055] A fourth method may comprise a) providing a thickener, an underflow pipeline, and a deposition cell, arranged in series, such that flotation tailings (FT) can be introduced into the thickener, formed into thickened tailings, and introduced into the deposition cell; b) introducing fluid fine tailings (FFT) downstream of the thickener as a bypass; and c) settling out at least a portion of the FFT in the deposition cell.

[0056] The fourth method may further comprise introducing flotation tailings (FT) into the thickener, forming thickened tailings in the thickener, and introducing the thickened tailings into the deposition cell. The FFT may be introduced into the thickener. A gravity distributor (GD) may be provided upstream of the thickener for receiving FT or FFT prior to passing to the thickener. FT may be introduced into the GD. FFT may be introduced into the GD.

[0057] A fifth method may comprise: a) providing a thickener, an underflow pipeline, and a deposition cell, arranged in series, such that flotation tailings (FT) can be introduced into the thickener, formed into thickened tailings, and introduced into the deposition cell; b) introducing fluid fine tailings (FFT) into the thickener; c) sending thickened tailings from the thickener to the deposition cell; and d) settling out at least a portion of the FFT in the deposition cell.

[0058] The fifth method may further comprise introducing FFT downstream of the thickener as a bypass. The fifth method may further comprise introducing FT into the thickener, forming thickened tailings in the thickener, and introducing the thickened tailings into the deposition cell. The fifth method may further comprise providing a gravity distributor (GD) upstream of the thickener for receiving FT or FFT prior to passing to the thickener. FT may be introduced into the GD. FFT may be introduced into the GD.

[0059] In any of the methods described herein, the following features may be present. A chemical may be added between the thickener and the deposition cell for assisting fines capture. The chemical may comprise a flocculent. The flocculent may comprise a polyacrylamide based flocculent. The flocculent may be anionic. The flocculent may have a molecular weight of 6,000,000 g/mol or less, or 400,000 g/mol or less, or between 5,000 g/mol and 6,000,000 g/mol, or between 5,000 and 400,000 g/mol, or between 50,000 and 400,000 g/mol, or between 100,000 and 400,000 g/mol.

[0060] A mix box may be provided between the thickener and the deposition cell.

[0061] The FT may be any suitable FT and may stem from a flotation cell, the feed of which may be derived from middlings from a primary separation vessel (PSV) of aqueous-based bitumen extraction of oil sand ore. The FT may comprise water, fines, sand, and residual bitumen, and may have 11-40 weight % solids. The FFT may be any suitable FFT and may have a sand to fines ratio (SFR) of 0.1 to 1, on a mass basis. The deposition cell may be a common deposition cell for depositing the TT along with the FFT added downstream of the thickener.

[0062] The gravity distributor may be any suitable gravity distributor which can combine and mix the feed, and distribute the feed to one or more thickeners through gravity outlet lines, or to any other mixing tank or pump box to provide stream mixing and feed thickening.

[0063] The thickener may be any suitable thickener or any suitable gravity sedimentation tank to separate solids from a liquid, where a polymer or flocculant can be added to bind the fines to accelerate their settling rate and increase the viscosity/density of a slurry without substantially changing its other properties.

[0064] The deposition cell may be any suitable deposition area suitable for storing treated tailings, including but not limited to thickened tailings, flocculated fluid fine tailings or both.

[0065] "Settling out" means separation of a slurry into two or more components, where one component is predominantly a fluid and the other is predominantly a solid, gel, or fluid. The first fluid typically will comprise water and solids, where the solids are less than 5 wt.% of the slurry. The second fluid is characterized by a different physical parameter than the first fluid, such as a higher density, an increased yield stress, and/or a higher concentration of solid particles. The two fluids may be flowing, and may be flowing at different rates. The second fluid may flow slower than the first fluid. Settling out in this context has similarities to the lab practice of decanting.

[0066] The FFT may be added to the thickener underflow in the mix box or other junction downstream of the thickener, such as in a deposition pump or pipeline. FFT may be introduced in the GD. The FFT would have to move through the thickener without significant thickening, which is counter to conventional wisdom for a thickener operation. However, it may be advantageous to be able to operate in this mode because it enables an immediate switch to FFT flocculation from FT/FFT feed during a short period of downtime. The thickener may be receiving flocculent to separate water from the incoming feed or it may not be receiving any chemical, and may be acting as a large flow-through device.

Oil Sand Thickener Shear Loop

[0067] In some thickeners, underflow can become overly consolidated, overly strong, or overly coarse. The resultant thickener underflow may develop a rheology or high yield stress that can cause it to be challenging to pump. One way to mitigate this risk is to introduce a continuous recirculation to the thickener. A portion of the underflow of the thickener may be recycled to the vessel, for instance to the bed of the thickener. The pumping of the slurry also has the effect of shearing of the fluid, thereby reducing its yield stress through shear thinning. As many thickeners also include a chemical addition to create flocs, the shearing may also reduce the size of the flocs to both change the fluid properties and the dewatering properties. The shear loop also keeps fluid moving even if the rate of discharge of the underflow is low. Keeping the fluid moving helps inhibit the development of yield stress, gelation, and "sanding out," which can cause downtime.

[0068] A method may comprise:

a) introducing oil sand tailings into a thickener; and

b) effecting a shear loop comprising removing thickened tailings (TT) from the thickener, combining at least a portion of the TT with fluid fine tailings (FFT) to form a recycle stream, and recycling the recycle stream back into the thickener.

[0069] Water may be introduced into the shear loop. FFT introduction, water introduction, and TT removal may be adjusted for use in the shear loop, for controlling thickener flow rate, thickener solids flow rate, or thickener fines flowrate. FFT introduction and the water introduction may be adjusted in the shear loop to respond to changes in the thickener to maintain a TT with a solids rate, density, or flow rate, for instance within 10% of target values.

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[0070] Since shear loops are not flocculated, introducing a fines source to a thickener that bypasses the chemical treatment step defies conventional thinking. Fines addition in the form of FFT in the shear loop may improve control of the underflow fines content independent of the underflow flowrate or solids content, which may be further controlled by water addition to the thickener underflow or shear loop.

Controlled Oil Sand Tailings Deposition

[0071] Presently, TT and FFT are deposited in separate deposition cells. There are many perceived benefits to doing so, such as that FFT and TT have different dewatering rates, and FFT would be perceived to shut down the dewaterability of an otherwise "healthy" TT deposit (that is, a TT deposit with good dewatering characteristics). These benefits are precisely the reason why those well-versed in the art would not contemplate placing the FFT and the TT in the same deposition cell. However, the experiments described below with reference to Figs. 4 and 5 show that FFT and TT may be deposited in the same deposition cell, thereby overturning the conventional thinking. Flocculated FFT placed into a TT cell periodically results in a heterogeneous deposit. The management of that heterogeneous deposit boils down to managing three risks: the thickness of the various layers, the strength of the layers, and the density. Strength and density can be modified by chemical additives and time, that is, layers may be placed and allowed to set and gain strength, dewater, solidify, and gain density, until they are a competent layer for a subsequent lift of a different material to be placed atop. This management strategy requires tuning of timing between layers and potentially additives such as chemicals, water, or other materials (e.g., FFT or other tailings streams). As an example, the management may take the form of bringing the TT back online slower than usual to enable the deposit to accept lower density and/or lower flowrate before placing a full TT stream atop the FFT layer. The reason that FFT and TT may be placed in the same cell goes to the key parameters that drive the dewatering of a cell. Typical reasoning compares diverse materials at the same void ratio. FFT and TT at the same void ratio have very different (e.g., two orders of magnitude different) dewatering rates – as per Fig. 4A. However, FFT and TT should be compared in the same cell at the same stress state, not the same void ratio. This phenomena and analysis will be discussed further herein in reference to Figs. 4A through 4F.

[0072] Figs. 4A and 4B depict typical geotechnical properties for two fines dominated tailings. TT is Thickened Tailings with a Sand to Fines Ratio (SFR) here of about 1.0. FFT refers to Fluid Fine Tailings and comprise mostly fines and clays with an SFR close to 0. In this example, both tailings types have received a similar chemical treatment such as an anionic polyacrylamide flocculant common to tailings processing. To those versed in the art, the charts in Fig 4B is typically interpreted as indicating that FFT has a much lower hydraulic conductivity than TT at the same void ratio. As an example, in Figure 4B, at the void ratio = 1.0 (indicated by the line 401), FFT has a hydraulic conductivity between 1.0E-10 and 1.0E-09, whereas the TT has a hydraulic conductivity at the same void ratio of 1.0 between 1.0E-08 and 1.0E-07, which is two orders of magnitude difference. Such a large difference in hydraulic conductivity is interpreted as impacting the dewatering, because at lower void ratios such as 1.4 and below, the dewatering is dominated by how fast water can move through the material, defined by the hydraulic conductivity. Two orders of magnitude thus represents a considerable impediment to dewatering. As a result, the common interpretation of these data is that adding FFT to a TT deposit would introduce a layer with much lower hydraulic conductivity than the TT alone. This would result in an essentially impenetrable layer, thus prohibiting TT from dewatering if the path for water to migrate out of the deposit must traverse through FFT. Furthermore, to even achieve a given void ratio, such as 1.0, the FFT must be subjected to considerably higher stresses. As depicted in Fig. 4A, FFT reaches a void ratio of 1.0 at an effective stress of about 1.0, whereas TT reaches the same void ratio at an effective stress between 1 and 10. Combining both interpretations leads to the prevailing opinion that FFT would contaminate an otherwise more rapidly dewatering TT deposit. This analysis is dependent on comparing the curves in Figs. 4A and 4B with respect to the same void ratio, which is the common axis to the charts in both figures.

[0073] Figures 4C and 4D depict an analysis of the same data as shown and described in Figs. 4A and 4B, but instead, in accordance with the discoveries herein, focus instead on a common effective stress state (instead of a common void ratio state). The effective stress is induced by the load on top of the material, which could be more tailings or it could be a cap (e.g., sand) that presses down on the tailings, causing stress. This approach is taken because, when these two materials are buried in the same deposit, at an interface between the two materials at equilibrium, the effective stress should be about the same in each material on both sides of that interface. By contrast, void ratio and density may be different. A common stress state line (405) is shown for these two materials at a little lower than 100 kPa effective stress in Fig. 4C. At this common effective stress state, the two materials have different void ratios, with the FFT at about 1.2 void ratio and the TT at about 0.7 void ratio. If these corresponding void ratios are identified in the Fig. 4D, they occur at hydraulic conductivities that are about half an order of magnitude apart as indicated by the line (410) corresponding to the corresponding hydraulic conductivity of the FFT and by line (415) corresponding to the corresponding hydraulic conductivity of the TT, both falling close to 1.0E-09. This means that at the same effective stress state, the two materials actually have a very similar hydraulic conductivity (half an order of magnitude is not widely dissimilar in this type of analysis, whereas 2 orders of magnitude is a much bigger difference). Since the hydraulic conductivity dominates how fast water migrates through the deposit, and since the hydraulic conductivities are much closer at the same effective stress state, this analysis reveals that both tailings types can be placed in the same deposit and the overall deposit can continue to pass water through at similar rates. This allows for dewatering and overturns the interpretation in the previous paragraph that FFT would contaminate a TT deposit by introducing an effectively impenetrable barrier. However, the two materials will not achieve the same void ratio or density; the TT will be a denser material than the FFT at the same effective stress state. This interpretation is supported by the observation that the materials may take time to reach an equilibrium state, but during that time while they are equilibrating, the materials will have a higher hydraulic conductivity than is shown here, and should thus transport water through the deposit even better than indicated by these charts. It is herein interpreted and believed that this convergence as a function of the clay and fines concentrations in the water. Both materials have similar clay and fines contents, but the TT has more sand. The sand contributes to density (and therefore affects void ratio) but does not impact hydraulic conductivity, which is a function of the fines concentration.

[0074] Figures 4E and 4F introduce a new material to the analysis discussed in references to Figs. 4A-4D. These figures compare the TT and FFT from Figures 4A, 4B, 4C, and 4D to the mixture of FFT and TT ("FFT + TT Mix" in Figs. 4E and 4F). The mixture represents a new tailings made by mixing the same quantities of FFT and TT as would otherwise have comprised the layered deposit. This mixed material has new curves for compressibility and hydraulic conductivity, identified as FFT + TT Mix. Predictably, the new homogenized tailings have properties that are between the individual constituent properties. That is, the new FFT + TT Mix curve sits between the curves from Figs. 4A and 4B. Interestingly and surprisingly, this mixed material also has almost the same properties as the layered, heterogeneous deposits. Models and experimental data substantiate this relationship and are depicted in the subsequent plots. As an example, at the same effective stress state identified for the TT and FFT, as shown by line (405), the new mixed material has a void ratio of about 0.83. At this void ratio, the hydraulic conductivity of the new material is a little bit higher than 1.0E-09, as shown by line (420), which is shown with respect to the line (410) corresponding to the corresponding hydraulic conductivity of the FFT (as was shown in Fig. 4D), and line (415) corresponding to the corresponding hydraulic conductivity of the TT (as was shown in Fig. 4D). Plotting a tie-line (425) between the TT and FFT at the same stress state on Figure 4F (long dashed oblique line) results in the same void ratio and same hydraulic conductivity as the mixture.

[0075] In fact, FFT and TT at the same stress state are at different void ratios, but quite similar hydraulic conductivities (e.g., within one half an order of magnitude, as per Fig. 4B). Figs. 4A and 4B are conventional oil sands geotechnical data on two different materials: a FFT with an SFR around 0.3, and a TT with an SFR between 1 and 2. Both tailings samples were flocculated according to normal processes. When read together at the same stress state, Figs. 4A and 4B show a much closer behavior in terms of hydraulic conductivity than would be interpreted by comparing the materials at the same solids content.

[0076] Figs. 5 and 6 illustrate modelling data produced using a consolidation modeling software with generic materials properties based on industry TT and FFT sample data available in the literature. The software was set up to evaluate the overall deposit performance given differing layered deposition schemes. Fig. 5 depicts a layered depositional scheme. Solids content is shown along the X axis. Depth is shown along the Y axis. Layers of FFT have lower solids content than layers of TT (30% for FFT, 45% for FFT, for example). As a result, the solids content makes discrete jumps for each layer. The left-most edge of the curve maps the solids content for the FFT layers. The right-most edge of the curve maps the solids content for the TT layers. Continuity along the edges reveals communication through the layer. Thus, the fact that the layers appear to dewater consistently instead of with a discrete break in behavior reveals that consolidation in this scheme is more feasible than would otherwise have been anticipated from a first principles study of Figs. 4A and 4B only.

[0077] Fig. 6 is similar to Fig. 5 (same starting materials properties, still a layered scheme), but the thickness of the layers is different. Despite the difference, the deposit consolidates similarly to the results in Fig. 5. This reveals a convergent behavior. Further analysis indicated that the overall deposit behaves like a mixture of the materials properties.

[0078] In Figs. 5 and 6, the series of zig-zags represent the different solids contents of each layer. There are several key observations from this model. With time, the curves shift from lower solids to higher solids throughout the deposit. The substantial increase in solids content throughout the deposit is counter to the prevailing view held by most in the art that a high fines layer will form a low permeable barrier preventing dewatering from the underlying layers. In fact, dewatering occurs in all layers relatively uniformly. There are discontinuities represented by the zig-zag, but there is also a continuity in both the lower bound and upper bound of these zigs and zags. This continuity is manifest by the curvature in the leftmost and rightmost sections of the lines and how that curvature is maintained despite each zig or zag in the data. That is to say, a zig-zag representing layers doesn't result in the subsequent zig-zag being at a much lower solids content than the nearest layer. Rather, one can imagine that if the layers were split out into an FFT only stack, it would have a continuous solids distribution throughout, as would a similar hypothetical stack of TT-only layers.

[0079] Another observation is that the number of layers does not have a significant effect. Fig. 5 depicts the model being run for twice as many thinner layers compared to as modeled in Fig. 6. If hydraulic conductivity shut down as a result of the layers, this structure should dewater worse than the first image. But in fact, comparing the modeling results of Figs. 5 and 6, the dewatering characteristics of both layering configurations behave about the same.

[0080] Fig. 7 represents lab data from an experimental campaign. In this effort, thickened tailings were made from flotation tailings only or a mixture of flotation tailings and FFT. The amount of solids derived from FT sources is indicated by the number as a percent of total solids. For example, TT75 refers to a mixture of TT derived from 75% flotation tailings, 25% FFT. TT50 refers to a mixture of TT derived from 50% flotation tailings, 50% FFT. TT100 refers to a TT that is 100% flotation tailings. The introduction of FFT in various amounts allows for a controlled increase in the fines / clays content of the resultant TT.

[0081] Fig. 7 shows the results of dewatering a 1L sample in a Buchner funnel over a 7 day period. The results indicate that layers, indicated by multiple numbers, such as TT(50/100) which refers to a layer of TT with 50% of its solids derived from FFT and 50% of its solids derived from flotation tailings on top of a layer of TT with 100% of its solids derived from flotation tailings only, dewater similarly to each other irrespective of the configuration, and furthermore, dewater similarly to a homogenized sample, such as TT75.

[0082] Fig. 8 depicts the final solids content of a 1L sample placed in a Buchner funnel after a 7 day period for a homogenized mixture (Homo TT) as well as layered configurations of the constituent components. The data plot along a single curve, revealing that the consolidation behavior can be interpreted as an average of the materials properties. This is in contrast to prevailing wisdom. Most practitioners intuit that a fines-dominated layer such as TT(50/100), comprising a high fraction of clays and fines, will determine the overall dewatering of the deposit, and for high fines containing layers, can effectively shut down dewatering altogether. This wisdom pushes operators toward careful and costly stewardship of fines layers. In contrast to the prevailing wisdom, these results indicate that the overall deposit continues to dewater – not as the worst layer, but as the average of the layers.

[0083] Fig. 9 depicts the strength and solids content profiles for the layered deposits described in Figs. 7 and 8. Fig. 9 indicates that the solids content-strength relationship for the layered deposits (colorful points) is more similar to the homogenized / mixed material behavior (open circles) than to either of the constituent materials by themselves (plus sign data on left and right trend lines).

[0084] TT (SFR 0.75 -3.5) and pure FFT (SFR 0 – 0.3) have very different geotechnical properties. The co-deposit of the two distinct layers subjected to identical self-weighted stress and dewatered to corresponding (but different) void ratios, converge to similar hydraulic conductivities (HC). The co-deposit had average HC falling in between TT and FFT, weighted by their respective thickness.

[0085] Therefore, FFT may be placed in the same cell as TT. FFT and TT may be comingled in the same deposition cell. Alternatively, TT may be allowed to segregate while still meeting Key Performance Indicators provided that the segregation does not result in a coarse-dominated stream (e.g., SFR>3.5). In another embodiment, dissimilar tailings materials that are all fines dominated may be placed together in a common deposition cell.

[0086] A method of controlled deposition for increasing deposition rate may comprise:

a) providing a first fines dominated stream having a first sand to fines ratio (SFR) of less than 0.6 and having first solids content;

b) providing a second fines dominated stream having a second SFR of between 0.6 and 3.0 (or between 0.6 and 2.5) and second solids content; wherein the first solids content and the second solids content differ by at least 5%, by mass; and

c) depositing the first and second dominated streams into a common deposition cell.

[0087] The first solids content and the second solids content may differ by at least 10%, by mass. The first solids content and the second solids content differ by at least 15%, by mass. The first solids content may be between 15 and 40%, by mass. The second solids content may be between 35 and 50%, by mass. The first SFR may be less than 0.5 and wherein the second SFR may be greater than 1.5.

[0088] The first fines dominated stream may comprise fluid fine tailings (FFT) and the second fines dominated stream may comprise thickened tailings (TT).

[0089] Step c) may comprise depositing layers of either the first or second fines dominated stream, and allowing each layer to rigidify prior to depositing a subsequent layer of either the first or second dominated stream.

[0090] Step c) may comprise depositing alternating layers of the first and second fines dominated streams, and allowing each layer to rigidify prior to depositing a subsequent layer.

[0091] The first and second fines dominated streams may be deposited using a common pipe.

[0092] Treated FFT may be deposited to panels next to polymer treated thickened tailings, a dedicated area in an external tailings area, or in the same cell as the thickened tailings. Treated FFT may be placed either in the same cell as the TT is placed, or in a separate area. If it is placed in a separate area, that area could be situated close to the TT deposition area, or it could be separated by a barrier such as an earthen structure.

[0093] FFT may be introduced either into the existing thickener system or downstream of the thickener as a bypass to the thickener. If the FFT is introduced into the thickener system, it may be introduced as feed to the thickener, into the shear loop, or into the underflow of the thickener. If it bypasses the thickener, the FFT may be introduced downstream of the thickener and its related units.

[0094] <u>Embodiments Group A</u>

1. A method comprising:
    a) providing a thickener, an underflow pipeline, and a deposition cell, arranged in series, such that flotation tailings (FT) can be introduced into the thickener, formed into thickened tailings, and introduced into the deposition cell;
    b) introducing fluid fine tailings (FFT) downstream of the thickener as a bypass; and
    c) settling out at least a portion of the FFT in the deposition cell.
2. The method of embodiment 1, further comprising introducing the flotation tailings (FT) into the thickener, forming the thickened tailings in the thickener, and introducing the thickened tailings into the deposition cell.
3. The method of embodiment 2, further comprising introducing additional FFT into the thickener.
4. The method of any one of embodiments 1 to 3, further comprising providing a gravity distributor (GD) upstream of the thickener for receiving the FT or the FFT prior to passing to the thickener.
5. The method of embodiment 4, further comprising introducing the FT into the GD.
6. The method of embodiment 4 or 5, further comprising introducing the FFT into the GD.
7. A method comprising:
    a) providing a thickener, an underflow pipeline, and a deposition cell, arranged in series, such that flotation tailings (FT) can be introduced into the thickener, formed into thickened tailings, and introduced into the deposition cell;
    b) introducing fluid fine tailings (FFT) into the thickener;
    c) sending thickened tailings from the thickener to the deposition cell; and
    d) settling out at least a portion of the FFT in the deposition cell.

8. The method of embodiment 6, further comprising introducing additional FFT downstream of the thickener as a bypass.

9. The method of embodiment 6 or 7, further comprising introducing the FT into the thickener, forming the thickened tailings in the thickener, and introducing the thickened tailings into the deposition cell.

10. The method of any one of embodiments 6 to 8, further comprising providing a gravity distributor (GD) upstream of the thickener for receiving the FT or the FFT prior to passing to the thickener.

11. The method of embodiment 9, further comprising introducing the FT into the GD.

12. The method of embodiment 9 or 10, further comprising introducing the FFT into the GD.

13. The method of any one of embodiments 1 to 12, further comprising adding a chemical between the thickener and the deposition cell for assisting fines capture.

14. The method of embodiment 13, wherein the chemical comprises a flocculent.

15. The method of embodiment 14, wherein the flocculent comprises a polyacrylamide based flocculent.

16. The method of embodiment 14, wherein the flocculent is anionic.

17. The method of embodiment 14, wherein the flocculent has a molecular weight of between 5,000 and 6,000,000 g/mol.

18. The method of any one of embodiments 1 to 17, wherein the FT derives from a flotation cell, the feed of which is derived from middlings from a primary separation vessel (PSV) of aqueous-based bitumen extraction of oil sand ore.

19. The method of any one of embodiments 1 to 18, wherein the FT comprises water, fines, sand, and residual bitumen, and has 5% -30 weight % solids.

20. The method of any one of embodiments 1 to 19, wherein the FFT derives from flotation tailings, coarse sand tailings, froth tailings, or a combination thereof.

21. The method of any one of embodiments 1 to 20, wherein the FFT comprises water, fines, sand, and residual bitumen, and has 10-40 weight % solids.

22. The method of any one of embodiments 1 to 21, wherein the FFT has a sand to fines ratio (SFR) of 0.1 to 1, on a mass basis.

23. The method of any one of embodiments 1 to 22, further comprising providing a mix box between the thickener and the deposition cell.

24. The method of any one of embodiments 1 to 22, further comprising effecting a shear loop comprising removing the thickened tailings (TT) from the thickener, combining at least a portion of the TT with added fluid fine tailings (FFT) to form a recycle stream, and recycling the recycle stream back into the thickener.

25. The method of embodiment 24, further comprising introducing water into the shear loop.

26. The method of embodiment 25, further comprising adjusting introduction of the added FFT, introduction of the water, and removal of the TT for use in the shear loop, for controlling thickener flow rate, thickener solids flow rate, or thickener fines flowrate.

27. The method of embodiment 25, further comprising adjusting introduction of the added FFT and introduction of the water in the shear loop to respond to changes in the thickener to maintain a solids rate of the TT, a density of the TT, or a flow rate of the TT, within 10% of target values.

28. The method of any one of embodiments 1 to 27, further comprising a method of controlling deposition to the deposition cell for increasing deposition rate, the method of controlling deposition comprising:

a) providing a first fines dominated stream having a first sand to fines ratio (SFR) of less than 0.6 and having first solids content;

b) providing a second fines dominated stream having a second SFR of between 0.6 and 3.0 and having a second solids content; wherein the first solids content and the second solids content differ by at least 5%, by mass; and

c) depositing the first and second dominated streams into a common deposition cell.

29. The method of embodiment 28, wherein the first solids content and the second solids content differ by at least 10%, by mass.

30. The method of embodiment 28, wherein the first solids content and the second solids content differ by at least 15%, by mass.

31. The method of embodiment 28, wherein the first solids content is between 15 and 40%, by mass.

32. The method of any one of embodiments 28 to 31, wherein the second solids content is between 35 and 50%, by mass.

33. The method of any one of embodiments 28 to 32, wherein the first SFR is less than 0.5 and wherein the second SFR is greater than 1.5.

34. The method of any one of embodiments 28 to 33, wherein the first fines dominated stream comprises fluid fine tailings (FFT) and wherein the second fines dominated stream comprises thickened tailings (TT).

35. The method of any one of embodiments 28 to 34, wherein step c) comprises depositing layers of either the first or the second fines dominated stream, and allowing each layer to rigidify prior to depositing a subsequent layer of either the first or the second dominated stream.

36. The method of any one of embodiments 28 to 34, wherein step c) comprises depositing alternating layers of the first and the second fines dominated streams, and allowing each layer to rigidify prior to depositing a subsequent layer.

37. The method of any one of embodiments 28 to 34, wherein the first and the second fines dominated streams are deposited using a common pipe.

38. The method of any one of embodiments 28 to 34, wherein the first dominated streams is deposited using a first pipe, and wherein the second fines dominated stream is deposited using a second pipe.

[0095] <u>Embodiments Group B</u>

1. A method comprising:
   a) introducing oil sand tailings into a thickener; and
   b) effecting a shear loop comprising removing thickened tailings (TT) from the thickener, combining at least a portion of the TT with fluid fine tailings (FFT) to form a recycle stream, and recycling the recycle stream back into the thickener.

2. The method of embodiment 1, further comprising introducing water into the shear loop.

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3. The method of embodiment 2, further comprising adjusting introduction of the FFT, introduction of the water, and removal of the TT for use in the shear loop, for controlling a thickener flow rate, a thickener solids flow rate, or a thickener fines flowrate.

4. The method of embodiment 1, further comprising adjusting introduction of the FFT for controlling a thickener flow rate, a thickener solids flow rate, or a thickener fines flowrate.

5. The method of embodiment 2, further comprising adjusting introduction of the water for controlling a thickener flow rate, a thickener solids flow rate, or a thickener fines flowrate.

6. The method of embodiment 2, further comprising adjusting removal of the TT for use in the shear loop, for controlling a thickener flow rate, a thickener solids flow rate, or a thickener fines flowrate.

7. The method of embodiment 2, further comprising adjusting introduction of the FFT, introduction of the water, and removal of the TT for use in the shear loop, for controlling a thickener flow rate.

8. The method of embodiment 2, further comprising adjusting introduction of the FFT, introduction of the water, and removal of the TT for use in the shear loop, for controlling a thickener solids flow rate.

9. The method of embodiment 2, further comprising adjusting introduction FFT, introduction of the water, and removal of the TT for use in the shear loop, for controlling a thickener fines flowrate.

10. The method of embodiment 2, further comprising adjusting introduction of the FFT and introduction of the water in the shear loop to respond to changes in the thickener to maintain a solids rate of the TT, a density of the TT, or a flow rate of the TT, within 10% of target values.

11. The method of embodiment 2, further comprising adjusting introduction of the FFT and introduction of the water in the shear loop to respond to changes in the thickener to maintain a solids rate of the TT, a density of the TT, or a flow rate of the TT, within 5% of target values.

12. The method of any one of embodiments 1 to 11, wherein the shear loop is operated to reduce consolidation, strength, or coarseness of the thickened tailings.

13. The method of any one of embodiments 1 to 12, wherein the recycle stream is recycled to a bed of thickener.

14. The method of any one of embodiments 1 to 12, wherein the recycle stream is pumped to shear the slurry.

[0096] Embodiments Group C

1. A method of controlled deposition for increasing deposition rate, the method comprising:

   a) providing a first fines dominated stream having a first sand to fines ratio (SFR) of less than 0.6 and having first solids content;

   b) providing a second fines dominated stream having a second SFR of between 0.6 and 3.0 and having a second solids content; wherein the first solids content and the second solids content differ by at least 5%, by mass; and

   c) depositing the first and second dominated streams into a common deposition cell.

2. The method of embodiment 1, wherein the first solids content and the second solids content differ by at least 10%, by mass.

3. The method of embodiment 1, wherein the first solids content and the second solids content differ by at least 15%, by mass.

4. The method of embodiment 1, wherein the first solids content is between 15 and 40%, by mass.

5. The method of any one of embodiments 1 to 4, wherein the second solids content is between 35 and 50%, by mass.

6. The method of any one of embodiments 1 to 5, wherein the first SFR is less than 0.5 and wherein the second SFR is greater than 1.5.

7. The method of any one of embodiments 1 to 6, wherein the first fines dominated stream comprises fluid fine tailings (FFT) and wherein the second fines dominated stream comprises thickened tailings (TT).

8. The method of any one of embodiments 1 to 7, wherein step c) comprises depositing layers of either the first or the second fines dominated stream, and allowing each layer to rigidify prior to depositing a subsequent layer of either the first or the second dominated stream.

9. The method of any one of embodiments 1 to 7, wherein step c) comprises depositing alternating layers of the first and the second fines dominated streams, and allowing each layer to rigidify prior to depositing a subsequent layer.

10. The method of any one of embodiments 1 to 9, wherein the first and the second fines dominated streams are deposited using a common pipe.

11. The method of any one of embodiments 1 to 10, wherein the first dominated streams is deposited using a first pipe, and wherein the second fines dominated stream is deposited using a second pipe.

12. The method of any one of embodiments 1 to 11, wherein the second SFR is between 0.6 and 2.5.

[0097] It should be understood that numerous changes, modifications, and alternatives to the preceding disclosure can be made without departing from the scope of the disclosure. The preceding description, therefore, is not meant to limit the scope of the disclosure. Rather, the scope of the disclosure is to be determined only by the appended claims and their equivalents. It is also contemplated that structures and features in the present examples can be altered, rearranged, substituted, deleted, duplicated, combined, or added to each other.

[0098] The scope of the claims should not be limited by particular embodiments set forth herein, but should be construed in a manner consistent with the specification as a whole.

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CLAIMS:

1. A method of controlled deposition for increasing deposition rate, the method comprising:

   a) providing a first fines dominated stream having a first sand to fines ratio (SFR) of less than 0.6 and having first solids content;

   b) providing a second fines dominated stream having a second SFR of between 0.6 and 3.0 and having a second solids content; wherein the first solids content and the second solids content differ by at least 5%, by mass; and

   c) depositing the first and second dominated streams into a common deposition cell.

2. The method of claim 1, wherein the first solids content and the second solids content differ by at least 10%, by mass.

3. The method of claim 1, wherein the first solids content and the second solids content differ by at least 15%, by mass.

4. The method of claim 1, wherein the first solids content is between 15 and 40%, by mass.

5. The method of any one of claims 1 to 4, wherein the second solids content is between 35 and 50%, by mass.

6. The method of any one of claims 1 to 5, wherein the first SFR is less than 0.5 and wherein the second SFR is greater than 1.5.

7. The method of any one of claims 1 to 6, wherein the first fines dominated stream comprises fluid fine tailings (FFT) and wherein the second fines dominated stream comprises thickened tailings (TT).

8. The method of any one of claims 1 to 7, wherein step c) comprises depositing layers of either the first or the second fines dominated stream, and allowing each layer to rigidify prior to depositing a subsequent layer of either the first or the second dominated stream.

9. The method of any one of claims 1 to 7, wherein step c) comprises depositing alternating layers of the first and the second fines dominated streams, and allowing each layer to rigidify prior to depositing a subsequent layer.

10. The method of any one of claims 1 to 9, wherein the first and the second fines dominated streams are deposited using a common pipe.

11. The method of any one of claims 1 to 10, wherein the first dominated streams is deposited using a first pipe, and wherein the second fines dominated stream is deposited using a second pipe.

12. The method of any one of claims 1 to 11, wherein the second SFR is between 0.6 and 2.5.

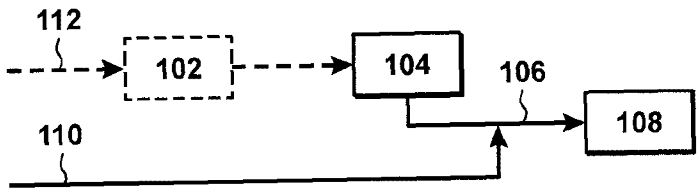


FIG. 1

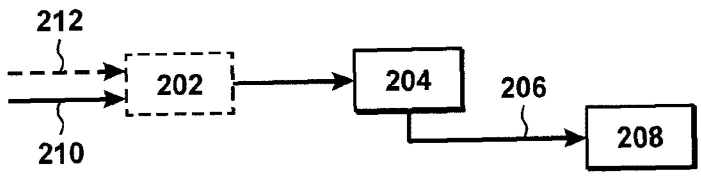


FIG. 2

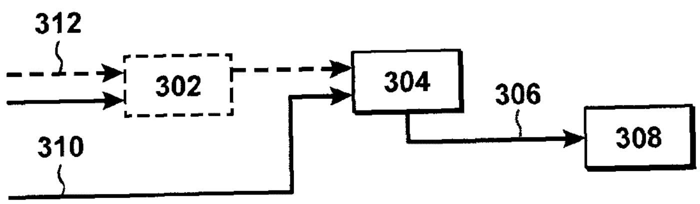


FIG. 3

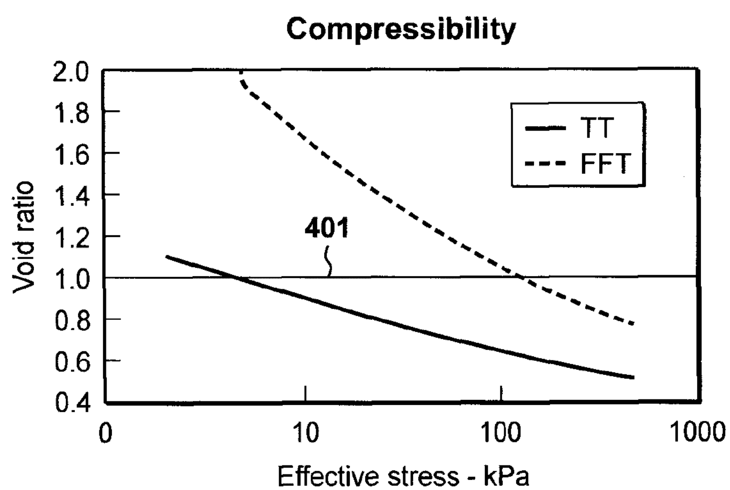

Compressibility
Void ratio
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
10
100
1000
Effective stress - kPa
TT
FFT
401

FIG. 4A

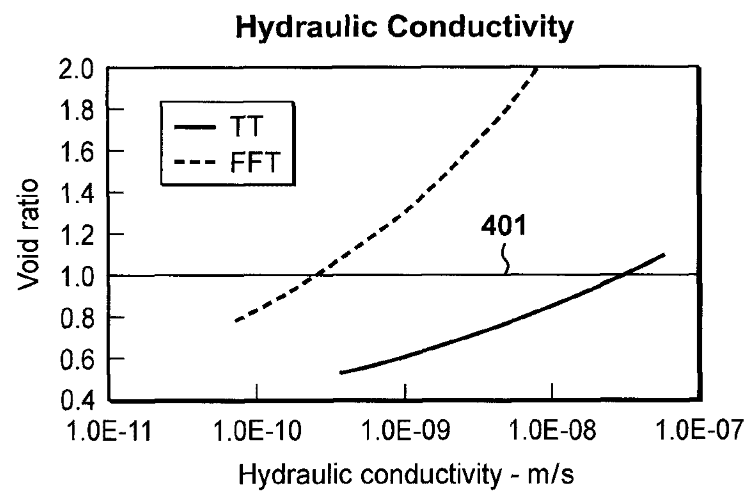

Hydraulic Conductivity
Void ratio
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
1.0E-11
1.0E-10
1.0E-09
1.0E-08
1.0E-07
Hydraulic conductivity - m/s
TT
FFT
401

FIG. 4B

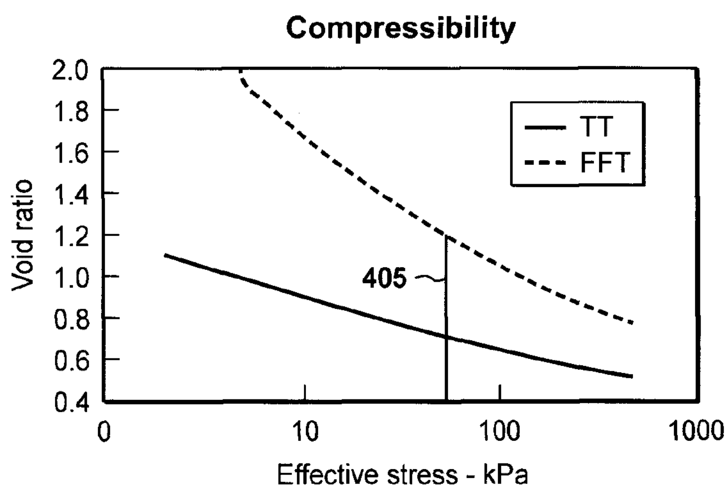

Compressibility
Void ratio
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
10
100
1000
Effective stress - kPa
TT
FFT
405

FIG. 4C

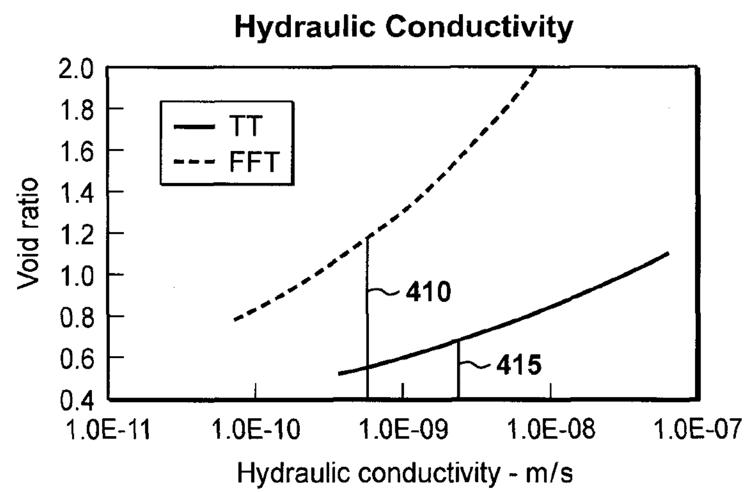

Hydraulic Conductivity
Void ratio
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
1.0E-11
1.0E-10
1.0E-09
1.0E-08
1.0E-07
Hydraulic conductivity - m/s
TT
FFT
410
415

FIG. 4D

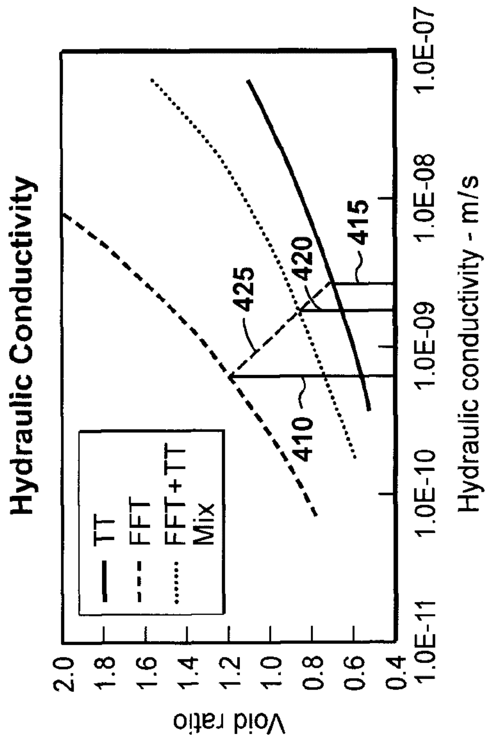

Hydraulic Conductivity
TT
FFT
FFT+TT Mix
Void ratio
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
1.0E-11
1.0E-10
1.0E-09
1.0E-08
1.0E-07
Hydraulic conductivity - m/s
410
425
420
415

FIG. 4F

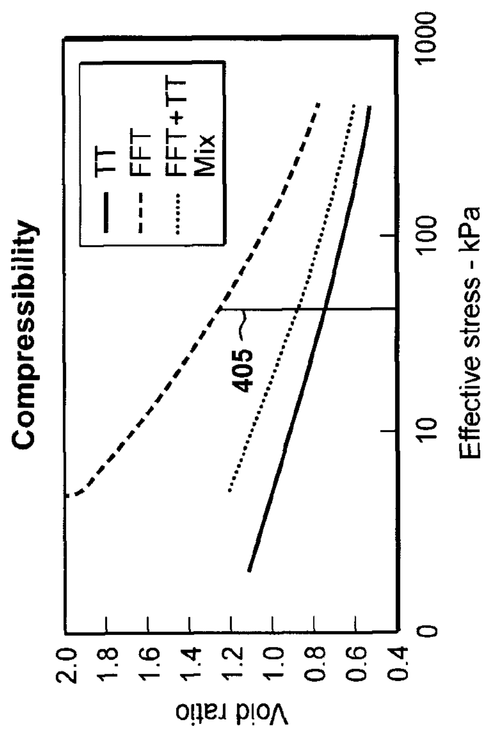

Compressibility
TT
FFT
FFT+TT Mix
Void ratio
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
10
100
1000
Effective stress - kPa
405

FIG. 4E

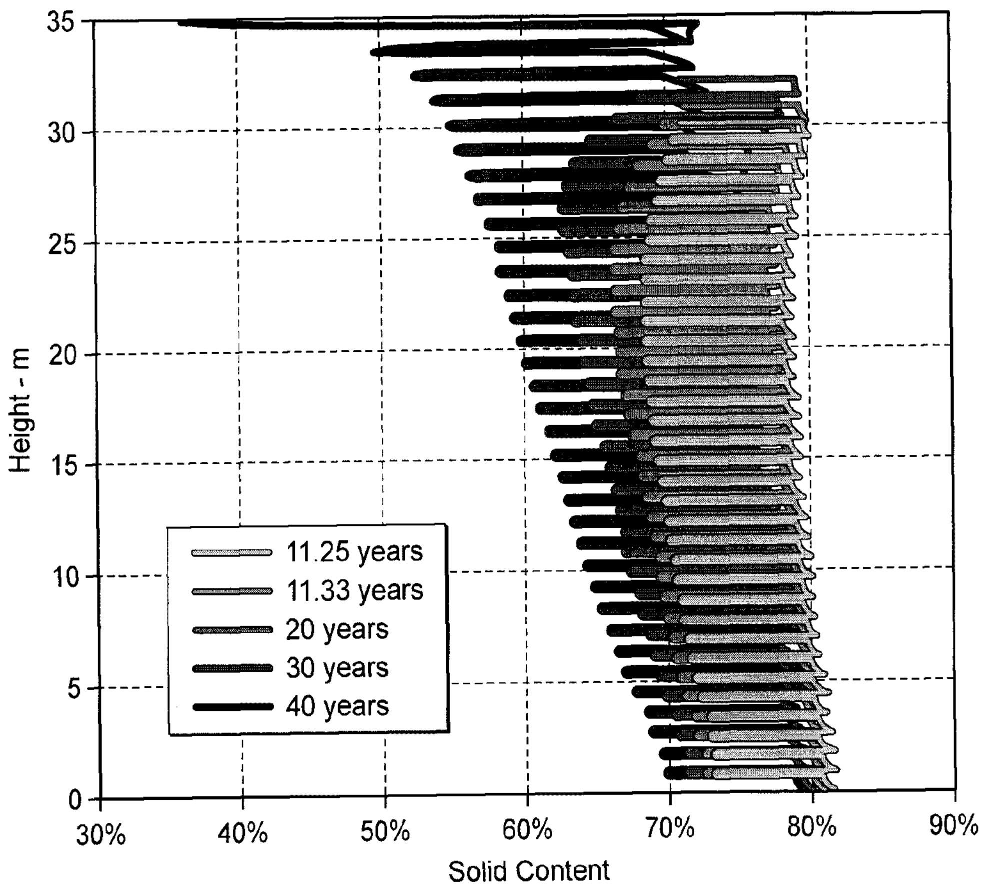

35
30
25
20
15
10
5
0
Height - m
30%
40%
50%
60%
70%
80%
90%
Solid Content
11.25 years
11.33 years
20 years
30 years
40 years

FIG. 5

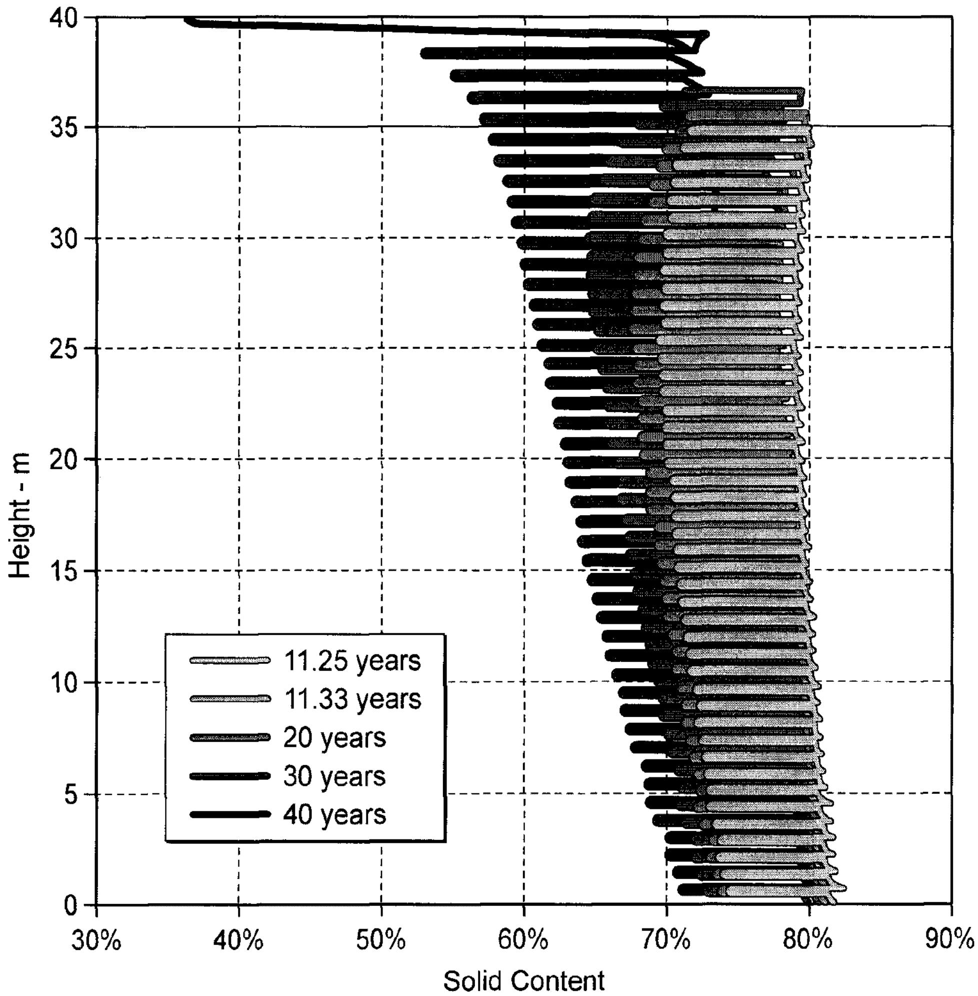
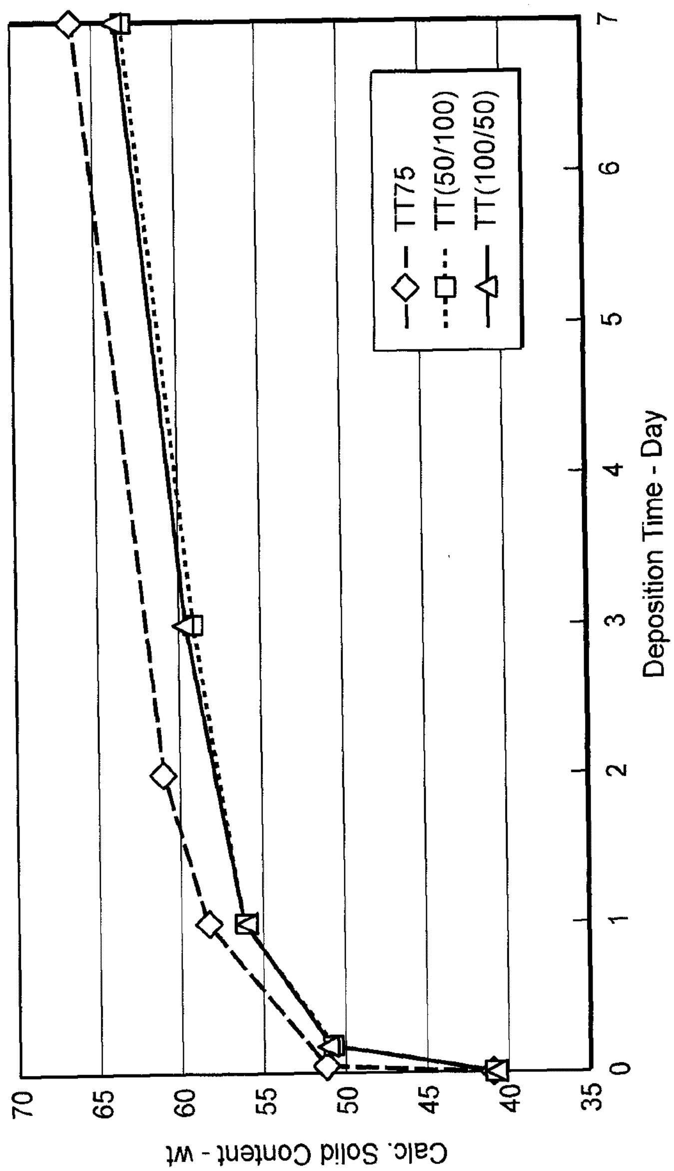
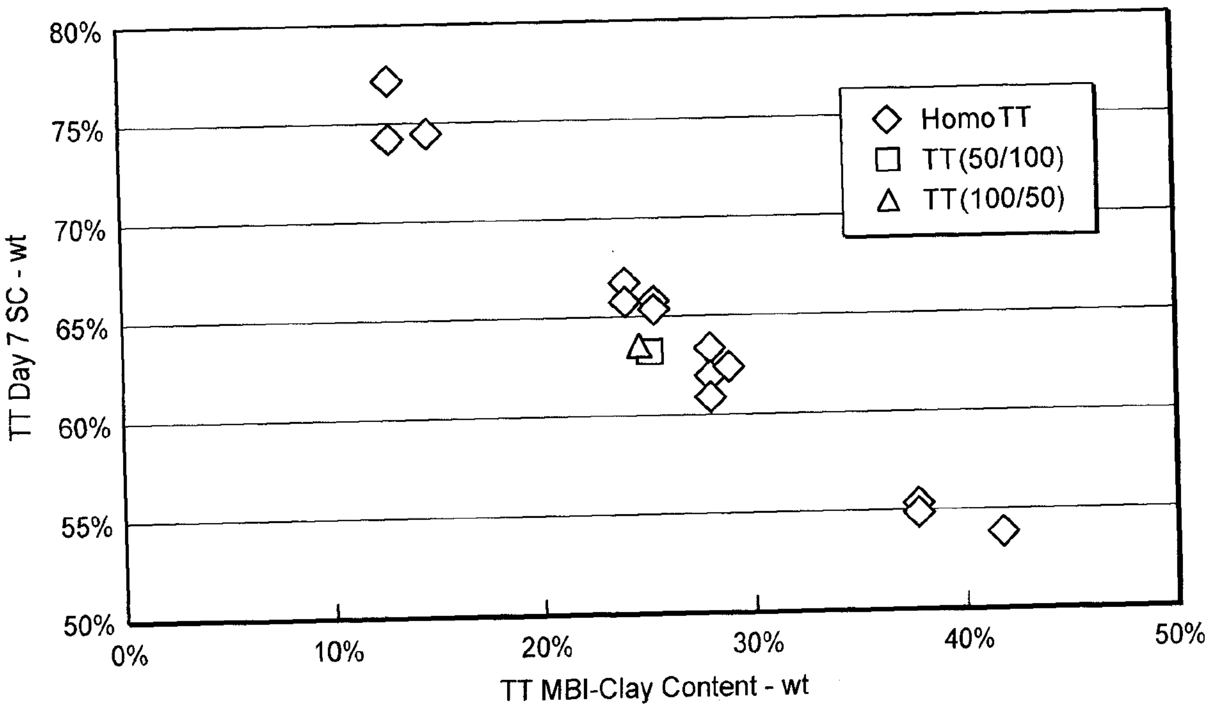

40
35
30
25
20
15
10
5
0
Height - m
30%
40%
50%
60%
70%
80%
90%
Solid Content
11.25 years
11.33 years
20 years
30 years
40 years

FIG. 6



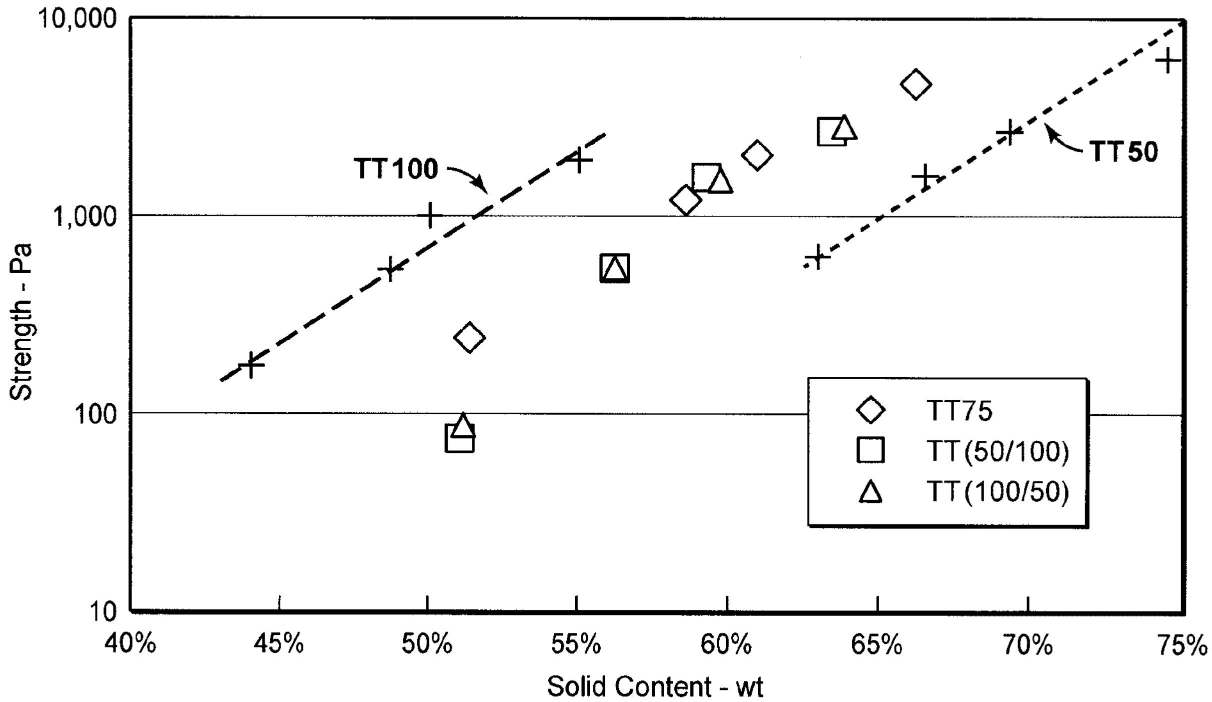
70
65
60
55
50
45
40
35
Calc. Solid Content - wt
0
1
2
3
4
5
6
7
Deposition Time - Day
TT75
TT(50/100)
TT(100/50)

FIG. 7



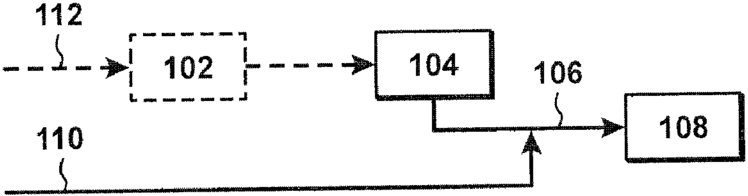
80%
75%
70%
65%
60%
55%
50%
TT Day 7 SC - wt
0%
10%
20%
30%
40%
50%
TT MBI-Clay Content - wt
HomoTT
TT(50/100)
TT(100/50)

FIG. 8



10,000
1,000
100
10
Strength - Pa
TT100
TT50
TT75
TT(50/100)
TT(100/50)
40%
45%
50%
55%
60%
65%
70%
75%
Solid Content - wt

FIG. 9


112
102
104
106
108
110