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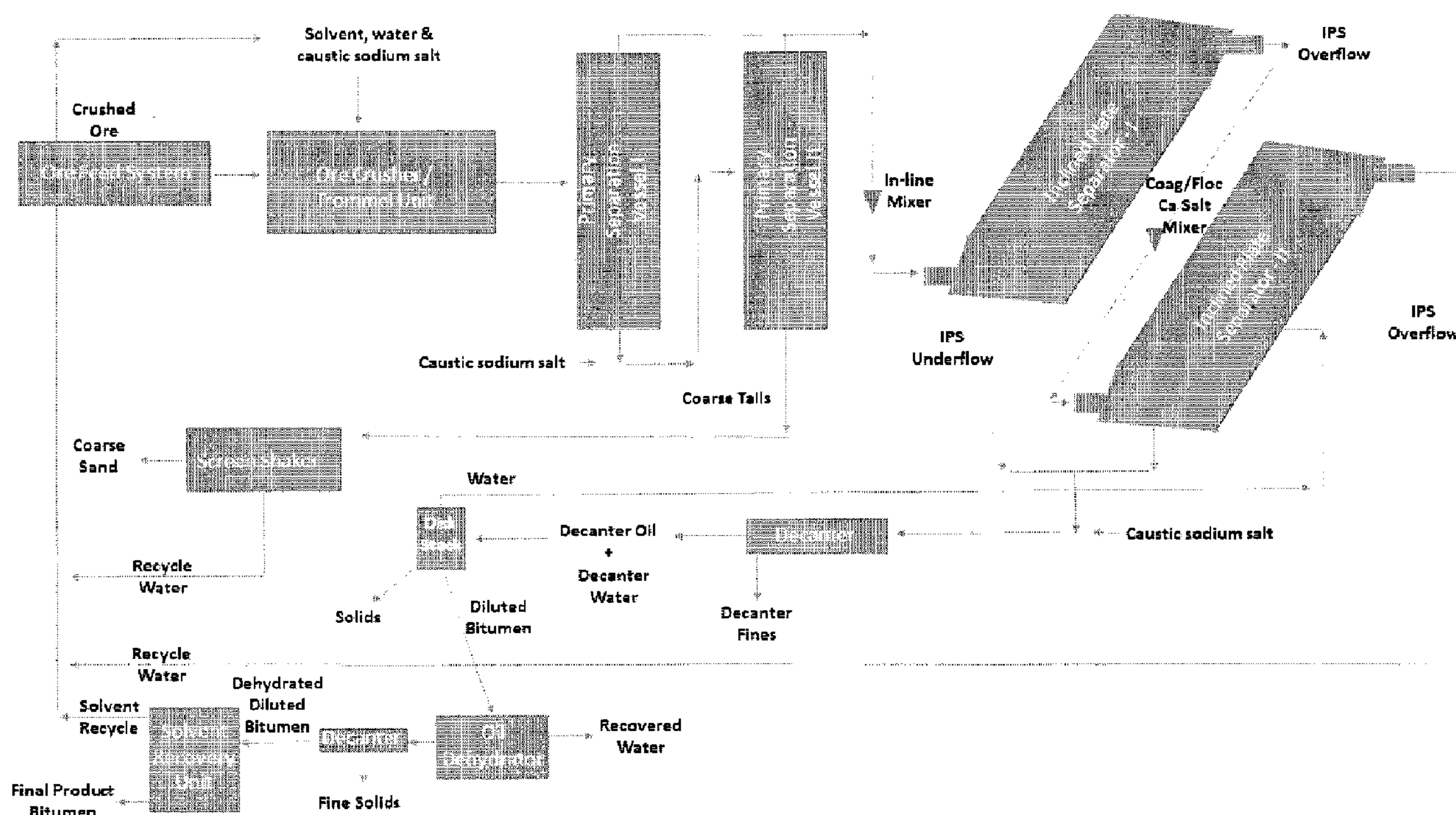
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(54) Titre : METHODE DE PRODUCTION DE BITUME DE QUALITE PIPELINE A PARTIR DES INSTALLATIONS
D~EXTRACTION ET D~EXPLOITATION DES SABLES BITUMINEUX

(54) Title: METHOD FOR PRODUCING PIPELINE SPECIFICATION BITUMEN FROM OIL SANDS MINING AND
EXTRACTION FACILITIES



(57) Abrégé/Abstract:

Pipeline quality bitumen containing less than 0.5 wt. % water and solids may be produced by conditioning oil sands ore in a water ~based bitumen extraction process by adding a solvent to the ore before or during a step of creating an aqueous slurry; and

(57) **Abrégé(suite)/Abstract(continued):**

agitating the slurry; separating the bitumen diluted with the solvent from water and coarse solids; thermally dehydrating the diluted bitumen at a temperature above about 100 C and below the boiling point of the solvent; separating any remaining fine solids and precipitates by gravitational separation; and recovering the solvent by distillation.

ABSTRACT

Pipeline quality bitumen containing less than 0.5 wt. % water and solids may be produced by conditioning oil sands ore in a water –based bitumen extraction process by adding a solvent to the ore before or during a step of creating an aqueous slurry; and agitating the slurry; separating the bitumen diluted with the solvent from water and coarse solids; thermally dehydrating the diluted bitumen at a temperature above about 100 C and below the boiling point of the solvent; separating any remaining fine solids and precipitates by gravitational separation; and recovering the solvent by distillation.

METHOD FOR PRODUCING PIPELINE SPECIFICATION BITUMEN FROM OIL SANDS MINING AND EXTRACTION FACILITIES

Field of the Invention

[0001] The invention relates to the treatment of the diluted bitumen produced in an oil sands bitumen extraction facility prior to solvent recovery, and particularly a method which produces pipeline specification bitumen without resorting to upgrading or carbon rejection at any time.

Background

[0002] Oil sands ore, known as bituminous sands, comprises a naturally occurring mixture of water, bitumen and a mineral phase comprising sand and clay. Oil sands ore may vary in quality and character from region to region, or deposit to deposit. Generally, Athabasca oil sands in Canada comprises water-wet sand grains, while Utah oil sands in the United States comprises oil-wet sand grains. The sand grains themselves may be of different composition. The mineral phase of Utah oil sands may be characterized by carbonate cementation, where upwards of 15 wt % of the mineral phase is calcite and dolomite.

[0003] Oil sand mining and extraction processes are used to liberate and separate bitumen from the water and mineral phases such that the bitumen can be further processed to produce market specification grade crude oil. Numerous oil sands mining and bitumen extraction processes have been developed and commercialized, all of which involve the use of water as the processing medium. The role of water is to provide sensible heat to enhance bitumen liberation through viscosity reduction, to produce a fluid that can be pumped and to create an

environment in which gravimetric separation can develop. One such water extraction process is the Clark Hot Water Extraction Process, which was the first commercially successful oil sand extraction process and upon which future improvements to the Clark Process have been based.

[0004] A water based extraction processes, such as the Clark Process, typically require that mined oil sand first be conditioned for extraction by being crushed to a desired lump size and then combined with hot water and caustic to form a conditioned slurry of bitumen, water, sand, fine particles and entrained air bubbles. In water based extraction processes, the water is heated to about 65° to 80° Celsius, and an amount of sodium hydroxide is added to the slurry to adjust or maintain the slurry pH upwards, which enhances the separation of bitumen from the oil sand. The addition of sodium hydroxide (caustic) is intended to elevate the concentration of natural surfactants through an acid – base reaction with organic acids present in the bitumen, and to increase the softness of the water phase by increasing the concentration of sodium ions. Other water extraction processes may have other temperature requirements and may include other conditioning agents which are added to the oil sand slurry.

[0005] Air entrainment and dispersion in ore processing and hydrotransport is considered an essential component of effective primary bitumen separation and recovery in conventional water based extraction processes. The mechanism of air bubble attachment onto bitumen surfaces aid in gravimetric separation of oil within primary separation columns. Extensive aeration of the oil sands slurry requires subsequent de-aeration in dedicated vessels after the coarse mineral is rejected in the first stage of primary extraction. As steam is often used in de-aeration, this additional process step adds to the energy intensity required, which translates to

higher capital and operating costs. Likewise, the reliance on hydrotransport retention time to achieve optimal conditioning further adds to capital and operating costs due to extensive pipeline wear. Also, it is commonly believed that the substantial mechanical energy added during standard ore processing and hydrotransport may be partly responsible for the limited ability to achieve rapid fines consolidation within mineral retention times in primary and secondary extraction stages.

[0006] Water based primary bitumen extraction processes typically result in the production of a number of product streams, some of which are disposed of as waste. For example, these streams include a bitumen froth stream comprising of aerated bitumen, residual fine particulate mineral solids and water, a middlings stream comprising bitumen with entrained fine particulate mineral solids and water, and a coarse tailings stream consisting primarily of coarse particulate mineral solids and water. The coarse tailings stream is not typically processed further, since the coarse particulate solids are relatively easy to dispose of and do not typically present a significant environmental risk. The bitumen froth stream and the middling's stream are typically processed further, both to recover or purify bitumen and to render the fine solids more readily disposable and less of an environmental hazard. Froth treatment typically involves introduction of either heavy naphthenic or light paraffinic solvents to produce a high oil content bitumen stream which is low in fines and water content. Subsequent stages of extraction are those associated with solvent recovery from separate fine mineral solids slurry and solvent diluted bitumen streams. The fine mineral solids and water recovered from the bitumen froth stream are typically ultimately disposed of in tailings ponds, where subsequent consolidation of the fine solids occurs and the water recovered and reused.

[0007] Pipeline specification oil must have a basic sediment and water (BS&W) content of less than 0.5 wt%. Most water based oil sands mining and extraction facilities are unable to consistently produce a final product bitumen stream having a BS&W of less than 0.5 wt. % without having to utilize carbon rejection process technology to eliminate residual sediment and process water in the final product. One specific example of such a process is the Naphthenic Extraction plus Delayed Coking technology as utilized by Suncor Energy, Syncrude and Canadian Natural Resources Ltd. Another specific example is the Paraffinic Froth Treatment Extraction technology as used by Albion Sands, Imperial Oil Canada and Suncor Energy.

[0008] Some of the problems with current state of art technology are high capital costs for said facilities, together with their elevated energy – emission intensities. Also, chloride corrosion in solvent recovery distillation overhead systems is a growing problem for oil sands operators using Naphthenic Extraction plus Delayed Coking as residual process water in diluted bitumen contains significant concentrations of dissolved chloride anions that hydrolyze to hydrochloric acid at higher solvent recovery temperatures. The fundamental separation challenge is that the elevated concentrations of residual fines plus high total dissolved solids process water in oil emulsions are highly recalcitrant and the strong interfacial tensions between the water and oil act as a barrier for coalescence – separation in centrifugal or electrostatic desalter vessels.

Summary of the Invention

[0009] In one aspect, the invention comprises a solvent-assisted bitumen extraction system and method, which comprises steps to achieve a bitumen stream with BS&W less than 0.5 wt.

%. After secondary froth treatment, one step utilizes a conventional oil dehydrator vessel to recover residual water by collapsing any residual water-in-oil emulsions. The dehydrator operates above the boiling point of water, but below the boiling point of the solvent. Another step takes the dehydrated diluted bitumen stream and, at or near the same temperature, passes it through a centrifuge to extract fine mineral and precipitated salts. The diluted bitumen thus treated may then pass to a solvent recovery stage.

[0010] Therefore, in one aspect, the invention may comprise a method of producing pipeline quality bitumen, comprising the steps of:

(a) conditioning oil sands ore in a water –based bitumen extraction process by adding a solvent to the ore before or during a step of creating an aqueous slurry; and agitating the slurry;

(b) separating the bitumen diluted with the solvent from water and solids;

(c) thermally dehydrating the diluted bitumen at a temperature above about 100 C and below the boiling point of the solvent; and

(d) separating any remaining fine solids and precipitates by gravitational separation at a temperature above about 100 C and below the boiling point of the solvent.

The solvent may subsequently be recovered, by distillation for example.

Brief Description of the Drawings

[0011] The following drawings form part of the specification and are included to further demonstrate certain embodiments or various aspects of the invention. In some instances,

embodiments of the invention can be best understood by referring to the accompanying drawings in combination with the detailed description presented herein. The description and accompanying drawings may highlight a certain specific example, or a certain aspect of the invention. However, one skilled in the art will understand that portions of the example or aspect may be used in combination with other examples or aspects of the invention.

[0012] Figure 1 shows a process flow diagram of one embodiment of a method of the present invention.

Detailed Description

[0013] As used herein, certain terms have the meanings defined below. All other terms and phrases used in this specification have their ordinary meanings as one of skilled in the art would understand.

[0014] The present invention relates to an improvement to a process of extracting bitumen from oil sands ore using a solvent. Generally, the method may be applied to oil sands ore which is surface mined. The method may comprise the stages of ore conditioning, bitumen separation or extraction which may comprise primary froth treatment and a secondary froth treatment stages, product polishing and solvent recycle, and tailings dewatering and solvent recovery. One specific embodiment is illustrated schematically in Figure 1.

[0015] Oil sands ore is typically mined and crushed to break down large chunks. The creation of a water-based oil sands ore slurry is known as wet ore processing. The present invention modifies conventional wet ore processing by adding a solvent to the oil sands ore-water slurry such that the ore is conditioned with solvent present. In one embodiment, the

crushed ore is mixed with solvent together with the addition of water, to create an aqueous slurry, which is then agitated. Elements of oil sands extraction methods are described in co-owned U.S. Patent No. 8,758,601, co-pending U.S. Patent Application 14/959,910 - Oilsands Processing Using Inline Agitation and an Inclined Plate Separator, filed December 4, 2015, or US Patent Application No. 15/453,318 entitled Process Water Chemistry in Bitumen Extraction from Oil Sands filed March 8, 2017, or US Patent Application No. 15/467,583, entitled Solvent Addition in Water Based Oil Sands Ore Digestion and Primary Extraction, filed March 23, 2017, the entire contents of each which are incorporated herein by reference for all purposes, where permitted.

[0016] In one embodiment, the methods described herein contemplate the use of any suitable solvent or solvent mixture. For example, the solvent may comprise a "biosolvent" which is a liquid substance which is substantially soluble in bitumen, and which has a biological origin. Exemplary bio-solvent may include terpenes such as, without limitation, pinene or limonene. Terpenes may be acidic, which may necessitate the use of a basic sodium salt to neutralize organic acids and to limit solubility of components of the mineral phase which may hinder bitumen extraction. Ultimately, the invention may apply to any solvent formulation applied in the early stages of primary extraction and in particular in ore digestion and hydrotransport.

[0017] In one embodiment, the creation of the aqueous slurry is the initial step in an ore conditioning stage, in preparation for bitumen separation. Ore conditioning is the series of processes required to reduce the aggregate size of the mined ore to a dimension and consistency suitable for treatment in bitumen extraction, and in particular the primary

separation process. Conditioning is a step whereby ore lumps are broken down and the process of bitumen liberation from sand begins.

[0018] Oil sands slurries may be conditioned in large rotating drums which provide sufficient agitation. More recently, oil sands slurries have been conditioned by hydrotransportation or hydrotransport in a pipeline to the bitumen extraction plant. Hydrotransport is a well-known technology which uses slurry transport in a pipeline to condition the slurry. Bitumen which is bound to chunks or lumps of sand, ice or clay is difficult to recover in an extraction process. These lumps will sink to the bottom of the gravity separation vessels during extraction and are likely be lost to the tailings pond. Hydrotransport provides extended residence time in a turbulent environment, resulting in lump ablation. Hydrotransport pipelines provide the residence time and turbulence to break down these lumps and begin to liberate the bitumen from the sand.

[0019] The inventors have found that solvent added to the slurry during the early stages of ore conditioning, whether in rotating drums or by hydrotransport, increases bitumen recovery in the subsequent water-based separation steps, allows for lower temperature separation efficiency, for example at temperatures less than about 60 C or less than about 45° C, and the co-production of a stackable fine mineral solid stream. Without restriction to a theory, application of solvent in the ore conditioning step is believed to be part of the reason why fine minerals dispersed into the slurry are able to be dewatered or consolidated above their liquid limit (Atterberg Limit) in subsequent separation stages further downstream using conventional centrifugal processing. The action of solvents during ore conditioning is believed to be at least one causal factor in reducing interfacial repulsion between fine mineral

particles, such that relatively low mechanical centrifuge treatment in extraction is able to produce a soil-like dewatered mineral stream.

[0020] In one embodiment, solvent is added at a rate relative to the known bitumen saturation and ore feed rate into ore conditioning and is reported as a ratio of weight of solvent to weight of bitumen. This ratio may vary from about 0.25:1 to about 2:1. The ratio depends at least in part on the grade and type of ore. Higher grades of oil sands ore may comprise up to about 12 wt % bitumen while lower grade may be around 7 wt% bitumen. Lower ore grades may benefit from a greater solvent proportion and oil wet ore types commonly require higher ratios than water wet oil sands ore to achieve comparable bitumen separation efficiencies. The amount of solvent added is not intended to "extract" the bitumen into a solvent phase. Rather, the amount of solvent is selected so as to be entirely dissolved into the bitumen phase. In one embodiment, there is substantially no free solvent in the slurry after the conditioning phase.

[0021] In one embodiment, sufficient water and solvent is added such that the density of the slurry ranges between about 25 to about 60 wt % solids, preferably about 35 to 45% wt % solids.

[0022] The solvent-assisted ore conditioning step of the present invention may be used in conjunction with any water-based bitumen separation or extraction process, including commercially practiced Karl Clark extraction methods.

[0023] In one embodiment, once the ore has been suitably conditioned with the addition of the solvent, the slurry passes to a primary separation stage, using the primary separation

vessels (PSV1 and PSV2) shown in Figure 1. In the PSVs, counter current lift water is added to produce a state of hindered settlement in each of the two separation vessels arranged in series. The bottom stream from the first separation vessel acts as feed to the second separation vessel. The bottom stream from the second separation vessel then is fed to a screen shaker unit for dewatering of the coarse tails stream. Separation in the PSVs is the core of the process, where the bitumen is stripped from the host sandstone, which comprises quartz, feldspar, plagioclase and minor percentages of clay minerals, using heat and water. The bio-solvent has absorbed into the bitumen phase during conditioning and facilitates this separation. During the separation phase, the solvent-diluted bitumen bond with the sand and clays is more easily broken. The lower specific gravity of the diluted bitumen allows for effective gravity separation from the water phase to occur.

[0024] The diluted bitumen follows the overflow from the primary separation vessels and is still mixed with a significant amount of water and fine solids. A secondary separation stage which utilizes a bulk separator produces a water phase, and a diluted bitumen stream which includes fine solids. In one embodiment, the secondary separation stage may use an agitator and inclined plate separators.

[0025] Inclined plate separators (IPS) function to reduce the water volumes reporting to downstream centrifuge units. This may be achieved by agitating the mixture from the PSVs in an inline mixer, such that both diluted bitumen and fines exit via the underflow stream of the IPS, and the overflow being predominately process water. The overflow stream from a first IPS unit may then be treated in a second IPS unit. The overflow from the second IPS unit is relatively clean process water and may be used as recycle water. The underflow from both

IPS units may then be combined and treated in a decanter (decanting centrifuge) which separates fine solids and outputs diluted bitumen with entrained water and residual fine solids.

[0026] The diluted bitumen from the decanter may then be sent to a dehydration unit to remove substantially all remaining water, which likely remains only in microemulsions within the diluted bitumen. The dehydrator operates at an elevated temperature, preferably above the boiling point of water, but below the boiling point of the solvent. Where a mix of solvents is used, it is preferred to limit the temperature below the lowest boiling point of any substantial component of the solvent mixture. Without restriction to a theory, it is believed that such thermal treatment of wet diluted bitumen prior to solvent recovery, water micelles are collapsed through evaporation, and dissolved solids are precipitated, including chloride anions.

[0027] The boiling point of terpenes is typically in the range of about 150 C to about 185 C. Therefore, a preferred range of thermal treatment may be in the range of about 100 to about 150, more preferably about 120 to about 140 C.

[0028] The dehydrated diluted bitumen will then be further processed using centrifuges, such as standard decanting centrifuges, to extract residual salts and fine mineral solids at or near the operating temperature of the dehydrator.

[0029] The resulting dehydrated diluted bitumen is now substantially free of water and solids, having a BS&W less than 0.5 wt. %. The diluted bitumen may then be treated in a distillation unit to recover the solvent, leaving saleable bitumen product. Approximately 98 to 99% of the solvent may be recovered with distillation and is recycled to a holding tank for re-use. In

tailings dewatering and solvent recovery approximately 90 to 95% of the circulating process water is recovered from the produced sand and fines tailings to be recycled indefinitely until fractionally lost to tailings discharge. Make up water and make up process chemical aids may be added as necessary.

[0030] Solvent-assisted conditioning, with subsequent bitumen extraction, and product polishing and solvent recycle, may permit bitumen recovery in excess of 80%, 85%, or 90% (wt.), solvent recovery and recycling in excess of 95, 96, 97 or 98% (wt.), and process water recovery and recycling in excess of 85, 90 or 95% (wt.).

Definitions and Interpretation

[0031] The description of the present invention has been presented for purposes of illustration and description, but it is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. Embodiments were chosen and described in order to best explain the principles of the invention and the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated. To the extent that the following description is of a specific embodiment or a particular use of the invention, it is intended to be illustrative only, and not limiting of the claimed invention.

[0032] The corresponding structures, materials, acts, and equivalents of all means or steps plus function elements in the claims appended to this specification are intended to include any

structure, material, or act for performing the function in combination with other claimed elements as specifically claimed.

[0033] References in the specification to "one embodiment", "an embodiment", etc., indicate that the embodiment described may include a particular aspect, feature, structure, or characteristic, but not every embodiment necessarily includes that aspect, feature, structure, or characteristic. Moreover, such phrases may, but do not necessarily, refer to the same embodiment referred to in other portions of the specification. Further, when a particular aspect, feature, structure, or characteristic is described in connection with an embodiment, it is within the knowledge of one skilled in the art to combine, affect or connect such aspect, feature, structure, or characteristic with other embodiments, whether or not such connection or combination is explicitly described. In other words, any element or feature may be combined with any other element or feature in different embodiments, unless there is an obvious or inherent incompatibility between the two, or it is specifically excluded.

[0034] It is further noted that the claims may be drafted to exclude any optional element. As such, this statement is intended to serve as antecedent basis for the use of exclusive terminology, such as "solely," "only," and the like, in connection with the recitation of claim elements or use of a "negative" limitation. The terms "preferably," "preferred," "prefer," "optionally," "may," and similar terms are used to indicate that an item, condition or step being referred to is an optional (not required) feature of the invention.

[0035] The singular forms "a," "an," and "the" include the plural reference unless the context clearly dictates otherwise. The term "and/or" means any one of the items, any combination of the items, or all of the items with which this term is associated.

[0036] As will be understood by one skilled in the art, for any and all purposes, particularly in terms of providing a written description, all ranges recited herein also encompass any and all possible sub-ranges and combinations of sub-ranges thereof, as well as the individual values making up the range, particularly integer values. A recited range (e.g., weight percents or carbon groups) includes each specific value, integer, decimal, or identity within the range. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, or tenths. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc.

[0037] As will also be understood by one skilled in the art, all language such as "up to", "at least", "greater than", "less than", "more than", "or more", and the like, include the number recited, and such terms refer to ranges that can be subsequently broken down into sub-ranges as discussed above. In the same manner, all ratios recited herein also include all sub-ratios falling within the broader ratio.

WHAT IS CLAIMED IS:

1. A method of producing pipeline quality bitumen containing less than 0.5 wt. % water and solids, comprising the steps of:
 - (a) conditioning oil sands ore in a water –based bitumen extraction process by adding a solvent to the ore before or during a step of creating an aqueous slurry; and agitating the slurry;
 - (b) separating the bitumen diluted with the solvent from water and coarse solids;
 - (c) thermally dehydrating the diluted bitumen at a temperature above about 100 C and below the boiling point of the solvent; and
 - (d) separating any remaining fine solids and precipitates by gravitational separation.
2. The method of claim 1 wherein the solvent comprises a terpene.
3. The method of claim 2 wherein the solvent comprises limonene or pinene.
4. The method of claim 2 wherein the thermal dehydration step occurs at a temperature between about 100 C and 150 C.
5. The method of claim 4 wherein the thermal dehydration step occurs at a temperature between about 120 C and 140 C.
6. The method of claim 1 wherein the separation step (d) is performed by a decanting centrifuge.

7. The method of claim 1 comprising the further step of recovering the solvent by distillation.

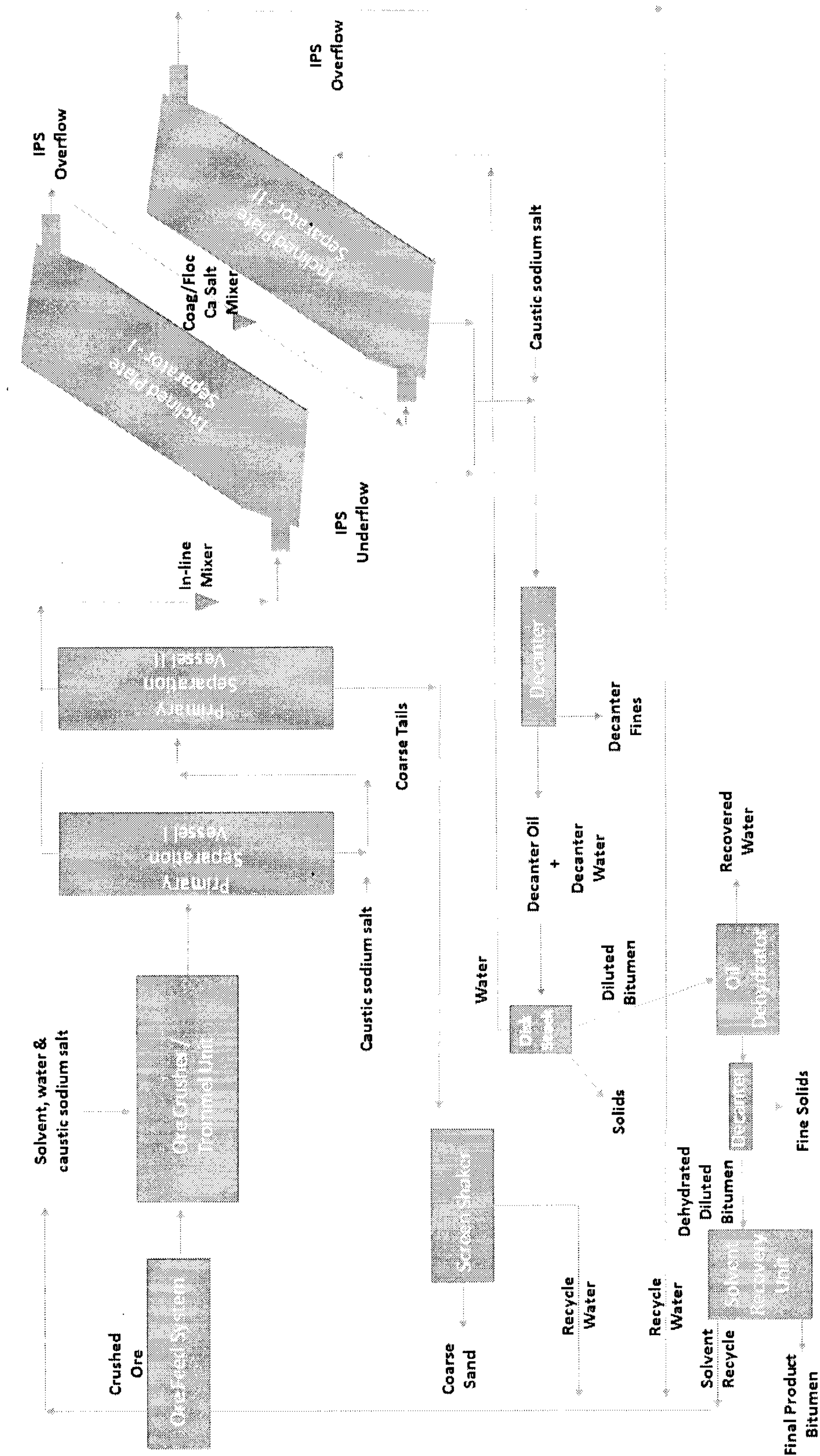


FIGURE 1

