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(54) Titre : PROCEDE D'AMELIORATION DE REDUCTION DE SOLIDES DANS LE TRAITEMENT DU BITUME
(54) Title: PROCESS FOR ENHANCING SOLIDS REDUCTION IN BITUMEN PROCESSING

(57) Abrégé/Abstract:
A process for treating bitumen froth comprising a hydrocarbon solvent comprises: adding a settling agent to enhance solids settling in the bitumen froth, and removing settled solids from the bitumen froth to obtain a low solids content bitumen product. Further, a process for treating a bitumen emulsion comprising a first water phase, a first oil phase, and solids, comprises: adding a settling agent to the bitumen emulsion, for enhancing separation of the solids into the water phase of the bitumen emulsion; and separating the bitumen emulsion into a second water phase containing the majority of the solids present in the bitumen emulsion and a second oil phase containing the majority of the bitumen present in the bitumen emulsion to produce a low solids content bitumen product.

ABSTRACT

A process for treating bitumen froth comprising a hydrocarbon solvent comprises: adding a settling agent to enhance solids settling in the bitumen froth, and removing settled solids from the bitumen froth to obtain a low solids content bitumen product. Further, a process for treating a bitumen emulsion comprising a first water phase, a first oil phase, and solids, comprises: adding a settling agent to the bitumen emulsion, for enhancing separation of the solids into the water phase of the bitumen emulsion; and separating the bitumen emulsion into a second water phase containing the majority of the solids present in the bitumen emulsion and a second oil phase containing the majority of the bitumen present in the bitumen emulsion to produce a low solids content bitumen product.

PROCESS FOR ENHANCING SOLIDS REDUCTION IN BITUMEN PROCESSING

BACKGROUND

Field of Disclosure

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

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] Recently, the harvesting of oil sand to remove heavy oil has become more economical. 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 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"), which is incorporated herein by reference. 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.

[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 naphtha froth treatment (NFT) processes. Other processes use a 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, which is incorporated herein by reference.

[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 2 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 provide an alternative or improved process for treating bitumen froth.

SUMMARY

[0014] It is an object of the present disclosure to provide a process of treating bitumen froth to enhance solids reduction in bitumen processing during an oil sand treatment process.

[0015] A process for treating bitumen froth comprising a hydrocarbon solvent is described, which comprises: adding a settling agent to enhance solids settling in the bitumen froth, and removing settled solids from the froth to obtain a low solids content bitumen product.

[0016] Further, a process is described for treating a bitumen emulsion comprising a first water phase, a first oil phase, and solids comprising: adding a settling agent to the bitumen emulsion, for enhancing separation of the solids into the water phase of the bitumen emulsion; and separating the bitumen emulsion into a second water phase containing the majority of the solids present in the bitumen emulsion and a second oil phase containing the majority of the bitumen present in the bitumen emulsion to produce a low solids content bitumen product.

[0017] 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

[0018] 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.

[0019] **Figure 1** is a flow chart showing bitumen froth processing.

[0020] **Figure 2** is a flow chart showing bitumen emulsion processing.

[0021] **Figure 3** is a plot presenting the amount of filterable solids versus C5 asphaltenes retained in bitumen following paraffinic froth treatment under conditions described herein.

[0022] 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

[0023] 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.

[0024] 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.

[0025] Throughout this disclosure, where a range is used, any number between or inclusive of the range is implied.

[0026] 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.

[0027] "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.

[0028] "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. The recovery of heavy oils is based on the viscosity decrease of fluids with increasing temperature or solvent concentration. Once the viscosity is reduced, the mobilization of fluid by steam, hot water flooding, or gravity is possible. The reduced viscosity makes the drainage or dissolution quicker and therefore directly contributes to the recovery rate.

[0029] 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.

[0030] "Fine particles" or "fines" are generally defined as those solids having a size of less than 44 microns (μm), as determined by laser diffraction particle size measurement.

[0031] "Coarse particles" are generally defined as those solids having a size of greater than 44 microns (μm).

[0032] The term "solvent" as used in the present disclosure should be understood to mean either a single solvent, or a combination of solvents.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] In current commercial practices for the processing of oil sands, it is desirable to reduce solids during bitumen paraffinic froth treatment, while minimizing the rejection of asphaltenes from the froth. By reducing the solids content and minimizing asphaltene loss in bitumen froth streams, a more economical outcome of oil sands processing may be realized by maximizing the overall bitumen product. The term "bitumen froth" is well known in the oil sands arts and the associated streams typically are comprised of bitumen, asphaltenes, oil, water, and solids comprised of organic and inorganic matter.

[0037] It has been found that using certain chemical additives in a bitumen froth stream results in a bitumen product that is low or ultra-low in solids relative to conventional paraffinic froth treated bitumen. Such additives are referred to herein interchangeably as "settling agents". Further, it has been found that the use of certain settling agents results in a bitumen product with a high asphaltene content, as the settling agent can have the effect of reducing asphaltene rejection.

[0038] Solids in bitumen can pose challenges for bitumen transportation, processing and refining. Solids can significantly contribute to fouling in downstream operations and are known to stabilize emulsions in crude oil. To reduce these solids to an acceptable level, current commercial methods result in a significant loss in the amount of asphaltenes dissolved in the bitumen. When asphaltenes are removed in this way, there is a concomitant loss in bitumen product yield.

[0039] Separation of bitumen from oil sands using conventional aqueous extraction technology, such as the Clark Hot Water Extraction Process, leads to the production of a bitumen-rich froth (herein: bitumen froth) containing a significant amount of solids. Using the current commercial (conventional) technology, solids are separated from the bitumen by adding a solvent to dilute the bitumen component, which allows the solids to settle by gravity. Currently, there are two major technologies used for froth treatment in the oil sands industry: conventional naphtha froth treatment (NFT) and paraffinic froth treatment (PFT).

[0040] In NFT, a predominantly aromatic solvent (naphtha) is used at relatively low solvent-to-bitumen ratio to dilute the bitumen component of the froth. The separation of solids and water from the oil phase is enhanced by chemically destabilizing the emulsion. The diluted bitumen products from NFT contain about 0.5% mineral solids, which further requires the bitumen to be upgraded before it is transported by pipeline or refined.

[0041] In PFT, a paraffinic solvent is used to dilute the bitumen component of the froth at a higher solvent-to-bitumen ratio than the NFT process. The addition of the paraffinic solvent causes heavy asphaltene molecules to precipitate out of the hydrocarbon phase of the froth, which further lowers the viscosity and density of the bitumen product. This consequently allows the asphaltene solids to agglomerate with the mineral solids and the emulsified water droplets in the froth stream. This agglomeration causes the formation of larger aggregates that have higher settling rates compared to those of contaminants in the NFT process, making their separation more effective. As a result, the diluted bitumen product from the PFT process contains significantly smaller amounts of solids than the NFT process. For froth streams produced in either PFT, NFT, or other froth streams produced from oil sands processing, it is desirable to decrease solids content while minimizing asphaltene rejection.

[0042] Separation of bitumen from oil sands causes the formation of a bitumen-aqueous slurry (typically referred to as "bitumen froth" in the industry as noted prior) which conventionally contains bitumen, a significant amount of contaminants, namely water (typically about 20-50 wt%) and mineral solids (typically about 10-30 wt%). The bitumen froth may be subjected to a PFT process, in which the bitumen froth is diluted with a paraffinic hydrocarbon solvent to reduce the viscosity and density of the oil phase, thereby accelerating the settling of the solid and water impurities. Furthermore, the addition of paraffinic solvent destabilizes asphaltenes present in the bitumen, causing asphaltenes to precipitate out with other solids. These precipitated asphaltenes agglomerate with the mineral solids and water in the slurry to form large flocs, which settle rapidly in gravity settlers. As noted, a significant problem in the industry is that these valuable asphaltenes are lost from the bitumen product into the sand tailings, as well as can cause further problems in the overall process in removing these asphaltenes in the tailings clean-up phase.

[0043] Certain methods have previously been proposed to address the problem of either increasing removal of solids, such as fine solids, or reducing asphaltene loss. Some of these previous approaches are described below. However, some previous approaches only involve adding chemicals that can reduce the solids to levels ranging between 0.3 – 0.5 wt% (3000 – 5000 wppm) solids while not addressing the minimization of loss of asphaltenes from the bitumen to the bottoms product (mineral solids + water).

[0044] Beetge, et al. describe such a method in Canadian Patent No. 2,538,464, using the addition of a polyoxyalkylate polymer to a naphtha solvent.

[0045] Power, et al. describe a method involving froth treatment in Canadian Patent No. 2,521,248, involving addition of a dispersant to bitumen froth.

[0046] Mishra, et al. describe reduction of water and solids in a bitumen stream in US Patent No. 6,019,888, which involves the addition of surfactants or flocculants to achieve a modest reduction in solids in the bitumen product.

[0047] Engel and Goliaszewski describe addition of acetylenic surfactants in US Patent No. 7,612,117 for improving resolution of oil and water emulsions having very low or no solids to begin with.

[0048] None of these documents addresses both the reduction of solids and the reduction of asphaltene loss.

[0049] A process is described for treating bitumen froth comprising a hydrocarbon solvent. The process comprises adding a settling agent to enhance solids settling in the bitumen froth, and then removing settled solids from the bitumen froth to obtain a low solids content bitumen product. The settling agent may be any agent capable of enhancing solids setting within froth, for example: a polyacrylamide polymer or an unsaturated alcohol, wherein the unsaturated alcohol comprises an unsubstituted or substituted alkene-ol or alkyne-ol of C-6 or greater. The polyacrylamide may be an ionic polyacrylamide polymer such as a cationic polymer, for example FLOPAM A3338. The unsaturated alcohol may be for example methyl-hexyne-ol, methyl-decyne-diol, or a combination of these. For example, 3,5-

dimethyl-1-hexyn-3-ol (DMHO) may be used as a settling agent. The settling agent may be one that is known to also have properties as a flocculant. The settling agent may also have the ability to reduce asphaltene rejection from the bitumen froth, to have C5 asphaltene present at 9 wt% or greater, such as at 10 wt% or 11 wt% or greater. C5 asphaltene content can be evaluated per ASTM D4055, based on pentane insolubility.

[0050] The levels of settling agents used to achieve this reduction of asphaltene rejection in the bitumen froth or in the bitumen emulsion may be 1000 wppm or less, for example 500 wppm or less, 100 wppm or less, 50 wppm or less, or 10 wppm or less. Specifically, the range of settling agent present within the bitumen froth or bitumen emulsion may be from 1 to 1000 wppm, for example: from 5 to 1000 wppm, or 10 to 1000 wppm,. Additional exemplary ranges include from 1 to 500 wppm, from 5 to 500 wppm, or from 10 to 500 wppm. Other exemplary ranges of settling agents to be used according to the processes described herein may be from 1 to 100 wppm, 5 to 100 wppm, 10 to 100 wppm or 1 to 50 wppm, 5 to 50 wppm, or 10 to 50 wppm.

[0051] The bitumen froth treated may be from a paraffinic froth treatment (PFT) process. Further, the bitumen froth may be from a naphtha froth treatment (NFT) process.

[0052] There is also described herein a process for treating a bitumen emulsion comprising a water phase and an oil phase. This embodiment of the process comprises adding a settling agent to the bitumen emulsion, for enhancing solids settling in the bitumen emulsion; and resolving the bitumen emulsion to remove settled solids with the water phase to obtain a low solids content bitumen product.

[0053] The processes described herein may entail, in certain embodiments, the addition of a settling agent comprising one or more polyacrylamides, methyl-hexyne-ols, methyl-decyne-diols, or a combination of these, to the bitumen froth during the PFT process. Further, in some embodiments, the use of the settling agent may increase the reduction of solids while reducing asphaltene loss. For example, unsaturated alcohols which fall into the classification of methyl-hexyne-ol or methyl-decyne-diol may have the effect of both increasing the reduction of solids from the bitumen froth, while also reducing asphaltene rejection from the bitumen froth. Thus, asphaltene loss is reduced.

[0054] For certain bitumen products, it may be desirable or advantageous to have a high level of asphaltenes. Current asphaltene rejection rates of 50% or greater may be improved by using certain embodiments of the process described.

[0055] The low level of solids can render the bitumen product appropriate for pipeline transport standards. When there is a lower solids content in bitumen froth, there can be a reduced amount of downstream processing for solids removal. There can also be a reduction in solvent use when the solids level is decreased in bitumen froth. It is desirable to achieve pipeline specification levels for reduced solids, while employing a lower volume of solvent.

[0056] The process described may be utilized on a consistent basis, or may be used only periodically, for example in an ongoing process when solids are being monitored and are found to be increasing. Then the process could be used on an "as needed" basis of for trim cleaning, to bring an off-specification level of solids back to a level that is consistent with pipeline solids specifications.

[0057] Typically in previous processes, polymers such as polyacrylamides may be used in applications relating to tailings, where an aqueous solution is to be de-watered. However, as employed herein, polymers such as polyacrylamides are employed in bitumen froth or bitumen emulsions which may be, for example, about 30% water. Using polymers at the recovery stage with oil had not been thought of previously, as the applications in tailings are conducted in aqueous media.

[0058] Unsaturated alcohols such as methyl-hexyne-ols, and methyl-decyne-diols had been previously employed in de-salting applications typically in early stage refinement, such as for removing electrostatic salts to prevent acid formation within a refinery. It had not been previously thought of to use such unsaturated alcohols as these as settling agents for bitumen froth or bitumen emulsions.

[0059] Polyacrylamide, also known by the IUPAC designations: poly(2-propenamide) or poly(1-carbamoylethylene), is a polymer with a repeating unit of ($-CH_2CHCONH_2-$), also represented as $(C_3H_5NO)_n$. Polyacrylamides of varying sizes or with different linear, branched, or cross-lined structures may be used. An ionic polyacrylamide can be used, such as a cationic polymer. For example, FLOPAM polymer may be used such as FLOPAM

A3338 (available from SNF Group). Various molecular weights of polyacrylamide polymer may be used. Polyacrylamide polymers which can also serve as a flocculant can be used.

[0060] Unsaturated alcohols having at least a C-6 core structure may be used, such as hexyne-ol, hexen-ol, decyn-ol, or decene-ol. Such compounds may be substituted, for example with 1 or more lower alkyl (C1-C6), such as methyl or ethyl. Diols can be used as well. Exemplary compounds include methyl-hexyne-ols, and methyl-decyne-diols. Specific examples may include 2,4,7,9-tetramethyl-5-decyn-4,7-diol or 3,5-dimethyl-1-hexyn-3-ol.

[0061] It has been found that the addition of this settling agent further enhances the agglomeration and settling of fine solid particles, producing a cleaner bitumen product with an ultra low solids content. At the same time, certain settling agents help stabilize asphaltene molecules in the bitumen froth, and can interfere with asphaltene rejection and removal. Thus the settling agent helps to maintain asphaltene content. Advantageously, this may help to increase bitumen product yield, as compared with the conventional process in which such settling agents are not included in bitumen froth.

[0062] There are significant economic incentives to produce a bitumen product with solid levels below 500 wppm, for example below 100 wppm, and even below 30 wppm, while minimizing the amount of asphaltenes lost to the water and solid phases.

[0063] The addition of this settling agent may be used in any bitumen froth, resulting from processing of oil sand. Thus, the described process is not limited to use in the PFT process, but may also be utilized to further reduce bitumen solids in naphtha froth treatment process, or other solvent-based froth treatment processes. This would also encompass use for releasing solids from oil/water and/or water/oil emulsions, which is advantageous to crude desalter operations.

[0064] In existing desalter operations, emulsfiers are added to the oil and/or to the wash water to promote the coalescence of the wash water droplets to the water droplets present in hydrocarbon feed (oil phase). The unintended consequence of this activity is the stabilization of solid particles in the crude emulsions, which hinders their release from the oil phase to the water phase at the desired efficiency. This is especially relevant to Western Canadian heavy crudes which can contain clay particles. This compromises desalter efficiency and results in a significant increase in desalter rag layer volume.

[0065] The process described herein when used with bitumen emulsions, may optimize the desalter emulsion interface by specifically controlling the amount of solids being transferred between the oil and water phases, thereby promoting emulsion resolution during desalter operations and enhancing desalter efficiency.

[0066] **Figure 1** illustrates a process (100) for bitumen froth processing. As shown in Figure 1, the process includes the steps of adding (102) a settling agent to bitumen froth and subsequently removing (104) settled solids from bitumen froth to obtain a low solids content bitumen product.

[0067] **Figure 2** illustrates a process (200) for the processing of a bitumen emulsion. As shown in **Figure 2**, the process includes adding (202) a settling agent to a bitumen emulsion comprising a first water phase, a first oil phase, and solids, and subsequently separating (204) the bitumen emulsion into a second water phase, containing majority of solids, and a second oil phase, containing majority of bitumen, to produce low solids content bitumen product.

[0068] **Figure 3** is a plot presenting the amount of filterable solids versus C5 asphaltenes retained in bitumen following paraffinic froth treatment under conditions described below.

[0069] Bench-scale batch tests were conducted using froth settling unit (FSU) tests under commercial design conditions (S:B = 1.6; T = 70°C, P = 100 psi). The tests were conducted using bitumen froth and 60/40 vol% nC5/iC5 solvent. Two settling agents were tested, referred to here as “Additive 1” and “Additive 2”. Additive 1 was 3,5-dimethyl-1-hexyn-3-ol or DMHO. Additive 2 was FLOPAM A3338, a polyacrylamide polymer available, for example, from SNF INC. of Riceboro, Georgia, USA. Filterable solids were measured using ASTM D4807 protocol (r = 38 wppm), nC5, and are reported as wt-ppm. Asphaltenes were measured using the ASTM D4055 protocol (r=0.8 wt%), and are reported as C5 asphaltenes (wt%). Additive 1 (DMHO) was tested at the levels of 10, 50, 100, and 1000 wt ppm. Additive 2 (FLOPAM A3338) was tested at a level of 10, 50, 100, 500 and 1000 wt ppm.

[0070] A base case (control) bitumen froth, containing no additive, was also evaluated in parallel for comparison.

[0071] Briefly, the plot shows the amount of filterable solids versus C5 asphaltenes retained in the bitumen product following paraffinic froth treatment (PFT) bench top tests under commercial PFT conditions, representative of a Kearl Lake PFT process bitumen froth. The Kearl Oil Sands Project is based in the Athabasca Oil Sands region of the Kearl Lake area, near Fort McMurray in Alberta, Canada.

[0072] Repeats of a base case test performed without any settling agent show that a bitumen product with an average of 97 wppm solids and 8.5 wt% C5 asphaltenes is produced. Tests with different dosages of the settling agent (based on bitumen froth) produced a bitumen product with significantly less solids as well as significantly more asphaltenes than the base case.

[0073] The addition of the settling agent in bitumen froth treatment tests resulted in a bitumen product with a solids content that is less than 500 wppm, and more specifically: less than 100 wppm. In certain instances of the test results shown, the filterable solids may be reduced to less than the 30 wppm threshold. Moreover, the addition of the settling agent in froth treatment tests or in bitumen emulsions can provide a bitumen product with a C5 asphaltene content that is more than 9 wt%, in some instances, more than 10%, and in other instances about 11 wt% or greater (subject to dosage). The process can result in the low solids content bitumen product containing the majority of the C5 asphaltenes present in the bitumen froth or the bitumen emulsion.

[0074] 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.

[0075] 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.

CLAIMS:

1. A process for treating bitumen froth comprising a hydrocarbon solvent, the process comprising:

adding a settling agent to enhance solids settling in the bitumen froth, and

removing settled solids from the bitumen froth to obtain a low solids content bitumen product.

2. The process of claim 1, wherein the settling agent comprises a polyacrylamide polymer or an unsaturated alcohol, wherein the unsaturated alcohol comprises an unsubstituted or substituted alkene-ol or alkyne-ol of C-6 or greater.

3. The process of claim 2, wherein the unsaturated alcohol comprises a substituted alkyne-ol.

4. The process of claim 1, wherein the settling agent comprises one or more polyacrylamide, methyl-hexyne-ol, methyl-decyne-diol, or a combination of these.

5. The process of claim 4, wherein the settling agent comprises a methyl-hexyne-ol or a methyl-decyne-diol.

6. The process of claim 4, wherein the settling agent comprises 3,5-dimethyl-1-hexyn-3-ol (DMHO).

7. The process of claim 4, wherein the settling agent comprises an ionic polyacrylamide polymer.

8. The process of claim 7, wherein the settling agent comprises FLOPAM A3338.

9. The process of claim 1, wherein the settling agent is a flocculant.

10. The process of any one of claims 1 to 9, wherein the low solids content bitumen product comprises less than 500 wppm solids.

11. The process of any one of claims 1 to 9, wherein the low solids content bitumen product comprises less than 100 wppm solids.

12. The process of any one of claims 1 to 9, wherein the low solids content bitumen product comprises less than 30 wppm solids.

13. The process of claim 1, wherein the settling agent reduces asphaltene rejection from the bitumen froth.

14. The process of claim 13, wherein the C5 asphaltene content of the low solids content bitumen product is 9 wt% or greater.

15. The process of claim 13, wherein the C5 asphaltene content of the low solids content bitumen product is 10 wt% or greater.

16. The process of claim 13, wherein the C5 asphaltene content of the low solids content bitumen product is 11 wt% or greater.

17. The process of any one of claims 1 to 16, wherein the bitumen froth is from a paraffinic froth treatment (PFT) process.

18. The process of any one of claims 1 to 16, wherein the bitumen froth is from a naphtha froth treatment (NFT) process.

19. A process for treating a bitumen emulsion comprising a first water phase, a first oil phase, and solids comprising:

adding a settling agent to the bitumen emulsion, for enhancing separation of the solids into the water phase of the bitumen emulsion; and

separating the bitumen emulsion into a second water phase containing the majority of the solids present in the bitumen emulsion and a second oil phase containing the majority of the bitumen present in the bitumen emulsion to produce a low solids content bitumen product.

20. The process of claim 19, wherein the settling agent comprises a polyacrylamide polymer or an unsaturated alcohol, wherein the unsaturated alcohol comprises an unsubstituted or substituted alkene-ol or alkyne-ol of C-6 or greater.

21. The process of claim 20, wherein the unsaturated alcohol comprises a substituted alkyne-ol.

22. The process of claim 19, wherein the settling agent comprises one or more polyacrylamide, methyl-hexyne-ol, methyl-decyne-diol, or a combination of these.

23. The process of claim 22, wherein the settling agent comprises a methyl-hexyne-ol or a methyl-decyne-diol.

24. The process of claim 22, wherein the settling agent comprises 3,5-dimethyl-1-hexyn-3-ol (DMHO).

25. The process of claim 22, wherein the settling agent comprises an ionic polyacrylamide polymer.

26. The process of claim 25, wherein the settling agent comprises FLOPAM A3338.

27. The process of claim 19, wherein the settling agent is a flocculant.

28. The process of any one of claims 20 to 27, wherein the low solids content bitumen product comprises less than 500 wppm solids.

29. The process of any one of claims 21 to 27, wherein the low solids content bitumen product comprises less than 100 wppm solids.

30. The process of any one of claims 21 to 27, wherein the low solids content bitumen product comprises less than 30 wppm solids.

31. The process of claim 21, wherein the settling agent reduces asphaltene rejection from the bitumen emulsion.

32. The process of claim 31, wherein the C5 asphaltene content of the low solids content bitumen product is 9 wt% or greater.

33. The process of claim 31, wherein the C5 asphaltene content of the low solids content bitumen product is 10 wt% or greater.

34. The process of claim 31, wherein the C5 asphaltene content of the low solids content bitumen product is 11 wt% or greater.

35. The process of claim 31, wherein the low solids content bitumen product contains the majority of the C5 asphaltenes present in the bitumen emulsion.

36. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 1 to 1000 wppm.

37. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 10 to 1000 wppm.

38. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 1 to 500 wppm.

39. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 10 to 500 wppm.

40. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 1 to 100 wppm.

41. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 10 to 100 wppm.

42. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 1 to 50 wppm.

43. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 10 to 50 wppm.

44. The process of any one of claims 1 to 35, wherein the settling agent is added at level of 1 to 10 wppm.

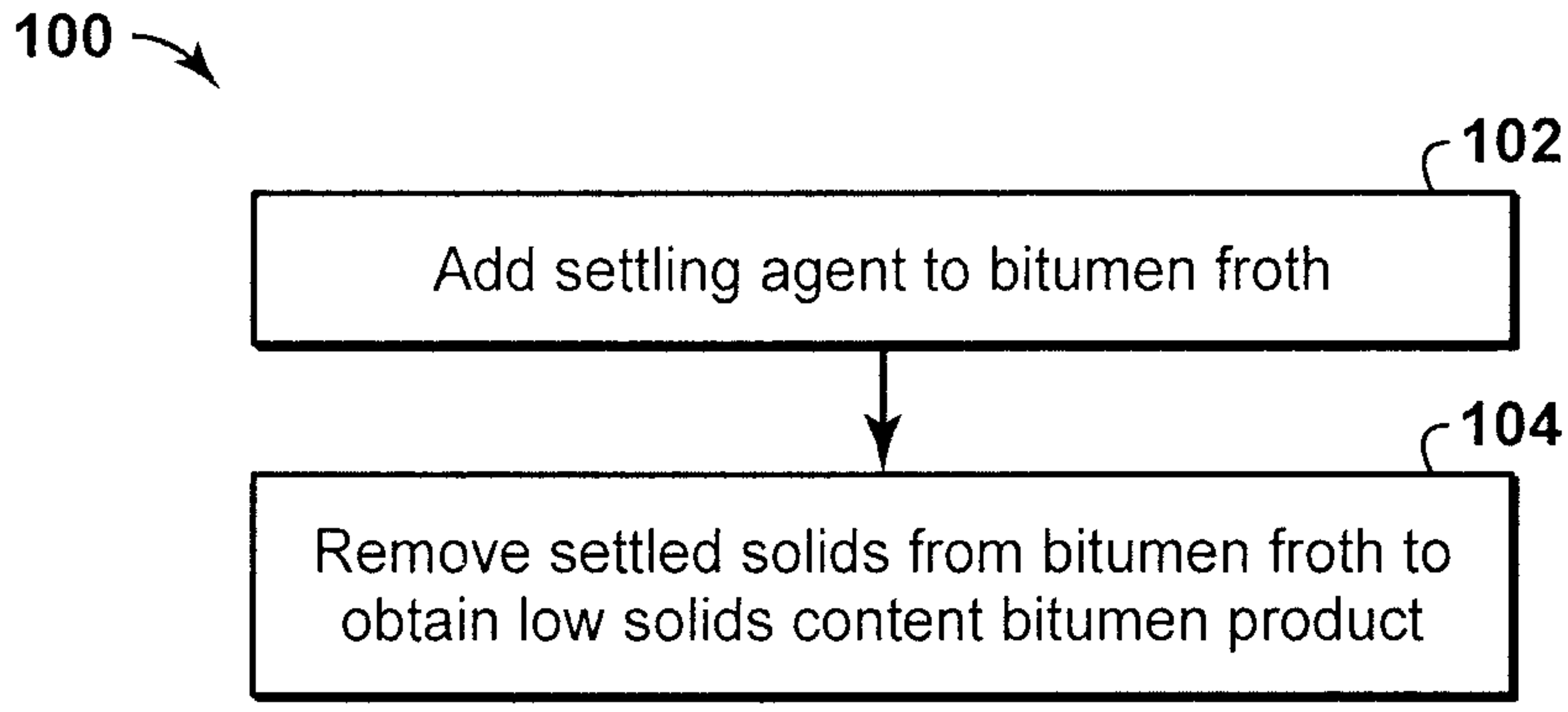
100
102
Add settling agent to bitumen froth
104
Remove settled solids from bitumen froth to obtain low solids content bitumen product

FIG. 1

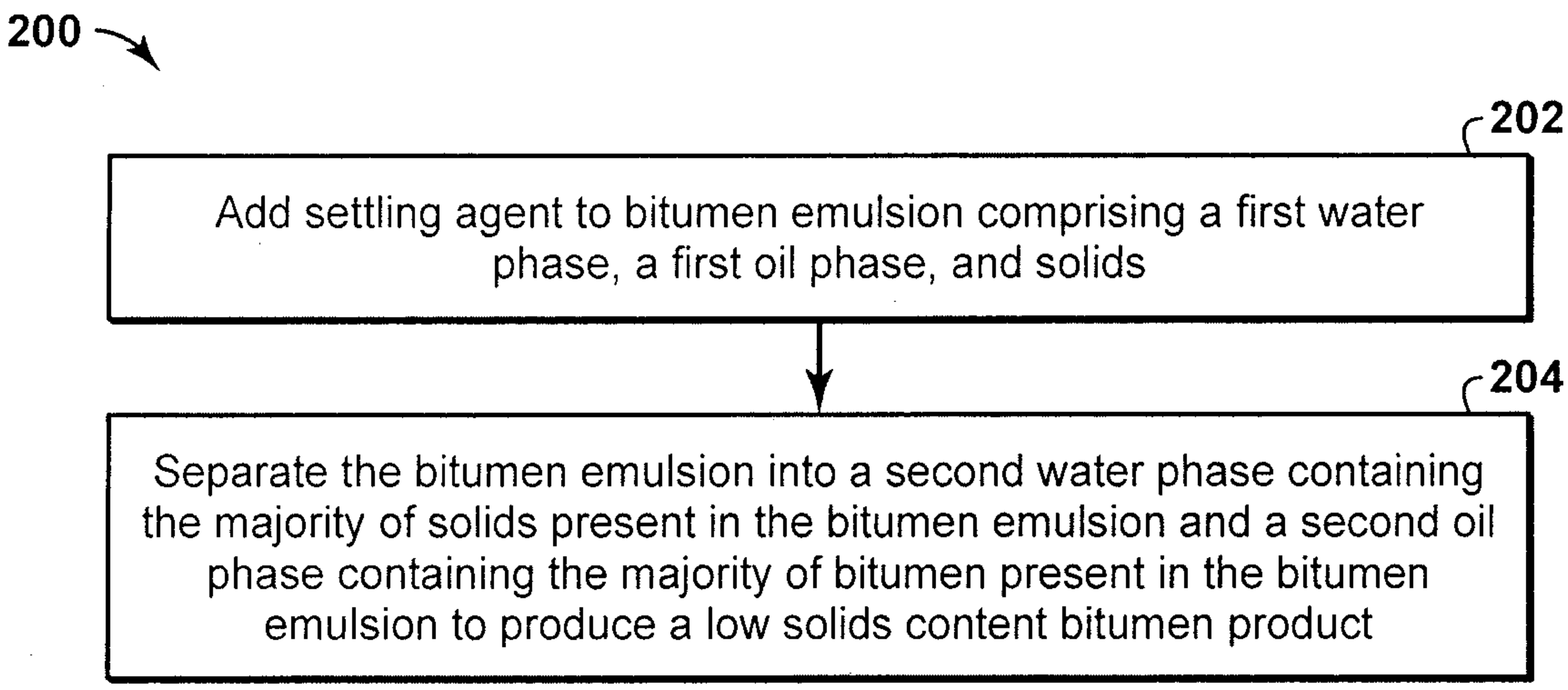
200
202
Add settling agent to bitumen emulsion comprising a first water phase, a first oil phase, and solids
204
Separate the bitumen emulsion into a second water phase containing the majority of solids present in the bitumen emulsion and a second oil phase containing the majority of bitumen present in the bitumen emulsion to produce a low solids content bitumen product

FIG. 2

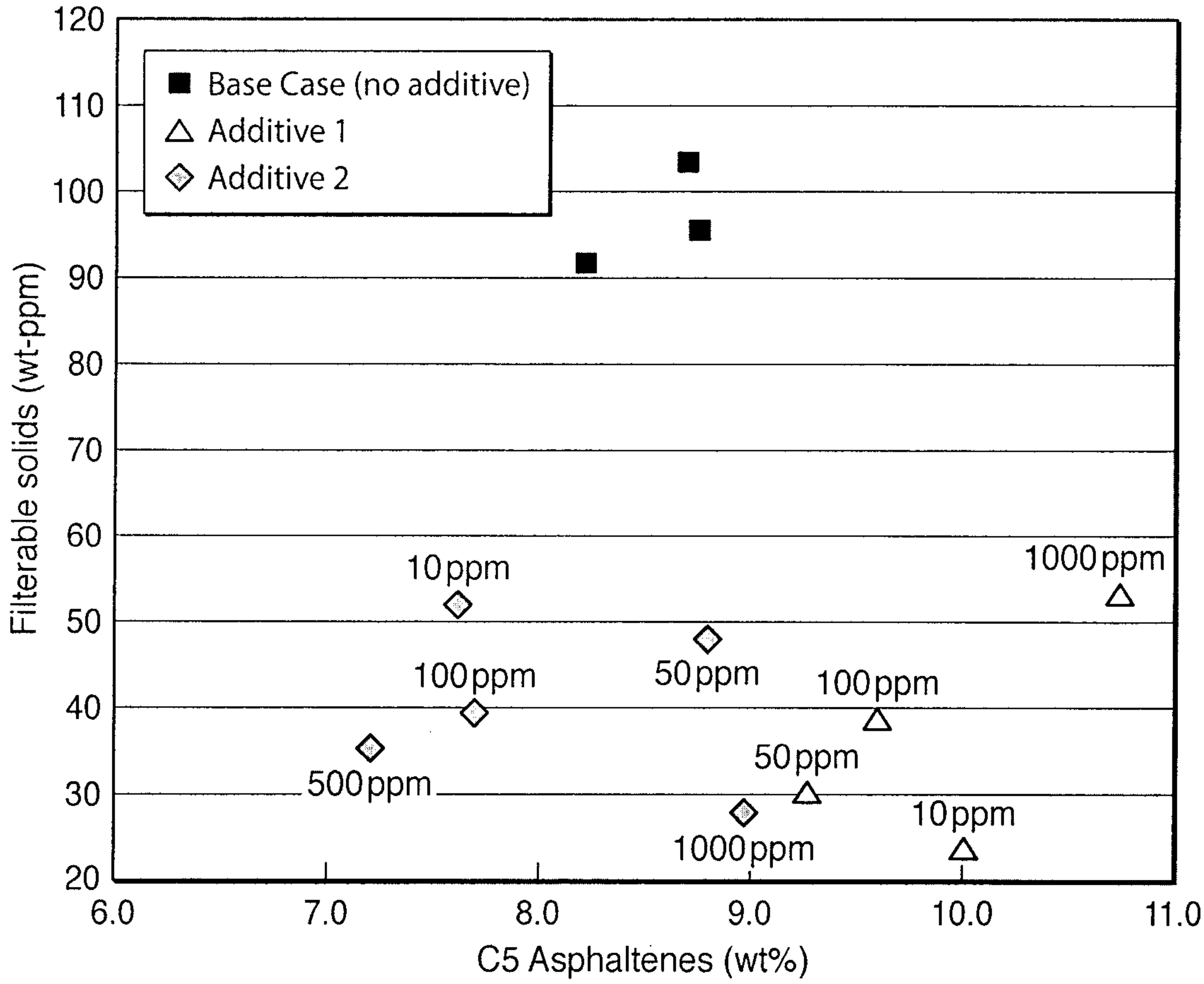
Base Case (no additive)
Additive 1
Additive 2
Filterable solids (wt-ppm)
C5 Asphaltenes (wt%)
120
110
100
90
80
70
60
50
40
30
20
6.0
7.0
8.0
9.0
10.0
11.0
10 ppm
100 ppm
500 ppm
50 ppm
1000 ppm
100 ppm
50 ppm
10 ppm
1000 ppm

FIG. 3