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(54) PROCESS FOR RECOVERING SOLVENT FROM ASHPHALTENE CONTAINING TAILINGS RESULTING FROM A SEPARATION PROCESS

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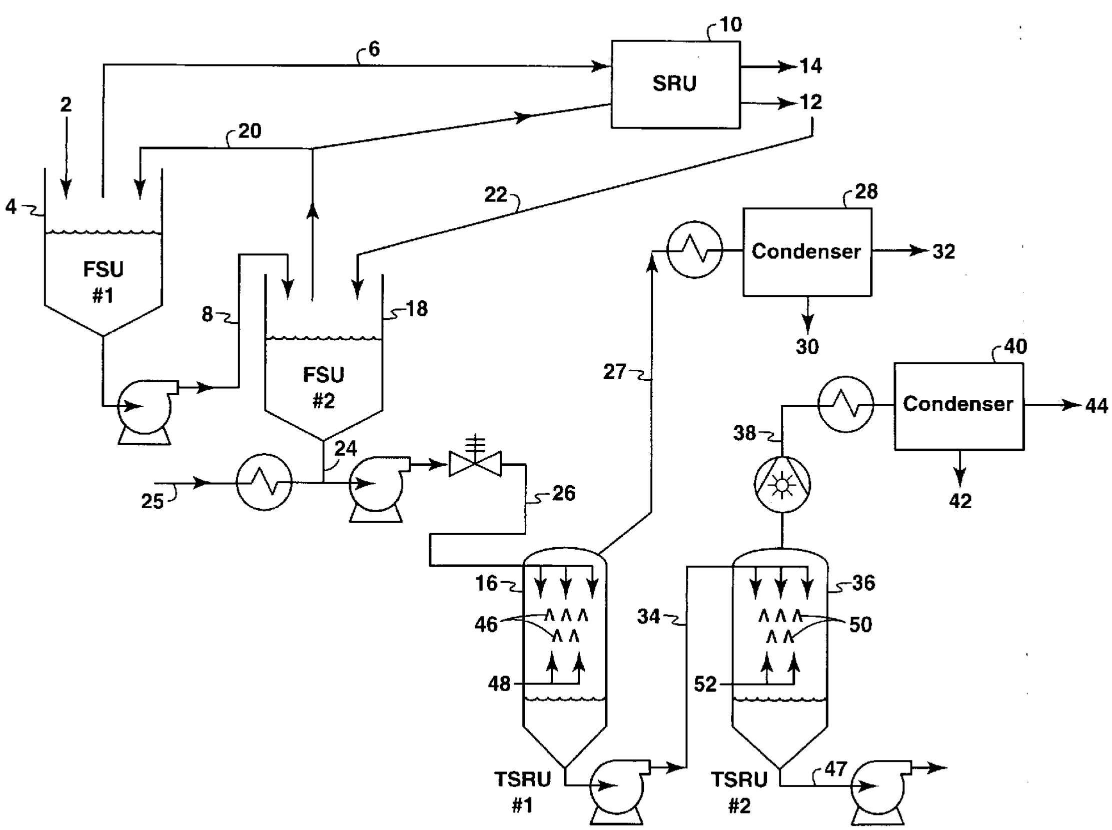
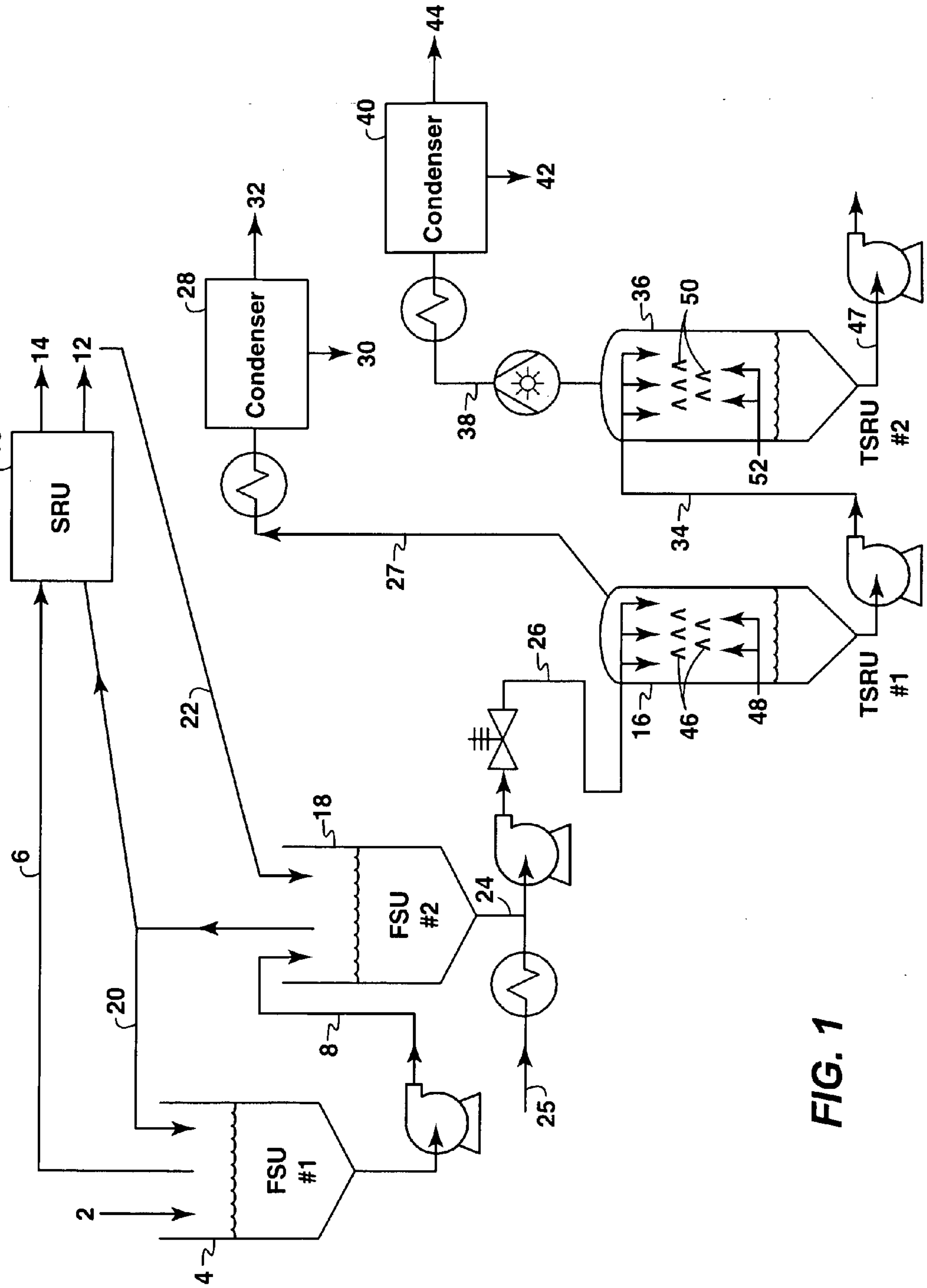
(57) ABSTRACT

A process for recovering paraffinic solvent from tailings produced in the treatment of bitumen froth comprising introducing the tailings into a tailings solvent recovery unit (TSRU), the TSRU having internals, and distributing the tailings over the internals. An inert gas or steam is then introduced below the internals and above the liquid pool for enhancing the vaporization of the contained solvent. Solvent is vaporized from asphaltene agglomerates. In one embodiment, the process is affected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene. In another aspect, the process comprises introducing the tailings into a first TSRU as described above and then into a second TSRU operated at a lower pressure. In another aspect, internals are optionally present and steam or inert gas is injected in the liquid pool.




SRU
10
14
12
6
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22
2
4
FSU #1
8
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FSU #2
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25
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46
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TSRU #1
27
Condenser
28
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50
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TSRU #2
38
47
Condenser
40
44
42

FIG. 1

PROCESS FOR RECOVERING SOLVENT FROM ASHPHALTENE CONTAINING TAILINGS RESULTING FROM A SEPARATION PROCESS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Canadian patent application number 2,587,166 which was filed on May 3, 2007.

FIELD OF THE INVENTION

[0002] The present invention relates generally to an improved process for recovering solvent from asphaltene containing tailings resulting from a separation process. More particularly, the invention relates to recovering paraffinic solvent from such tailings.

BACKGROUND OF THE INVENTION

[0003] The extraction of bitumen from mined oil sands involves the liberation and separation of bitumen from the associated sands in a form that is suitable for further processing to produce a marketable product. Among several processes for bitumen extraction, the Clark Hot Water Extraction (CHWE) process represents a well-developed commercial recovery technique. In the CHWE process, mined oil sands are mixed with hot water to create slurry suitable for extraction. Caustic is added to adjust the slurry pH to a desired level and thereby enhance the efficiency of the separation of bitumen. Recent industry developments have shown the feasibility of operating at lower temperatures and without caustic addition in the slurrying process.

[0004] Regardless of the type of water based oil sand extraction process employed, the extraction process will typically result in the production of a bitumen froth product stream comprising bitumen, water and fine solids (also referred to as mineral matter) and a tailings stream consisting of essentially coarse solids and some fine solids and water. A typical composition of bitumen froth is about 60 wt % bitumen, 30 wt % water and 10 wt % solids, with some variations to account for the extraction processing conditions. The water and solids in the froth are considered as contaminants and must be either essentially eliminated or reduced to a level suitable for feed to an oil refinery or an upgrading facility, respectively. The contaminants rejection process is known as a froth treatment process and is achieved by diluting the bitumen froth with a sufficient quantity of an organic solvent such as naphtha. There are two commercial approaches to reject the froth contaminants, namely naphtha based and paraffinic solvent based. Solvent addition (dilution) increases the density differential between bitumen and water and solids and as well enable the contaminants rejection using multi-stage gravity settling units. The separation schemes generally result in a bitumen diluted product and another tailings stream, commonly referred to as the froth treatment tailings, containing residual bitumen, residual solvent, solids and water. The froth treatment tailings stream must be processed further to recover the residual solvent and be suitable for disposal. Residual solvent recovery is dictated by both environmental and economic reasons. This recovery operation is referred to as a tailings solvent recovery process.

[0005] In the naphtha based separation, the resulting bitumen product contains 1 to 3 wt % water and <1.0 wt % solids and is not suitable for transporting through a common pipeline carrier. The addition of sufficient amounts of paraffinic solvent results in asphaltene precipitation, formation of aggregates with the contaminants (entrained water and carryover solids in the froth) and a rapid settling to provide a solids free dry bitumen product suitable for transportation in a common carrier and to refineries.

[0006] The addition of paraffinic solvent to bitumen froth and the resulting benefits are described in Canadian Patents Nos. 2,149,737 and 2,217,300. According to Canadian Patent No. 2,149,737, the efficiency (rate and extent) of removal of water and solids generally increases as (i) the carbon number or molecular weight of the paraffinic solvent decreases, (ii) the solvent to froth ratio increases, and (iii) the amount of aromatic and naphthene impurities in the paraffinic solvent decreases. The inventors further demonstrated that the separation of water and solids from the bitumen is achieved at temperatures above 30° C. The effect of temperature on bitumen recovery and bitumen product quality obtainable in this separation process was studied in a scale up pilot using natural gas condensate (NGC) which contains about 83% paraffin. While bitumen recovery was higher (97.6 vs. 83.8 wt %) if the run was conducted at 117° C., the product quality obtained was significantly lower (99.2 vs. 90.6 wt %) than obtained at 50° C. In accordance with the one of the discoveries stated above, the inventors used a relatively high solvent/froth ratio to obtain a better product quality with NGC in a continuous process but this test was done at 50° C. Although the inventors obtained a satisfactory product quality using pure paraffinic solvents at laboratory conditions and up to 80° C., it was not obvious such a result would be duplicated at a pilot scale continuous test unit due to uncertain hydrodynamics as well as increasing solubility of water in hydrocarbon at higher temperatures. In general, in a continuous separation, product quality and yield are inter-related and judicious fine-tuning of process parameters is required to establish optimum quality for a given yield. As discussed above, the froth treatment process must have a reliable and economic technique for solvent recovery from the tailings. However, the unique nature of the solvent-containing tailings makes solvent removal a challenge to the industry. Various processes have been devised for recovering solvent from solvent-containing tailings, some of which will now be described.

[0007] Canadian Patent No. 1,027,501 describes a process for treatment of tailings to recover naphtha. The process comprises introducing the tailings into a distributor at the upper end of the chamber of a vacuum flash vessel or tower maintained at 35 kPa, in order to flash the naphtha present in the tailings. The vessel is also equipped with a stack of internal shed decks for enhancing contact between stripping steam and the tailings feed. The steam is introduced at a point above the liquid pool in the vessel and below the stack of shed decks. The steam is intended to heat the flashed tailings as they pass down through the shed decks, to vaporize contained solvent and some water, for recovery as an overhead stream. In practice, however, this process results in only 60 to 65% recovery of the solvent; hence, a large amount of solvent is still being released to the environment.

[0008] Canadian Patent No. 2,272,045 describes a method for recovery of hydrocarbon solvent from tailings produced in a bitumen froth treatment plant comprising introducing the tailings into a steam stripping vessel maintained at near atmospheric pressure, the vessel having a plurality of interior, vertically spaced shed decks, and distributing the tailings over said shed decks. Steam is introduced below the shed decks for vaporizing the major portion of the contained solvent and some water. However, the tailings are free of asphaltenes according to page 4, lines 11 to 13. Canadian Patent No. 2,272,035 describes a process for recovery of hydrocarbon solvent from tailings produced in a bitumen froth treatment plant comprising introducing the tailings into a vacuum flash vessel maintained at a sufficiently low sub-atmospheric pressure to vaporize the major portion of the contained solvent and some water. The residuals then pool near the bottom of the flash vessel. Steam is then introduced into the tailings pool for vaporizing residual solvent and some water. However, as with Canadian Patent No. 2,272,045, discussed above, the tailings are free of asphaltenes according to page 4, lines 12 to 15. Thus, the inventors of these two patents did not have to contend with the challenges associated with having asphaltenes in the tailings. Certain of such challenges are discussed below with reference to Canadian Patent No. 2,353,109 and Canadian Patent Application No. 2,454,942.

[0009] Canadian Patent No. 2,353,109 describes a process for treating an underflow stream (or tailings) containing water, solvent, asphaltenes and solids, from one of the last separation steps in a paraffinic solvent process for separating bitumen from an oil sands froth, wherein a) the stream is introduced to a solvent recovery vessel that is substantially free of internals wherein the temperature and pressure are such that the solvent is normally a vapor; b) a pool of liquid and solids is maintained in the lower part of the vessel at a controlled level for sufficient time to allow the solvent to vaporize; c) the pool is agitated to the point where the asphaltenes are dispersed, submerged and prevented from re-agglomerating and the solids are maintained in suspension; d) the solvent is recovered as an overhead vapor stream; and e) the solvent depleted remainder of the stream is removed from the bottom of the vessel as a liquid slurry. Agitation is preferably effected by means of an impeller. An alternate agitation means is a pump-around circuit to pump the slurry from the top of the liquid pool to the lower part of the liquid pool or vice versa. The typical composition of this underflow stream is described as about 40 to 60 wt % water, about 15 to 35 wt % mineral solids (sand and clay), about 5 to 15 wt % entrained solvent, and about 10 to 15 wt % asphaltenes and unrecovered bitumen. Page 3, second full paragraph of that patent describes (a) that conventional solvent technology employs vessels with internals such as trays, packing and baffles; (b) that such internals provide the residence time required for the necessary solvent vaporization to take place; (c) that vessels with such internals are not practical for an underflow stream having the aforementioned composition; (d) that the aforementioned conventional approach is unworkable because of the accumulation of inorganic and organic solids and the fouling or plugging of vessel internals, lines and valves; and (e) that in that invention, the necessary residence time is achieved by having a liquid pool form in the lower part of the vessel. The invention teaches that agitation must be provided in or around the solvent recovery unit primarily to disperse or prevent the growth of aggregates of precipitated asphaltenes thereby enhancing the release of solvent from the precipitated asphaltenes to the vapor phase. In one embodiment, first and second stage solvent recovery vessels are used, where the second stage vessel is typically operated at a reduced pressure relative to the first stage vessel to reduce any amount of foam that may still be associated with the liquid slurry removed from the bottom of the first stage vessel. The second stage vessel is mechanically identical to the first stage vessel.

[0010] Canadian Patent Application No. 2,454,942 describes a process for solvent recovery from froth treatment tailings comprising water, particulate solids, and precipitated asphaltenes. According to the inventors, recycling a pre-determined portion of the solvent recovered tailings stream to the solvent recovery apparatus is necessary to maintain downward flux in the apparatus which inhibits accumulation of asphaltene mat in the solvent recovery unit and suppress the formation of foam. Furthermore, shearing conditions (provided by pumps, mixers or another apparatus) is preferably provided in the recycle circuit first, to break up asphaltene flocs/aggregates and second, to enhance recovery of solvent from the tailings. There is no introduction of steam or inert gas to vaporize solvent from the asphaltenes.

[0011] Thus, Canadian Patents Nos. 2,272,045 and 2,272,035 deal with solvent recovery from tailings that are free of asphaltenes. Canadian Patent No. 2,353,109 deals with solvent recovery without the use of internals. Canadian Patent Application No. 2,454,942 deals with solvent recovery without the introduction of steam or inert gas to vaporize solvent from the asphaltenes. Both of Canadian Patent No. 2,353,109 and Canadian Patent Application No. 2,454,942 deal with solvent recovery from tailings containing asphaltenes using agitation or shearing in or around the recovery vessel, so that the asphaltenes are dispersed, submerged and prevented from re-agglomerating.

SUMMARY OF THE INVENTION

[0012] It is an object of the present invention to obviate or mitigate at least one disadvantage of previous processes.

[0013] In a first aspect, the present invention provides a process for recovering paraffinic solvent from froth treatment tailings produced in the treatment of bitumen froth comprising: introducing the froth treatment tailings into a tailings solvent recovery unit (TSRU), the TSRU having internals, and distributing the froth treatment tailings over the internals to increase the surface area of the froth treatment tailings; introducing inert gas or steam below the internals so that it flows counter currently to the froth treatment tailings and heats the froth treatment tailings to vaporize at least a portion of the paraffinic solvent; and removing the vaporized solvent from the TSRU; wherein the froth treatment tailings contain asphaltenes; and wherein the at least a portion of the solvent is vaporized from asphaltene agglomerates.

[0014] Within this first aspect, the following embodiments may be included. The process may be affected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene. The TSRU may have an absolute pressure of about 100 and about 200 kPa. The internals may comprise a plurality of interior, vertically spaced shed decks. The internals may be coated with an asphaltene fouling resistant coating to mitigate fouling or plugging in the TSRU. The froth treatment tailings may contain at least 1.0 wt % asphaltenes, or at least 5.0 wt % asphaltenes. The inert gas or steam introduced below the internals may be introduced above a liquid level that forms in the bottom of the TSRU. The paraffinic solvent may be a C_4 to C_6 paraffinic hydrocarbon solvent. The paraffinic solvent may be pentane, iso-pentane, or a combination thereof. The temperature of the TSRU may be about 75 to about 100° C. The TSRU may have an absolute pressure of about 120 to about 170 kPa. The inert gas may be nitrogen, methane, carbon dioxide, argon, steam or any other inert gas that is not reactive under process conditions. The inert gas or steam to froth treatment tailings mass ratio may be about 1:1 to about 10:1. The process may further comprise: feeding tailings from the TSRU into a second TSRU maintained at an absolute pressure that is lower than the pressure of the TSRU recited above, the second TSRU having internals, and distributing the tailings from the TSRU over the internals to increase the surface area of the tailings from the TSRU; introducing inert gas or steam below the internals of the second TSRU so that it flows counter currently to the tailings from the TSRU and heats the tailings from the TSRU to vaporize at least a portion of the paraffinic solvent; and removing the vaporized solvent from the second TSRU. The second TSRU may have an absolute pressure of about 20 to about 200 kPa. The internals of the second TSRU may comprise a plurality of interior, vertically spaced shed decks. The inert gas or steam introduced below the internals in the second TSRU may be introduced above a liquid level that forms in the bottom of the second TSRU. The second TSRU may have an absolute pressure of about 35 kPa to about 125 kPa, or about 35 kPa to about 100 kPa. The temperature of the second TSRU may be about 75 to about 100° C.

[0015] In a second aspect, the present invention provides a process for recovering paraffinic solvent from froth treatment tailings produced in the treatment of bitumen froth comprising: introducing the froth treatment tailings into a first tailings solvent recovery unit (TSRU), the first TSRU having internals; distributing the froth treatment tailings over the internals to increase the surface area of the froth treatment tailings; introducing inert gas or steam below the internals so that it flows counter currently to the froth treatment tailings and heats the froth treatment tailings to vaporize at least a portion of the paraffinic solvent; removing the vaporized solvent from the first TSRU; feeding tailings from the first TSRU into a second TSRU maintained at an absolute pressure that is lower than the pressure of the first TSRU, the second TSRU having internals; distributing the tailings from the first TSRU over the internals of the second TSRU to increase the surface area of the tailings from the first TSRU; introducing inert gas or steam below the internals of the second TSRU so that it flows counter currently to the tailings from the first TSRU and heats the tailings from the first TSRU to vaporize at least a portion of the paraffinic solvent; and removing the vaporized solvent from the second TSRU.

[0016] Within this second aspect, the following embodiments may be included. The TSRU may have an absolute pressure of about 100 and 200 kPa and the second TSRU may have an absolute pressure of 20 to 200 kPa. The internals may comprise interior, vertically spaced shed decks. The insert gas or steam introduced below the internals may be introduced above a liquid level in the first and second TSRU's. The froth treatment tailings may contain asphaltenes, at least a portion of the solvent may be vaporized from asphaltene agglomerates, and the process may be affected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene. The froth treatment tailings may contain at least 1.0 wt % asphaltenes, or at least 5.0 wt % asphaltenes. The paraffinic solvent may be a C_4 to C_6 paraffinic hydrocarbon solvent. The paraffinic solvent may be pentane, iso-pentane, or a combination thereof.

[0017] In a third aspect, the present invention provides a process for recovering paraffinic solvent from froth treatment tailings produced in the treatment of bitumen froth comprising: introducing the froth treatment tailings into a tailings solvent recovery unit (TSRU); introducing inert gas or steam into a liquid pool formed in the bottom of the TSRU to vaporize at least a portion of the paraffinic solvent; and removing the vaporized solvent from the TSRU; wherein the froth treatment tailings contain asphaltenes; and wherein the at least a portion of the solvent is vaporized from asphaltene agglomerates.

[0018] Within this third aspect, the following embodiments may be included. The TSRU may be substantially free of internals. The process may be affected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene. The froth treatment tailings may contain at least 1.0 wt % asphaltenes, or at least 5.0 wt % asphaltenes. The TSRU may have an absolute pressure of about 20 and about 200 kPa. The paraffinic solvent may be a C_4 to C_6 paraffinic hydrocarbon solvent. The paraffinic solvent may be pentane, iso-pentane, or a combination thereof. The temperature of the TSRU may be about 75 to about 100° C. The process may further comprise feeding tailings from the TSRU into a second TSRU maintained at an absolute pressure that is lower than the pressure of the TSRU recited above.

[0019] Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figure, wherein:

[0021] FIG. **1** is a schematic of a diluted bitumen froth treatment process, including a tailings solvent recovery process according to an embodiment of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0022] Generally, the present invention provides, in one aspect, a process for recovering paraffinic solvent from tailings produced in the treatment of bitumen froth comprising introducing the tailings into a tailings solvent recovery unit (TSRU), the TSRU having internals, and distributing the tailings over the internals. An inert gas or steam is then introduced below the internals for enhancing the vaporization of the contained solvent. Solvent is vaporized from asphaltene agglomerates. In one embodiment, the process is affected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene. In another aspect, the process comprises introducing the tailings into a first TSRU as described above and then into a second TSRU operated at a lower pressure.

[0023] It has been shown that prior art methods of agitation or use of shearing devices in the recovery of solvent from diluted tailings containing asphaltene agglomerates actually results in significant increase in operability problems such as plugging and fouling as well as lower solvent recovery.

[0024] FIG. **1** is a schematic of a diluted bitumen froth treatment process, including a tailings solvent recovery process according to an embodiment of the present invention. The paraffinic solvent diluted bitumen froth (**2**) enters froth separation unit FSU (**4**).

[0025] The diluted bitumen froth (**2**) may be produced in a number of ways known in the art and comprises bitumen, asphaltenes, mineral solids, water, and a paraffinic solvent.

[0026] The diluted bitumen froth (**2**) contains a paraffinic solvent because such a solvent has been added to a bitumen froth to induce precipitation of a portion of the asphaltenes present in bitumen, aggregation with water droplets and solids present in froth and settling rapidly in a gravity settler (FSU).

[0027] The term "paraffinic solvent" (also known as aliphatic) as used herein means solvents containing normal paraffins, isoparaffins and blends thereof in amounts greater than 50 wt %. Presence of other components such as olefins, aromatics or naphthenes counteract the function of the paraffinic solvent and hence should not be present more than 1 to 20 wt % combined and preferably, no more than 3 wt % is present. The paraffinic solvent may be a C_4 to C_{20} paraffinic hydrocarbon solvent or any combination of iso and normal components thereof. In one embodiment, the paraffinic solvent comprises pentane, iso-pentane, or a combination thereof. In one embodiment, the paraffinic solvent comprises about 60 wt % pentane and about 40 wt % iso-pentane, with none or less than 20 wt % of the counteracting components referred above.

[0028] By using a blend of pure paraffins and operating at a temperature range of 70 to 90° C. in a continuous separation unit as shown in FIG. **1**, it is possible to achieve both a high quality (containing <0.01 wt %, or at least <0.5 wt. %, water+solids) and a high yield (98 wt %) bitumen product.

[0029] With the addition of a sufficient amount of paraffinic solvent, and by way of gravity settling, the diluted bitumen froth (**2**) separates in FSU (**4**) into a diluted bitumen component (**6**) comprising bitumen and solvent and a froth treatment tailings component (**8**) comprising mainly of water, mineral matter, precipitated asphaltenes, solvent, and very small amounts of unrecovered bitumen. The tailings stream (**8**) may be withdrawn from the bottom of FSU (**4**), which may be conical. In one embodiment, FSU (**4**) operates at a temperature of about 60° C. to about 80° C., or about 70° C. In one embodiment, FSU (**4**) operates at a pressure of about 700 to about 900 kPa, or about 800 kPa.

[0030] Diluted bitumen component (**6**) is passed through a solvent recovery unit, SRU (**10**), such as a conventional fractionation vessel or other suitable apparatus in which the solvent (**12**) is flashed off and condensed in a condenser associated with the solvent flashing apparatus and recycled/reused in the process. The solvent free bitumen product (**14**) is then stored or transported for further processing in a manner well known in the art.

[0031] Froth treatment tailings component (**8**) may be passed directly to the tailings solvent recovery unit, TSRU, (**16**) or may, as shown in FIG. **1**, first be passed to a second FSU (**18**). Diluted tailings component (**8**) may typically comprise approximately 50 to 70 wt % water, 15 to 25 wt % mineral solids, and 5 to 25 wt % hydrocarbons. The hydrocarbons comprise asphaltenes (for example 2.0 to 12 wt % or 9 wt % of the tailings), bitumen (for example about 7.0 wt % of the tailings), and solvent (for example about 8.0 wt % of the tailings). In further embodiments, the tailings comprise greater than 1.0, greater than 2.0, greater than 3.0, greater than 4.0, greater than 5.0, or greater than 10.0 wt % asphaltenes.

[0032] Tailings component (**8**) is a tailings stream generated in a paraffinic-based bitumen froth treatment process or other separation process and while certain means resulting in a froth treatment tailings component have been described above, the present invention is not limited thereby.

[0033] FSU (**18**) performs generally the same function as FSU (**4**). The operating temperature of FSU (**18**) may be higher than that of FSU (**4**) and may be between about 80° C. and about 100° C., or about 90° C. In one embodiment, FSU (**18**) operates at a pressure of about 700 to about 900 kPa, or about 800 kPa. A diluted bitumen component stream (**20**) comprising bitumen and solvent is removed from FSU (**18**) and is either sent to FSU (**4**) feed for use as solvent to induce asphaltene separation or is passed to SRU (**10**), or to another SRU, for treatment in the same way as the diluted bitumen component (**6**). The ratio of solvent:bitumen in diluted bitumen component (**20**) may be, for instance, 1.4 to 30:1, or about 20:1 in the configuration shown in FIG. **1**. Alternatively, diluted bitumen component (**20**) may be partially passed to FSU (**4**) and partially passed to SRU (**10**), or to another SRU. Solvent (**12**) from SRU **10** may be combined with the diluted tailing stream (**8**) into FSU (**18**), shown as stream (**22**), or returned to a solvent storage tank (not shown) from where it is recycled to make the diluted bitumen froth stream (**2**), thus, streams (**20**) and (**22**) show recycling. In the art, solvent or diluted froth recycling steps are known such as described in Canadian Patent No. 2,021,185.

[0034] The froth treatment tailings (**8**) or tailings component (**24**) (with a composition similar to underflow stream (**8**) but having less bitumen and solvent), is combined with dilution water (**25**) to form diluted tailings component (**26**) and is sent to TSRU (**16**). The dilution water may be at about 70° C. to about 95° C., or about 90° C. and the addition rate may vary between 0.5 to 2.0 times the mass of the tailings stream (**8**) or (**24**). Diluted tailings component (**26**) may be pumped from the FSU (**18**) or FSU (**4**) (for a single stage FSU configuration) to TSRU (**16**) at the same temperature and pressure in FSU (**18**) or FSU (**4**), as the case may be. A backpressure control valve may be used before an inlet into TSRU (**16**) to prevent solvent flashing prematurely in the transfer line between FSU (**18**) and TSRU (**16**). The operation of TSRU (**16**) is discussed in more detail below.

[0035] Flashed solvent vapor and steam (together **27**) is sent from TSRU (**16**) to a condenser (**28**) for condensing both water (**30**) and solvent (**32**). Recovered solvent (**3**) may be reused in bitumen froth treatment. Tailings component (**34**) may be sent directly from TSRU (**16**) to a tailings storage area for future reclamation or, as shown in FIG. **1**, may be sent to TSRU (**36**). Tailings component (**34**) contains mainly water, asphaltenes, mineral matter, and small amount of solvent as well as unrecovered bitumen. Solvent vapor and steam (together **38**) are sent from TSRU (**36**) to a condenser (**40**). Water (**42**) and solvent are condensed in the condenser (**40**) resulting in recovered solvent (**44**). As with recovered solvent (**32**), recovered solvent (**44**) may be reused in the same manner as stream (**32**). Tailings (**47**) from TSRU (**36**) may be further treated or may be sent to a tailings storage area for future reclamation.

[0036] TSRU (**16**) and TSRU (**36**) will now be discussed in further detail. TSRU (**16**) is a flash vessel or drum maintained at an absolute pressure of about 100 to about 200 kPa (or about 120 to about 170 kPa, or about 140 kPa). This TSRU may be operated at a temperature of about 75° C. to about 100° C., and has internals **46**. In FIG. **1**, the internals (**46**) are illustrated as a plurality of interior, vertically spaced shed decks. Internals (**46**) (and internals (**50**) described below) may alternatively be trays, packing, baffles or other such internals known in the art. The diluted tailings component (**26**) is distributed over the internals (**46**) to increase the surface area of the diluted tailings component (**26**). Below the internals (**46**) is a ring (not shown) having a plurality of openings for the release of inert gas or steam (**48**). The inert gas or steam (**48**) counter currently contacts the downward flowing diluted tailings component (**26**) distributed over the internals **46** and provide both the necessary heat for vaporizing the solvent and a driving force for the vaporized solvent to the vapor phase. The internals (**46**) ensure that the diluted tailings stream is spread relatively uniformly over a large surface area that can be subsequently exposed to inert gas or steam. A distributor (not shown), having a plurality of openings, may be used to evenly distribute diluted tailings component (**26**) over the internals (**46**). The surface of the internals (**46**) may be covered with a suitable coating, such as an asphaltene fouling resistant coating, to mitigate or eliminate fouling and plugging.

[0037] An inert gas or steam (**48**) is introduced below the internals (**46**), and above a tailings liquids pool in the bottom of TSRU (**16**), so that it flows counter currently diluted tailings component (**26**) and heats diluted tailings component (**26**) to vaporize the paraffinic solvent and some water. The mass of inert gas or steam addition rate may vary between 1 to 10 times the mass of the solvent depleted tailings flow from TSRU (**16**). Vaporized solvent and steam (together **27**) is removed from the TSRU (**16**) as discussed above.

[0038] As the solvent depleted slurry leaves the last layer of internals (**46**), it is collected in a conical section of TSRU (**16**) to allow for pumping from the bottom of TSRU (**16**) at a steady flow rate to either a final disposal area or to TSRU (**36**) for additional solvent recovery. The conical arrangement creates a pool of liquid slurry. The slurry is removed from the TSRU, as tailings component (**34**), using a pump in a conventional manner to the final disposal area or TSRU (**36**). Tailings component (**34**) may have about the same composition of diluted tailings component (**26**) minus the solvent recovered (**32**).

[0039] TSRU (**36**) operates in generally the same manner as TSRU (**16**) but is maintained at an absolute pressure of about 20 to about 200 kPa (or about 35 to about 125 kPa, or about 35 to about 100 kPa, or about 50 kPa). The operating pressure of TSRU (**36**) is lower than the pressure of TSRU (**16**). That is, TSRU (**36**) may be operated below atmospheric pressure. TSRU (**36**) may be operated at about 75° C. to about 100° C., or about 82° C. to about 90° C., or about 85° C. to about 90° C., or about 90° C. Because TSRU (**36**) may be operated at lower pressures and at below atmospheric pressure, TSRU (**36**) may be operated at lower temperatures, for instance about 65° C. to about 80° C., or about 70° C. As with TSRU (**16**), the internals (**50**) of TSRU (**36**) are illustrated as a plurality of interior, vertically spaced shed decks. Inert gas or steam (**52**) may be introduced below the internals (**50**), and above a tailings pool in the bottom of TSRU (**36**).

[0040] A third TSRU could also be used in series and, in each subsequent stage; the operating pressure may be lower than the previous one to achieve additional solvent recovery. In fact, more than three TSRU's could be used.

[0041] In one embodiment, one, two, or more than two TSRU's are used where the froth treatment tailings solvent recovery is affected in the absence of "mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene". The term "agglomerates" as used herein is not limited by shape and includes flocs and aggregates. The term "substantially" is used here to exclude means that does not, to a substantial extent, mechanically break up asphaltene agglomerates or prevent the agglomeration of asphaltene. Non-limiting examples of "mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene" are the agitation means described Canadian Patent No. 2,353,109 where the tailings pool is agitated to the point where the asphaltenes are dispersed, submerged and prevented from re-agglomerating and the solids are maintained in suspension. In that patent, agitation may be effected by a mechanical impeller, or an alternate agitation means, such as a pump-around circuit to pump the slurry from the top of the liquid pool to the lower part of the liquid pool or vice versa. Another non-limiting example of such means are the shearing conditions provided by pumps, mixers or other apparatuses, described in Canadian Patent Application No. 2,454,942, which are said to be preferably provided in the recycle circuit first, to break up asphaltene flocs/aggregates and second, to enhance recovery of solvent from the tailings. The "mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene" does not include means, the purpose of which is unrelated to breaking up asphaltene agglomerates or to preventing agglomeration of asphaltenes, such as a pump disposed before or after the TSRU as shown herein.

[0042] Water may be recovered from the solvent depleted tailings stream (**34** or **47**) downstream of the slurry pump and may be recycled for re-use upstream of the tailing solvent recovery unit in order to recover valuable heat contained in the water, thus reducing the energy requirements of the process. For example, recovered water may be combined with the dilution water (**25**) upstream of the tailings solvent recovery unit but this is not to provide additional agitation to the unit.

Example 1

[0043] In a small scale pilot test, a run was operated at about atmospheric pressure without shearing or agitation in or around TSRU (**16**) with internals (**46**) and successfully resulted in solvent loss of less than 2.8 bbl per thousand barrels of bitumen product (**6**). The addition of steam resulted in a further reduction to less than 1.0 bbl of solvent loss per thousand barrels of bitumen product. A typical TSRU (**16**) tailings (**34**) sample was then subjected laboratory scale vacuum separation tests to simulate the performance of the second stage TSRU (**36**). These results are shown in Table 1.

TABLE 1

Solvent Recovery Performance

Pressure (atm · abs)	Average solvent content (wt %)	Solvent Loss (bbl/ 1000 bbls of bitumen)
1.00	0.028	1.18
0.79	0.024	0.97
0.59	0.015	0.63

[0044] Pumps are used to maintain a specified level in each TSRU and the vessels are sized to maintain a high downward velocity of the slurry.

[0045] As discussed herein, it has been discovered that recovery of solvent from asphaltene agglomerates in a TSRU is effective without agitation in or around the TSRU. Thus, mechanical means used to substantially physically break up asphaltene agglomerates or to prevent the agglomeration of asphaltene may be omitted. In addition to the embodiments discussed herein using internals, in another embodiment, there is provided a process for recovering paraffinic solvent from froth treatment tailings produced in the treatment of bitumen froth comprising: introducing the froth treatment tailings into a tailings solvent recovery unit (TSRU) (which may or may not have internals); introducing inert gas or steam into a liquid pool formed in the bottom of the TSRU to vaporize at least a portion of the paraffinic solvent; and removing the vaporized solvent from the TSRU; wherein the froth treatment tailings contain asphaltenes; and wherein the at least a portion of the solvent is vaporized from asphaltene agglomerates. In one embodiment, the process is affected in the absence of mechanical means used to substantially physically break up asphaltene agglomerates or to prevent the agglomeration of asphaltene.

[0046] The phrase "to vaporize at least a portion of the paraffinic solvent" is used herein to make clear that not all of the solvent is necessarily vaporized. In certain embodiments, the percentage, by volume, of solvent that is vaporized is: at least 70%, at least 80%, at least 90%, at least 95%, at least 98%, at least 99%, at least 99.5%, at least 99.9%, or at least 99.9%.

[0047] In the preceding description, for purposes of explanation, numerous details are set forth in order to provide a thorough understanding of the embodiments of the invention. However, it will be apparent to one skilled in the art that these specific details are not required in order to practice the invention

[0048] The above-described embodiments of the invention are intended to be examples only. Alterations, modifications and variations can be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.

What is claimed is:

1. A process for recovering paraffinic solvent from froth treatment tailings produced in the treatment of bitumen froth comprising:

introducing the froth treatment tailings into a tailings solvent recovery unit (TSRU), the TSRU having internals, and distributing the froth treatment tailings over the internals to increase the surface area of the froth treatment tailings;

introducing inert gas or steam below the internals so that it flows counter currently to the froth treatment tailings and heats the froth treatment tailings to vaporize at least a portion of the paraffinic solvent; and

removing the vaporized solvent from the TSRU;

wherein:

the froth treatment tailings contain asphaltenes; and

the at least a portion of the solvent is vaporized from asphaltene agglomerates.

2. The process of claim **1**, wherein the process is affected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene.

3. The process of claim **1**, wherein the TSRU has an absolute pressure of about 100 and about 200 kPa.

4. The process of claim **1**, wherein the internals comprise a plurality of interior, vertically spaced shed decks.

5. The process of claim **1**, wherein the internals are coated with an asphaltene fouling resistant coating to mitigate fouling or plugging in the TSRU.

6. The process of claim **1**, wherein the froth treatment tailings contain at least 1.0 wt % asphaltenes.

7. The process of claim **1**, wherein the froth treatment tailings contain at least 5.0 wt % asphaltenes.

8. The process of claim **1**, wherein the inert gas or steam introduced below the internals is introduced above a liquid level that forms in the bottom of the TSRU.

9. The process of claim **1**, wherein the paraffinic solvent is a C_4 to C_6 paraffinic hydrocarbon solvent.

10. The process of claim **1**, wherein the paraffinic solvent is pentane, iso-pentane, or a combination thereof.

11. The process of claim **1**, wherein the temperature of the TSRU is about 75 to about 100° C.

12. The process of claim **1**, wherein the TSRU has an absolute pressure of about 120 to about 170 kPa.

13. The process of claim **1**, wherein the inert gas is nitrogen, methane, carbon dioxide, argon, steam or any other inert gas that is not reactive under process conditions.

14. The process of claim **1**, wherein the inert gas or steam to froth treatment tailings mass ratio is about 1:1 to about 10:1.

15. The process of claim **1**, further comprising feeding tailings from the TSRU into a second TSRU maintained at an absolute pressure that is lower than the pressure of the TSRU recited in claim **1**, the second TSRU having internals, and distributing the tailings from the TSRU over the internals to increase the surface area of the tailings from the TSRU; introducing inert gas or steam below the internals of the second TSRU so that it flows counter currently to the tailings from the TSRU and heats the tailings from the TSRU to vaporize at least a portion of the paraffinic solvent; and removing the vaporized solvent from the second TSRU.

16. The process of claim **15**, wherein the second TSRU has an absolute pressure of about 20 to about 200 kPa.

17. A process for recovering paraffinic solvent from froth treatment tailings produced in the treatment of bitumen froth comprising:

introducing the froth treatment tailings into a first tailings solvent recovery unit (TSRU), the first TSRU having internals;

distributing the froth treatment tailings over the internals to increase the surface area of the froth treatment tailings;

introducing inert gas or steam below the internals so that it flows counter currently to the froth

treatment tailings and heats the froth treatment tailings to vaporize at least a portion of the paraffinic solvent;

removing the vaporized solvent from the first TSRU;

feeding tailings from the first TSRU into a second TSRU maintained at an absolute pressure that is lower than the pressure of the first TSRU, the second TSRU having internals;

distributing the tailings from the first TSRU over the internals of the second TSRU to increase the surface area of the tailings from the first TSRU;

introducing inert gas or steam below the internals of the second TSRU so that it flows counter currently to the tailings from the first TSRU and heats the tailings from the first TSRU to vaporize at least a portion of the paraffinic solvent; and

removing the vaporized solvent from the second TSRU.

18. The process of any one of claims **22** to **25**, wherein the froth treatment tailings contain asphaltenes; wherein the at least a portion of the solvent is vaporized from asphaltene agglomerates; and wherein the process is effected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene.

19. A process for recovering paraffinic solvent from froth treatment tailings produced in the treatment of bitumen froth comprising:

introducing the froth treatment tailings into a tailings solvent recovery unit (TSRU);

introducing inert gas or steam into a liquid pool formed in the bottom of the TSRU to vaporize at least a portion of the paraffinic solvent; and

removing the vaporized solvent from the TSRU;

wherein:

the froth treatment tailings contain asphaltenes; and

the at least a portion of the solvent is vaporized from asphaltene agglomerates.

20. The process of claim **19**, wherein the TSRU is substantially free of internals.

21. The process of claim **19**, wherein the process is effected in the absence of mechanical means used to substantially break up asphaltene agglomerates or to prevent the agglomeration of asphaltene.

22. The process of claim **19**, wherein the froth treatment tailings contain at least 1.0 wt % asphaltenes.

23. The process of claim **19**, wherein the froth treatment tailings contain at least 5.0 wt % asphaltenes.

24. The process of claim **19**, wherein the TSRU has an absolute pressure of about 20 and about 200 kPa.

25. The process of claim **19**, wherein the paraffinic solvent is a C_4 to C_6 paraffinic hydrocarbon solvent.

26. The process of claim **19**, wherein the paraffinic solvent is pentane, iso-pentane, or a combination thereof.

27. The process of claim **19**, wherein the temperature of the TSRU is about 75 to about 100° C.

28. The process of claim **19**, further comprising feeding tailings from the TSRU into a second TSRU maintained at an absolute pressure that is lower than the pressure of the TSRU recited in claim **19**.

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