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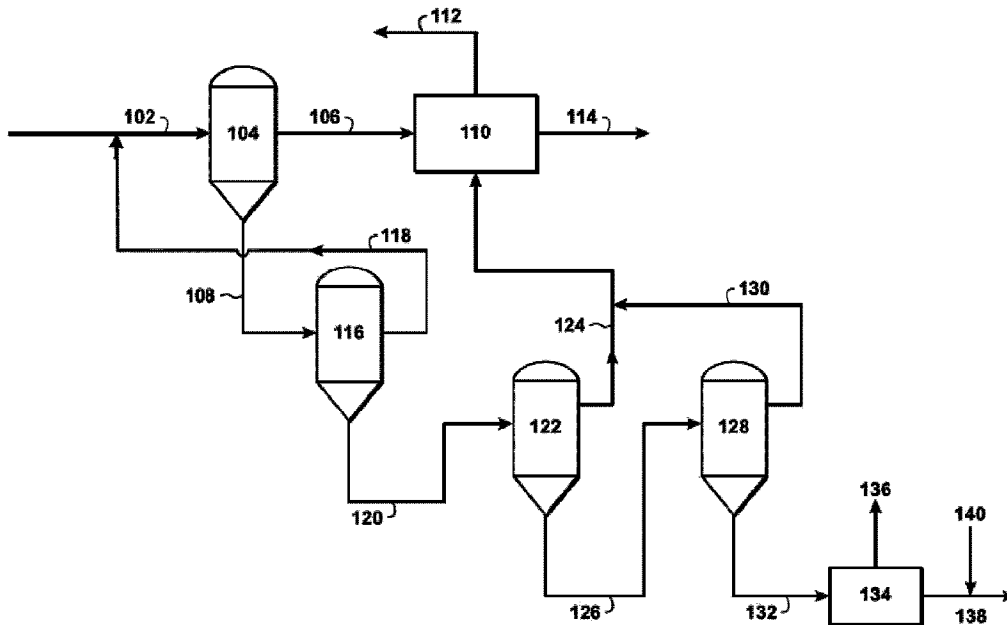
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(54) **Titre :** SEPARATION D'EAU TIEDE DE RESIDUS DE MOUSSE

(54) **Title:** SEPARATION OF WARM WATER FROM FROTH TAILINGS



(57) **Abrégé/Abstract:**

A process for recovering heat from a bitumen froth tailings stream, the process comprising operating with the bitumen froth tailings stream between 52 C and 70 C such that an insulating layer is present in a lower portion of the bitumen froth tailings stream; removing warm water, with a temperature between 52 C and 70 C, from an upper portion of the bitumen froth tailings stream, above the insulating layer; adding colder water, with a temperature less than 52 C, to the bitumen froth tailings stream; and adding at least a portion of the warm water upstream of the bitumen froth tailings stream to a bitumen process.

ABSTRACT

A process for recovering heat from a bitumen froth tailings stream, the process comprising operating with the bitumen froth tailings stream between 52°C and 70°C such that an insulating layer is present in a lower portion of the bitumen froth tailings stream; removing warm water, with a temperature between 52°C and 70°C, from an upper portion of the bitumen froth tailings stream, above the insulating layer; adding colder water, with a temperature less than 52°C, to the bitumen froth tailings stream; and adding at least a portion of the warm water upstream of the bitumen froth tailings stream to a bitumen process.

SEPARATION OF WARM WATER FROM FROTH TAILINGS

BACKGROUND

Field of Disclosure

[0001] The disclosure relates generally to the field of oil sand processing, and more particularly to bitumen froth tailings treatment.

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) or as a water-based oil sand extraction process. WBE is a commonly used process to extract bitumen from mined oil sand.

[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 WBE process, a water and oil sand slurry is separated into three major streams in the PSC: bitumen froth, middlings, and a PSC underflow (also referred to as coarse sand tailings (CST)).

[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, pentanes, hexanes, and heptanes) is used to dilute the froth before separating the product, diluted bitumen, by gravity. A portion of the asphaltenes in the bitumen is also rejected by design in the PFT process and this rejection is used to achieve

reduced solids and water levels. In both the NFT and the PFT processes, the diluted tailings (comprising water, solids and some hydrocarbon) are separated from the diluted product bitumen.

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

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

[0011] From the PSC, the middlings, which may comprise 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 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 the TSRU, solvent is removed to produce TSRU tailings, also called froth tailings or bitumen froth tailings. It would be desirable to recover heat from such tailings.

SUMMARY

[0013] A process is disclosed for recovering heat from a bitumen froth tailings stream, the process comprising operating with the bitumen froth tailings stream between 52°C and 70°C such that an insulating layer is present in a lower portion of the bitumen froth tailings stream; removing warm water, with a temperature between 52°C and 70°C, from an upper portion of the bitumen froth tailings stream, above the insulating layer; adding colder water,

with a temperature less than 52°C, to the bitumen froth tailings stream; and adding at least a portion of the warm water upstream of the bitumen froth tailings stream to a bitumen process.

[0014] 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

[0015] 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.

[0016] Figure 1 is a schematic of a bitumen froth separation process, in particular a paraffinic froth treatment process, including a warm water recovery process.

[0017] Figure 2 is a graph of temperature profile measurements made across a diameter of froth tailings in a tailings pipe.

[0018] Figure 3 is a graph of the wt. % of bitumen in froth tailings samples taken from a tailings pipe.

[0019] Figure 4 is a graph of the wt. % of solids in froth tailings samples taken from a tailings pipe.

[0020] It should be noted that the figures are merely examples and no limitations on the scope of the present disclosure is 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

[0021] 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.

[0022] 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.

[0023] Throughout this disclosure, where a range is used, any number between or inclusive of the range is implied.

[0024] 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.

[0025] “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.

[0026] “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, as well as lighter materials that may be found in a sand or carbonate reservoir. 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.

[0027] “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.

[0028] “Coarse particles” are generally defined as those solids having a size of greater than 44 microns (μm).

[0029] The term “solvent” as used in the present disclosure should be understood to mean either a single solvent, or a combination of solvents.

[0030] 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.

[0031] 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.

[0032] 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 C₄ to C₂₀ or C₄ to C₆ paraffinic hydrocarbon solvent or a combination of iso and normal components thereof. The paraffinic solvent may comprise pentanes, hexanes, and heptanes.

[0033] The term “bitumen froth tailings stream” means a tailings stream from a bitumen froth separation process, in particular from a paraffinic froth treatment process producing asphaltenes. In certain aspects, a bitumen froth tailings stream may be a tailings stream from a tailings solvent recovery unit (TSRU).

[0034] The term “insulating layer” means a layer within a tailings stream having a different thermal conductivity profile than a remaining part of the tailings stream. For instance, an insulating layer may form within a tailings stream within a pipe or pump box. An insulating layer may generally comprise asphaltenes.

[0035] As described above, in the TSRU, solvent is removed to produce TSRU tailings, also called bitumen froth tailings or froth tailings, and it would be desirable to recover heat from such tailings.

[0036] Temperature profile measurements were made across a diameter of froth tailings within a tailings pipe. The results are illustrated in Figure 2 and described below. An insulating layer was surprisingly observed at the bottom of the tailings pipe when the operating temperature was between 52°C and 70°C. This behaviour may be due to an in-pipe separation of a hydrocarbon phase (insulating layer), which may generally comprise asphaltenes, from the remainder of the tailings at this temperature, and deposition of the insulating layer at the bottom of the pipe. Without wishing to be bound by theory, it is believed when asphaltenes are present that this separation relates to the complexity of asphaltene structure and properties at different temperatures. It is further believed that normal fluids will have a lower viscosity at higher temperatures, and less chance of deposition. It has surprisingly been discovered that these tailings separation findings can be leveraged by recovering warm water from the tailings stream and recycling it to the bitumen recovery process.

[0037] It is interesting to note that the temperature profile measurements were made, not to evaluate the possibility of recovering heat, but to investigate process upsets. Prior to the observation of the tailings separation, the present inventors did not see an option for recovering warm water from the tailings as the tailings were presumed to be more uniform across the diameter of the pipe and thus not efficiently separable.

[0038] Thus, a process is disclosed for recovering heat from a bitumen froth tailings stream. The process comprises: a) operating with the bitumen froth tailings stream between 52°C and 70°C such that an insulating layer is present in a lower portion of the bitumen froth tailings stream; b) removing warm water, with a temperature between 52°C and 70°C, from an upper portion of the bitumen froth tailings stream, above the insulating layer; c) adding colder water, with a temperature less than 52°C, to the bitumen froth tailings stream; and d) adding at least a portion of the warm water upstream of the bitumen froth tailings stream to a bitumen process.

[0039] The tailings separation described above is observed when the tailings are between 52°C and 70°C. Thus, the removed warm water is between 52°C and 70°C. While the warm water is advantageously removed to recover its heat, colder water below 52°C is added in its stead. For instance, the colder water may be below 50°C, or below 40°C. The process may also be operated with the bitumen froth tailings stream between 52°C and 65°C.

[0040] The warm water may be removed using a take-off pipe at an angle from the main tailings pipe. The warm water flow and composition may be controlled using a valve on the take-off.

[0041] Steps b) and c) may be performed while the bitumen froth tailings stream is in a pipe.

[0042] Steps b) and c) may be performed while the bitumen froth tailings stream is in a pump box downstream of a tailings solvent recovery unit (TSRU).

[0043] Steps b) and c) may be performed while the bitumen froth tailings stream is in a hydrocyclone.

[0044] The bitumen process may be a paraffinic froth treatment process, an aqueous bitumen extraction process, or an ore preparation process.

[0045] The warm water may be added to a froth separation unit (FSU), a primary separation vessel (PSC), a flotation cell, a hydrocyclone, or a utility.

[0046] Figure 1 is a schematic of a froth separation process including the warm water recovery described herein. This is merely an example of how the froth separation and warm water recovery may be operated. Bitumen froth (102) is fed into a first separation unit (FSU-1) (104) producing an FSU-1 overflow stream (106) (comprising bitumen and solvent) and an FSU-2 underflow (108). The FSU-1 overflow (106) is passed to a solvent recovery unit (SRU) (110) to recover solvent (112) and produce a bitumen stream (114). The FSU-1 underflow (108) is passed to a second froth separation unit (FSU-2) (116). An FSU-2 overflow (118) is recycled to the FSU-1 (104). An FSU-2 underflow (120) is passed to a first tailings solvent recovery unit (TSRU-1) (122). Solvent (124) is recovered from the TSRU-1 (122) and is recycled to the SRU (110). TSRU-1 tailings (126) are passed to a second TSRU (TSRU-2) (128) where additional solvent (130) is recovered and recycled to the SRU (110). TSRU-2 tailings (132) are passed through at least one pump box (134) and on to a tailings pond. Warm water (136), having a temperature between 52°C and 70°C, is recovered from the TSRU-2 tailings (132), for instance while in-pipe or within a pump box (134), and is recycled into the bitumen process. For example, the warm water may be recycled (not depicted) to one of the FSUs (104 or 116). Colder water (140), having a temperature below 52°C, is added to tailings (138) to replenish the recovered warm water (136).

[0047] Figure 2 is a graph illustrating the temperature profile measurements across a diameter of froth tailings within a tailings pipe. A temperature profiler was installed with multiple sensors attached on the external surface of the pipe circumferentially. Temperature changes were measured every second. As can be seen in Figure 2, when the tailings temperature ranged from 52°C to 70°C, a separation in the temperature bands was observed, indicating the presence of an insulating layer.

[0048] Figure 3 is a graph illustrating the wt. % of bitumen in the froth tailings samples taken from a tailings pipe. A total of 24 samples were collected. Samples were collected every 12 hours for 2 weeks or every 8 hours for 1 week. Samples were collected making sure to capture some of the solvent in the froth tailings. The date and time were indicated on the

samples, and then they were sent to a lab for analysis. The lab reported on the composition of the samples, namely the composition of solvent, asphaltene, maltene, solids and water.

[0049] Figure 4 is a graph illustrating the wt. % of solids in the froth tailings samples taken from a tailings pipe. The composition of solids was analyzed from the same samples as described above.

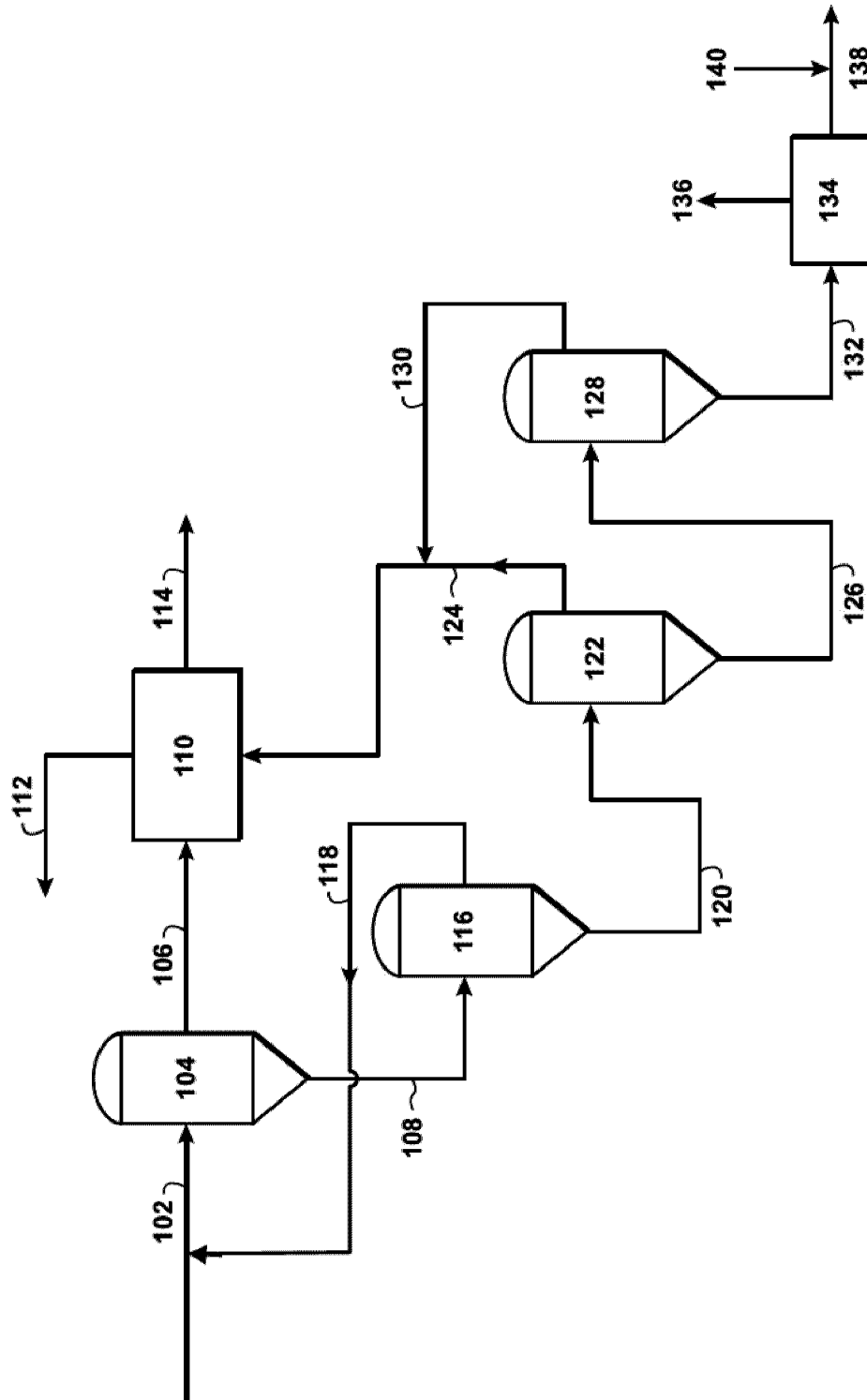
[0050] As can be seen in Figure 3 and Figure 4, low compositions of bitumen and solids were reported for the samples. It was observed that there is a lower composition of bitumen and solids at the top of the pipe. As expected, higher flow rates and warm process water to the TSRU pump box also impacts the compositions of the samples, increasing the wt. % of bitumen and solids.

[0051] 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. 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 recovering heat from a bitumen froth tailings stream, the process comprising:
 - a) operating with the bitumen froth tailings stream between 52°C and 70°C such that an insulating layer is present in a lower portion of the bitumen froth tailings stream;
 - b) removing warm water, with a temperature between 52°C and 70°C, from an upper portion of the bitumen froth tailings stream, above the insulating layer;
 - c) adding colder water, with a temperature less than 52°C, to the bitumen froth tailings stream; and
 - d) adding at least a portion of the warm water upstream of the bitumen froth tailings stream to a bitumen process,wherein steps b) and c) are performed while the bitumen froth tailings stream is in a pipe.
2. The process of claim 1, wherein the bitumen process is a paraffinic froth treatment process, an aqueous bitumen extraction process, or an ore preparation process.
3. The process of claim 1 or 2, wherein the warm water is added to a froth separation unit (FSU), a primary separation vessel (PSC), a flotation cell, a hydrocyclone, or a utility.
4. The process of any one of claims 1 to 3, wherein the colder water has a temperature of less than 50°C.
5. The process of any one of claims 1 to 3, wherein the colder water has a temperature of less than 40 °C.
6. The process of any one of claims 1 to 5, wherein the insulating layer comprises asphaltenes.

7. The process of any one of claims 1 to 6, wherein the process is operated with the bitumen froth tailings stream between 52°C and 65°C.

**FIG. 1**

Temperature Profile Measurements Across Diameter of Froth Tailings

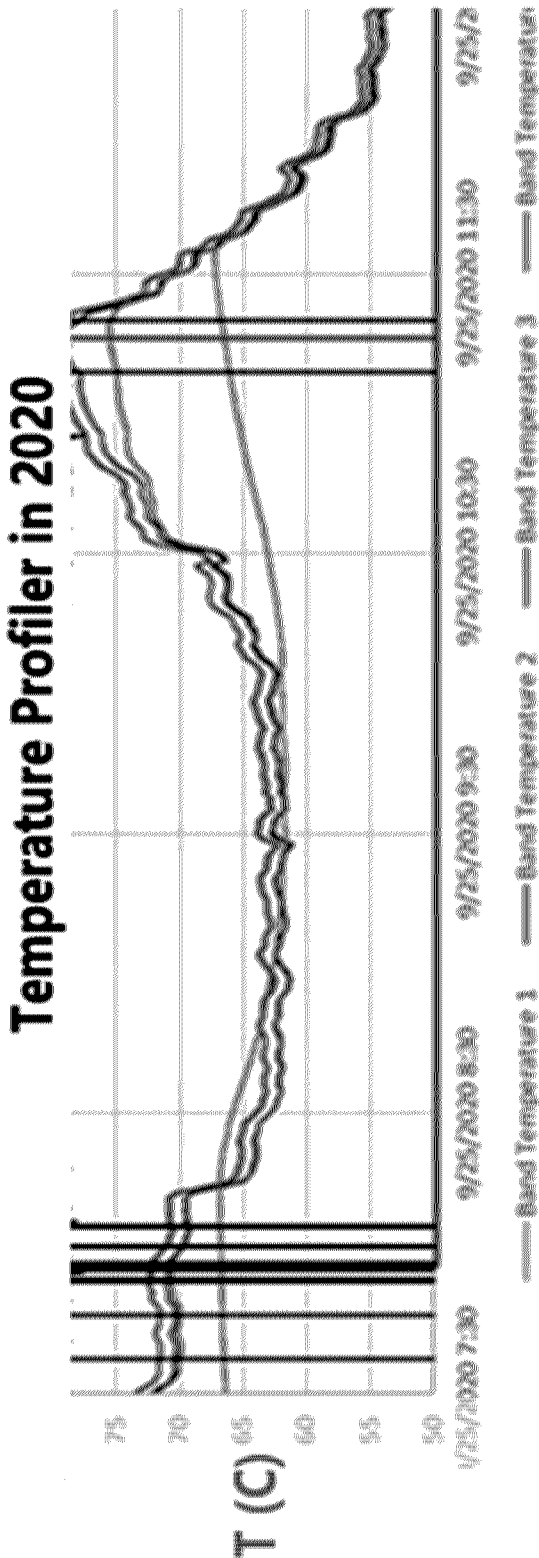
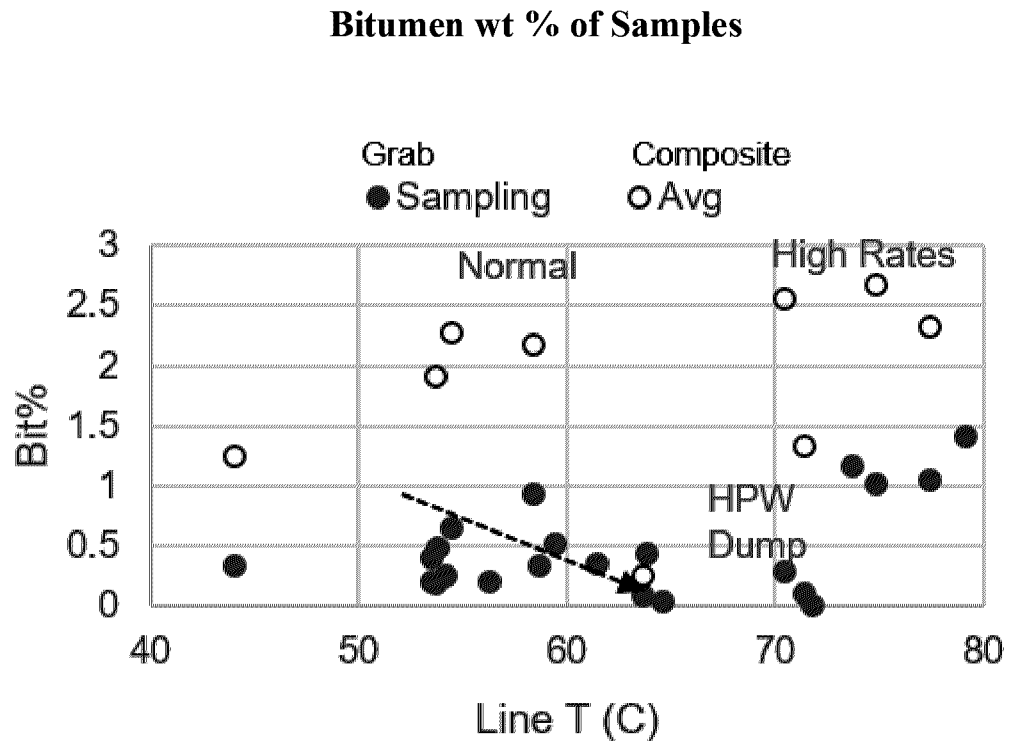
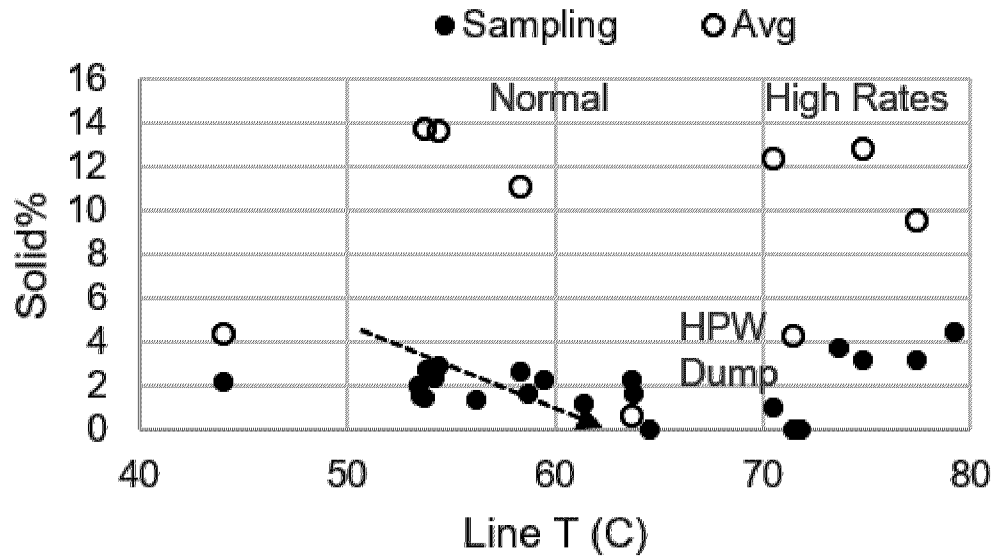


FIG. 2

**FIG. 3**

Solid wt % of Samples**FIG. 4**

