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(54) Method for improving oil sands hot water extraction process

(57) In order to increase the bitumen extraction efficiency in a hot water oil sands extraction process, a method for recovering bitumen comprising adding carbon dioxide to a pipeline containing an oil-bearing formation being transported is proposed.

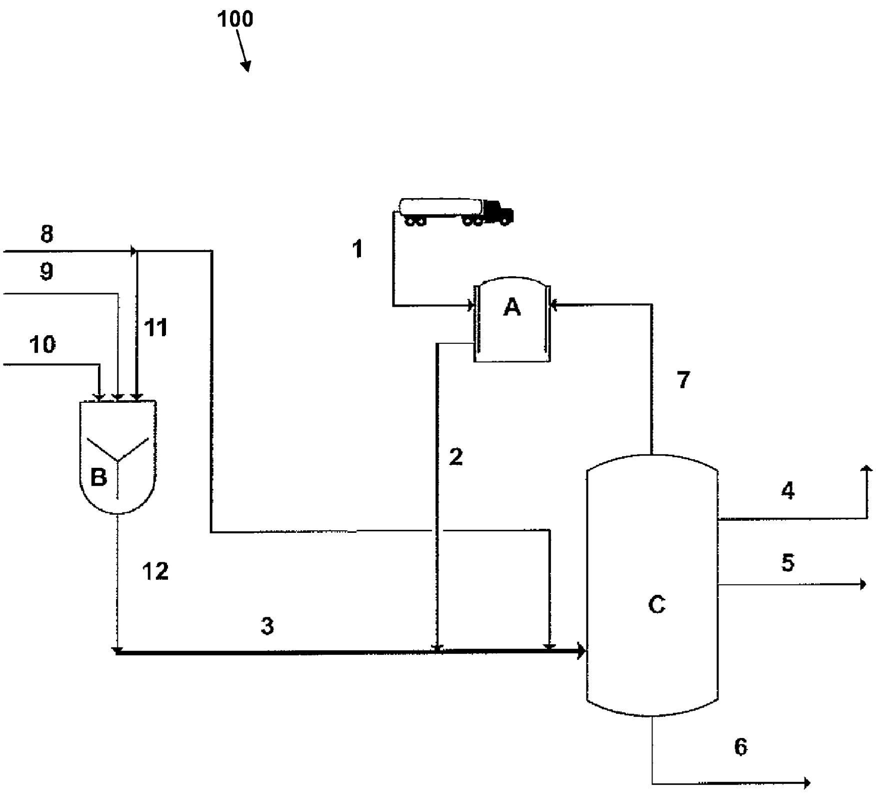

Fig. 1

EP 2 497 815 A1

Description

Technical field

[0001] The present invention relates to a process for adding carbon dioxide in a hydrotransport pipeline through which oil sands slurry is transported to an extraction plant in order to improve bitumen recovery efficiency.

Background of the present invention; prior art

[0002] Hot water extraction process is the most frequently employed technique to recover bitumen from surface mined oil sands. Due to the high capacity and low operating cost of modern hot water extraction process for oil sands and other mined oil bearing formations, other alternative processes are not likely to replace this process in the near future.

[0003] In a conventional hot water extraction process, before bitumen is extracted in a separation vessel, a mixture of oil sand, hot process water, and extraction additive, normally caustic reagent such as sodium hydroxide or sodium carbonate, is conditioned in a large tumbler or drum by intense mechanical agitation for a predetermined period to achieve a desired separation degree of bitumen from sand grains and entraining of air bubbles in the slurry.

[0004] This modern hot water extraction process, which is developed from the conventional hot water process, transports oil sand, hot process water and extraction additives to a separation vessel in a pipeline wherein conditioning of oil sand is achieved during transportation.

[0005] This method, called hydrotransport, is one of the most important developments in the oil sands surface mining industry since it greatly increases treatment capacity of the oil sands extraction plant and reduces energy cost.

[0006] Prior art document US 5 264 118 describes a pipeline conditioning process for mined oil sands wherein oil sands is transported with hot water and sodium hydroxide via a pipeline of sufficient length. During the conditioning process, with assistance of sodium hydroxide, bitumen is liberated from sand grains and entrained air facilitates subsequent aeration of the bitumen.

[0007] The conditioned oil sands slurry is fed to a gravity separation vessel, known as primary separation vessel (PSV), to settle into three layers, bitumen froth, middlings, and sand under quiescent conditions. The middlings, which is normally processed in a secondary separation vessel, is a mixture of buoyant bitumen, clay and water.

[0008] In one embodiment of US 5 264 118 achieving more than ninety percent total bitumen recovery efficiency, the pipeline has a length of 2.5 kilometers to achieve a desired extraction efficiency for a mixture of fifty percent to seventy percent by weight of oil sands, fifty percent to thirty percent by weight of hot water, and less than 0.05% by weight of sodium hydroxide at a temperature between 40°C to 70°C. The residence time of oil sands slurry in the pipeline is about fourteen minutes.

[0009] It is believed that bitumen flecks tend to coalesce and attach or coat to the air bubbles entrained in the slurry. Because the amount of the entrained air is an important factor for oil sands conditioning in the hydrotransport pipeline, a more effective method of adding air into oil sands slurry can significantly improve the overall bitumen extraction efficiency.

[0010] A device, cyclofeeder, described in prior art documents CA 2 029 795 A1 and US 5 039 227, can simultaneously entrain air into the slurry when it is mixing oil sands with hot water.

[0011] In prior art document US 6 007 708, the aeration effects by gas bubbles are enhanced by injecting compressed air in the hydrotransport pipeline to improve the bitumen extraction efficiency at a relatively low conditioning temperature.

[0012] The drawback of this process is that the extracted bitumen contains relatively high concentration of impurities due to bitumen's high viscosity at low temperature and incomplete separation of bitumen from sand grains. The volume ratio of air to slurry can be up to 2.5:1 and the overall bitumen recovery efficiency can be as high as 98 percent.

[0013] Another example to explore the separation and floatation effects of gas bubbling is described in prior art document CA 2 703 835 A1, in which the oil sands and hot water mixture is treated in a closed vessel by cyclic compression and decompression of compressed air or carbon dioxide in the vessel.

[0014] This method can achieve more than ninety percent bitumen extraction efficiency for tar sands or oil sands from different countries without the assistant of caustic reagent and does not generate middlings. The major drawback of this method is that the extraction capacity of a device is limited by the vessel size due to the high construction cost of a large pressure vessel.

[0015] Also, prior art document WO 2005/123608 A1 teaches a method of adding hydrogen peroxide into a conditioned mixture of oil sands and hot water. The oxygen bubbles generated through decomposition of hydrogen peroxide may accelerate separation and floatation of bitumen.

[0016] An obvious drawback of this process is that the high purchasing price of hydrogen peroxide makes this process less competitive. Also, oxygen, which is not preferred in the subsequent bitumen upgrading processes, may have been added into bitumen structures.

[0017] Caustic reagent is normally required to improve the conditioning effects in the hot water extraction process. However, addition of caustic reagent such as sodium hydroxide has many drawbacks.

[0018] The major problem is that caustic reagent will cause emulsification of released bitumen in water and suspension of fine particles in the aqueous phase. Those effects greatly reduce the overall bitumen extraction efficiency and cause serious environmental problems when the process water is being disposed.

[0019] Another problem is generation of large amount of middlings in the separation vessel. Although most bitumen contained in the middlings and tailings can be recovered in the subsequent extraction processes, improving the primary separation vessel's froth production and quality is the most effective way to reduce the overall operating cost.

[0020] Prior art document CA 2 004 352 A1 has addressed these problems by replacing the caustic reagent by kerosene and methyl-isobutyl carbinol. This method also has a problem of high operating cost due to usage of large amount of chemicals.

[0021] In order to treat the process water from the hot water extraction process that contains suspended solids and emulsified bitumen at a high pH level by the caustic reagent, prior art document CA 1 022 098 discloses a method to break the emulsion to recover additional bitumen and accelerate precipitation of the suspended solids through neutralizing the process water by addition of inorganic acids and carbon dioxide.

[0022] It has been recognized that neutralizing the process water to pH at around 7 by an inorganic acid is not sufficient for emulsion breaking. The purpose of utilizing inorganic acid to adjust water pH is to facilitate the emulsion breaking effect of carbon dioxide since carbon dioxide is not a strong acid for pH adjustment. But the addition of inorganic acid generates permanent unwanted salt in the process water and limits reuse of the process water.

[0023] It is noticed that after bitumen is separated from sand grains and bitumen droplets are formed with the help of the caustic reagent, the basic condition is not necessarily to be maintained in the separation vessel for formation of froth. On the contrary, the caustic condition can cause emulsification of bitumen in hot water and generate large amount of middlings. De-emulsification of the emulsion, such as reducing pH of the process water or adding flocculent, can improve the total recovery ratio of bitumen in the primary separation vessel.

[0024] Since carbon dioxide is a good reagent to neutralize process water, using carbon dioxide to adjust oil sands slurry's pH level is a practical measure. To achieve the emulsion breaking effect, a lower pH value by dissolving more carbon dioxide under elevated pressure may be required.

[0025] In addition, since noticeable amount of carbon dioxide is dissolved in bitumen under elevated pressure, pressure drop in the primary separation vessel can significantly increase bitumen's buoyancy through expansion of the bitumen droplets. Also, reduction of emulsified bitumen in water and increase of bitumen's buoyancy can prevent generation of large amount of middlings.

[0026] So the operating costs for middlings treatment and subsequent process water treatment can be reduced. Compared to adjusting water pH using assistant inorganic acid, which is used in other methods because carbon dioxide is not sufficient for pH adjustment in a non pressure vessel or a low pressure vessel, using carbon dioxide will not permanently increase the water salt concentration since the product of carbon dioxide and sodium hydroxide is sodium carbonate, which is also used as a caustic reagent for oil sands extraction in the how water extraction process.

[0027] However, pressurizing the primary separation vessel in a larger oil sands extraction plant is not practical because of the high construction cost of a large pressure vessel. Injecting carbon dioxide in the hydrotransport pipeline is a more practical method for adjusting the oil sands slurry's pH.

Disclosure of the present invention: object, solution, advantages

[0028] Starting from the disadvantages and shortcomings as described above and taking the prior art as discussed into account, an object of the present invention is to increase the bitumen extraction efficiency in a hot water oil sands extraction process; more particularly, the present invention aims to improve the bitumen recovery efficiency in a primary separation vessel by simultaneous improvement of the aeration effect and reduction of the bitumen emulsification degree.

[0029] This object is accomplished by a method comprising the features of claim 1. Advantageous embodiments and expedient improvements of the present invention are disclosed in the dependent claims.

[0030] A method for improving oil sands hot water extraction process, in particular for recovering bitumen comprising adding carbon dioxide to a pipeline containing an oil-bearing formation being transported is disclosed. By this method, the bitumen extraction efficiency in a hot water oil sands extraction process is increased.

[0031] According to an advantageous embodiment of the present invention, the oil-bearing formation is selected from the group consisting of an oil sands slurry, tar sands slurry and oil-contaminated soil slurry.

[0032] According to an expedient embodiment of the present invention, the volumetric flow rate ratio of the carbon dioxide to process water in the pipeline is controlled from 0.2:1 to 15:1.

[0033] According to a favoured embodiment of the present invention, the carbon dioxide injection pressure is maintained at a pressure from 1.2 bars to 21 bars.

[0034] According to a preferred embodiment of the present invention, the pressure in the pipeline behind the carbon dioxide injection point is maintained between 1.1 bars to twenty bars.

[0035] According to an advantageous embodiment of the present invention, the pH of the oil sands slurry in the pipeline is adjusted to a level below 8.

[0036] According to an expedient embodiment of the present invention, the carbon dioxide is injected in the pipeline at a point where the oil-bearing formation has been conditioned to a degree higher than fifty percent.

[0037] According to a favoured embodiment of the present invention, the length of the pipeline is from one meter to two kilometers.

[0038] According to a preferred embodiment of the present invention, the oil-bearing formation flow is merged with a fresh water stream before it is fed to a separation vessel and the volumetric flow rate ratio of the fresh water to oil-bearing formation is from 0:1 to 3:1,

- wherein the separation vessel can be operated under ambient pressure and/or
- wherein the separation vessel can be operated at a pressure lower than the pressure in the hydrotransport pipeline.

[0039] According to an advantageous embodiment of the present invention, the carbon dioxide is directly injected into the oil-bearing formation through a device selected from the group consisting of nozzles and a venturi device.

[0040] According to an expedient embodiment of the present invention, carbon dioxide is mixed with a water stream before being injected in the pipeline, wherein the volumetric flow rate ratio of the carbon dioxide to the water can be from 1:0 to 20:1.

[0041] According to a favoured embodiment of the present invention, carbon dioxide is injected in the pipeline at several points.

[0042] In more detail, a volume of gaseous carbon dioxide can be added into the oil sands slurry that is being transported through a hydrotransport pipeline from the oil sands mining site to the bitumen extraction plant at a position where the oil sands has been conditioned to a desired degree.

[0043] Carbon dioxide can be injected into the slurry under elevated pressure through a gas distribution device while the hydraulic pressure in the pipeline can be maintained at an elevated pressure. After the carbon dioxide-bearing oil sands slurry is fed into the separation vessel, a part of the carbon dioxide can be recovered for reinjection.

[0044] The present invention can be applied, but is not limited to, improving the oil extraction of oil sands and other oil bearing formation in a hot water extraction process. The same method can be applied to remediation of contaminated soil, treatment of waste water, and mine floatation in order to improve treatment efficiency.

[0045] In one embodiment of the present invention, carbon dioxide is injected into the hydrotransport pipeline, through which oil sands slurry is conditioned when being transported from a mining site to an extraction plant, at a position where the oil sands have been conditioned to a desired degree.

[0046] The pH of the oil sand slurry after dissolving carbon dioxide in the process water, which can be measured by a set of pH probes installed on the pipeline, is adjusted to a value below 8 and preferably below 7 by controlling the carbon dioxide's flow rate.

[0047] Since the volumetric ratio of the dissolved carbon dioxide to water is mainly decided by the water temperature and the pressure, the hydraulic pressure in the pipeline is maintained at an elevated pressure to guarantee that a desired amount of carbon dioxide is dissolved in the process water. Also, some other aspects such as the salt concentration and alkalinity of water that can affect the equilibrant carbon dioxide concentration in the aqueous phase are taken into account.

[0048] In the pipeline in which carbon dioxide is being dissolved, the hydraulic pressure is maintained between 1.1 bars to twenty bars for the purpose of dissolving more carbon dioxide and a boosting pump is installed if necessary. The pressure used in describing the present invention is absolute pressure.

[0049] The improvement of bitumen extraction is also facilitated by other synergetic effects due to injection of carbon dioxide, such as aeration and gas bubble floatation effect in the separation vessel and higher buoyancy of the bitumen droplets. Therefore, by maintaining an elevated hydraulic pressure in the pipeline, the volumetric flow rate ratio of carbon dioxide to the process water in the hydrotransport pipeline is controlled from 0.2:1 to 15:1.

[0050] The gas volume used in the present invention is its volume under standard condition. Adding carbon dioxide into the hydrotransport pipeline can be achieved by one venturi device or other gas dissolving devices such as a set of nozzles. The pressure of carbon dioxide is maintained at a pressure higher than the hydraulic pressure in the hydrotransport pipeline for the purpose of injection at a high gas flow rate, preferably between 1.5 bars to 21 bars.

[0051] To adjust the dissolved carbon dioxide concentration in the oil sands slurry, a fresh water stream can be optionally mixed with the oil sands slurry flow prior to being fed into the primary separation tank. The volumetric mixing ratio of the fresh water to the oil sands slurry is from 0:1 to 3:1. The water's temperature can be controlled from 20°C to 120°C.

[0052] Also, the present invention comprises a carbon dioxide recycling pipeline to recover the released carbon dioxide from the oil sands slurry in the primary separation vessel, in which the operating pressure is at ambient pressure or a pressure lower than the hydraulic pressure in the pipeline.

[0053] The recovered carbon dioxide can be stored in a carbon dioxide storage tank or be injected into another hydrotransport pipeline in parallel operation with or without treatment, depending on the insoluble gas concentration in it. Since a part of carbon dioxide that dissolved in the process water under ambient pressure is not recoverable, supplementary carbon dioxide is provided to maintain the carbon dioxide flow rate.

[0054] To reduce corrosion of equipment caused by the dissolved carbon dioxide in water and to recycle process water for continuous conditioning of oil sands in the hydrotransport pipeline under basic conditions, the process water recovered from the separation vessel is aerated by air or other inert gases such as nitrogen, methane, carbon monoxide and argon, or is heated to an elevated temperature by injection of steam.

[0055] The present invention also relates to a system, in particular to an apparatus, for conducting the method as described above.

[0056] The present invention finally relates to the use of a method as described above and/or of a system as mentioned above for increasing the bitumen extraction efficiency in the hot water oil sands extraction process.

Brief description of the drawing

[0057] As already discussed above, there are several options to embody as well as to improve the teaching of the present invention in an advantageous manner. To this aim, reference is made to the claims dependent on claim 1; further improvements, features and advantages of the present invention are explained below in more detail with reference to a preferred embodiment by way of non-limiting example and to the accompanying drawing where

Fig. 1 is a schematic process flow diagram showing injection of carbon dioxide in the hydrotransport pipeline in the oil sands hot water extraction process, with this process flow being realized according to the method of the present invention.

Detailed description of the drawings; best way of embodying the present invention

[0058] As shown in the schematic process flow diagram according to Fig. 1 referring to a method for improving oil sands hot water extraction process according to the present invention, carbon dioxide from carbon dioxide tank A is injected into the hydrotransport pipeline 3, which transports oil sands slurry to an extraction plant, through line 2, at a position where the oil sands slurry has been conditioned to a desired degree higher than fifty percent, preferably higher than eighty percent, and more preferably higher than ninety percent, that the basic condition is no longer required for liberation of bitumen from sand grains.

[0059] The carbon dioxide may be supplied to the carbon dioxide tank A through line 1 from a trailer or other ready source of carbon dioxide.

[0060] In order to neutralize the slurry by dissolving a desired amount of carbon dioxide in the process water, the hydrotransport pipeline 3 pressure for carbon dioxide injection is maintained at an elevated pressure from 1.2 bars to 21 bars, preferably from three bars to ten bars.

[0061] The pH of the oil sands slurry in the hydrotransport pipeline 3, which can be measured by a set of pH probes installed on the hydrotransport pipeline 3, is adjusted to a level below 8 and preferably below 7 by controlling the carbon dioxide flow rate.

[0062] Carbon dioxide can be directly injected in oil sand slurry through a set of nozzles or a gas disperser such as a venturi device. Although it is not necessary that all carbon dioxide be dissolved in the oil sands slurry since existence of gas bubbles in the slurry improves conditioning effect, an elevated pressure is maintained in the pipeline to keep as much as possible of carbon dioxide is dissolved in the oil sands slurry.

[0063] The pressure in the hydrotransport pipeline 3 behind the carbon dioxide injection point is maintained between 1.1 bars to twenty bars, preferably between two bars to ten bars.

[0064] The length of the hydrotransport pipeline 3 for dissolving carbon dioxide and the residence time of oil sands slurry in the hydrotransport pipeline 3 for breaking emulsion are decided by the hydraulic pressure, the slurry's pH, amount of impurities in water such as suspended fine particles, alkalinity of the process water and the emulsification degree of bitumen in water, preferably from one meter to two kilometers, more preferably from hundred meters to one kilometer.

[0065] The volumetric flow rate ratio of carbon dioxide to the process water in the hydrotransport pipeline 3 is controlled from 0.2:1 to 15:1, preferably from 0.5:1 to 10:1.

[0066] The oil sands slurry is fed into the hydrotransport pipeline 3 from mixer B through line 12. The oil sands slurry is fed into mixer B through line 9; hot water is also fed into the mixer B through line 8 to line 11 and additives such as sodium hydroxide or sodium carbonate are also fed into the mixer B through line 10. The mixer B is typically a cyclofeeder. The hot water in line 8 can also be directed immediately or in addition to its transport into line 11 and mixer B, directly into the hydrotransport pipeline 3.

[0067] Before the carbon dioxide-bearing oil sands slurry is added into the primary separation vessel C or other separation vessels, the oil sands slurry flow in hydrotransport pipeline 3 is merged with a fresh water stream through line 8 to adjust the volumetric ratio of gas to water for the purpose of optimizing the gas flotation effect for bitumen in the vessel.

[0068] The mixing volumetric flow rate ratio of the fresh water to oil sands slurry is controlled from 0:1 to 3:1, preferably from 0.1:1 to 1:1. And the water's temperature is controlled from 20°C to 120°C.

[0069] After dilution, the oil sands slurry is fed into the separation vessel C though a pressure reducing device such as a nozzle or a valve.

[0070] In this embodiment, the primary separation vessel C is operated under ambient pressure or a pressure lower than the hydraulic pressure in the hydrotransport pipeline 3. Therefore, a part of carbon dioxide dissolved in water and bitumen transforms into bubbles after pressure drop to provide additional bitumen separation and flotation effects in the separation vessel.

[0071] Gaseous carbon dioxide in the primary vessel's overhead space can be recycled through a carbon dioxide recovery pipeline 7 to a carbon dioxide storage tank A or be directly injected into another hydrotransport pipeline in parallel operation, not shown in Fig. 1.

[0072] The recycled carbon dioxide may contain air entrained in oil sands during conditioning, so the carbon dioxide is diluted by fresh carbon dioxide or be treated by other measures to control the insoluble gas concentration in it if it is necessary. The overall impurities concentration in carbon dioxide is controlled lower than twenty percent, preferably less than ten percent, and more preferably less than five percent by volume. Also, the recovered carbon can be used for other purposes.

[0073] The primary separation vessel C is typically a large, conical-bottomed, cylindrical vessel. The primary separation vessel C will separate the oil sand slurry that is fed through hydrotransport pipeline 3 into three distinct components plus excess carbon dioxide that may be present in the oil sand slurry.

[0074] The sand and water will exit through the bottom of the primary separation vessel C through the bottom line 6 which can be treated and returned to where the oil sand was originally derived from or transported for other disposal means.

[0075] The middlings which are separated in the primary separation vessel C are removed through line 5 and froth is removed through line 4. As mentioned previously, carbon dioxide is recovered and recycled through line 7 back to the carbon dioxide storage tank A where it can be used for injection into the hydrotransport pipeline 3.

[0076] Since the process water recovered through line 6 from the separation vessel C contains dissolved carbon dioxide, which may cause corrosion of the equipments and pipelines and require additional caustic reagent to condition the oil sands when the recovered water is to be reused, the process water is aerated by air or other inert gases such as nitrogen, methane, carbon monoxide and argon, or is heated to a higher temperature by injection of steam or other heating methods before reuse.

[0077] In another embodiment, carbon dioxide is mixed with a fresh water stream before being added in the oil sands slurry. The purpose of mixing the fresh water with carbon dioxide is to make carbon dioxide partially dissolved in water at a pressure higher than the pressure in the pipeline.

[0078] The fresh water's temperature can be higher or lower than the oil sands slurry's temperature transported in the pipeline. The volumetric flow rate ratio of the carbon dioxide to fresh water is controlled from 1:0 to 20:1. The water's temperature is controlled from 1°C to 100°C.

[0079] In another further embodiment, the carbon dioxide is injected into the hydrotransport pipeline at several points and the distance between two adjacent points is from one meter to 500 meters, more likely from ten meters to 200 meters.

[0080] The number of injection points is from two to twenty, and the carbon dioxide's injection rate at different injection points can be the same, close to or different at each injection point. The flow rate ratio of the overall of carbon dioxide to the process water in the oil sands slurry is from 0.2:1 to 15:1, preferably from 0.5:1 to 10:1.

[0081] Fig. 1 also illustrates a corresponding system 100, in particular to a corresponding apparatus, for recovering bitumen, with such system 100 working according to the method of the present invention.

[0082] While the present invention has been described with respect to particular embodiments thereof, it is apparent that numerous other forms and modifications of the present invention will be obvious to those skilled in the art. The appended claims in the present invention generally should be construed to cover all such obvious forms and modifications which are within the true scope of the present invention.

List of reference numerals

[0083]

1	line to carbon dioxide tank A
2	line from carbon dioxide tank A to hydrotransport pipeline 3
3	pipeline, in particular hydrotransport pipeline
4	line from separation vessel C, in particular for froth
5	line from separation vessel C, in particular for middlings
6	line, in particular bottom line, from separation vessel C, in particular for sand and/or for water
7	line, in particular carbon dioxide recovery pipeline, from separation vessel C to carbon dioxide tank A
8	line to mixer B and/or to hydrotransport pipeline 3
9	line to mixer B, in particular for oil sands slurry
10	line to mixer B, in particular for additives, for example for sodium hydroxide and/or for sodium carbonate
11	line from line 8 to mixer B
12	line from mixer B to hydrotransport pipeline 3
100	system, in particular apparatus, for recovering bitumen
A	carbon dioxide tank, in particular carbon dioxide storage tank

B mixer, in particular cyclofeeder

C separation vessel, in particular primary separation vessel

Claims

1. A method for recovering bitumen comprising adding carbon dioxide to a pipeline (3) containing an oil-bearing formation being transported.

2. The method according to claim 1 wherein said oil-bearing formation is selected from the group consisting of an oil sands slurry, tar sands slurry and oil-contaminated soil slurry.

3. The method according to claim 1 or 2 wherein the volumetric flow rate ratio of said carbon dioxide to process water in the pipeline (3) is controlled from 0.2:1 to 15:1.

4. The method according to at least one of claims 1 to 3 wherein said carbon dioxide injection pressure is maintained at a pressure from 1.2 bars to 21 bars.

5. The method according to at least one of claims 1 to 4 wherein the pressure in the pipeline (3) behind the carbon dioxide injection point is maintained between 1.1 bars to twenty bars.

6. The method according to at least one of claims 1 to 5 wherein the pH of the oil sands slurry in the pipeline (3) is adjusted to a level below 8.

7. The method according to at least one of claims 1 to 6 wherein said carbon dioxide is injected in the pipeline (3) at a point where the oil-bearing formation has been conditioned to a degree higher than fifty percent.

8. The method according to at least one of claims 1 to 7 wherein the length of the pipeline (3) is from one meter to two kilometers.

9. The method according to at least one of claims 1 to 8 wherein the oil-bearing formation flow is merged with a fresh water stream before it is fed to a separation vessel (C) and the volumetric flow rate ratio of the fresh water to oil-bearing formation is from 0:1 to 3:1.

10. The method according to claim 9 wherein said separation vessel (C) is operated under ambient pressure.

11. The method according to claim 9 or 10 wherein said separation vessel (C) is operated at a pressure lower than the pressure in the pipeline (3).

12. The method according to at least one of claims 1 to 11 wherein said carbon dioxide is directly injected into said oil-bearing formation through a device selected from the group consisting of nozzles and a venturi device.

13. The method according to at least one of claims 1 to 12 wherein carbon dioxide is mixed (B) with a water stream before being injected in the pipeline (3).

14. The method according to claim 13 wherein the volumetric flow rate ratio of said carbon dioxide to said water is from 1:0 to 20:1.

15. The method according to at least one of claims 1 to 14 wherein carbon dioxide is injected in the pipeline (3) at several points.

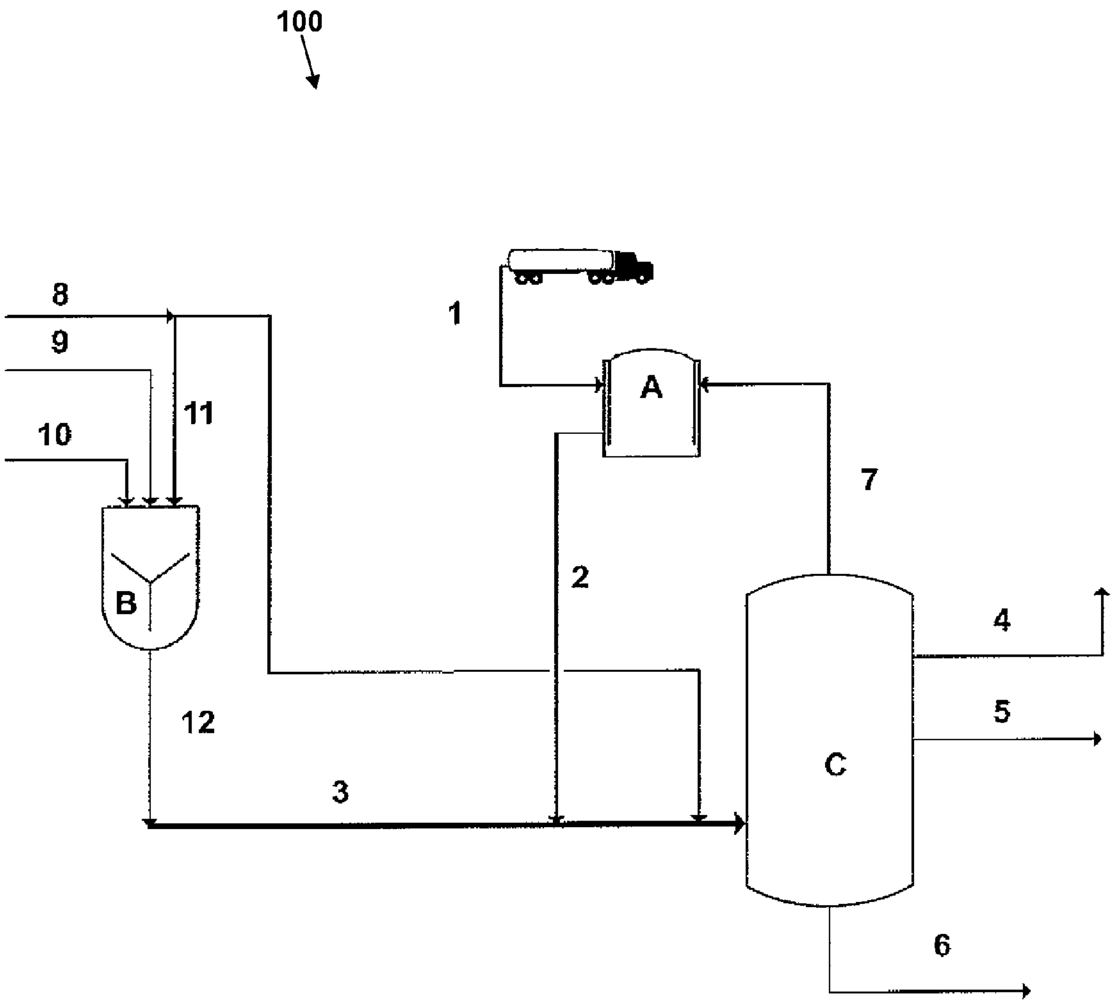

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 0433

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 004 455 A (RENDALL JOHN S [US]) 21 December 1999 (1999-12-21) * claim 1; figure 3 * -----	1-15	INV. C10G1/04
X	US 4 968 412 A (GUYMON E PARK [US]) 6 November 1990 (1990-11-06) * claim 1; figure 1 * -----	1-15	
X	CA 1 237 689 A1 (BRENDA MINES LTD) 7 June 1988 (1988-06-07) * page 2, line 23 - page 3, line 5; claims 1,8; example 1 * * page 4, line 23 - line 25 * -----	1-15	
A	US 4 120 777 A (GLOBUS ALFRED R) 17 October 1978 (1978-10-17) * the whole document * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

C10G

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	1 November 2011	Deurinck, Patricia

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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E : earlier patent document, but published on, or after the filing date
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 17 0433

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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01-11-2011

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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- CA 1022098 **[0021]**