METHOD FOR UPGRADING BITUMINOUS FROTH

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References Cited
UNITED STATES PATENTS
2,965,557 12/1960 Price 208/11
2,968,603 1/1961 Coulson 208/11
3,267,998 8/1966 Simpson 208/11
3,607,720 9/1971 Paulson 208/11
3,607,721 9/1971 Nagy 208/11

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ABSTRACT
An improved method for processing bitumen froth containing water, mineral matter, and bitumen to provide a froth product substantially reduced in water and mineral matter which comprises diluting the bitumen froth with a liquid hydrocarbon diluent boiling in the range of 350°-750°F, thereafter subjecting said diluted froth to centrifuging and settling steps, said settling conducted at elevated temperature and pressure to provide a bitumen froth product substantially reduced in water and mineral matter.

4 Claims, 2 Drawing Figures
METHOD FOR UPGRAADING BITUMINOUS FROTH

BACKGROUND OF THE INVENTION

The present invention relates to a process for the improvement of bitumen froth recovered by the hot water process for separating bitumen from tar sands. The present invention, more particularly, relates to a method wherein the final bitumen froth product recovered from the process is substantially reduced in mineral matter and water thereby providing a distinctly improved bitumen froth product suitable for cooking, hydrosisbreaking, or other well-known petroleum refining techniques.

Numerous deposits of bituminous tar sands exist throughout the world. The most extensive deposits are found in Northern Alberta, Canada. The sands are composed of a siliceous material, generally having a size greater than that passing a 325 mesh screen, saturated with a relatively heavy, viscous bitumen in quantities of from 5 to 21 weight percent of the total composition. More typically, the bitumen content of the sands is between 8 to 15 percent. This bitumen is quite viscous and contains typically 4.5 percent sulfur and 38 percent aromatics. Its specific gravity at 60°F. ranges typically from about 1.00 to about 1.06. The tar sands also contain clay and silt. Silt is defined as material which will pass a 325 mesh screen but which is larger than 2 microns. Clay is material smaller than 2 microns including some siliceous material of that size.

There are several well-known procedures for effecting separation of bitumen from tar sands. One particularly effective method is that disclosed in Canadian Pat. No. 841,581 issued May 12, 1970 to Paul H. Floyd et al. The method of this disclosure provides that the bituminous sands are jetted with steam and milled with a minor amount of hot water at a temperature in the range of 140°-210°F. in a conditioning drum.

Alkaline reagents can also be added to the conditioning drum usually in amounts of from 0.1 to 3.0 lbs. per ton of tar sands. The amount of such alkaline reagent preferably is regulated to maintain the pH of the middlings layer in a subsequent separator zone within the range of 7.5 to 9.0. Best results seem to be obtained at a pH value of 8.0 to 8.5. The amount of the alkaline reagent that needs to be added is dependent upon the range of 7.5 to 9.0 may vary from time to time as the composition of the tar sands as obtained from the mine site varies. The best alkaline reagents to use for this purpose are caustic soda, sodium carbonate, or sodium silicate, although any of the other monovalent alkaline reagents can be used if desired.

Mulling of the tar sands produces a pulp which then passes from the conditioning drum to a screen. The purpose of the screen is to remove from the tar sand pulp any debris, rocks, or oversized lumps. The pulp then passes from the screen to a sump where it is diluted with additional water including middlings recycle stream from the separation cell. Recycling of the middlings is not essential in all cases, particularly when the clay content of the tar sands is high. In this event, a relatively high rate of fresh feed water is employed to compensate for the high clay content while a correspondingly high rate of transfer of middlings layer to a secondary scavenger zone can be maintained.

The process as above described can also includes sending a minor portion of the middlings recycle stream to the conditioning drum to supply all or a part of the water needed therein other than that supplied through condensation of the steam which is consumed. Also, a stream of the middlings recycle is sometimes introduced into a screen to flush the pulp therethrough and into the sump. As a general rule, the total amount of water added to the natural bituminous sands as liquid water and as steam prior to the separation step is in the range of 0.2 to 3.0 tons per ton of the bituminous sands. The amount of water needed within this range increases as the slurry and clay content of the bituminous sand increases. The resulting pulp is thereafter carried into a separation cell maintained at a temperature of about 150°-200°F.

In the separation cell, sand settles to the bottom as tailings and bitumen rises to the top in the form of an oil froth which is the primary bitumen froth product. An aqueous middlings layer containing some mineral and bitumen is formed between these layers. A scavenger step is normally conducted on this middlings layer in a secondary flotation zone normally referred to as a scavenger zone. In the scavenger zone, the feed material is aerated so as to produce a scavenger froth product and a scavenger tailings product. The scavenger cell froth product normally contains a substantial amount of water and mineral matter and is thereafter treated in accordance with the procedure disclosed in Canadian Pat. No. 857,306 issued Dec. 1, 1970 to Ernest W. Dobson. This method comprises passing the scavenger froth to a settling zone wherein a froth product rises to the surface and the mineral matter within the froth product settles to the bottom of the settler zone. The froth product from this settling zone is thereafter combined with the froth product from the heretofore disclosed primary separation zone and subsequently combined with a diluent to provide a bituminous froth product suitable for further treatment prior to upgrading to synthetic petroleum crude.

Heretofore, this froth product recovered as a combination of the primary separation zone froth and the settled scavenger zone froth has been diluted with a hydrocarbon diluent and then upgraded by a series of one or more centrifuging steps wherein the amount of mineral in the centrifuge bitumen product is about 1 to 2 weight percent. U.S. Pat. No. 2,968,603 to G. R. Coulson issued Jan. 17, 1961 discloses that two or more centrifuging steps in series can be used to demineralize and dewater a diluted bitumen froth product. When a bitumen product containing 1 to 2 weight percent minerals in later coked to produce synthetic crude, the minerals are concentrated to about 7 to 8 weight percent in the coke. This large quantity of mineral matter is generally undesirable and renders the product somewhat difficult to recover. In one type of commercial operation, this coke is burned to provide power. When the coke is burned in boilers, the contained minerals form ash which must be removed to keep the boiler tubes from fouling. Excessive quantities of minerals reduce operational ability and require expensive maintenance and air pollution preventative equipment.

U.S. Pat. No. 3,607,721 issued Sept. 21, 1971 to Elmer Nagy discloses that solids and emulsified water can be removed from a bituminous froth resulting from the hot water treatment of tar sands by diluting the froth with a light hydrocarbon diluent, such as coker naphtha, settling the diluted froth in a settling zone, recovering the upper froth layer from the settling zone and thereafter centrifuging the settling zone tailings. Al-
though each of these patents disclose advances in the art, the need to provide a method with attractive commercial advantages still exists.

Hereinafore, efficient and economical procedures which provide high volume production of substantially mineral-free and water-free bitumen froth from raw bitumen froth have been overlooked. By way of the present invention, a new procedure for recovering a substantially mineral-free and water-free bitumen froth product from a raw bitumen froth product produced by the hereinabove disclosed hot water separation procedure for recovering bitumen from tar sands is provided.

DESCRIPTION OF THE INVENTION

The present invention provides a method for upgrading bituminous froth recovered from tar sands via hot water extraction techniques.

By the method of the present invention, the raw bitumen froth product is first diluted with a liquid hydrocarbon boiling in the range of 350°-750°F. The diluted froth product is processed in a scroll centrifuge. The centrifuge froth product is thereafter transferred to an autoclave settling zone wherein the froth is settled at a pressure in the range of 0-1000 psig and a temperature in the range of 300°-1000°F.

The bitumen froth feed material normally suitable for use in the method of the present invention is that froth which can be recovered by procedures disclosed in Canadian Pat. No. 841,581 issued May 12, 1970 to P. H. Floyd et al. and/or Canadian Pat. No. 857,306 issued Dec. 1, 1970 to Ernest W. Dobson. This bitumen froth product normally comprises 20 to 45 percent and more typically 30 percent water, 2.0 to 6.0 percent and more typically 3.0 to 5.0 percent mineral matter, and the remainder comprising hydrocarbons. The hydrocarbon diluent used in the present invention can be a petroleum naphtha-type hydrocarbon liquid normally recovered as a petroleum refining stream, containing aromatics, saturates, and olefins boiling in the range of 350°-750°F. The weight ratio of diluent to bitumen (D/B) in the diluted froth is preferably within the range of 0.3 to 1.0.

The method of the present invention can be defined by referring to the figures. FIG. 1 is a flow diagram illustrating methods of the present invention wherein tailings from the autoclave settling zone step can be combined with the froth feed to the scroll centrifuge step of the process, or processed in a disc centrifuge to recover additional bitumen.

FIG. II provides a diagram of another alternative method wherein the froth recovered from a scroll centrifuge step is divided so that separate fractions can be concurrently processed in a disc centrifuge step and an autoclave settling step.

The centrifuging steps hereinafter defined can be conducted utilizing both a scroll-type centrifuge and a disc-type nozzle and bowl centrifuge according to the feed material provided and the type of separation desired. A description of each of these types of centrifuges is disclosed in Canadian Pat. No. 918,091 issued Jan. 2, 1973 to George H. Evans et al. and Canadian Pat. No. 918,589 issued Jan. 9, 1973 to Robert J. Thompson et al. In the process of the present invention, the procedures and equipment outlined in the above-noted Canadian patents are applicable.

Autoclave settling vessels employed in the method of the present invention can be any of the well-known pressure vessels suitable for maintaining a pressure of 0-1000 psig and can also be fitted with a steam jacket or other means for heat exchange purposes. This type of vessel is well known to those skilled in the art.

The essence of the present invention is the combined steps of centrifuging diluted bitumen froth and subsequently settling the centrifuge froth product at an elevated temperature in the range of 300°-1000°F. Using a liquid hydrocarbon diluent boiling in the range of 350°-750°F. These combined steps provide efficient processing of the froth at substantially good volume throughput rates. Also, because of its higher boiling range, less diluent is lost in aqueous waste streams by the method of this invention as compared to methods using diluents having a lower boiling range.

To more clearly define one method of the present invention, the following examples are presented and described as they relate to the figures herewith presented.

EXAMPLE I

Referring to FIG. 1, a raw bitumen froth provided via line 11 is diluted with a hydrocarbon diluent having a boiling range of 350°-750°F. Added via line 12 into line 13. The diluted froth is thereafter transferred to scroll centrifuge 15 via line 14. The feed to scroll centrifuge 15 can also contain recycled tailings from hereinafter defined autoclave settling zone 19 which are provided by line 22 into line 14. Scroll centrifuge 15 provides a tailings stream containing water and mineral matter which is removed via line 16 and discarded. Also, a scroll centrifuge froth is recovered via line 17 and transferred to heat exchange 18 wherein the froth is heated to a temperature in the range of 300°-1000°F. and thereafter transferred into autoclave settling zone 19.

In autoclave settling zone 19, the froth is permitted to settle to provide an upper bitumen froth layer, a lower tailings layer containing mineral matter, water, and bitumen, and an intermediate water layer substantially comprised of water containing minor quantities of bitumen and mineral matter. The bitumen froth product substantially reduced in mineral matter and water is recovered via line 20 from autoclave settling zone 19. Water is recovered from autoclave settling zone 19 via line 21 and can be discarded or recycled to other processes requiring the use of fresh water.

The lower layer in autoclave settling zone 19 is comprised of mineral matter and water and some bitumen and is withdrawn via line 22 and transferred to line 14 where it can be combined with the diluted froth feed being fed to scroll centrifuge 15. Alternately, the tailings from autoclave settling zone 19 withdrawn via line 22 can be discarded via line 27. In autoclave settling zone 19, a substantial separation of bitumen from water and mineral matter is accomplished. Further, the tailings from this autoclave separation zone can be recycled to the scroll centrifuge and thus provide additional bitumen recovery. The product withdrawn via line 20 is of sufficient quality to be suitable for coking, hydrovisbreaking, or any of the many petroleum refining techniques normally applied to this type of feed material.

Typically, this final bitumen froth product contains at least 96 percent hydrocarbon and no more than 0.5 percent mineral matter and 3.5 percent water. The advantages of this froth refining technique are particularly realized in the greater volume throughput of froth as well as the improved quality of the bitumen froth.
product as compared to other well-known techniques. Thus, generally the method of the present invention comprises:

a. diluting a bitumen froth containing mineral matter and water with a liquid hydrocarbon boiling in the range of 350°–750°F;
b. centrifuging said diluted froth to provide a centrifugal tailings stream and a centrifuge froth product;
c. settling said centrifuge froth product in an autoclave settling zone at a temperature in the range of 300°–1000°F and a pressure in the range of 0–1000 psig; and
d. recovering a bitumen froth product substantially reduced in mineral matter and water from said settling zone.

This mode of the present invention can additionally and optionally include the step:

e. recovering a tailings product from said settling zone comprised of mineral matter, water, and bitumen and recycling said tailings to the centrifuge of step (b).

An alternative method of this invention can include subjecting the tailings layer from the autoclave settling zone to additional processing in a second centrifuging step preferably a disc centrifuge to recover additional bitumen. The tailings layer contained mineral matter, water, and some bitumen can be withdrawn from the autoclave settler 19, cooled, and transferred to a disc centrifuge 23. In the disc centrifuge, mineral matter and water are removed and discarded as tailings and a disc centrifuge froth product substantially reduced in mineral matter and water is recovered. This froth can be combined with the froth product directly recovered from the autoclave settling zone. This procedure is disclosed in detail in the Example II given below.

**EXAMPLE II**

Again, referring to the drawing shown in FIG. 1, raw bituminous froth of the this type normally recovered by way of hot water extraction of tar sands, as herein above described, is transferred via line 11 and combined in line 13 with a liquid hydrocarbon diluent boiling in the range of 350°–750°F from line 12 and thereafter transferred to scroll centrifuge 15. Scroll centrifuge 15 provides a tailings product comprised substantially of mineral matter and water which is withdrawn and discarded via line 16 and a scroll centrifuge froth product which is withdrawn via line 17 and transferred into heat exchange 18 and thereafter transferred to autoclave settling zone 19. In autoclave settling zone 19, an upper bituminous froth layer is formed and a lower layer of water, mineral matter, and some bitumen is formed. The upper froth layer is withdrawn from autoclave settling zone 19 via line 20 and transferred into line 26. The tailings layer of autoclave settling zone 19 is withdrawn via line 28, cooled via heat exchange means 29, and thereafter transferred to disc centrifuge 23 wherein mineral matter and water are separated from the tailings and discarded via line 25. A bituminous froth substantially free of mineral matter and water is recovered via line 24 and combined with the froth recovered from the autoclave settling zone in line 26. In autoclave settling zone 19, the diluted bitumen froth recovered from the scroll centrifuge is normally settled at a temperature in the range of 300°–1000°F and a pressure in the range of 0–1000 psig.

The centrifuging step of the method of the present invention in which autoclave settler tailings are treated utilizes a disc-type nozzle bowl centrifuge which is engineered primarily for the removal of water as well as fine mineral matter from a bitumen feed product. A tailings portion recovered from this centrifuging stage is composed substantially of fine mineral matter and water.

Typically, the bituminous froth product recovered from autoclave settling zone 19 and disc centrifuge 23 can be characterized as containing at least 96 percent hydrocarbons and no more than 0.5 percent mineral matter and 3.5 percent water. The product is suitable for further refining techniques including coking, hydrocracking, as well as other petroleum refining techniques well known to those skilled in the art.

Essentially, this method comprises:

a. diluting raw bitumen froth with a liquid hydrocarbon diluent boiling in the range of 350°–750°F;
b. centrifuging said diluted froth in a centrifuge zone preferably using a scroll centrifuge to provide a centrifuge froth product reduced in mineral matter and water;
c. transferring said centrifuge froth product to an autoclave settling zone wherein said froth product is settled at a temperature in the range of 300°–1000°F, at a pressure in the range of 0–1000 psig;
d. recovering an improved bitumen froth substantially reduced in mineral matter and water from said autoclave settling zone; and

e. centrifuging in a second centrifuge zone, tailings recovered from the autoclave settling zone of step (d) to provide additional bituminous froth substantially reduced in mineral matter and water.

An alternate procedure of the process of the present invention is set forth in FIG. II. In this method, raw bitumen froth is first diluted with a hydrocarbon diluent boiling in the range of 350°–750°F. The diluted froth product is thereafter subject to a first centrifuging step preferably using a scroll-type centrifuge wherein a centrifugal froth product is produced and a tailings product is produced. The tailings product can be discarded and the centrifugal froth product is subsequently divided into two froth streams. The first froth stream which can comprise 20 to 80 volume percent of the centrifuge tailings is transferred to an autoclave settling zone wherein the froth is settled at a temperature in the range of 300°–1000°F and at a pressure of 0–1000 psig wherein an upper bitumen froth layer is formed, a middle water layer is formed, and a lower tailings layer is formed containing mineral matter, water, and some bitumen. The tailings layer of the settling zone is thereafter withdrawn from the autoclave and combined with the second part of the centrifuge froth product. The combined centrifuge froth product and autoclave tailings product and thereafter processed in a second centrifuge. By treating the froth in a second centrifuge, preferably a disc centrifuge, the remainder of mineral matter in that product is removed as well as water. Subsequently, the froth product obtained from the second centrifuge and the froth product obtained from the autoclave settling zone are combined to provide a final froth product substantially reduced in mineral matter and water and suitable for appropriate petroleum refining procedures.

This method of the present invention is disclosed in more detail in Example III herein resented.
EXAMPLE III

Referring to the drawing in FIG. II, raw bituminous froth product generally characterized as disclosed above is fed via line 51 wherein it is combined in line 53 with a liquid hydrocarbon diluent from line 52. The diluent has a boiling range of 350°F–750°F. Thereafter the diluted froth is transferred to scroll centrifuge 54. The froth is normally fed to the scroll centrifuge at a temperature in the range of 100°F–300°F, and normally 160°F. The quantity of diluent to froth is generally on a weight ratio basis in the range of 0.3 to 1.0 part diluent per part of bitumen. Coarse mineral separated from the froth in the centrifuge is discharged from the centrifuge as tailings via line 55. A centrifuge froth product is transferred from the scroll centrifuge via line 56 and is divided into a first-part scroll centrifuge froth stream and a second-part scroll centrifuge froth stream.

The bitumen froth product recovered from the scroll centrifuge is generally characterized containing 65 to 70 weight percent hydrocarbon is a combination of the diluent and the bitumen recovered from tar sands. 25 to 35 percent water and 1 to 2 percent mineral matter of the size smaller than 20 microns. The first-part scroll centrifuge froth stream is transferred via line 57 to heat exchanger 66 wherein the diluted bitumen froth product is heated to a temperature in the range of 300°F–1000°F, and thereafter transferred via line 58 into autoclave settling zone 59. The bitumen froth in settling zone 59 is permitted to settle at a temperature in the range of 300°F–1000°F, and a pressure in the range of 0–1000 psig for the time necessary to provide separation of the basic constituents of the feed so that bitumen rises to the surface of the zone. The mineral matter containing some bitumen settles to the bottom of the zone with an intermediate water layer containing some mineral matter and minor quantities of bitumen separating the bitumen layer and mineral matter layer. This water layer can be withdrawn via line 70. A substantially improved bitumen froth is recovered as the upper layer of the settling zone 59 and is withdrawn via line 62. This froth product can be combined with the hereinafter defined bitumen product recovered from the disc centrifuging stage to provide a final bitumen froth product substantially reduced in water and mineral matter.

Thus, the mode of the present invention provides a method for upgrading raw bituminous froth containing mineral matter, water, and bitumen comprising:

a. diluting raw bitumen froth with a hydrocarbon diluent boiling in the range of 350°F–750°F;

b. centrifuging said diluted froth to provide a centrifugal bitumen froth product and a centrifugal tailings product comprising water and mineral matter;

c. thereafter dividing said centrifugal bitumen froth product into a first product stream and a second product stream;

d. settling said first product stream in an autoclave settling zone at a temperature in the range of 300°F–1000°F, and at a pressure in the range of 0–1000 psig to provide an autoclave froth product and an autoclave tailings product;

e. withdrawing said autoclave froth product and combining with the hereinafter disclosed second centrifuging stage froth product;

f. withdrawing said autoclave tailings product and combining it with said second product stream from the first centrifuging step;

g. centrifuging in a second centrifuging step the combination of the second product stream froth from the first centrifuging step and the autoclave tailings stream to provide a second centrifugal tailings stream and a second step centrifugal froth stream; and

h. thereafter recovering said second step centrifugal froth stream and said autoclave froth product stream to provide a final bitumen froth product substantially reduced in mineral matter and water.

The invention claimed is:

1. A method of removing mineral matter and water from a bituminous froth containing bitumen, mineral matter, and water comprising:

a. diluting said froth with a liquid hydrocarbon boiling in the range of 350°F–750°F;

b. centrifuging said diluted froth in a centrifuge to separate a centrifugal tailings stream from a centrifugal froth;

c. heating said centrifugal froth to a temperature in the range of 300°F–1000°F;

d. settling said heated centrifugal froth in an autoclave settling zone at a temperature in the range of 300°F–1000°F, and at a pressure in the range of 0–1000 psig to provide a froth product layer, a water layer, and a tailings layer; and

2. A method according to claim 1 wherein said tailings layer of step (c) is combined with said diluted froth from step (a).

3. A method according to claim 1 wherein said tailings layer of step (c) is processed in a disc centrifuge to provide additional bituminous froth.

4. A method according to claim 1 wherein a portion of said centrifugal froth from step (b) is combined with the tailings from step (d) and passed to a disc centrifuge to separate additional bitumen froth product.

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