

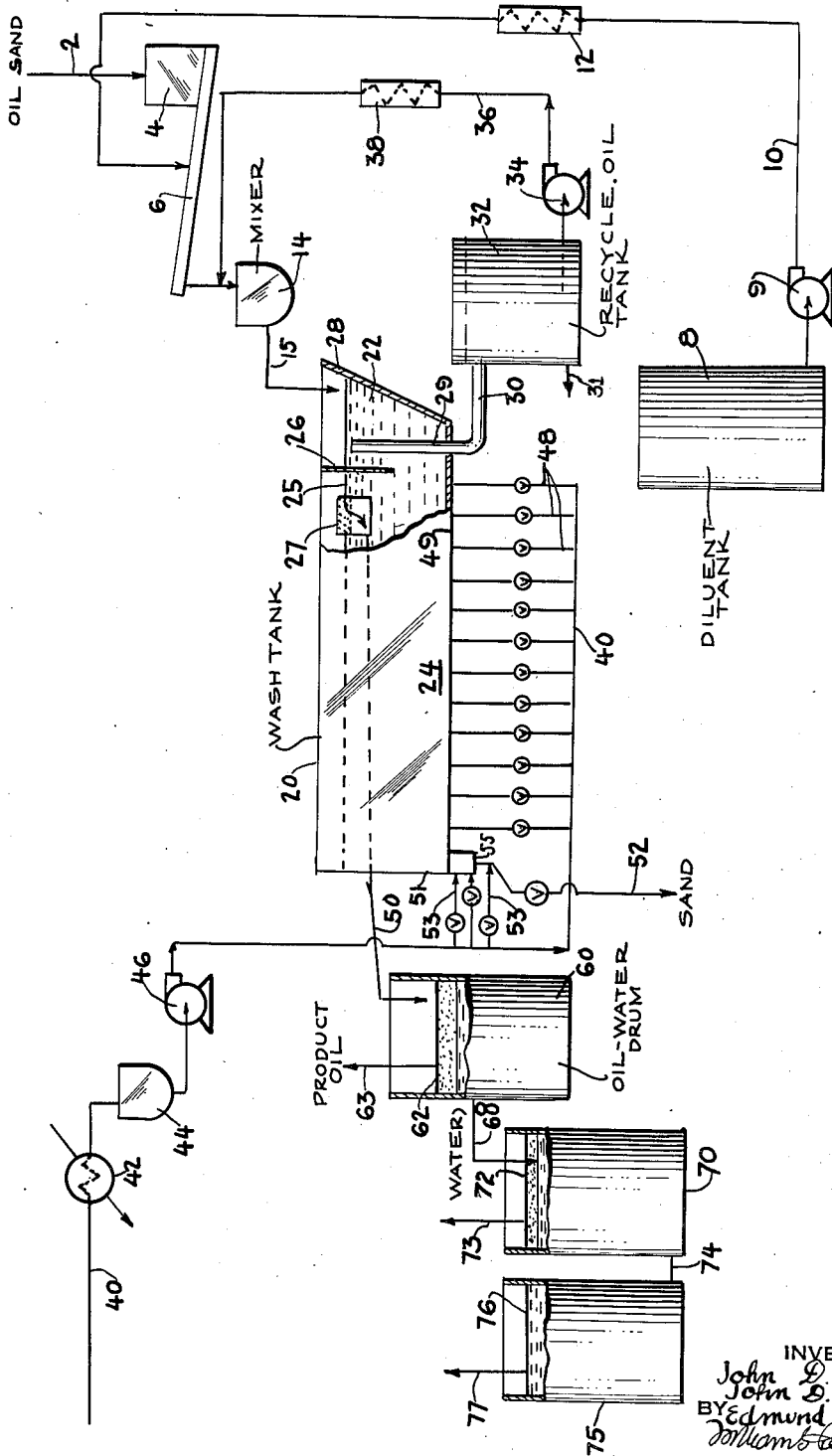
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RECOVERY OF OIL FROM TAR SAND

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RECOVERY OF OIL FROM TAR SAND

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4 Claims. (Cl. 208—11)

This invention relates to the recovery of oil from bituminous sands and more particularly relates to an improved process and apparatus for the more effective recovery of valuable hydrocarbon products from oil bearing minerals, such as the well-known tar sands.

The material treated according to the method of the present invention is obtained from natural deposits existing in various parts of the world. Typical of such deposits are those found in the Province of Alberta, Canada, particularly in the vicinity of the Athabasca River. It is from the latter that the tar sand formations in that area draw their name. These tar sands, in their naturally existing state, are heavily saturated with a viscous oil and may be mined or removed from their naturally existing state by conventional mining methods. The tar sands with which we are concerned here are to be distinguished from the highly carbonaceous solid shale materials which, on thermal treating, yield a hydrocarbon product. The tar sands are primarily silica, having closely associated therewith an oil film which may amount from 2% to as much as 30% or higher of the weight of a given quantity of the tar sand material.

In addition to the silica with which the heavy viscous oil is associated, other mineral materials, including clays, carbonates, sulfates, pyrites and solid carbonaceous matter may be present. In prior attempts to recover the valuable oil from the sand, it is the latter materials which have often given rise to problems which were not satisfactorily solved either from an economic or process point of view.

Several attempts have been made to economically recover oil from tar sand. Certain of these processes have included thermal treating, solvent washing, physical separation and various combinations of these. Separation has been attempted with water in both so-called cold water and hot water processes. The latter techniques are more completely described in U.S. 2,825,677. In the latter patent, separation of the oil from the tar sand is accomplished by adding diluent capable of dissolving the bitumen constituent. The mixture is then introduced to a large volume of water, water with a surface agent added or a solution of a neutral salt in water, which salt is capable of acting as an electrolyte. The combined mass is then subjected to pressure separation preferably in a centrifuge. While the foregoing technique can be used with limited application, centrifuging normally results in the formation of emulsions which cannot be satisfactorily and economically broken. In addition, utilization of centrifuge equipment is initially expensive to install and maintain and substantially limits the volume of materials which must be handled to make the recovery economically feasible.

Separation of tar sand according to the two-stage water wash system of the present invention makes possible the recovery of a hydrocarbon product having less than 1% by weight of solids and a sand product which will have less than about 1% to 5% by weight of oil. The separation carried out according to the present method is considerably more economical than prior techniques in that a wash water is obtained having an oil content below .1% by weight and a solids content of from 0.01 to 0.5% by weight. The recovery of product oil with such a low solids content with no emulsion formation and substan-

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tially complete recovery of oil from sand is a considerable advance over prior techniques which utilized diluents in both hot and cold water recovery systems.

It is accordingly an object of the present invention to provide an improved process for the recovery of valuable hydrocarbons from tar sand.

It is another object of the present invention to provide a method of separating hydrocarbons from bituminous sands in which the oil product will be substantially free of solid materials.

It is a still further object of the present invention to provide a more efficient separation of valuable mineral oil products from tar sand without the use of complicated treating steps and equipment heretofore required in tar sand separation processes.

These and other objects are accomplished according to the method of the present invention by mixing the tar sand with a hydrocarbon diluent in sufficient amount to form a pumpable slurry. This is accomplished by utilizing the diluent in a volume ratio of tar (bitumen) to diluent of from 1:2 to 1:5. The tar sand slurry after gentle mixing to insure substantially complete solution of the tar or bitumen in the diluent and recycled oil which is added thereto, is delivered to the first stage in a two step separating and disengaging treatment. In the first stage wherein separation and disengagement of tar and diluent from sand is accomplished, the sand diluent mixture is eased gently into a water wash tank that includes at the inlet end an inclined surface. The sand, in the presence of water moves at a slow rate, less than the rate of gravitational free flow down the inclined or sloping surface during which movement a substantial portion of the diluent tar mixture is disengaged and separated from the sand particles. As the sand moves down the sloped surface it assumes a natural angle of repose at which time, and while in movement, the sand is gently fluffed or fluidized by water. The fluidization of the sand is conducted in such a manner as to continuously move the sand away from the area of the bottom of the inclined surface along the bottom of the wash tank to a sand outlet. In this fluidized zone the second stage of the disengagement and separation of hydrocarbons from sand is accomplished. The gentle fluffing of the sand in this stage effects a substantially complete disengagement of hydrocarbons (diluent tar mix) from the sand particles. After disengagement a hydrocarbon water mixture is withdrawn from the water wash tank and delivered to conventional separatory means with separated water being recycled to the wash tank. The recovered oil product after separation is processed according to conventional hydrocarbon processes such as hydrocracking, visbreaking or similar processing techniques.

By referring to the accompanying drawing which shows one embodiment of the means by which the process of the present invention may be carried out, and by referring to the description of the same which follows, a better understanding of the present invention will be obtained.

Referring now to the drawing numeral 2 indicates a feed means by which tar sand is delivered to a hopper such as shown at 4. The feed means may be a conveyor belt bucket system or any other conventional solids handling system adapted to deliver the tar sand from its naturally existing state to hopper 4. Tar sand withdrawn from hopper 4 is passed by a transfer means 6 to mixer 14. During this transfer an initial mixing of the tar sand with diluent is accomplished. Diluent withdrawn from tank 8 is passed by pump 9 and line 10 through heater 12 to delivery means 6. Sufficient diluent is added to permit easy movement of the sand by delivery means 6 to mixer 14. It has been found that a volume ratio of diluent to tar in the amount of from 2:1 to 5:1 is most satisfactory.

Generally speaking, a diluent to tar ratio in an amount of about 2:1 is preferred.

The diluent material used may be any suitable hydrocarbon that will provide the oil diluent mixture with a specific gravity less than the gravity of water. For such purposes, it has been found that comparatively low-boiling hydrocarbons such as naphtha, gasoline, kerosene, benzene, diesel fuel or other like materials generally boiling in the range 350-500° F. can be used. The diluent is preferably heated in heater 12 to a temperature of from 70° F. to about 400° F. prior to being added to the tar sand mass.

In mixer 14 the diluent together with recycle oil will substantially dissolve all of the bitumen present. It has been found desirable not to provide additional heat at the mixing stage since the possibility exists that the water film surrounding the sand particle might be ruptured. The latter conclusion is based on the fact that the sand particle is surrounded by a film of water which in turn is surrounded by a film of tar or hydrocarbon. Rupturing of the water film either by too much heat or violent agitation as often occurred in prior separating techniques, is believed to give rise to the undesirable emulsion formation.

After mixing the tar sand diluent slurry is delivered by line 15 to wash tank 20. Tank 20 is designed to effect separation and disengagement of oil and diluent from the sand in two stages. Tank 20 includes in the initial disengaging and separating zone an inclined or sloped delivery surface 28 which terminates at the tank bottom 49. A vertical baffle 26 partitions the initial disengaging and separating zone 22 from the secondary disengaging zone identified by numeral 24. On introduction into zone 22 the tar sand slurry moves gently down the inclined surface 28 at a rate that is less than the rate of gravitational free fall if the sand slurry were introduced directly into the tank without utilizing the sloping surface. During the movement of the sand down the inclined surface the water present in the tank disengages the major portion of the oil diluent mixture from the sand particles. Initial disengaging zone 22 is sufficiently large to permit the accumulation of a substantial amount of oil diluent on the surface of the water. All or a portion of this initially disengaged and separated oil diluent is withdrawn in draw off 29 and delivered by line 30 to recycle oil tank 32.

The recycle oil in tank 32 is used in addition to slurring the sand as a means of maintaining control of temperature in mixer 14 at a desired level. To accomplish this recycle oil is withdrawn from tank 32 and passed by pump 34 and line 36 through heater 38, and thence to mixer 14. Since it is desired to maintain the temperature of the oil sand slurry in the mixer within the range of from 150° F. to 200° F. heater 38 will normally be operated at a temperature of from about 150° F. to 250° F. The quantity of recycle oil used will vary in volume with respect to the total tar or bitumen present in the ratio of from 2:1 to 10:1. Preferably the volume ratio of recycle oil to total tar will be about 3:1. Excess recycle oil not used in maintaining temperature control in mixer 14 is withdrawn from time to time from tank 32 in line 31 and passed to product oil storage.

The sand after moving down inclined end 28 has sufficient linear velocity to carry it beneath baffle 26 and into the second stage disengaging zone 24 of tank 20. In this disengaging zone the sand is gently fluffed or fluidized by jets of water delivered to nozzles 48 by line 40. The water introduced through nozzles 48 is obtained from any suitable source including recycle as hereafter described after passing the same through heat exchanger 42 and deaerator 44 prior to being introduced into tank 20. Heating of the water to a temperature of from about 80° F. to 150° F. substantially improves the disengagement of oil from sand in zone 24. While the disengagement of oil from sand in zone 24 is more readily accom-

plished at higher temperatures, the temperature of the water in zone 24 should not exceed the flash point.

The plurality of nozzles 48 in the bottom 49 of tank 20 are provided with independent control valves so as to permit balanced fluidization throughout disengaging zone 24. Control of the jets permits fluidization and turbulence of the sand in a manner that provides a continuous gentle fluffing of the bed without violent agitation or extreme turbulence. The fluffing action must be sufficient to keep the sand particles in motion so as to allow the oil to be easily disengaged from contact with the sand particles. Quite obviously there will be a slightly increased agitation in the immediate vicinity of the nozzles. The rate however at which water is introduced therethrough must be so controlled so as not to upset the gentle fluidized nature of the bed and thereby producing undesirable frothing and agitation which under certain circumstances might lead to emulsion formation.

During the gentle and continuous fluffing of the sand particles which is accomplished by the continuous migration of the sand toward the sand outlet end of the wash tank, a final and substantially complete disengagement of residual oil from the sand particles is accomplished. This most effective separation and disengagement permits a higher recovery of total oil products from the sand than has heretofore been obtainable by water wash tank.

The residual oil and diluent disengaged in 24 rises to the top of the water present in 20 and is continuously withdrawn together with water at draw off 27 and delivered by line 50 to oil-water separator 60.

The volume of water withdrawn with the oil and diluent at this point will be substantially equal to the volume of water introduced to tank 20 by way of nozzles 48 and 53. The level of oil, sand and water in tank 20 may be varied, but it has been found that a sand bed of approximately one-third the height of the combined oil diluent water level provides a satisfactory volume ratio of materials in tank 20. Maintaining the quantity of sand on a volume basis at about one-third of the total water-oil diluent mixture insures balanced recovery of oil free of sand and a sand product free of oil and diluent.

The sand product, substantially free of oil, is withdrawn at drawoff 55 and passed through line 52 to disposal. To insure a sand product free of oil, stripping of the sand product is carried out in drawoff 55 and line 52 by water injected in line 53. The water introduced for stripping purposes similar to the water introduced to tank 20 via nozzles 48 can be withdrawn from any suitable source including water recovered from separators 60 and 70. The water used for stripping similar to the water utilized in fluidizing is preferably heated to a temperature of from 80° F. to 150° F.

The oil and diluent product withdrawn from wash tank 20 in line 50 is delivered to an oil water separator 60. Accumulated oil identified at 62 is withdrawn in drawoff line 63 with the separated water being passed by line 68 to further separation tanks 70 and 75. In a manner similar to the separation carried out in drum 60, product oil can be withdrawn in line 73 with further separation of water being carried out in drum 75 as shown.

In carrying out the separation of bitumen from the sand particles in tank 20 it has been found essential that the sand particles be kept continuously moving in a very gentle manner as opposed to violently agitating the same. The gentle fluffing or fluidizing provided by the nozzles 48 releases the oil from the sand particle permitting the same to rise to the top of the water in the tank. The reason for substantially complete recovery of oil from the sand particles by this gentle fluffing technique is not clearly understood.

The effectiveness of the method of the present invention for separating valuable hydrocarbon products from tar sands will be more readily apparent from the specific example which follows:

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To a processing unit similar to that shown in the accompanying drawing, 93 lbs. per hour of Athabasca tar sand was delivered. To the tar sand 1.3 gallons per hour of a diluent having a gravity of 31.7 A.P.I. with an initial boiling point of 376° F. and an end boiling point of 503° F. were added. Bitumen in the tar sand amounted to 20.3 wt. percent. The diluent was introduced at a temperature of 128° F. at a rate of 1.3 gallons per hour. Recycle oil was introduced to the mixing zone at a temperature of 152° F. at the rate of 2.78 gallons per hour. Fluidization in the wash zone was obtained by introducing 120° F. water through 12 nozzles at the total rate of 6.86 gallons of water per square foot per minute. The wash tank had a total volume of 1.4 cubic feet. The oil product recovered contained 56.6 wt. percent of bitumen, 38.9 wt. percent of diluent and .38 wt. percent of total solids. Wash water recovered from the oil product contained 0.36 wt. percent of total oil and 0.036 wt. percent of total solids. The sand product removed after fluidization and stripping contained 0.27 wt. percent total oil and had the following screen analysis: +100—93.9%; +200—5.4% and Pan—0.8%. The product oil losses amounted to 5.01 wt. percent oil lost in the wash water and 0.602 wt. percent oil with the washed sand.

It is with the latter two numbers, namely, the weight percent of oil lost in wash water and weight percent of oil lost with wash sand, that is most significant as far as the economics of the process are concerned. With product losses in the order of those reported in the foregoing example the present invention gives a far more effective separation and recovery of oil product than has heretofore been possible according to methods previously utilized.

In the table which follows, the results of several runs carried out in a method similar to the foregoing example is provided. The feed material in all runs was Athabasca tar sand. The runs identified under the column headed Run No. averaged from two to eight hours with runs 3 and 4 being conducted in approximately 75 hours. The data provided for these runs is representative data accumulated over the total run period.

TABLE

Run No.	Feed Rate, Lbs./Hr.	Wt. Percent Bit. in Feed	Wash Tank Temp., ° F.	Recycle Oil Temp., ° F.	Diluent Temp., ° F.	Water Wash Rate, Gal./ft. ² Min.
1.....	107	30.9	133	167	1 167	4.94
2.....	92	21.2	75	97	1 88	3.40
3.....	104	-----	116	148	2 108	5.64
4.....	98	-----	116	129	2 106	-----

Run No.	Oil Product Quality			Wash Water Effluent		Washed Sand, Wt. Percent Total Oil
	Wt. Percent Bitumen	Wt. Percent Diluent	Wt. Percent Total Solids	Wt. Percent Oil	Wt. Percent Total Solids	
1.....	46.9	52.2	0.23	0.083	0.054	0.35
2.....	60.3	37.2	0.42	0.032	0.045	0.37
3.....	39.2	58.8	0.16	0.011	0.061	0.36
4.....	45.8	52.1	0.18	0.021	0.263	0.18

¹ Pan oil.

² Kerosene.

As will be readily apparent from the foregoing data, carrying out the separation of bitumen from sand according to the method of the present invention provides an oil product substantially free of solid materials and a sand having only negligible amounts of oil present.

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From an economic point of view the latter is most significant since, in order to make the process economically attractive, substantially complete recovery of the total oil present must be accomplished. It is, of course, understood that once the product recovery of oil has been accomplished, further processing of the same can be carried out by conventional petroleum refining methods. Such methods would include the production of cuts having characteristics making them particularly suitable for use as diluent. By this means the process can be self-sustaining with respect to the diluent requirement. In addition, heat requirements can be provided by burning of residual stocks obtained from processing of the product tar recovered.

While the present invention has been described with respect to the particular embodiment shown in the accompanying drawing, it is to be understood that it is not intended that the process be limited to the same, but limited only as required by the claims appended hereto.

We claim:

1. The process for recovering hydrocarbon oil from bituminous sand containing the same which comprises mixing said bituminous sand with hydrocarbon diluent to form a slurry, passing said slurry down an inclined slope positioned within a wash tank containing water to separate hydrocarbon oil therefrom, separating additional hydrocarbon oil from the sand partially cleaned by initial contact with water by moving the sand horizontally and in a fluidized manner across the bottom of the wash tank, the moving and fluidization being accomplished by the introduction of water into the bottom of said tank in a manner that substantially limits the formation of emulsion.

2. The process for recovering hydrocarbon oil from bituminous sand containing the same which comprises mixing said sand with a liquid hydrocarbon diluent to form a slurry, passing said slurry down an inclined slope positioned within a wash tank containing water to thereby separate hydrocarbon liquid from sand, maintaining a fluidized horizontally moving bed of thus separated sand in the bottom of said wash tank by the controlled injection of water into said bed to thereby separate further amounts of hydrocarbon liquid from said sand without substantial emulsion formation, and withdrawing sand from said wash tank at a point horizontally remote from said inclined slope to thereby assist continuous movement of sand down said slope and in the horizontally moving fluidized bed of sand.

3. The method of recovering hydrocarbons from bituminous sand containing the same which comprises mixing said bituminous sand with a diluent to form a pumpable slurry, disengaging a major amount of a diluent-hydrocarbon mixture from said slurry by passing the same down an inclined slope positioned within a wash tank containing water, recovering a diluent-hydrocarbon product from such initial contact with water, passing thus separated sand to secondary contact with additional water, maintaining said sand in a horizontally moving fluidized bed during said secondary contact, said additional water being introduced to the bottom of the wash tank at a plurality of inlets recovering additional diluent-hydrocarbon mixture from said sand in said secondary contact, and recovering a sand product substantially free of diluent and hydrocarbon.

4. The process for recovering hydrocarbon oil from bituminous sand containing the same which comprises mixing said bituminous sand with liquid hydrocarbon diluent to form a slurry, introducing said slurry to water separation and disengagement, said water separation and disengagement being carried out in two stages, the first of said stages including gently mixing said slurry with water in a manner that permits the sand present in the slurry to move slowly to the bottom of a separation vessel at a rate less than the free fall rate of sand in water, continuously moving sand from the first stage sep-

aration and disengagement to the second stage separation and disengagement, said second stage being accomplished by fluidizing the sand with water, said water being introduced to the bottom of said tank at a plurality of points said fluidization being carried out in a horizontally moving bed under gentle fluidizing conditions to avoid emulsion formation while permitting substantially complete disengagement of hydrocarbons from sand particles, accumulating and withdrawing disengaged hydrocarbons mixed with water and passing the same to a separation zone for recovering of hydrocarbons there-

from, and withdrawing sand from said second stage disengagement.

References Cited in the file of this patent

UNITED STATES PATENTS

2,885,339 Coulson et al. ----- May 5, 1959
2,903,407 Fischer et al. ----- Sept. 8, 1959

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,041,267

June 26, 1962

John D. Frame et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 44, for "substantialyy" read -- substantially --; line 51, for "visebreaking" read -- visbreaking --.

Signed and sealed this 23rd day of October 1962.

SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents