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PROCESS FOR THE RECOVERY OF BITUMEN FROM TAR SANDS UTILIZING A COOLING TECHNIQUE

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The present invention is broadly concerned with the recovery of hydrocarbons from tar sands. The invention is particularly concerned with an improved technique for efficiently removing hydrocarbons, such as bitumen, tars, and the like from tar sands containing the same, such as Athabaska tar sands. In accordance with the present invention, the method comprises a unique technique for reducing the tar sands to a relatively low temperature in a manner to remove hydrocarbons and carbon to the sand. The mixture is then readily fractured by grinding and the like and the smaller and lighter bitumen particles are separated therefrom.

In various areas of the world, tar sands exist which contain various types of hydrocarbons as, for example, the heavy deposits of Athabaska tar sands existing in Canada. These sands contain tremendous reserves of hydrocarbon constituents. For example, the oil in the sands may vary from about 5% to 21% by weight, generally in the range of about 12% by weight. The gravity of the oil ranges from about 6° to 10° API, generally about 8° API. These sands may lie from about zero to several hundred feet below an overburden and the beds may range from about 100 to 400 feet thick. A typical oil recovered from the sands has an initial boiling point of about 200° F., 1% distilled to 450° F., 20% distilled to 650° F., and 50% distilled up to 908° F. However, the recovery of hydrocarbons in the past has not been effective to any great extent due to the deficiencies in operating techniques for the recovery of these hydrocarbons. For example, a relatively small amount of oil (from about 0% to 30%) usually about 5%) in the sand greatly reduces the recovery of the oil utilizing water techniques. Apparently the oil and the clay form skins which envelop the water and sand resulting in an emulsion of water containing a water-coated sand. The tar is too viscous to allow satisfactory operations of conventional oil extraction equipment without mechanical agitation.

Numerous attempts have been made in the past to recover bitumen from the Athabaska tar sands in various manners. For example, it has been suggested that a solvent be added in order to reduce the viscosity of the bitumen, and in conjunction with water, to float the bitumen solvent mixture away from the sand. Although this technique achieves a good separation of clean sand, the addition of water results in problems with the formation of stable emulsions and sludges which have been very difficult to separate. Thus, extensive supplementary processing has been required in order to avoid large oil losses.

Generally, in extracting the bitumen from tar sands, two main methods have been proposed: (1) the hot water wash employs water at about 180° F. plus a small amount of air; (2) the cold water wash at about 80° F. employs a large amount of light hydrocarbon diluent. In each of these processes, the major problem results from the very tight emulsions or sludges which are formed by interaction of the small amount of very fine solids in the sands, plus oil, plus water. These tight emulsions are very difficult to break and the mixture of oil, water and solids is too dilute in hydrocarbon to make it practical to feed the whole "mess" to, for example, a coking operation.

It has also been suggested in the past that tar sands as they are mined be handled by a thermal process in order to recover the bitumen therefrom. However, this process has been uneconomical due to the large amount of heat which is lost due to the fact that the heat is imparted to the sand and cannot be effectively and efficiently recovered therefrom. It has been suggested for example that tar sands be handled in a direct fluid coking operation. However, as pointed out, this process is uneconomical for the reasons given above. Also, any process that will effectively handle tar sands must have the ability to handle a very wide range of tar sand and compositions which occur even in an immediate location.

In accordance with the present invention, a unique efficient operation is utilized for cooling the tar sands to the required low temperature, preferably in the range from about 50° F. to 60° F. The process employed involves cooling the sands by direct contact with boiling propylene or equivalent compounds, such as ethylene and the like. One source of propylene is available from the off-gas from a fluid coker associated with the recovery of oil from tar sands. The frozen mixture is then ground to the desired extent in a manner to efficiently and effectively separate the smaller and lighter bitumen particles therefrom.

The process of the present invention may be readily understood by reference to the drawing illustrating one embodiment of the same. Mined tar sands from a suitable source are introduced into ball mill 2 by means of conveyor 1. These tar sands are ball milled to lumps approximately 1" in diameter in order to facilitate the freezing of the sands. Generally, the diameter of the lumps will vary in the range from about 1/4" to 1/2".

The crushed tar sands are withdrawn from ball mill 2 by means of line 3 and introduced into tar sand cooler zone 4. Sand cooler zone 4 may comprise one or more stages. In the sand cooler zone 4, the sands are contacted with, for example, cold propylene liquid. In the upper area of cooler 4, the sands countercurrently contact vaporous propylene which has boiled off from the liquid propylene in the lower area of the cooler. This propylene liquid preferably comprises 100% propylene, but may contain other hydrocarbons. The liquid is at a temperature of about 54° F. which is its normal boiling point at atmospheric pressure. The liquid propylene is introduced into zone 4 by means of line 5 and is withdrawn overhead from zone 4 as a vapor by means of line 6.

The cooled sands at a temperature of about 54° F. are withdrawn from the bottom of zone 4 by means of line 7 and are separated. The particular method of separating the bitumen from the tar sands may vary appreciably.

A preferred method is to introduce the sand into a fractionating zone 8 wherein the bitumen-sand agglomerates are fractionated. This may be accomplished by ball milling, ultrasonics, and the like. The mixture is then introduced into an elutriation zone 9 which may comprise a cylindrical tower wherein upwelling gases are introduced by means of line 51. These upwelling gases carry out the smaller and lighter bitumen particles by means of line 30 wherein the same may be further processed for the recovery of the bitumen. The clean sand is removed by means of line 9 and handled as hereinafter described.

The bitumen agglomerates removed overhead by means of line 30 may be solvent treated in order to recover the bitumen or may be thermally treated as, for example, in a fluid coker. The fluid coker may comprise a fluid coking operation such as described in U.S. Patent 2,881,150, issued April 7, 1959, entitled "Fluid Coking of Heavy Hydrocarbons"; inventor: Robert W. Pfeiffer et al. In essence, the fluid coking operation uses two vessels,
3,114,694

3. a reactor and a burner, and solids are circulated between these to transfer heat to the reactor. The reactor will contain a fluid bed of the sticky enriched tar sands together with sticky coke particles. Reactor temperature averages from about 950° to 1100° F, and is controlled by the flow of hot coke from the burner. Pressure is about 0 to 50 pounds. Steam is introduced into the bottom of the reactor to fluidize the bed. The enriched sand feed may be introduced into the bed through a number of injection points. In the fluid coking operation, the mixing is good and the feed distributes uniformly over the surface of the particles. Here it cracks and vaporizes, leaving a sticky residue which slowly drips to form coke. The volume of vapors increases progressively up through the bed due to the formation of cracked products. Vapor products leave the bed and pass through cyclones which remove most of the entrained coke. The vapors then discharge into the bottom of the scrubber. Here the remaining coke thrust is scrubbed out and the products are cooled to condense out a heavy tar. The resulting slurry is recycled to the lower part of the coking reactor so that it is subjected to maximum cracking intensity. The upper part of the scrubber tower is a fractionation zone from which coke gas oil is withdrawn. Naphtha and gas oil are taken overhead to condensers.

In the reactor, the coke particles flow down through the vessel into a stripping zone at the bottom. Stripping steam displaces product vapors between the particles. The coke then flows down a standpipe, and through a slide valve which controls reactor bed level. A riser carries the coke up to the burner. Steam is added to the riser to reduce the solids loading and induce upward flow. Average bed temperature in the burner is 1100°-1150° F, air being added as needed to maintain the temperature by burning part of the product coke. If desired, extraneous oil fuel can be burned preferentially in order to increase coke production. Flue gases from the bed pass through two stages of cyclones, and discharge into the stack through a variable orifice which controls burner pressure. Hot coke from the burner bed is returned to the reactor through a standpipe, slide valve, and riser.

Since coke is one of the products of the process, it must be withdrawn from the system in order to keep the solids inventory from increasing. The coke product is removed from the burner bed through a quench-gluatator drum. Water is added to the latter to cool the coke, and make steam which entrains the fine particles and carries them back into the burner. Cooled coarse coke is withdrawn and sent to storage. In essence, the sand from the fluid coke will be removed with the coke and can be readily separated therefrom by mechanical separation or any other technique.

Typical operating conditions for fluid coking are as follows:

<table>
<thead>
<tr>
<th>Temp., °F</th>
<th>Reactor</th>
<th>Burner</th>
</tr>
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<tbody>
<tr>
<td>Press., psi</td>
<td>900</td>
<td>1100</td>
</tr>
<tr>
<td>Valve, in.</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td>Bed depth, ft</td>
<td>20-50</td>
<td>10-15</td>
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Reactor space velocity is expressed as w./w. hr., which means pounds of pitch fed per hour, per pound of coke bed. The reactor pressure is usually in the range of 0.5-1.0 w./w. hr. The slurry is recycled to the reactor from the scrubber amounts to 20%-40% on pitch fed. Coke circulation from the burner is about 5-10 pounds per pound of pitch fed.

In accordance with the present invention, a subterranean sand is withdrawn from separation zone 50 by means of line 9 and introduced into a fluid bed condenser 10. The temperature of the sand at this point is about 44°F. The sand, after exchanging heat with propylene vapors in fluid bed condenser 10, is withdrawn by means of line 19 and introduced into a second fluid bed condenser 11. Here the sand, at a somewhat higher temperature than in zone 10, exchanges heat with propylene vapors and is withdrawn from the system by means of line 20 and handled as desired.

Fluidization of the sand in zones 10 and 11 is secured preferably by means of propylene vapor which is introduced into zone 10 by line 18 and withdrawn by means of line 53. Fluidizing propylene is introduced into zone 11 by means of line 54 and is withdrawn by means of line 55. Satisfactory distribution and fluidization means known in the art are used. Furthermore, the propylene vapors withdrawn by means of lines 53 and 55 are handled to regenerate entrained sand which is removed from the bottom of the respective zones. The propylene withdrawn by means of lines 53 and 55 is condensed, cooled, and recycled to the system. Although only two fluid bed condensers 10 and 11 are illustrated, it is to be understood that additional stages may be utilized.

The propylene withdrawn overhead from zone 4 by means of line 6 is passed successively through heat exchangers 16, 17 and 18 and is withdrawn from heat exchanger 18 by means of line 56. In the final stage 22, all the propylene not condensed in the fluid bed condensers is condensed with cooling water as illustrated.

Clean sand from separation zone 50 is introduced into fluid bed condenser 10 by means of line 9 and withdrawn by means of line 19. Propylene vapor is used to fluidize the sands instead of the air or steam normally used for fluidizing solids. This is done so that the propylene vapor left in the sand pores in the separation zone will not be diluted and, therefore, can be recovered from the spent sand by water displacement. The propylene fluidizing gas system required for each fluid bed is not shown.

A portion of the propylene vapor to be condensed is passed by means of line 36 through a heat exchanger 22 wherein the same is compressed to about 3-35 atmospheres, at which point it can be condensed in fluid bed condenser 10 at about -10°F. Prior to introducing the vapors into heat exchanger 10, the same are passed through heat exchanger 11 wherein water is introduced at a temperature of about 40°F.

An additional portion of the propylene vapor is compressed in compressor 23 to 6 atmospheres. This stream is then passed through heat exchanger 14 wherein it is heated and exchanged with water at about 40°F. The cold propylene vapor is then passed into heat exchanger 15 wherein it condenses to a temperature at about -15°F.

The remainder of the propylene is compressed in compressor 24 to about 5 atmospheres and then passed in heat exchange through heat exchangers 15 and 12 wherein the propylene contacts water at about 40°F. Under these conditions, the propylene condenses.

As pointed out heretofore, the condensed propylene from heat exchangers 10, 11, and 14 are passed and heat exchanged with vapors in heat exchangers 16, 17, and 18 respectively. The liquid propylene is then passed into storage tank 27 and introduced into zone 4 by means of line 5 as hereinbefore described. Thus, the liquid propylene is passed into heat exchanger 11 wherein it condenses at a temperature at about -8°F.

Thus, the present invention is concerned with a unique technique for effective recovering of bitumen from tar sands. In essence, the operation comprises a cold method wherein efficient heat transfer between the respective streams is secured, utilizing a plurality of fluid bed condensers in conjunction with a plurality of heat exchange units wherein condensation from the respective condensers is in heat exchange with the boiling propylene utilized to cool the incoming fresh sands.

What is claimed is:

1. Process for recovering bitumen from tar sands which
comprises grinding the tar sands to produce lumps having diameters in the range from about $\frac{1}{2}$" to $1\frac{1}{2}$", thereafter introducing said lumps into the top of a cooling zone and countercurrently contacting said lumps with boiling liquefied propylene which is introduced into the bottom of said cooling zone, withdrawing vapor of said propylene from the top of said zone, withdrawing cold tar sand lumps from the bottom of said cooling zone at a temperature in the range from about $-60^\circ$ to $-50^\circ$ F., passing said lumps to a separation zone wherein bitumen lumps are separated from chilled sand, heat exchanging said chilled sand with said vapor of said propylene under conditions to condense said vapor and recycling said condensed propylene to said cooling zone.

2. Process for recovering bitumen from tar sands which comprises grinding the tar sands to produce lumps having diameters in the range from about $\frac{1}{2}$" to $1\frac{1}{2}$", thereafter introducing said lumps into the top of a cooling zone and countercurrently contacting said lumps with a boiling liquefied normally gaseous hydrocarbon which is introduced into the bottom of said cooling zone, withdrawing vapor of said hydrocarbon from the top of said zone, withdrawing cold tar sand lumps from the bottom of said cooling zone at a temperature in the range from about $-60^\circ$ to $-50^\circ$ F., passing said lumps to a separation zone wherein bitumen lumps are separated from chilled sand, heat exchanging said chilled sand with said vapor under conditions to condense said vapor and recycling said condensed vapor to said cooling zone.

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