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RECOVERY OF OIL FROM BITUMINOUS SANDS

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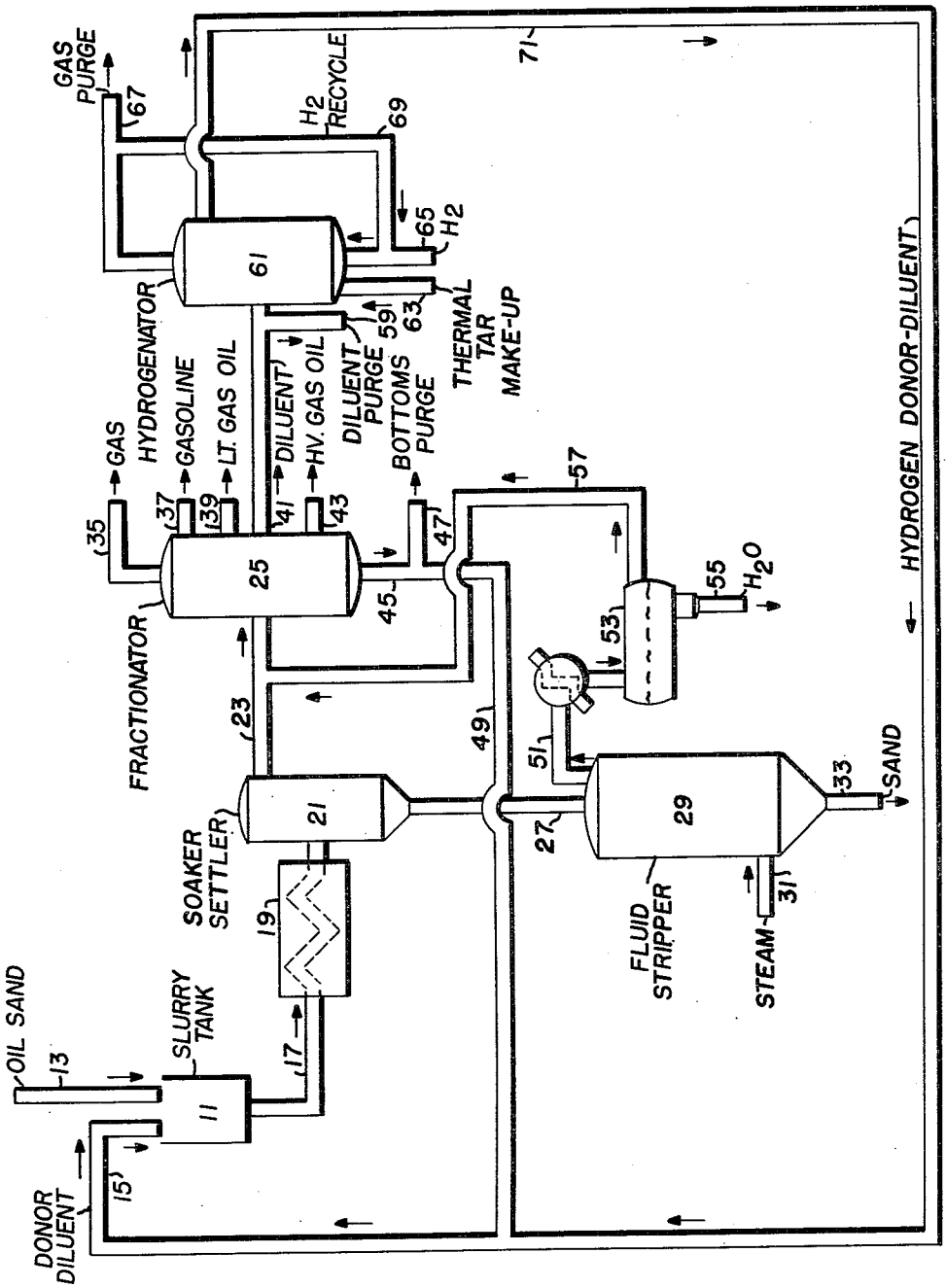

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RECOVERY OF OIL FROM BITUMINOUS SANDS

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3 Claims. (Cl. 196—14)

The present invention relates to the recovery of oil from bituminous sands. It relates more particularly to an improved system and process for the more efficient recovery of optimum quantities of oil from oil-bearing minerals such as the so-called tar sands.

Bituminous sands or tar sands are well known in various parts of the world. One of the most important deposits is found in Alberta, Canada, along the Athabasca River and its tributaries. Layers of sand heavily impregnated or saturated with oil are found over a substantial area in this region. Other deposits which are less conspicuous or well known appear in numerous other places and doubtless many others are still to be discovered. These tar sands or bituminous sands are not to be confused with oil shale which really contains no liquid oil as such but contains a solid organic material, kerogen, which can be cracked thermally to produce oil. By contrast, typical tar sands or bituminous sands contain 10 to 16% by weight of a heavy viscous oil or bitumen as such. In some areas, deposits containing as much as 100,000,000 barrels of such oil or bitumen per square mile are known to exist. Notwithstanding their abundance, to date no commercially feasible method for recovery has been developed.

In a copending application filed concurrently herewith by the present inventors, Serial No. 365,343 a process and system are disclosed for extracting oil from shale by a thermal treatment in the presence of a hydrogen donor-diluent material. The present application is somewhat similar but since oil shale and bituminous sands are quite different in their physical and chemical construction they must be processed differently and the present invention relates to the bituminous sands.

In another copending application filed concurrently herewith by Langer, one of the present inventors, a process is described wherein various heavy oils, particularly petroleum residual oils, may be upgraded by the use of an inexpensive hydrogen donor and diluent material. Such process, described in detail and claimed in application Serial No. 365,335 is generally applicable to the present situation. However, bituminous sands present a particular problem, since some 84 to 90% or more is mineral matter and the oils recovered therefrom are not only of high viscosity but also contain high proportions of sulfur and other non-hydrocarbon materials which give rise to substantial problems in handling them.

It is therefore an object of the present invention to so treat the oil bearing sands as to recover optimum quantities of useful products from them at low cost. In part, this object is achieved by making use of an inexpensive hydrogen donor diluent, such as a partially hydrogenated thermal tar obtained from catalytic cracking operations on hydrocarbon fractions such as petroleum gas oils and the like. Preferably, the hydrogen donor diluents used for purposes of the present invention are of somewhat lower boiling range, in general, than those used in the copending applications mentioned above. In the present process it is preferred to use a donor-diluent

having a boiling range within the limits roughly of about 500 to 700° F. The lower boiling material makes it easier to strip the oil from the sand in later stages of the process. However, diluents boiling above 700° F. and up to about 900° F. may be used in many cases without difficulty.

The diluent is preferably used in sufficient proportions to form a liquid or pumpable slurry with the sand. For this purpose, with high grade sands, the diluent should have a weight ratio of up to about 5 to 1, based on the tar content of the sand. For sands of low bitumen or oil content, even larger proportions may be needed, up to about 10 to 1 on the same basis. Using 5 to 10 parts of donor-diluent by weight for each part of tar or bitumen, the transferable hydrogen in the donor-diluent need not be very high. Hydrogenation to the extent of about 200 to 600 s. c. f. of hydrogen per barrel of diluent is quite adequate.

It is not always necessary to form a pumpable slurry of the sand, though that is the method presently preferred. It is also possible to prepare a viscous paste by using, for example, about 1 part of diluent for each part of tar or bitumen. In this case, the paste may be transferred by an extruder type feeding device, as is known in the art. In this case also, the hydrogen requirements, per unit of diluent, tend to be higher. Overall, diluent ratios may vary from about 1 to 1 to 10 to 1, compared with the bitumen content of the sand and the hydrogen added to the diluent may vary from as little as about 50 to as much as 1000 s. c. f. or more per barrel of diluent.

In the preferred process, sand is broken up and mixed with the donor-diluent in proportions suitable for forming a mobile slurry. The slurry is pumped through a fired coil and into a soaking and settling zone where the mixture is heated to a temperature within the range of about 700 to 1000° F., preferably between 750 and 900° F. The material is held for a period sufficient to obtain good extraction, sufficient agitation being applied to accomplish this result. The usual residence time is from about 10 minutes to about 120 minutes. The process is preferably carried out under moderate pressure, e. g. up to 500 p. s. i. g., a pressure of about 200 p. s. i. g. being very satisfactory. However, the pressure need be no greater than is necessary to prevent loss of volatile ingredients.

The sand settles gradually to the bottom, as its oil content is extracted, and an oil phase forms at the top. The rate of sand settling and the completeness of oil extraction varies in part with the viscosity of the slurry and in part with the degree of agitation. The latter should be so controlled as to obtain maximum extraction of oil, consistent with good throughput. If the average residence time of the sand is within the limits described above and the sand slurry is free flowing, extraction will be reasonably complete. With a residence time of 1 hour for example, and a ratio of diluent to bitumen of 4:1, using a temperature of at least 750° F., and a diluent of boiling range about 500 to 700° F., 95% or more of the bitumen may be extracted.

The extracted portion is then fractionated to obtain several cuts including one that is suitable for partial hydrogenation and recycling as a diluent. Bottoms may be partly or wholly recycled with the diluent, at least a small part preferably being discarded to prevent build-up of undesirable constituents.

The invention will be more fully understood by reference to the attached drawing where an embodiment is shown diagrammatically.

As shown in the drawing, oil sand is broken into small lumps or particles of a maximum size of 1 inch or less, preferably not over ¼ inch in average diameter. The subdivided bituminous sand is fed to a slurry tank 11

through a line 13. There it is mixed by any conventional means, not shown, with a liquid donor-diluent fraction supplied through a line 15, to form a slurry, preferably a free flowing or pumpable slurry.

The slurry leaves tank 11 through a line 17 and passes to a heating coil 19 and into a soaking and settling tank 21. Additional heat may be applied to or in tank 21 by conventional means if desired. In any case, the temperature of the slurry in the settler is brought up to at least 700° F. and not more than 1000° F., preferably between 750 and 900° F.

Agitation by a propeller or stirrer or the equivalent is maintained in the tank 21 so that the sand settles slowly to the bottom with a residence time between about 10 and about 120 minutes, as previously described. Oil moves to the top of the tank 21 and is drawn off through a line 23 to fractionator 25. The sand is taken out at the bottom through a line 27 to a receiver, shown as a fluid solids stripper vessel 29. Here a stripping fluid, preferably steam, though an inert gas may be used, is introduced through one or more lines 31 to fluidize the sand and to strip its residual oil content. The spent sand may be withdrawn through a line 33, preferably to a heat exchanger to make use of its sensible heat. Thereafter it is discarded.

The oil is fractionated in fractionator 25 to obtain desired products such as gas through line 35, gasoline through line 37, light gas oil through line 39, a diluent-donor base material through line 41 (preferably boiling between 500 or 550 and about 700° F.) and a heavy gas oil through line 43. Bottoms are withdrawn through a line 45, from which part may be purged through line 47. The remainder, or all if desired, may be recycled to the diluent line 15 through line 49.

The stripped products from stripper vessel 29 go through line 51 to a condenser 53 where the steam is condensed and removed through a line 55. The oil products then go through line 57 to join the feed to the fractionator described above.

In order to control the quality of the diluent, part of it may be purged from line 41 through line 59. The remainder is taken to a hydrogenator 61. Here make-up thermal tar may be added, to keep the condensed ring aromatics content high, through a line 63. This is preferably a tar from catalytic cracking of petroleum (gas oil), with the same general boiling range, i. e. above 500° F. and below 900° F. Gaseous hydrogen is added, from any suitable source such as a hydroformer, or the like, through line 65. As noted above, hydrogen requirements may vary between about 50 and 1000 s. c. f. per barrel of diluent, more or less, depending upon the ratio of diluent to bitumen, as well as upon other factors such as pressure and temperature in the soaker. Gas may be purged overhead through line 67, but preferably much or most of it is recycled through line 69. Hydrogenation is carried out in a conventional manner.

The partially hydrogenated donor-diluent material is then recycled through line 71 to join line 15 into the slurry tank 11. From here the process is repeated.

It will be understood that various modifications may be made in the process and system for recovery of oil from bituminous sands, the salient feature being particularly the use of partially hydrogenated liquid donor-diluent of middle boiling range and at moderate temperatures. The use of thermal tar as the diluent base is a particular feature. As suggested above a pasty mixture may be used instead of a liquid slurry in some cases and it is intended that the term "slurry," when used in the claims without further qualification shall cover both. The liquid slurry system and process is more flexible and is specifically preferred.

What is claimed is:

1. The process of efficiently extracting oil from bituminous sand which comprises breaking up said sand into small particles, forming a liquid slurry of said particles in a liquid hydrogen donor-diluent of boiling range between about 500° and about 700° F., feeding said slurry to a settling and soaking zone, heating said slurry non-catalytically and at a pressure sufficient to prevent loss of volatile ingredients, a maximum of 500 p. s. i. g. to a temperature between about 750° and 900° F., allowing a period of about 10 to 120 minutes for said sand to separate from said oil by phase formation, passing the sand to a stripping zone, fluidizing the sand in said stripping zone with steam to remove residual oil therefrom, separating the residual oil so removed from said steam and passing said residual oil to a fractionation zone along with the oil separated from the sand in the settling and soaking zone, fractionating said oils to obtain gasoline, gas oil, a diluent base fraction, boiling between 500° and 700° F., and a bottoms fraction, bleeding off a portion of said diluent base fraction, adding a thermal tar of similar boiling point from catalytic cracking of a petroleum fraction, partially hydrogenating said combined diluent base fraction and thermal tar by adding 200 to 600 s. c. f. of hydrogen gas thereto under hydrogenating conditions, recycling the partially hydrogenated material to join said slurry, and adding said bottoms fraction thereto.

2. Process according to claim 1 wherein the ratio of donor diluent to bitumen in said sand is between 1 and 5/1.

3. Process according to claim 1 wherein a thin liquid pumpable slurry is formed.

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