

[54] HYDROCONVERSION OF TAR SAND
BITUMENS

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[22] Filed: June 18, 1973

[21] Appl. No.: 370,809

[52] U.S. Cl. 208/108, 23/288 E, 208/48 R,
208/95, 208/107, 208/109, 208/157,
208/162, 208/251 H

[51] Int. Cl. C10g 9/16, C10g 13/14

[58] Field of Search 208/108, 11, 48 R; 210/71;
134/25 R

[56] References Cited
UNITED STATES PATENTS

3,151,054 9/1964 Layng 208/11

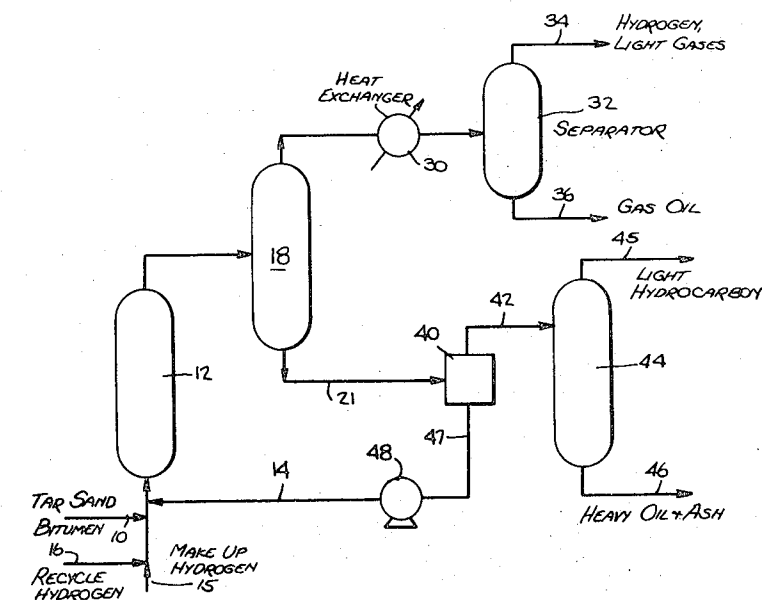
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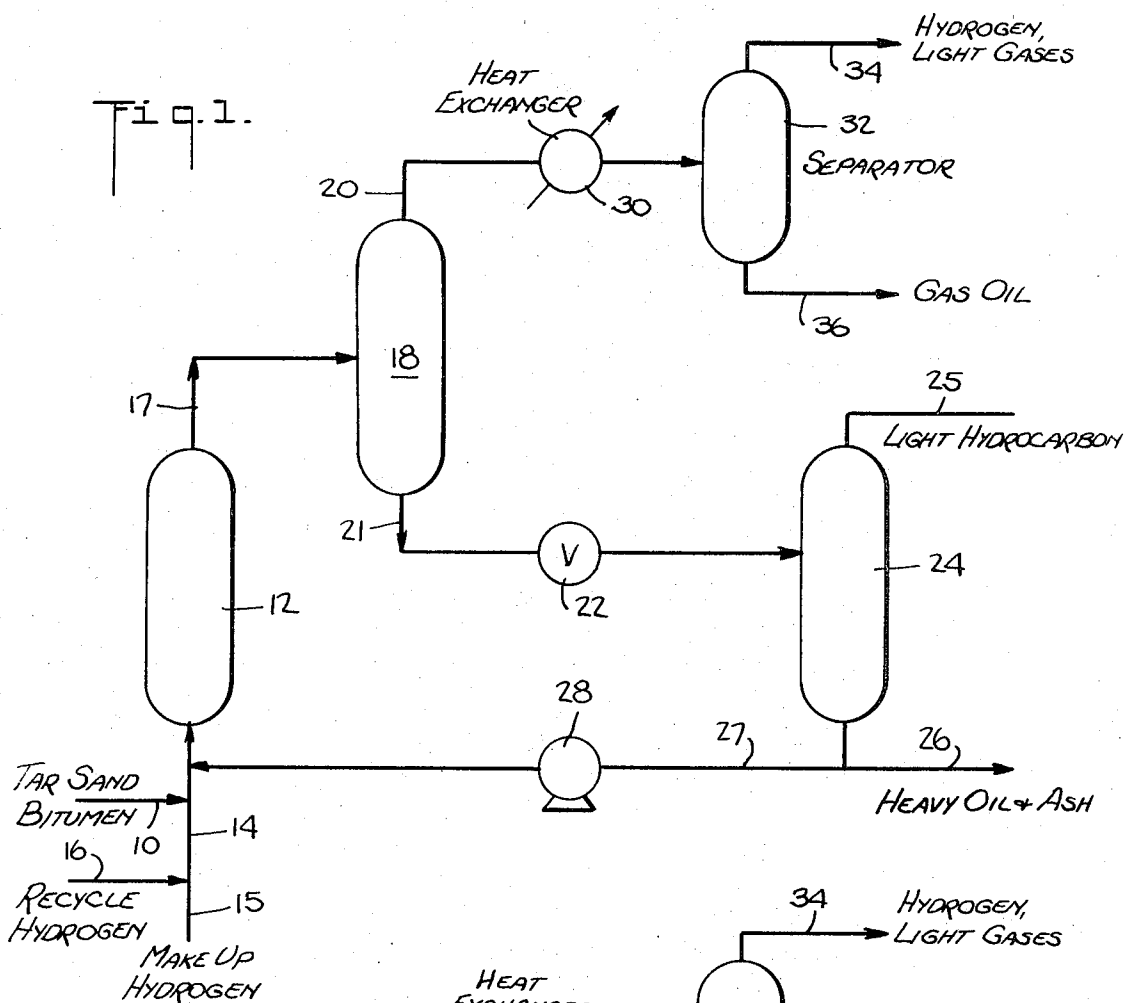
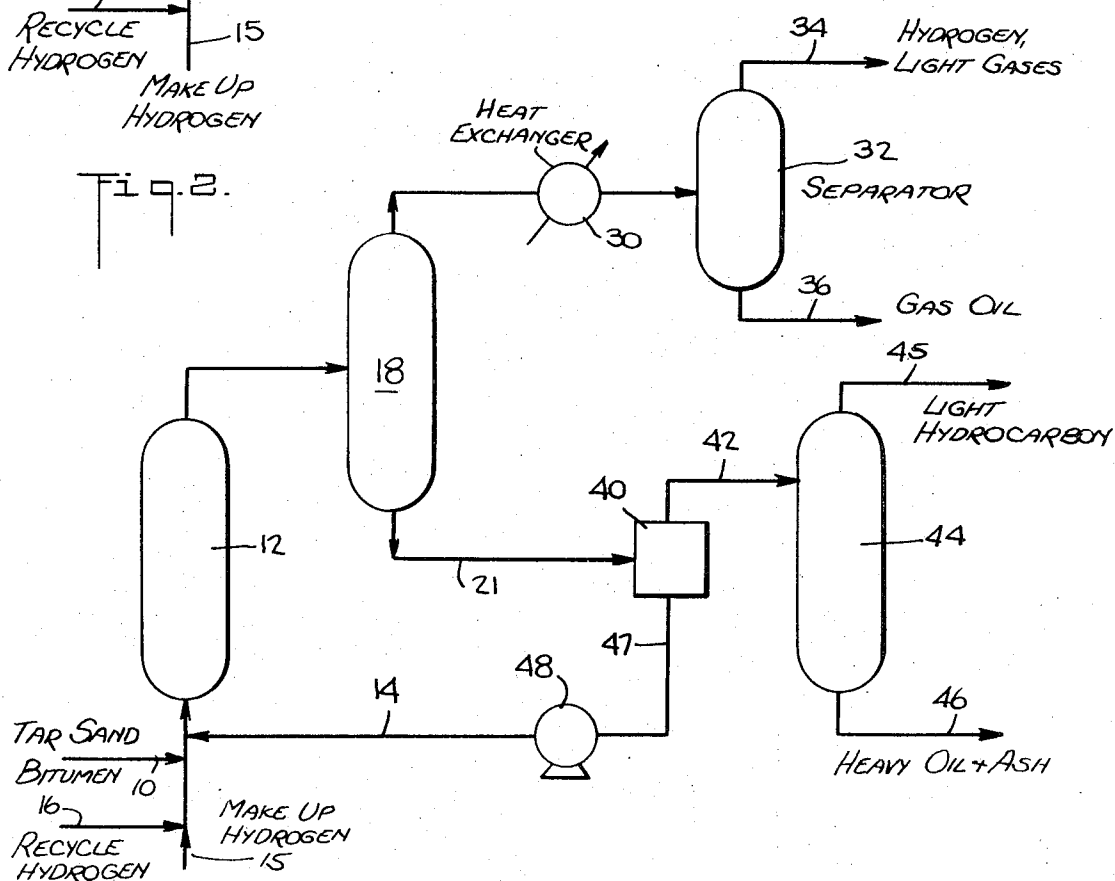
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[57] ABSTRACT

The recovery of valuable liquid hydrocarbons from tar sand bitumens by hydroconversion in an upflow reactor is improved when the concentration of ash in the reactor liquid is maintained at from about 4 percent to about 10 percent by weight. Suitably, this is effected by feeding the reactor liquid phase effluent to a separation unit such as a liquid cyclone and recycling the ash-enriched underflow liquid from the separation unit to the reactor.

4 Claims, 2 Drawing Figures





HYDROCONVERSION OF TAR SAND BITUMENS

BACKGROUND OF THE INVENTION

U.S. Pat. No. 3,151,054 describes a method for the recovery of fuels in the nature of distillate and a heavy fuel oil from tar sands bitumen using an upflow liquid phase hydrogenation system. This method makes available a means for the economical conversion of naturally occurring tar sands, such as Athabasca tar sands, to valuable liquid hydrocarbons. However, it has been found that in the hydrogenation of tar sand bitumens there is a tendency toward the formation of coke deposits, leading to fouling of equipment such as the reactor and downstream vapor-liquid separators. This necessarily affects the operability of the hydroconversion system, leading to undesirable down-time with attendant labor costs and to a generally reduced operating efficiency.

It is, therefore, highly desirable to provide a means for inhibiting or materially reducing coke formation in the reactor and thus improve the hydroconversion treating of tar sands bitumens.

SUMMARY OF THE INVENTION

The present invention relates to and has for its objects the production of valuable liquid hydrocarbons from tar sand bitumens which are difficult to process. More particularly, the present invention relates to a new and improved process for the hydroconversion of tar sand bitumens containing from about 0.5 to about 3.5 wt. percent sand in which the attainment of high on-stream efficiency and trouble-free operation is realized.

It has been found that the disadvantageous deposition of coke heretofore encountered in the hydrogenation of tar sand bitumens can be avoided by the inclusion of certain additional features in the hydroconversion process. In accordance with the present invention, the formation of coke in the reactor can be substantially prevented by regulating the concentration of ash in the reactor liquid. Advantageously, this is carried out by recycling part of the liquid phase reactor effluent which is enriched in ash concentration as compared to the feed because of cracking and vaporization of a substantial fraction of the feed, back to the reactor lower end.

This can be accomplished by feeding the reactor liquid product to a separation unit, such as a lower pressure phase separator, preferably a liquid cyclone, and recycling the underflow stream, having an increased ash concentration, to the reactor. By thus regulating the concentration of ash in the reactor to from about 4 weight percent to about 10 weight percent, the formation of coke can be substantially reduced to the point where it does not adversely affect the operability of the hydroconversion process.

DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic drawing of a flow diagram of an embodiment of the invention.

FIG. 2 is a schematic drawing showing another embodiment of the invention utilizing a liquid cyclone separator unit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1, a preheated natural tar sand bitu-

men feed is introduced through line 10 to a reactor 12 through line 14. A hydrogen rich gas (more than 60 percent hydrogen) is also introduced directly to the feed stream through line 14. This will include, as needed, a fresh make-up hydrogen in line 15 and a recycle hydrogen in line 16.

The reactor 12, preferably having an L/D ratio of at least 2 is maintained under upflow liquid conditions such as to keep the contact solids (ash or sand) in an ebullated bed condition, such as disclosed in U.S. Reissue Pat., No. 25,770, to Johanson. The hydroconversion operation is normally carried out at a total pressure of the order of from about 400 to about 2,000 psig and with a hydrogen partial pressure of from about 200 to about 1,500 psi. Temperatures generally employed in the reactor will range from about 700°F to about 950°F with space velocity of about 0.5 to 2.0 V_h/hr/V_r, (volume of feed per hour per volume of reactor). The conversion of 975°F plus boiling range material to material boiling below 975°F will be in excess of 50 percent by volume.

Conveniently, the reactor liquid together with the ash and the gas, is taken overhead in line 17 and passed to separator 18. In this separator 18, which is at substantially reactor pressure and temperature, there will be a phase separation of gas and vapors which are removed overhead in line 20 and the reactor liquid and ash which are removed as bottoms through line 21. The liquid is then passed through pressure reducing valve 22 to separation unit 24, shown as a phase separator. Other suitable separation units can be employed such as a liquid cyclone as hereinafter described.

The light hydrocarbons from separator 24 are taken off through line 25, and the liquid stream portion is taken off through line 26. A portion of this liquid which is enriched in ash is recycled through line 27 and pump 28 to reactor 12 through line 14.

The vapors and gas removed overhead through line 20 can be cooled at heat exchanger 30 and passed to separator 32, from which the light gases such as hydrogen, methane, naphtha, etc. can be removed through overhead line 34. The hydrogen can be recovered by conventional processing and reintroduced in line 16. The liquid fraction removed at 36 as bottoms from the separator 32 is a gas oil product.

A preferred embodiment of this invention is shown in FIG. 2, wherein the liquid stream 21 from separator 18 is passed to a liquid cyclone or hydroclone type separation unit 40 for separation into ash-depleted overflow stream 42 and ash-enriched underflow stream 47. Stream 47 is recycled by pump 48 through line 14 to reactor 12 in accordance with this embodiment. Ash-depleted stream 42 is passed to separator 44, from which a light hydrocarbon stream is removed overhead at 45 and a heavy hydrocarbon bottoms liquid stream is removed at line 46.

The vapors and gas removed through line 20 can be cooled as before at heat exchanger 30 and passed to separator 32, from which the light gases such as hydrogen, methane, naphtha, etc. can be removed through overhead line 34. The hydrogen can be recovered by conventional processing and reintroduced in line 16. The liquid fraction removed at 36 as bottoms from separator 32 is a gas oil product.

The concentration of ash in the reactor liquid is regulated by controlling the recycle ration of liquid from the separator unit (phase separator or hydroclone) to

fresh feed and the operating conditions in the reactor. The ratio of liquid recycled to fresh feed will vary from about 0.05:1.0 to about 1.0:1.0 depending on separation device efficiency. In general, it has been found that a recycle ratio of about 0.9:1.0 of liquid or 0.09:1.0 of hydroclone underflow provides the most satisfactory results. The recycle ratio will, of course, depend to some extent on the relative proportions of vapor and of liquid product coming off the reactor.

The tar sand bitumen employed as feed in the process of the present invention is in general a tar sand hydrocarbon or similar natural bitumen and is characterized by an initial boiling point of about 400°F, and API gravity of from about 2.0 to about 10.0, and an ash content of from about 0.5 to about 3.5 percent.

Some typical bitumens recovered from Athabasca tar sands which are useful in this invention have the characteristics listed below. The three different bitumen feeds labeled 1, 2 and 3 were obtained from two different sources designated A and B.

Bitumen Number	1	2	3
Bitumen Source	A	A	B
Gravity, °API	9.1	5.6	5.5
Sulfur, W %	4.64	4.84	4.85
Ash, W %	0.79	3.09	3.38
Carbon, W %	83.35	81.8	80.8
Hydrogen, W %	10.53	10.39	10.29
Metals (V plus Ni).ppm	210	198	253
Nitrogen	3900	3700	4100

The invention is more particularly illustrated in the following examples which are intended for purposes of illustration only and are not to be construed as limitative of the scope of the present invention.

EXAMPLE I

A tar sand bitumen having the following characteristics is hydrogenated under the conditions set forth in Table I, without recycle of any part of the reactor effluent to the reactor to increase the ash solids concentration therein.

BITUMEN

Boiling Range, V % of Feed	
IBP-650°F	16.7
650-975°F	33.3
975°F plus	50.0
Total Feed Inspections	
Gravity	9.5
Sulfur, W %	4.65
Ash, W %	0.85
Carbon, W %	83.5
Hydrogen, W %	10.64

TABLE I

Reactor Temperature °F	838
Hydrogen Partial Pressure, psi	1250
Space Velocity, $V_f/hr/V_r$	1.5
Recycle Ratio	0
Conversion, V %	
(Disappearance of 975°F plus feed)	73.9
Solids Concentration	
In reactor liquid, W % Ash	2.8
Percent of Feed Vaporized	70
Superficial Liquid Upflow	
Velocity in Reactor, fps	.0017

The coke formation in the reactor is extensive at 73.9 percent conversion and adversely affects the operabil-

ity of the process to a significant degree. This coke formation is believed due to the low ash concentration in the reactor of only 2.8 weight percent.

EXAMPLE II

The tar sand bitumen employed in Example I is hydrogenated under the conditions set forth in Table II, with recycle of flashed reactor liquid effluent back to the reactor lower end as illustrated in FIG. 1.

TABLE II

Reactor Temperature, °F	850
Hydrogen Partial Pressure, psi	1200
Space Velocity, $V_f/hr/V_r$	1.0
Recycle Ratio	
Volume Flashed Reactor liquid/ volume Fresh Feed	0.9
Conversion, V %	
(Disappearance of 975°F plus feed)	87.2
Solids Concentration	
In Reactor Liquid, W % Ash	4.5
Percent of Feed Vaporized	85
Superficial Liquid Upflow	
Velocity in Reactor, fps	.0011

This Example demonstrates the operability of the bitumen hydroconversion process at an even higher conversion rate for the bitumen feed than is employed in Example I. The operability is attributable to the higher concentration in the reactor.

EXAMPLE III

The tar sand bitumen employed in Examples I and II is hydrogenated under the conditions set forth in Table III, wherein the ash-enriched underflow stream from a liquid hydroclone is recycled to the reactor lower end as illustrated in FIG. 2.

TABLE III

Reactor Temperature, °F	840
Hydrogen Partial Pressure, psi	1200
Space Velocity, $V_f/hr/V_r$	1.5
Recycle Ratio	
Volume Hydroclone Underflow containing 10 Wt. % ash/volume Fresh Feed	0.091
Conversion, V %	
(Disappearance of 975°F plus Feed)	75
Solids Concentration	
In Reactor Liquid, W % Ash	4.5
Percent of Feed Vaporized	70
Superficial Liquid Upflow	
Velocity in Reactor	.0022

This Example demonstrates the operability of a hydroconversion process under conditions essentially similar to those employed in Example I, except that a higher ash concentration is established in the reactor liquid by feeding reactor effluent liquid through a liquid cyclone separation unit and recycling the ash-enriched underflow stream from the cyclone to the reactor lower end.

I claim:

1. In a process for hydroconversion of a bitumen derived from tar sands in which a tar sand bitumen is passed through a reaction zone containing a continuous liquid phase and a contact material derived from the feed itself and a hydrogen-containing gas at a temperature in the range of from about 700°F to about 950°F and under a hydrogen partial pressure of from about 200 to about 1,500 psi wherein the contact material is maintained in an ebullated state by the passage of fluids through the reaction zone and an ash-containing efflu-

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ent is removed from the reaction zone, the improvement which comprises:

- a. separating said effluent in a separation unit into an ash-depleted fraction and an ash-enriched fraction, and
- b. recycling said ash-enriched fraction to the reaction zone to maintain the solids concentration in the reactor liquid from about 4 to about 10 weight percent.

2. The process of claim 1 wherein the ratio of recy- 10

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clad ash-enriched fraction of fresh bitumen feed to the reactor is from about 0.05:1 to about 1.0:1.

3. The process of claim 1 wherein the enrichment of ash is accomplished in a liquid cyclone.

4. The process of claim 1 wherein the passage of fluids through the reaction zone is at a space velocity of 0.5 to 2.0 volume of feed per hour per volume of reactor.

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