



(86) Date de dépôt PCT/PCT Filing Date: 2004/02/20
(87) Date publication PCT/PCT Publication Date: 2004/09/02
(45) Date de délivrance/Issue Date: 2012/05/08
(85) Entrée phase nationale/National Entry: 2005/08/18
(86) N° demande PCT/PCT Application No.: IB 2004/000890
(87) N° publication PCT/PCT Publication No.: 2004/074408
(30) Priorité/Priority: 2003/02/21 (US10/369,869)

(51) Cl.Int./Int.Cl. *C10G 67/04* (2006.01),
C10G 65/18 (2006.01)
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(54) Titre : PROCEDE ET INSTALLATION FAISANT INTERVENIR UN DESASPHALTAGE AU SOLVANT ET UN
TRAITEMENT EN LIT BOUILLONNANT
(54) Title: PROCESS AND INSTALLATION INCLUDING SOLVENT DEASPHALTING AND EBULLATED-BED
PROCESSING

(57) **Abrégé/Abstract:**

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
2 September 2004 (02.09.2004)

PCT

(10) International Publication Number
WO 2004/074408 A1

(51) International Patent Classification⁷: **C10G 67/04**,
65/18

(21) International Application Number:
PCT/IB2004/000890

(22) International Filing Date: 20 February 2004 (20.02.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/369,869 21 February 2003 (21.02.2003) US

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,

AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,
MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,
PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM,
ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), Euro-
pean (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR,
GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— as to the applicant's entitlement to claim the priority of the
earlier application (Rule 4.17(iii)) for all designations

Published:

— with international search report
— before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: PROCESS AND INSTALLATION INCLUDING SOLVENT DEASPHALTING AND EBULLATED-BED PROCESS-
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**PROCESS AND INSTALLATION INCLUDING SOLVENT DEASPHALTING AND
EBULLATED-BED PROCESSING**

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TECHNICAL FIELD

This invention relates to a novel method for economically processing atmospheric or vacuum residue from heavy crude oils. This is accomplished by selectively processing the difficult and easy components obtained by solvent deasphalting ("SDA") of the residue in downstream conversion reactor systems whose design and operating conditions are optimized for the specific SDA component. The invention also concerns an installation for residue conversion/upgrading.

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DEFINITIONS

The term "asphaltenes" as used herein means a heavy polar fraction and are the residue which remains after the resins and oils have been separated from the feed residue fed to a deasphalting unit. Asphaltenes from vacuum resid are generally characterized as follows: a Conradson or Ramsbottom carbon residue of 15 to 90 weight% and a hydrogen to carbon (H/C) atomic ratio of 0.5 to 1.5. Asphaltenes can contain from 50 ppm to over 5000 ppm vanadium and from 20 ppm to over 2000 ppm nickel. The sulfur concentration of asphaltenes can be from 110% to 350% greater than the concentration of sulfur in the resid feed oil to the deasphalter. The nitrogen concentration of asphaltenes can be from 100% to 350% greater than the concentration of nitrogen in the resid feed oil to the deasphalter.

The terms "resid oil", "residue", and "resid" as used herein mean residual oil.

As used herein, the terms "solvent deasphalter", "deasphalting unit" and "deasphalter" mean one or more vessels or other equipment which are used to separate atmospheric or vacuum resid into deasphalted oil ("DAO"), resins, and asphaltenes, by means of one or more solvents.

The term "deasphalted oil" (DAO) as used herein means oils that are generally the least dense products produced in a deasphalting unit and comprise saturate aliphatic, alicyclic, and some aromatic hydrocarbons. Deasphalted oil generally comprises less than 30% aromatic carbon and relatively low levels of heteroatoms except sulphur. Deasphalted oil from vacuum resid can be generally characterized as follows: a Conradson carbon residue of 0 to less than 20%, preferably 1 to less than 12 weight % and generally a hydrogen to carbon (H/C) ratio of 1.0% to 2%. Deasphalted oil can contain 150 ppm or 100 ppm or less than 100 ppm, preferably less than 50 ppm or less than 5 ppm, and most preferably less than 2 ppm, of vanadium and 100 ppm or less, preferably less than 50 ppm or less than 5 ppm, and most preferably less than 2 ppm of nickel. The sulfur and nitrogen concentrations of deasphalted oil can be 90% or less of the sulfur and nitrogen concentrations of the resid feed oil to the deasphalter.

Hydrogen efficiency in a hydrogen addition upgrading process refers to a fraction of chemically consumed hydrogen which is used for heteroatom removal and for hydrogenation/saturation of liquid hydrocarbons..

BACKGROUND OF THE INVENTION

Hydrocarbon compounds are useful for a number of purposes. In particular, hydrocarbon compounds are useful, inter alia, as fuels, solvents, degreasers, cleaning agents, and polymer precursors. The most important source of hydrocarbon compounds is petroleum crude oil. Refining of crude oil into separate hydrocarbon compound fractions is a well-known processing technique.

Crude oils range widely in their composition and physical and chemical properties. In the last two decades the need to process heavier crude oils has increased. Heavy crudes are characterized by a relatively high viscosity and low API gravity (generally lower than 25°) and high percentage of high boiling components(> 950 °F) (> 510°C).

Refined petroleum products generally have higher average hydrogen to carbon ratios on a molecular basis. Therefore, the upgrading of a petroleum refinery hydrocarbon fraction is classified into one of two categories: hydrogen addition and carbon rejection. Hydrogen addition is performed by processes such as hydrotreating and hydrocracking. Carbon rejection processes typically produce a stream of rejected high carbon material which may be a liquid or a solid; e.g., coke deposits.

Some carbon rejection processes such as FCC and coking include cracking of heavy molecules. Others such as solvent deasphalting consist only of physical separation of the lighter and heavier hydrocarbons. For instance, in solvent deasphalting of a heavy oil, a light solvent such as a C₄ or C₅ hydrocarbon is used to dissolve or suspend the lighter hydrocarbons allowing the asphaltenes to be "precipitated". These phases are separated and then the solvent is recovered. Additional information on solvent

deasphalting conditions, solvents and operations may be obtained from U.S. Pat. Nos. 4,239,616; 4,440,633; 4,354,922; and 4,354,928.

To facilitate processing, heavy crudes or their fractions are generally subjected to thermal cracking or hydrocracking to convert the higher boiling fractions to lower boiling fractions, followed by hydrotreating to remove heteroatoms such as sulfur, nitrogen, oxygen and metallic impurities.

10 Further information on hydrotreating catalysts, techniques and operating conditions for residue feeds may be obtained by reference to U.S. Pat. Nos. 5,198,100; 4,810,361; 4,810,363; 4,588,709; 4,776,945 and 5,225,383.

Crude petroleums with greater amounts of impurities including asphaltenes, metals, organic sulfur and organic nitrogen require more severe processing to remove them. Generally speaking, the more severe the conditions required to treat a given feedstock (e.g. higher temperature and pressures), the greater the cost of overall plant.

20 In particular, asphaltenes produce high amounts of coke which deactivates the hydrotreating and hydrocracking catalysts. Asphaltenes also form precipitates and contain precipitate precursors which greatly hinder subsequent processing.

30 In general, ebullated-bed reactors are utilized to process heavy crude oil feed streams, particularly those feeds with high metals and CCR. The ebullated-bed process comprises the passing of concurrently flowing streams of liquids, or slurries of liquids and solids, and gas through a vertically elongated fluidized catalyst bed. The catalyst is fluidized and completely mixed by the upwardly flowing liquid streams. The ebullated-bed process has commercial application in the upgrading of heavy liquid hydrocarbons and converting coal to synthetic oils.

The ebullated-bed reactor and related process is generally described in U.S. Pat. No. 25,770 to Johanson. A mixture of hydrocarbon liquid and hydrogen is

passed upwardly through a bed of catalyst particles at a rate such that the particles are forced into random motion as the liquid and gas pass upwardly through the bed. The catalyst bed motion is controlled by a recycle liquid flow so that at steady state, the bulk of the catalyst does not rise above a definable level in the reactor. Vapors, along with the liquid which is being hydrogenated, pass through the upper level of catalyst particles into a substantially catalyst free zone and are removed from the upper portion of the reactor.

10 Ebullated-bed reactors are generally operated at high temperatures and pressures in order to process these heavy feedstocks. Since such operating parameters substantially increase the cost of designing and constructing the reactors, it would therefore be advantageous to have a system wherein the overall design and manufacturing costs were optimized for specific feedstocks or feedstock components. This optimization would result in a lower initial investment and lower annual operating costs. Moreover, there is always a need to design process systems that convert greater amounts of feedstock into
20 high quality products.

SUMMARY OF THE INVENTION

The object of this invention is to provide a new integrated SDA/ebullated-bed process for economically converting and/or upgrading atmospheric or vacuum residue from heavy crudes. It is a process which relieves downstream burdens and fouling in a residue conversion/upgrading unit.

30 It is another object of this invention to provide an integrated SDA/ebullated-bed process which is optimized for particular feedstock components resulting in a lower overall cost of design, manufacture, and operation.

 It is a further object of the invention to provide an integrated SDA/ebullated-bed process that utilizes catalysts that are specifically tailored for a given feedstock or feedstock component.

It is yet another object of this invention to provide an integrated SDA/ebullated-bed process that minimizes the risk of over-conversion of the feedstock and resulting excessive sedimentation and fouling with no over-conversion. Additionally, the invention will result in reduced light gas yields and increases in hydrogen efficiency.

10 A novel feature of this invention is the utilization of a solvent deasphalter ("SDA") in the initial processing of the atmospheric or vacuum resid feedstock to separate it into DAO and asphaltenes. The DAO can thereafter be further processed at lower temperature and pressure in an ebullated-bed reactor while the smaller quantity of asphaltenes are processed through a more severe ebullated-bed reactor system.

More particularly, this invention teaches a process for residual conversion, upgrading or a combination thereof, the process comprising the steps of:

- a) feeding a atmospheric or vacuum residue feedstock, 30%-100% of said feedstock boiling above 524°C (975°F), to a solvent deasphalter ("SDA") to provide an asphaltene stream and a deasphalted oil stream;
- 20 b) processing said asphaltene stream through one or more ebullated-bed reactors;
- c) processing said deasphalted oil stream through at least one ebullated-bed reactor;
- d) separating the effluent from step b) in a steam stripper to provide a stripper bottoms stream; and
- e) recycling at least a fraction of said stripper bottoms stream back to the solvent deasphalter,

wherein steps a - c achieve an overall vacuum residue conversion of greater than 65%.

Preferably, the overall residue conversion is greater than 70%, and preferably greater than 75%.

Preferably, step b) is operated at a total pressure of between 10.335 and 20.670 kPa (1500 and 3000 psia), a temperature of between 399-454°C (750°F-850°F), a LHSV of between 0.1 and 1.0 hr⁻¹, and a catalyst replacement rate of between 0.285 and 2.85 kg/m³ (0.1 and 1.0 lbs/bbl)

10 More preferably, step b) is operated at a total pressure of between 3445-20.670 kPa (500 and 3000 psia), a temperature of between 388-438°C (730°F-820°F), a LHSV of between 0.2 and 1.5 hr⁻¹, and a catalyst replacement rate of between 0.142 and 1.42 kg/m³ (0.05 and 0.5 lbs/bbl).

Preferably, step b) and/or step c) is operated in one reactor, or also in two reactors in series or three reactors in series.

In a preferred embodiment, a fraction of the heavy effluent separated from the last ebullated bed reactor treating the asphaltene stream is recycled to step a).

20 The process is particularly suitable for treating atmospheric or heavy residue feedstock having greater than 50% vol. boiling above 524°C (975°F).

The invention also concerns an installation for residue conversion, upgrading or a combination thereof, including:

- a solvent deasphalter in which residue is introduced, and from which an asphaltene stream and deasphalted oil stream (DAO) are recovered;

- at least one ebullated bed in which asphaltene stream is introduced, and from which effluent is recovered;

- a separation unit in which said effluent is introduced, which comprises at least one gas-liquid separator and one steam stripper, and from which a gaseous phase, an overhead products and stripper bottoms are recovered;

30 - at least one ebullated bed in which DAO and said overhead product are introduced, and from which an effluent is recovered; and

- a recycle line for recycling at least a portion of stripper bottoms to the solvent deasphalter.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic flowsheet of an embodiment for the atmospheric or vacuum resid hydroconversion process.

Figure 2 shows a schematic flowsheet of another embodiment of the vacuum resid process showing the recycling of stripper bottoms to the solvent deasphalting unit.

DETAILED DESCRIPTION OF THE INVENTION

10 Figure 1 shows a schematic flowsheet of the atmospheric or vacuum resid hydroconversion process. Resid feedstock is provided at 10 and fed into a solvent deasphalting separator ("SDA") 11 where it is separated into deasphalted oil ("DAO") stream 12 and an asphaltene stream 13.

The solvent utilized in the SDA unit may be any suitable hydrocarbonaceous material which is a liquid within suitable temperature and pressure ranges for operation of the countercurrent contacting column, is less dense than the feed stream, and has the ability to readily and selectively dissolve
20 desired components of the feed stream and reject the asphaltic materials also commonly known as pitch. The solvent may be a mixture of a large number of different hydrocarbons having from 3 to 14 carbon atoms per molecule, such as a light naphtha having an end boiling point below about 200° F. (93° C.).

Preferably, the SDA unit is operated with a C₃/C₄/C₅ solvent to obtain a high lift (high DAO yield). More specifically, the solvent may be a relatively light hydrocarbon such as ethane, propane, butane, isobutane, pentane, isopentane, hexane, heptane, the corresponding mono-olefinic hydrocarbons or mixtures thereof.

Preferably, the solvent is comprised of paraffinic hydrocarbons having from 3 to 7 carbon atoms per molecule and can be a mixture of 2 or more hydrocarbons. For instance, a preferred solvent may be comprised of a 50 volume percent mixture of normal butane and pentane or isopentane.

10 The solvent deasphalting conditions include a temperature from about 50° F. (10° C.) to about 600° F. (315° C.) or higher, but the deasphalter operation is preferably performed within the temperature range of 100° F. (38° C.)-400° F. (204° C.). The pressures utilized in the solvent deasphalter 11 are preferably
sufficient to maintain liquid phase conditions, with no advantage being apparent to the use of elevated pressures which greatly exceed this minimum. A broad range of suitable pressures is from about 100 psig (689 kPa) to 1000 psig (6895 kPa) with a preferred range being from about 200 psig (1379 kPa) to 600 psig (4137 kPa). An excess of solvent to charge stock should preferably be maintained. The solvent to charge stock volumetric ratio should preferably be between 2:1 to about 20:1 and preferably from about 3:1 to about 9:1. The preferred residence time of the charge
20 stock in the solvent deasphalter 11 is from about 10 to about 60 minutes.

The resulting deasphalted oil stream 12 produced in the solvent deasphalter 11 is introduced into the mild ebullated bed hydrocracking reactor as herein above described. Preferably, the SDA unit operated with a C4/C5 solvent to obtain a high lift (higt DAO yield).

The aphaltenes stream 13 are thereafter fed into an ebullated-bed unit 15 along with make-up and recycle hydrogen provided at 14. The first ebullated-bed unit 15 is operated at a relatively high pressure greater than 17.225 kPa (2,500 psi) total pressure and
30 for example 17.225-20.670 kPa (2500-3000 psi) total pressure.

In a two stage in series reactor system, the effluent from the first ebullated bed reactor is sent through line 16 to an interstage separation vessel 17 where it is phase separated into a gaseous and a liquid fraction. The interstage separation unit maximizes the process efficiency in this two-stages example. The gaseous phase effluent, comprised largely of hydrogen and gaseous and vaporized hydrocarbons is drawn off by line 19 and thereafter conventionally treated to recover hydrogen, hydrocarbon gases, etc. The liquid phase effluent is sent through line 18 where it is combined with make-up and recycle hydrogen and thereafter sent to a second ebullated-bed reactor 20.

Typically, two reactors in series would be utilized in order to achieve high conversion and good hydrocracking/hydrogenation of the asphaltenes. Moreover, both reactors would be required to operate at a relatively high temperature in order to achieve 60-80% conversion of the asphaltenes to distillates.

For a high metals feedstock, it is preferable to use a wide pore extrudate catalyst since it would provide a high level of asphaltene conversion and metals retention.

However, it is noted that although this particular description of the invention utilizes separate ebullated-bed reactors to process the asphaltenes, it is conceivable that a single reactor may be utilized depending on the product slate, qualities required, and the composition of the feedstock to be processed.

The second ebullated-bed reactor effluent 21 is passed through the external hot, high pressure separator ("HHPS") 22 wherein it is separated into gas and liquid phases. The gas phase, comprised largely of hydrogen and gaseous and vaporized hydrocarbons is drawn off by line 23 and thereafter conventionally treated to recover hydrogen, hydrocarbon gases, etc. Although not shown here, it is typical to utilize the separated purified hydrogen as

part of the hydrogen feed 14 to the system. Preferably, at least a portion of gas phase 23 and gaseous effluent 19 are sent to third ebullated-bed 30, advantageously with DAO entering in unit 30.

5 The net liquid phase drawn from the HHPS 22 through line 24 is sent to a steam stripper 25. Steam is supplied to the atmospheric steam stripper through line 27. Stripper bottoms products (nominal 343°C+ i.e. 650°F+ boiling) are drawn off to the battery limits at line 28 and can be utilized for combustion,
10 coking, or heavy fuel oil production. Optionally, as shown in figure 2, a portion of the stripper bottoms recycle can be recycled back via stream 35 to the SDA unit. The unconverted asphaltenes in the stripper bottoms will be separated in the SDA and will be partially converted in the first two ebullated-bed
15 reactor 15 and 20.

Overhead product from steam stripper 25 is drawn off by line 26 and is pumped to reactor pressure using a stripper pump 29 and sent through line 38 to a third ebullated-bed reactor 30 after being combined with DAO feedstock 12 from the SDA unit 11.

20 The combined DAO and steam stripper overhead product is now much easier to process because the asphaltenes and other contaminants have been removed. Therefore, the temperature and pressure and required catalyst volume in this third ebullated-bed reactor 30 is substantially lower than in the initial
25 ebullated-beds 15 and 20. This will result in significantly reduced plant investment. The total pressure in this third ebullated-bed reactor 30 is typically between 8260 and 13.780 kPa (1,200 and 2000 psi).

The third ebullated-bed unit 30 is operated at a high residue
30 conversion (80%-90%) and would utilize a catalyst tailored

specifically for DAO and heavy vacuum gas oil ("HVGO") type feedstocks.

This (these) reactor(s) is different from those used to process asphaltene steam, that means that technology used is different since feedstock is optimized (more clean), for example a T-Star is used. Conversion of this third reactor (step c)) working on DAO is higher then conversion of first and second reactors (step b). Advantageously one single third reactor is used.

Product from this third reactor 30 is thereafter sent to another external hot, high pressure separator ("HHPS") 32 and further downstream processing. The gas phase, comprised largely of hydrogen and gaseous and vaporized hydrocarbons is drawn off by line 33 and thereafter conventionally treated with the gas phase from the other HHPS unit to recover hydrogen, hydrocarbon gases, etc. for use as recycle to the ebullated-bed reactors.

The net liquid phase drawn from the HHPS 32 through line 34 and is suitable for producing good quality fuel oil.

The reactors are maintained at broad reaction conditions as shown in the Tables 1 and 2 below:

Table 1**EBULLATED BED REACTORS #1 & 2 – Asphaltene Feed**

<u>Condition</u>	<u>Broad</u>	<u>Preferred</u>
Feedstock Residue Content, vol. % 1000°F+ (538°C+) ^o	50 - 100	80 - 100
Overall Reactor LHSV (liquid hourly space velocity), hr-1	0.1 - 1.0	0.2 - 0.5
Reactor Temperature °F	700 - 850	770 - 820
Reactor Temperature °C	371-454	410-438
Reactor total pressure, psig	500 - 3500	2,500 - 3,000
Reactor total pressure, kPa	3445-24.115	17.225-20.670
Reactor outlet hydrogen partial pressure, psi	1500 - 2,500	1,800 - 2,100
Reactor outlet hydrogen partial pressure, kPa	10.335-17.225	12.402-14.469
Catalyst Replacement Rate, lb/bbl	0.03 - 1.0	0.05 - 0.30
Catalyst Replacement Rate, kg/m3	0.085-2.85	0.142-0.85

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Table 2**EBULLATED BED REACTOR #3 – DAO and Cracked Distillate Feeds**

<u>Condition</u>	<u>Broad</u>	<u>Preferred</u>
Feedstock Residue Content, vol. % 650°F+(343°C+)	50 - 100	80 - 100
Reactor LHSV (liquid hourly space velocity), hr-1	0.3 - 3.0	0.5 - 1.5
Reactor Temperature °F	700 - 850	750 - 800
Reactor Temperature °C	371-454	399-427
Reactor total pressure, psig	500 - 3000	800 - 2,000
Reactor total pressure, kPa	3445-20.670	5512-13780
Reactor outlet hydrogen partial pressure, psi	400 - 2,000	500 - 1,500
Reactor outlet hydrogen partial pressure, kPa	2756-13.780	3445-10.335
Catalyst Replacement Rate, lb/bbl	0.03 - 0.5	0.05 - 0.20
Catalyst Replacement Rate, kg/m3	0.085-1.42	0.142-0.57

10

Relative to processing the entire atmospheric or vacuum residue in an ebullated-bed reactor system, this novel configuration selectively processes the difficult and easy components in reactor systems whose design and operating conditions are

optimized for a specific feed. Because the asphaltenes are separated in an SDA unit, the overall efficiency of the process design in this invention is greater as shown in Table 3 below. As shown in the table, using a smaller total reactor volume, a higher total level of conversion is achieved. This process results in a higher conversion of the feedstock vacuum residue since the separately processed DAO can be treated at a higher (80 - 90V%) level of residue conversion. For even higher levels of overall vacuum residue conversion, the total reactor volume requirement may be higher than for pre-invention (typical) designs.

Table 3**Comparison of Overall Process Efficiency**

	Typical Processing in Two-Stage Unit	Processing Utilizing Current Invention
Feedrate to First Two Ebullated-Bed Reactor (In Series) BPSD	50,000	15,000 (asphaltenes)
Relative Reactor Volume	1.00	0.36
Heavy Unconverted Vacuum Residue, BPSD (65% conversion)	17,500	5,250
Feed rate to third ebullated-bed reactor, BPSD	—	35,000 (DAO)
Relative Reactor Volume of third reactor	—	0.42
Unconverted residue DAO (80% conversion)	—	7,000
Total Reactor Volume	1.00	0.78
Total unconverted vacuum residue, BPSD	17,500	12,250
Overall Vacuum Residue Conversion, vol%	65	75.5

Figure 2 shows the same process described above except that a portion of the stripper bottoms products (nominal 343°C+ i.e. 650°F+ boiling) can be sent through line 35 to the SDA unit 11 after it has been combined with fresh vacuum resid feedstock from line 10. The vacuum resid is a good peptizing agent for the unconverted asphaltenes, thus minimizing the risk of asphaltene precipitation and fouling. The remaining net stripper bottoms are utilized for combustion, coking, or heavy oil production. This recycle increases the concentration of asphaltenes to the first ebullated-bed reactors and further increases the level of net conversion.

EXAMPLE 1

A vacuum residue feedstock derived from a Western Canadian heavy crude is converted in order to produce distillate material and a heavy fuel oil. Because of the heavy nature (high CCR and metals) of this crude, an ebullated-bed reactor is typically specified. This example will illustrate and compare conventional processing and processing incorporating this invention. The Western Canadian vacuum residue has the following inspections and yields/qualities when processed in a SDA unit.

Table 4

	Vacuum Residue	Asphaltenes	DAO
W%	100	42.1	57.9
Gravity, °API	100	42.1	57.9
Residue Content (975°F), (524°C) Wt. %	94	0	12
Nitrogen, Wt. %	0.62	0.85	0.42
Sulfur, wt. %	5.53	7.36	4.2
CCR, W%	24	42	11
Nickel, wppm	115	232	30
Vanadium, Wppm	270	551	66
C ₇ insolubles, W%	17	40	Less than 50 wppm

In a pre-invention processing configuration, all of the vacuum residue is sent to an ebullated-bed reactor system and a typical maximum conversion of 65% is obtained. Typical product rates and required ebullated-bed reactor volume is shown in Table 5.

Table 5

Feed	Pre-Invention	Present Invention		
	Vacuum Residue	Asphaltene Step	DAO Step	Total
Reactor Volume, $V_{\text{reactor}}/v_{\text{feed/hr}}$	2.0	4.0	2.0	2.5
Residue (524°C ⁺) Conversion, %	65	65	90	79.5
Product Rates, w%				
Naphtha	10.0	11	16.1	14.0
Diesel	20.3	18	36.5	28.7
Gas Oil	30.2	28	30.1	29.2
Residue	32.9	35	9.4	20.2
HDS, W%	75	72	96.8	86.3
HDN, W%	25	22	68.5	48.9
HDCCR, W%	52	48	88.5	71.4
Total Distillate Yield, W%	60.5	57	82.7	71.9

As shown in Table 5, the invention results in a higher overall conversion of the vacuum residue (79.5% versus 65%) and greatly improved product quality as indicated by higher levels of heteroatom removal (86.3W% versus 75W% HDS and 48.9W% versus 25W% HDN). Because of the higher residue conversion, the yield of

desirable distillates is increased by nearly 20 percent, from 60.5W% of the feed to 71.9W% of the feed. This improvement in overall process performance is accomplished in this example by using a total reactor volume of just 25% greater than the pre-invention design.

Although not illustrated in the example, as shown in Figure 2, the unconverted atmospheric bottoms from the asphaltene conversion step, obtained via an atmospheric stripper (stream 35) can be recycled to the SDA unit.

This recycle is effective since during ebullated-bed processing of the asphaltene stream, a small quantity of additional asphaltenes can be produced via condensation/polymerization reactions. The SDA will phase separate these recycled asphaltenes and route this material back to the first ebullated-bed system. The net effect will be an even higher level of vacuum residue conversion than indicated in Table 5. An overall conversion of 85W% or more will be obtained.

The invention described herein has been disclosed in terms of specific embodiments and applications. However, these details are not meant to be limiting and other embodiments, in light of this teaching, would be obvious to persons skilled in the art. Accordingly, it is to be understood that the drawings and descriptions are illustrative of the principles of the invention, and should not be construed to limit the scope thereof.

WHAT IS CLAIMED IS:

1. A process for residue conversion, upgrading or a combination thereof said process comprising the steps of:

a) feeding an atmospheric or vacuum residue feedstock, 30%-100% of said feedstock boiling above 524°C (975°F), to a solvent deasphalter ("SDA") to provide an asphaltene stream and a deasphalted oil (DAO) stream;

b) processing said asphaltene stream through one or more ebullated-bed reactors;

10 c) processing said deasphalted oil stream through at least one ebullated-bed reactor;

d) separating the effluent from step b) in a steam stripper to provide a stripper bottoms stream; and

e) recycling at least a fraction of said stripper bottoms stream back to the solvent deasphalter,

wherein steps a - c achieve an overall residue conversion of greater than 65%.

2. The process according to claim 1, wherein steps a - c achieve an overall residue conversion of greater than 70%.

3. The process according to claim 1 or 2, wherein steps a - c achieve an overall residue conversion of greater than 75%.

20 4. The process according to any one of claims 1 to 3, wherein the ebullated-bed unit used in step b) to process said asphaltene stream is operated at a total pressure of between 10.335 and 20.670 kPa (1500 and 3000 psia), a temperature of between 399-454°C (750°F-850°F), a LHSV of between 0.1 and 1.0 hr⁻¹, and a catalyst replacement rate of between 0.285 and 2.85 kg/m³ (0.1 and 1.0 lbs/bbl).

5. The process according to any one of the preceding claims 1 to 4, wherein the ebullated-bed unit or units used in step b) to process said asphaltene stream is operated at a total pressure of between 3445-20.670 kPa (500 and 3000 psia), a temperature of between 3445-20.670 kPa (500 and 3000 psia), a temperature of between 388-438°C (730°F-820°F), a LHSV of between 0.2 and 1.5 hr⁻¹, and a catalyst replacement rate of between 0.142 and 1.42 kg/m³ (0.05 and 0.5 lbs/bbl).
6. The process according to any one of claims 1 to 5, wherein the SDA unit utilizes a C₄/C₅ solvent to separate the heavy residue feedstock into a asphaltene stream and a deasphalted oil stream.
- 10 7. The process according to any one of claims 1 to 6, wherein the asphaltene stream is processed in only one ebullated-bed reactor.
8. The process according to any one of claims 1 to 7, wherein the asphaltene stream is processed in two ebullated-bed reactors in series.
9. The process according to any one of claims 1 to 8, wherein the asphaltene stream is processed in three ebullated-bed reactors in series.
10. The process according to any one of claims 1 to 9, wherein the deasphalted oil stream is processed in only one ebullated-bed reactor.
11. The process according to any one of claims 1 to 10, wherein the deasphalted oil stream is processed in two ebullated-bed reactors in series.
- 20 12. The process according to any one of claims 1 to 11, wherein the deasphalted oil stream is processed in three ebullated-bed reactors in series.
13. The process according to any one of claims 1 to 12, wherein greater than 50% of the atmospheric or heavy residue feedstock boils above 524°C (975°F).

14. The process according to any one of the claims 1 to 13, wherein conversion in step c) is higher than in step b).

15. An installation for residue conversion, upgrading or a combination thereof, including:

- a solvent deasphalter (11) in which residue is introduced, and from which an asphaltene stream (13) and deasphalted oil stream (DAO) (12) are recovered;

- at least one ebullated bed in which asphaltene stream is introduced, and from which effluent is recovered;

- a separation unit in which said effluent is introduced, which comprises at least one gas-liquid separator (22) and one steam stripper (25), and from which a gaseous phase (19), an overhead products (29) and stripper bottoms are recovered;

- at least one ebullated bed in which DAO and said overhead product are introduced, and from which an effluent is recovered; and

- a recycle line for recycling at least a portion of stripper bottoms to the solvent deasphalter.

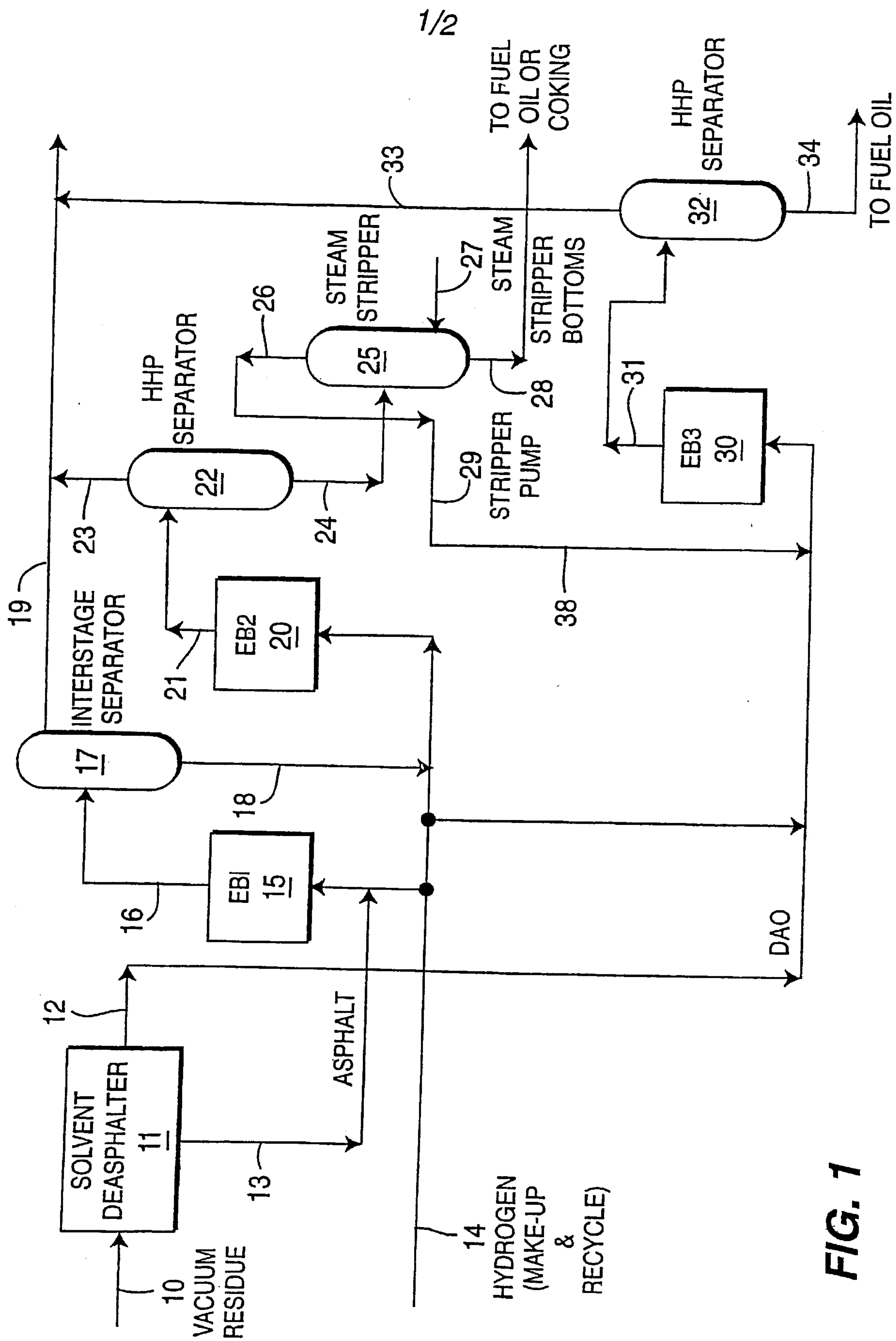


FIG. 1

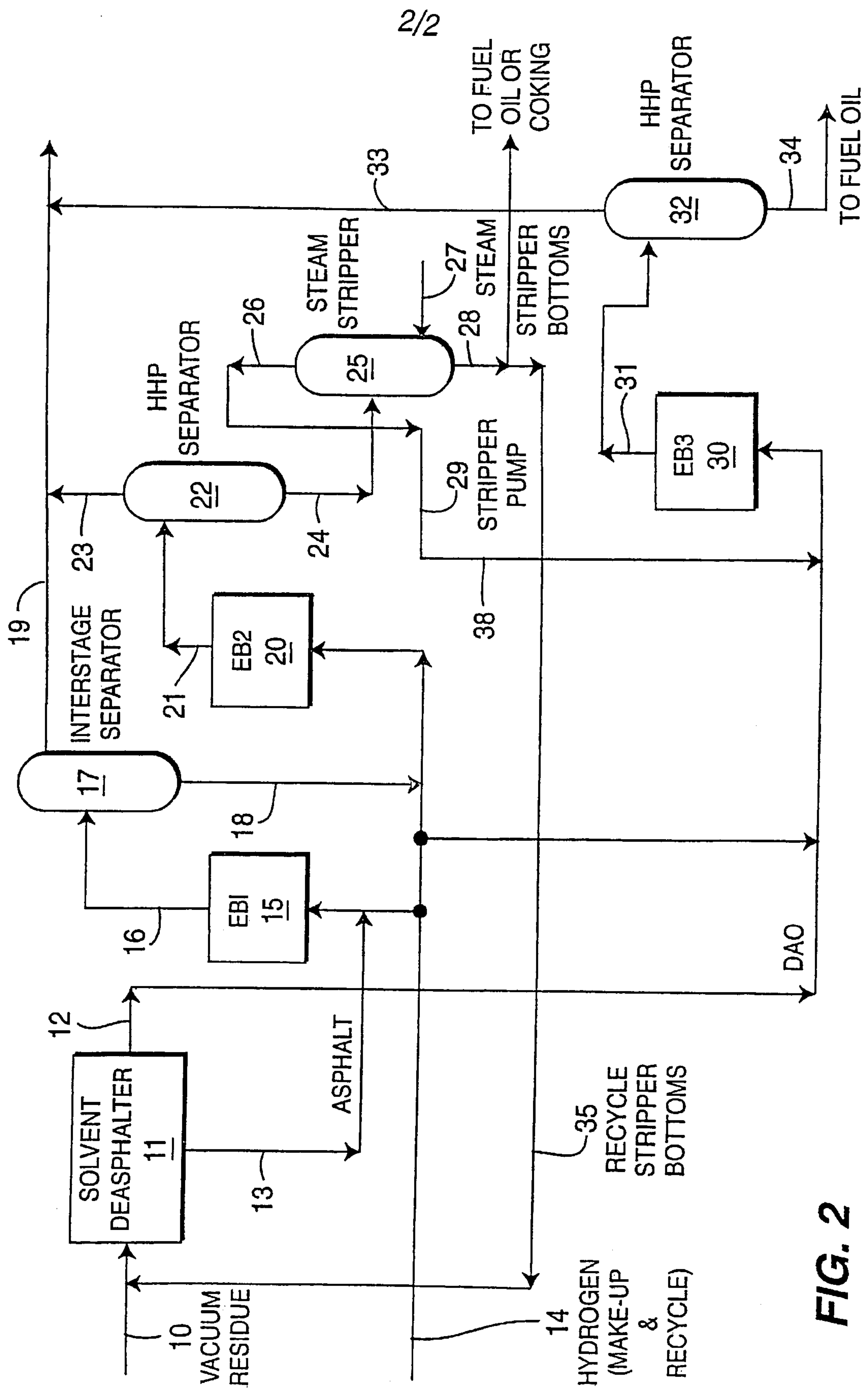


FIG. 2