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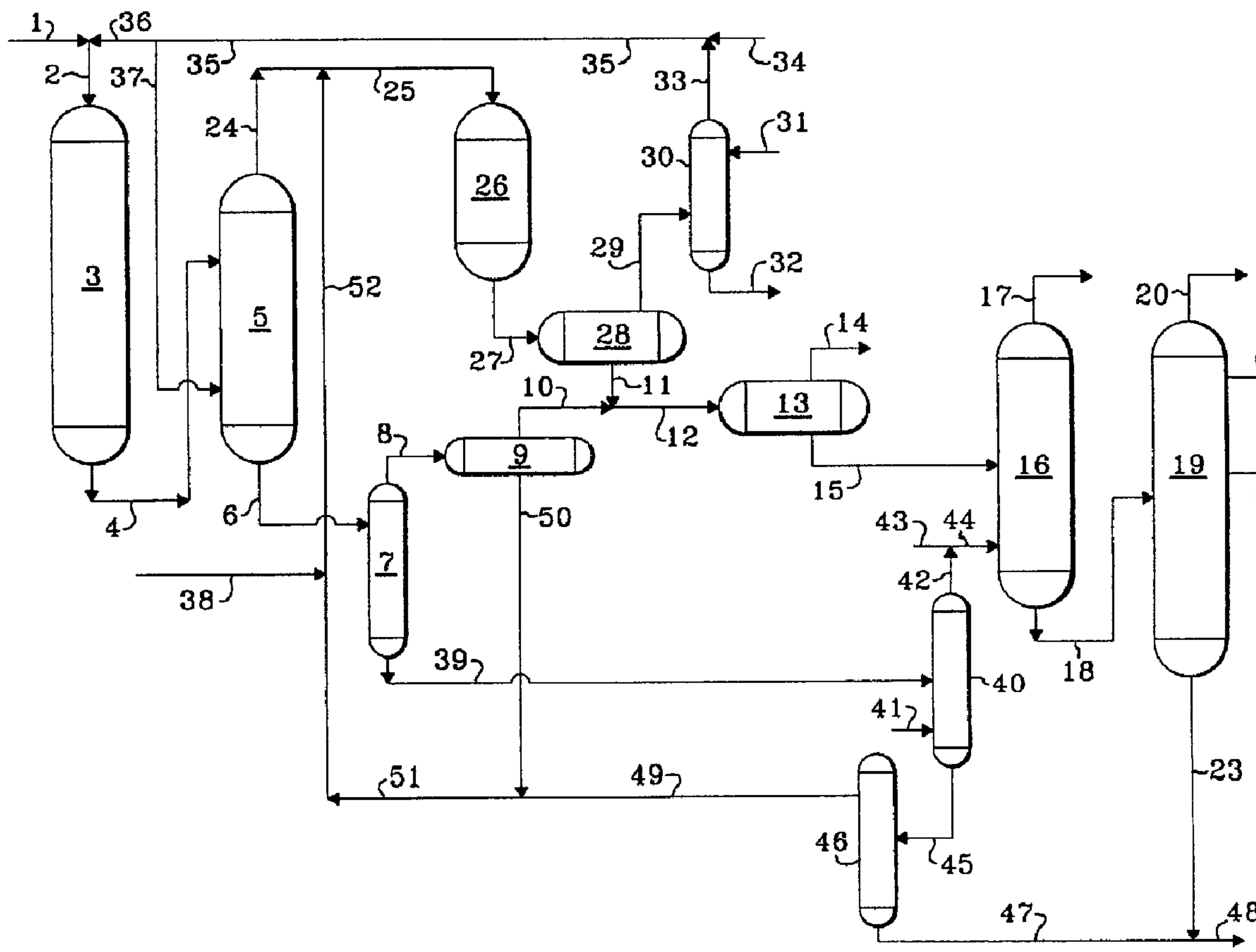
(54) Titre : METHODE D'HYDROCRAQUAGE POUR LA PRODUCTION DE CARBURANT DIESEL A TRES BASSE TENEUR EN SOUFRE

(54) Title: A HYDROCRACKING PROCESS FOR THE PRODUCTION OF ULTRA LOW SULFUR DIESEL



(57) **Abrégé/Abstract:**
A catalytic hydrocracking process for the production of ultra low sulfur diesel wherein a hydrocarbonaceous feedstock is hydrocracked at elevated temperature and pressure to obtain conversion to diesel boiling range hydrocarbons. The resulting

(57) **Abrégé(suite)/Abstract(continued):**
hydrocracking zone effluent is hydrogen stripped in a stripping zone maintained at essentially the same pressure as the hydrocracking zone to produce a first gaseous hydrocarbonaceous stream and a first liquid hydrocarbonaceous stream. The first gaseous hydrocarbonaceous stream containing diesel boiling range hydrocarbons is introduced into a desulfurization zone and subsequently partially condensed to produce a hydrogen-rich gaseous stream and a second liquid hydrocarbonaceous stream containing diesel boiling range hydrocarbons. The first liquid stream is separated to produce a third liquid hydrocarbonaceous stream containing diesel boiling range hydrocarbons which is also introduced into the desulfurization zone. An ultra low sulfur diesel product stream is recovered.

A HYDROCRACKING PROCESS FOR THE PRODUCTION OF ULTRA LOW SULFUR DIESEL

ABSTRACT

A catalytic hydrocracking process for the production of ultra low sulfur diesel wherein a hydrocarbonaceous feedstock is hydrocracked at elevated temperature and pressure to obtain conversion to diesel boiling range hydrocarbons. The resulting hydrocracking zone effluent is hydrogen stripped in a stripping zone maintained at essentially the same pressure as the hydrocracking zone to produce a first gaseous hydrocarbonaceous stream and a first liquid hydrocarbonaceous stream. The first gaseous hydrocarbonaceous stream containing diesel boiling range hydrocarbons is introduced into a desulfurization zone and subsequently partially condensed to produce a hydrogen-rich gaseous stream and a second liquid hydrocarbonaceous stream containing diesel boiling range hydrocarbons. The first liquid stream is separated to produce a third liquid hydrocarbonaceous stream containing diesel boiling range hydrocarbons which is also introduced into the desulfurization zone. An ultra low sulfur diesel product stream is recovered.

A HYDROCRACKING PROCESS FOR THE PRODUCTION OF ULTRA LOW SULFUR DIESEL

BACKGROUND OF THE INVENTION

[0001] The field of art to which this invention pertains is the hydrocracking of a hydrocarbonaceous feedstock. Petroleum refiners often produce desirable products such as turbine fuel, diesel fuel and other products known as middle distillates as well as lower boiling hydrocarbonaceous liquids such as naphtha and gasoline by hydrocracking a hydrocarbon feedstock derived from crude oil, for example. Feedstocks most often subjected to hydrocracking are gas oils and heavy gas oils recovered from crude oil by distillation. A typical gas oil comprises a substantial portion of hydrocarbon components boiling above 371°C (700°F), usually at least 50 percent by weight boiling above 371°C (700°F). A typical vacuum gas oil normally has a boiling point range between 315°C (600°F) and 565°C (1050°F).

[0002] Hydrocracking is generally accomplished by contacting in a hydrocracking reaction vessel or zone the gas oil or other feedstock to be treated with a suitable hydrocracking catalyst under conditions of elevated temperature and pressure in the presence of hydrogen so as to yield a product containing a distribution of hydrocarbon products desired by the refiner. The operating conditions and the hydrocracking catalysts within a hydrocracking reactor influence the yield of the hydrocracked products.

[0003] One of the preferred hydrocarbonaceous products from a hydrocracking process is diesel or diesel boiling range hydrocarbons. Marketable products must meet minimum specifications. Environmental concerns and newly enacted rules and regulations continue to drive lower contaminants limits on such sulfur and nitrogen in diesel fuel. Recently new regulations were proposed in the United States and Europe which basically require the complete removal of sulfur from liquid hydrocarbons which are used as transportation fuels such as gasoline and diesel.

[0004] Although a wide variety of process flow schemes, operating conditions and catalysts have been used in commercial hydrocracking activities, there is always a demand for new hydrocracking methods which provide lower costs and improved product characteristics. The present invention is able to economically hydrocrack a hydrocarbonaceous feedstock while simultaneously producing ultra low sulfur diesel product.

INFORMATION DISCLOSURE

[0005] US-A-6,096,191 B1 discloses a catalytic hydrocracking process wherein a hydrocarbonaceous feedstock and a liquid recycle stream are contacted with hydrogen and a hydrocracking catalyst to obtain conversion to lower boiling hydrocarbons. The resulting effluent from the hydrocracking zone is hydrogen stripped at essentially the same pressure as the hydrocracking zone and at least a portion is recycled to the hydrocracking reaction zone.

BRIEF SUMMARY OF THE INVENTION

[0006] The present invention is a catalytic hydrocracking process which provides lower costs and maximizes the recovery of ultra low sulfur diesel by utilizing an integrated flow scheme to minimize major equipment requirements and utility costs.

[0007] One embodiment of the present invention relates to a hydrocracking process for the production of ultra low sulfur diesel from a hydrocarbonaceous feedstock wherein the process comprises the steps of: (a) reacting the hydrocarbonaceous feedstock and hydrogen in a hydrocracking zone containing hydrocracking catalyst to produce diesel boiling range hydrocarbons; (b) stripping a hydrocracking zone effluent in a hot, high pressure stripping zone maintained at essentially the same pressure as the hydrocracking zone and a temperature in the range from 232°C (450°F) to 468°C (875°F) with a first hydrogen-rich gaseous stream to produce a first gaseous hydrocarbonaceous stream comprising diesel boiling range hydrocarbons and a first liquid hydrocarbonaceous stream; (c) passing the first gaseous hydrocarbonaceous stream comprising diesel boiling range hydrocarbons to a desulfurization zone containing desulfurization catalyst and producing a desulfurization zone effluent stream; (d) condensing at least a portion of the desulfurization zone effluent stream to produce a second hydrogen-rich gaseous stream and a second liquid hydrocarbonaceous stream comprising diesel boiling range hydrocarbons; (e) passing the first liquid hydrocarbonaceous stream to a hot flash zone maintained at a pressure from 445 kPa (50 psig) to 2858 kPa (400 psig) and a temperature from 232°C (450°F) to 468°C (875°F) to produce a third liquid hydrocarbonaceous stream comprising unconverted hydrocarbons and diesel boiling range hydrocarbons; (f) stripping the third liquid hydrocarbonaceous stream and introducing the resulting stripped stream in a flash column operated at a temperature from 232°C (450°F) to 468°C (875°F) and a pressure from 3.5 kPa (0.5 psia) to 196.4 kPa (28.5 psia) to produce a fourth liquid hydrocarbonaceous stream comprising unconverted hydrocarbons and a second gaseous hydrocarbonaceous stream comprising diesel boiling range hydrocarbons; (g) reacting at least a portion of the second gaseous hydrocarbonaceous stream in the desulfurization zone containing desulfurization catalyst; and (h) recovering an ultra low sulfur diesel product stream.

[0008] Another embodiment of the present invention relates to a hydrocracking process for the production of ultra low sulfur diesel from a first hydrocarbonaceous feedstock and a second hydrocarbonaceous feedstock boiling in a range lower than that of the first hydrocarbonaceous feedstock. In addition to the steps of the previous embodiment wherein the first feedstock is reacted in the hydrocracking zone the first gaseous hydrocarbonaceous stream and the second hydrocarbonaceous feedstock pass to the desulfurization zone. In further variation of this embodiment the process produces diesel boiling range hydrocarbons boiling in the range from 154°C (309°F) to 370°C (680°F).

[0009] Other embodiments of the present invention encompass further details such as types and descriptions of feedstocks, hydrocracking catalysts and preferred operating conditions including temperatures and pressures, all of which are hereinafter disclosed in the following discussion of each of these facets of the invention.

BRIEF DESCRIPTION OF THE DRAWING

[0010] The drawing is a simplified process flow diagram of a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0011] It has been discovered that a maximum recovery of ultra low sulfur diesel and a lower cost of production can be achieved in the above-described hydrocracking process unit.

[0012] The process of the present invention is particularly useful for hydrocracking a hydrocarbon oil containing hydrocarbons and/or other organic materials to produce a product containing hydrocarbons and/or other organic materials of lower average boiling point and lower average molecular weight. More particularly, the present invention is readily able to produce ultra low sulfur diesel. The hydrocarbon feedstocks that may be subjected to hydrocracking by the method of the invention include all mineral oils and synthetic oils (e.g., shale oil, tar sand products, etc.) and fractions thereof. Illustrative hydrocarbon feedstocks include those containing components boiling above (288°C) 550°F, such as atmospheric gas oils, vacuum gas oils, deasphalted, vacuum, and atmospheric residua, hydrotreated residual oils, coker distillates, straight run distillates, pyrolysis-derived oils, high boiling synthetic oils, cycle oils and cat cracker distillates. A preferred hydrocracking feedstock is a gas oil or other hydrocarbon fraction having at least 50% by weight, and most usually at least 75% by weight, of its components boiling at temperatures above the end point of the desired product. One of the most preferred gas oil feedstocks will contain hydrocarbon components which boil above 288°C (550°F) with best results being achieved with feeds containing at least 25 percent by volume of the components boiling between 315°C (600°F) and 538°C (1000°F). In a preferred embodiment, a second hydrocarbonaceous feedstock having a boiling range lower than the boiling range of the primary feedstock is introduced into the desulfurization zone.

[0013] The selected feedstock is introduced into a hydrocracking zone. The hydrocracking zone may contain one or more beds of the same or different catalyst. In one embodiment, when the preferred products are middle distillates the preferred hydrocracking catalysts utilize amorphous bases or low-level zeolite bases combined with one or more Group VIII or Group VIB metal hydrogenating components. In another embodiment, when the preferred products are in the gasoline boiling range, the hydrocracking zone contains a catalyst which comprises, in general, any crystalline zeolite cracking base upon which is deposited a minor proportion of a Group VIII metal hydrogenating component. Additional hydrogenating components may be selected from Group VIB for incorporation with the zeolite base. The zeolite cracking bases are sometimes referred to in the art as molecular sieves and are usually composed of silica, alumina and one or more exchangeable cations such as sodium, magnesium, calcium, rare earth metals, etc. They are further characterized by crystal pores of relatively uniform diameter between 4 and 14 Angstroms (10^{-10} meters). It is preferred to employ zeolites having a relatively high silica/alumina mole ratio between 3 and 12. Suitable zeolites found in nature include, for example, mordenite, stilbite, heulandite, ferrierite, dachiardite, chabazite, erionite and faujasite. Suitable synthetic zeolites include, for example, the B, X, Y and L crystal types, e.g., synthetic faujasite and mordenite. The preferred zeolites are those having crystal pore diameters between 8-12 Angstroms (10^{-10} meters), wherein the silica/alumina mole ratio is 4 to 6. A prime example of a zeolite falling in the preferred group is synthetic Y molecular sieve.

[0014] The natural occurring zeolites are normally found in a sodium form, an alkaline earth metal form, or mixed forms. In any case, for use as a cracking base it is preferred that most or all of the original zeolitic monovalent metals be ion-exchanged with a polyvalent metal and/or with an ammonium salt followed by heating to decompose the ammonium ions associated with the zeolite, leaving in their place hydrogen ions and/or exchange sites which have actually been decationized by further removal of water. Hydrogen or "decationized" Y zeolites of this nature are more particularly described in US-A-3,130,006.

[0015] Mixed polyvalent metal-hydrogen zeolites may be prepared by ion-exchanging first with an ammonium salt, then partially back exchanging with a polyvalent metal salt and then calcining. In some cases, as in the case of synthetic mordenite, the hydrogen forms can be prepared by direct acid treatment of the alkali metal zeolites. The preferred cracking bases are those which are at least 10 percent, and preferably at least 20 percent, metal-cation-deficient, based on the initial ion-exchange capacity. A specifically desirable and stable class of zeolites are those wherein at least 20 percent of the ion exchange capacity is satisfied by hydrogen ions.

[0016] The active metals employed in the preferred hydrocracking catalysts of the present invention as hydrogenation components are those of Group VIII, i.e., iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, iridium and platinum. In addition to these metals, other promoters may also be employed in conjunction therewith, including the metals of Group VIB, e.g., molybdenum and tungsten. The amount of hydrogenating metal in the catalyst can vary within wide ranges. Broadly speaking, any amount between 0.05 percent and 30 percent by weight may be used. In the case of the noble metals, it is normally preferred to use 0.05 to 2 weight percent. The preferred method for incorporating the hydrogenating metal is to contact the zeolite base material with an aqueous solution of a suitable compound of the desired metal wherein the metal is present in a cationic form. Following addition of the selected hydrogenating metal or metals, the resulting catalyst powder is then filtered, dried, pelleted with added lubricants, binders or the like if desired, and calcined in air at temperatures of, e.g., 371°-648°C (700°-1200°F) in order to activate the catalyst and decompose ammonium ions. The foregoing catalysts may be employed in undiluted form, or the powdered zeolite catalyst may be mixed and copelleted with other relatively less active catalysts, diluents or binders such as alumina, silica gel, silica-alumina cogels, activated clays and the like in proportions ranging between 5 and 90 weight percent.

These diluents may be employed as such or they may contain a minor proportion of an added hydrogenating metal such as a Group VIB and/or Group VIII metal.

[0017] Additional metal promoted hydrocracking catalysts may also be utilized in the process of the present invention which comprises, for example, aluminophosphate molecular sieves, crystalline chromosilicates and other crystalline silicates.

[0018] The hydrocracking of the hydrocarbonaceous feedstock in contact with a hydrocracking catalyst is conducted in the presence of hydrogen and preferably at hydrocracking conditions which include a temperature from (232°C) (450°F) to 468°C (875°F), a pressure from 3448 kPa gauge (500 psig) to 20685 kPa gauge (3000 psig), a liquid hourly space velocity (LHSV) from 0.1 to 30 hr^{-1}, and a hydrogen circulation rate from 337 normal m^3/m^3 (2000 standard cubic feet per barrel) to 4200 normal m^3/m^3 (25,000 standard cubic feet per barrel). In accordance with the present invention, the term "substantial conversion to lower boiling products" is meant to connote the conversion of at least 10 volume percent of the fresh feedstock. Total conversion of the feedstock to lower boiling products is preferably less than 80 volume percent, more preferably less than 60 volume percent and even more preferably less than 50 volume percent.

[0019] In one embodiment, after the hydrocarbonaceous feedstock has been subjected to hydrocracking as hereinabove described, the resulting effluent from the hydrocracking reaction zone is introduced into a stripping zone maintained at essentially the same pressure as the hydrocracking zone and a temperature from 232°C (450°F) to 468°C (875°F), and counter-currently contacted with a hydrogen-rich gaseous stream to produce a first gaseous hydrocarbonaceous stream containing hydrocarbonaceous compounds comprising diesel boiling range hydrocarbons and a first liquid hydrocarbonaceous stream preferably containing hydrocarbonaceous compounds boiling at a temperature greater than 371°C (700°F). Maintaining the pressure of the stripping zone at essentially the same pressure as the reaction zone means that any difference in pressure is due to the pressure drop required to flow the effluent stream from the reaction zone to the stripping zone. It is preferred that the pressure drop is less than 445 kPa (50 psig).

[0020] The resulting first gaseous hydrocarbonaceous stream containing diesel boiling range hydrocarbons is introduced into a desulfurization zone containing desulfurization catalyst. Preferred desulfurization conditions include a temperature from 204°C (400°F) to 482°C (900°F) and a liquid hourly space velocity from 0.1 to 10 hr^{-1}. It is contemplated that the desulfurization zone may also perform other hydroprocessing reactions such as aromatic saturation, nitrogen removal, cetane improvement and color improvement, for example.

[0021] Suitable desulfurization catalysts for use in the present invention are any known conventional hydrotreating catalysts and include those which are comprised of at least one Group VIII metal, preferably iron, cobalt and nickel, more preferably cobalt and/or nickel and at least one Group VI metal, preferably molybdenum and tungsten, on a high surface area support material, preferably alumina. Other suitable desulfurization catalysts include zeolitic catalysts, as well as noble metal catalysts where the noble metal is selected from palladium and platinum. It is within the scope of the present invention that more than one type of desulfurization catalyst be used in the same reaction vessel. The Group VIII metal is typically present in an amount ranging from 2 to 20 weight percent, preferably from 4 to 12 weight percent. The Group VI metal will typically be present in an amount ranging from 1 to 25 weight percent, preferably from 2 to 25 weight percent. Typical desulfurization temperatures range from 204°C (400°F) to 482°C (900°F) with pressures from 2.1 MPa (300 psig) to 17.3 MPa (2500 psig), preferably from 2.1 MPa (300 psig) to 13.9 MPa (2000 psig).

[0022] A preferred embodiment uses a second hydrocarbonaceous feedstock that boils in a range lower than that of the first hydrocarbonaceous feedstock. The second hydrocarbonaceous feedstock preferably boils at a temperature from 180°C (356°F) to 370°C (698°F) and may be selected from the group consisting of visbroken distillate, light cycle oil, straight run kerosene, straight run diesel, coker distillate and tar sand derived distillate.

[0023] The resulting effluent from the desulfurization zone is partially condensed and introduced into a vapor-liquid separator operated at a temperature from 21°C (70°F) to 60°C (140°F) to produce a hydrogen-rich gaseous stream containing hydrogen sulfide and a second liquid hydrocarbonaceous stream. The resulting hydrogen-rich gaseous steam is preferably passed through an acid gas scrubbing zone to reduce the concentration of hydrogen sulfide to produce a purified hydrogen-rich gaseous stream, a portion of which may then be recycled to the hydrocracking zone and the hot, high pressure stripper. The first liquid hydrocarbonaceous stream is preferably introduced into a cold flash drum to remove dissolved hydrogen and normally gaseous hydrocarbons and subsequently sent to a stripping zone.

[0024] The second liquid hydrocarbonaceous stream is preferably introduced into a stripping zone to remove dissolved hydrogen and normally gaseous hydrocarbons. In one embodiment, the first liquid hydrocarbonaceous stream is first introduced into a hot flash drum and then passed into a steam stripping column. In another embodiment, the stripping zone may be a single stripper. The resulting stripped hydrocarbonaceous liquid is introduced into a fractionation zone to preferably produce a naphtha, kerosene and low sulfur diesel product streams. The bottoms stream from the fractionation zone contains unconverted feedstock having a reduced concentration of sulfur.

DETAILED DESCRIPTION OF THE DRAWING

[0025] With reference to the drawing, a line 1 introduces a feed stream comprising vacuum gas oil and light cycle oil into the process and into admixture with a hydrogen-rich gaseous stream provided form line 36. Line 2 introduces the resulting admixture into hydrocracking zone 3. Line 4 transports a resulting hydrocracking zone effluent into hot, high pressure stripper 5 to produce an overhead hydrocarbonaceous vapor stream carried via line 24 and admixed with a hereinafter hydrocarbonaceous stream provided via line 52 and a line 25 carries the resulting admixture into hydrodesulfurization zone 26. Line 27 carries a resulting hydrodesulfurization zone effluent stream into high pressure separator 28. A line 28 removes a hydrogen-rich gaseous stream high pressure separator 28 and introduces it into acid gas recovery zone 30. A lean solvent enters acid gas recovery zone 30 via line 31and contacts the hydrogen-rich gaseous stream to dissolve an acid gas. A line 32 recovers a rich solvent containing acid gas from zone 30 via line 32. Line 33 removes a hydrogen-rich gaseous stream containing a reduced concentration of acid gas from zone 30 and admixes it with a hydrogen makeup stream provided via line 34. A line 35 transports one portion of the resulting admixture into hydrocracking zone 3 via line 36 and another portion as stripping gas into hot, high pressure stripper 5 via line 37. A line 6 removes a liquid hydrocarbonaceous stream stripper 5 via line 6 and introduces it into hot flash drum 7 to produce a vaporous stream, carried via line 8, which is cooled by heat exchange, not shown, and the resulting cooled stream is introduced into hot flash drum overhead receiver 9. Line 10 removes a vaporous stream from receiver 9, admixed with a liquid hydrocarbonaceous stream carried from high pressure separator 28 via line 11. Line 12 carries the resulting admixture into cold flash drum 13. Line 14 recovers a normally gaseous hydrocarbonaceous stream from drum 13. A line 15 transports a liquid stream from drum 13into stripper 16. Line 17 recovers a gaseous stream from stripper 16. A line 18 carries a liquid hydrocarbonaceous stream from stripper 16 into fractionation zone 19. A line 20 recovers a naphtha hydrocarbonaceous from fractionation zone 19. A line 21 recovers a kerosene boiling range hydrocarbonaceous stream from fractionation zone 19. A line 22 recovers a diesel boiling range hydrocarbonaceous stream from fractionation zone 19. Line 39 carries a liquid hydrocarbonaceous stream from hot flash drum 7 into stub column 40 to produce an overhead vaporous stream which is introduced into stripper 16 via lines 42 and 44. Lines 43 and 44 introduce steam into stripper 16. Line 41 introduces steam into stub column. A line 45 carries a liquid hydrocarbonaceous stream from stub column 40 into a refluxed flash column 46 to produce a condensed overhead stream carried via line 49 and admixed with a liquid hydrocarbonaceous stream produced in hot flash drum overhead receiver 9 and carried via line 50. Lines 51 and 25 carry the resulting mixture into hydrodesulfurization zone 26. A second feed is introduced via line 38 and is carried via lines 52 and 25 and introduced into hydrodesulfurization zone 26. Line 47 carries a liquid stream from flash column 46 into admixture with a liquid bottoms stream from fractionation zone 19 carried via line 23 and line 48 recovers the resulting admixture.

EXAMPLE

[0026] The commercial operation of the process was calculated for sending a feedstock in an amount of 201.3 nm^3/hr (30,388 BPSD) and having the characteristics presented in Table 1 to a hydrocracker where it is hydrocracked in a partial conversion single stage hydrocracker operated at a temperature of 385°C and a pressure of 90 bar to provide an overall conversion of 35 volume percent. The resulting effluent from the hydrocracker is introduced into a hot, high pressure stripper operated at 89 bar and stripped with a hydrogen-rich gaseous stream in an amount of 130 nm/m^3 based on the fresh feed to the hydrocracker. An overhead gaseous hydrocarbonaceous stream containing diesel boiling range hydrocarbons from the hot, high pressure stripper and a co-feedstock in an amount of 50.45 nm^3/hr (7615 BPSD) and having the characteristics presented in Table 1 are introduced into a desulfurization zone operated at a pressure of 89 bar and a temperature of 355°C. The effluent from the desulfurization zone is cooled and partially condensed to produce a hydrogen-rich gaseous stream and a liquid hydrocarbonaceous stream which is flashed, stripped and fractionated.

[0027] A bottom liquid stream is removed from the hot, high pressure stripper and is flashed, stripped and fractionated to produce a stream containing unconverted primary feedstock and a liquid hydrocarbonaceous stream boiling below the primary feedstock which is introduced into the desulfurization zone together with the co-feedstock. The overall product yields on a total feed basis are presented in Table 2 and the product properties are presented in Table 3.

Table 1 - Feedstock Analysis

	Hydrocarbon Feedstock	Co-Feedstock
Specific Gravity	0.905	0.842
Sulfur, weight percent	2.15	0.9
Distillation, °C		
IBP	201	201
5%	251	240
10%	302	251
30%	409	269
50%	435	285
70%	461	301
90%	512	327
95%	526	339
EP	554	370

Table 2-Overall Product Yields

Gas Products, weight percent	
H_2O	0.09
NH_3	0.1
H_2S	2.02
C_1	0.03
C_2	0.05
C_3	0.19
Liquid Products, weight percent	
C_4	0.61
C_5	0.62
C_6	0.53
MCP	0.25
CH	0.04
Benzene	0.03
C_7-154°C	3.69
154-370°C	46.91
370°C+	45.99

Table 3 - Product Properties

C_5-C_6	
Density	0.667
Sulfur, wppm	<0.5
Nitrogen, wppm	<0.5
C_7-154°C	
Density	0.797
Sulfur	<0.5
Nitrogen	<0.5
154-370°C	
Density	0.835
Sulfur, wppm	10
Nitrogen, wppm	0.5
Flash Point, °C	56
Cetane Index	56
370°C+	
Density	0.898
Sulfur, wppm	<100
Nitrogen, wppm	10

[0028] From Table 3, it is noted that the diesel stream having a boiling range from 154 to 370°C contains only 10 wppm sulfur which is considered to be in the ultra low sulfur diesel range. The other two hydrocarbon streams boiling below the diesel boiling range contain less than 0.5 wppm sulfur, while the unconverted feedstock boiling above 370°C has the sulfur level reduced to less than 100 wppm.

[0029] The foregoing description, drawing and illustrative embodiment clearly illustrate the advantages encompassed by the process of the present invention and the benefits to be afforded with the use thereof.

CLAIMS:

1. A hydrocracking process for the production of ultra low sulfur diesel from a primary hydrocarbonaceous feedstock wherein the process comprises the steps of:
   (a) reacting the primary hydrocarbonaceous feedstock and hydrogen in a hydrocracking zone containing hydrocracking catalyst to produce diesel boiling range hydrocarbons;
   (b) stripping a hydrocracking zone effluent in a hot, high pressure stripping zone maintained at essentially the same pressure as the hydrocracking zone and a temperature in the range from 232°C (450°F) to 468°C (875°F) with a first hydrogen-rich gaseous stream to produce a first gaseous hydrocarbonaceous stream comprising diesel boiling range hydrocarbons and a first liquid hydrocarbonaceous stream;
   (c) passing the first gaseous hydrocarbonaceous stream comprising diesel boiling range hydrocarbons to a desulfurization zone containing desulfurization catalyst and producing a desulfurization zone effluent stream;
   (d) condensing at least a portion of the desulfurization zone effluent stream to produce a second hydrogen-rich gaseous stream and a second liquid hydrocarbonaceous stream comprising diesel boiling range hydrocarbons;
   (e) passing the first liquid hydrocarbonaceous stream to a hot flash zone maintained at a pressure from 445 kPa (50 psig) to 2858 kPa (400 psig) and a temperature from 232°C (450°F) to 468°C (875°F) to produce a third liquid hydrocarbonaceous stream comprising unconverted hydrocarbons and diesel boiling range hydrocarbons;
   (f) stripping the third liquid hydrocarbonaceous stream and introducing the resulting stripped stream in a flash column operated at a temperature from 232°C (450°F) to 468°C (875°F) and a pressure from 3.5 kPa (0.5 psia) to 196.4 kPa (28.5 psia) to produce a fourth liquid hydrocarbonaceous stream comprising unconverted hydrocarbons and a second gaseous hydrocarbonaceous stream comprising diesel boiling range hydrocarbons;

(g) reacting at least a portion of the second gaseous hydrocarbonaceous stream in the desulfurization zone containing desulfurization catalyst; and

(h) recovering an ultra low sulfur diesel product stream.

2. The process of Claim 1 wherein at least 25% by volume of the primary hydrocarbonaceous feedstock boils between 315°C (600°F) and 538°C (1000°F).

3. The process of Claim 1 wherein the hydrocracking zone is operated at conditions which include a temperature from 232°C (450°F) to 468°C (875°F) and a pressure from 3.45 MPa (500 psig) to 20.7 MPa (3000 psig).

4. The process of Claim 1 wherein the conversion of the feedstock in the hydrocracking zone is less than 80 volume percent.

5. The process of Claim 4 wherein the conversion of the feedstock in the hydrocracking zone is less than 60 volume percent.

6. The process of Claim 4 wherein the conversion of the feedstock in the hydrocracking zone is less than 50 volume percent.

7. The process of Claim 1 wherein at least a majority of the diesel boiling range hydrocarbons boils in the range from 154°C (309°F) to 370°C (698°F).

8. The process of Claim 1 wherein at least a portion of the second hydrogen-rich gaseous stream is recycled to the hydrocracking zone in step (a) or the hot, high pressure stripping zone in step (b).

9. The process of Claim 1 wherein the ultra low sulfur diesel product stream comprises less than 50 wppm sulfur.

10. The process of Claim 9 wherein the ultra low sulfur diesel product stream comprises less than 10 wppm sulfur.

11. The process of any one of Claims 1 through 10 wherein a secondary feedstock comprising hydrocarbonaceous material boiling from 180°C (356°F) to 370°C (698°F) is introduced into and reacted in the desulfurization zone of step (c).

12. The process of Claim 11 wherein the primary hydrocarbonaceous feedstock is selected from the group consisting of atmospheric gas oils, vacuum gas oils, deasphalted, vacuum, and atmospheric residua, hydrotreated residual oils, coker distillates, straight run distillates, pyrolysis-derived oils, high boiling synthetic oils, cycle oils and cat cracker distillates and the secondary feedstock is selected from the group consisting of visbroken distillate, light cycle oil, straight run kerosene, straight run diesel, coker distillate and tar sand derived distillate.

13. The process of Claim 11 wherein at least a majority of the secondary hydrocarbonaceous feedstock boils in the diesel boiling range.

14. The process of Claim 11 wherein at least a majority of the second hydrocarbonaceous feedstock boils in the range from 180°C (356°F) to 370°C (698°F).

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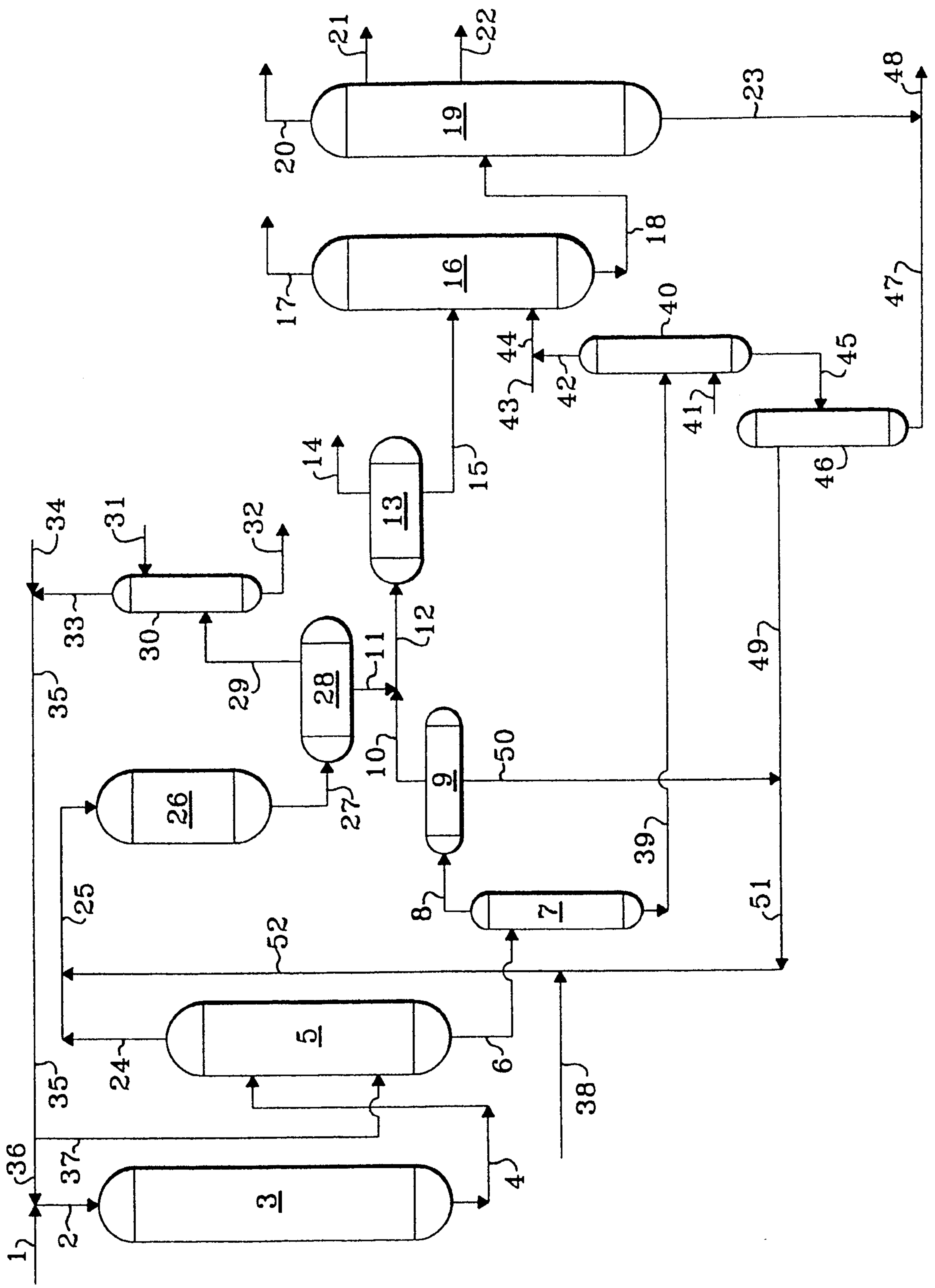
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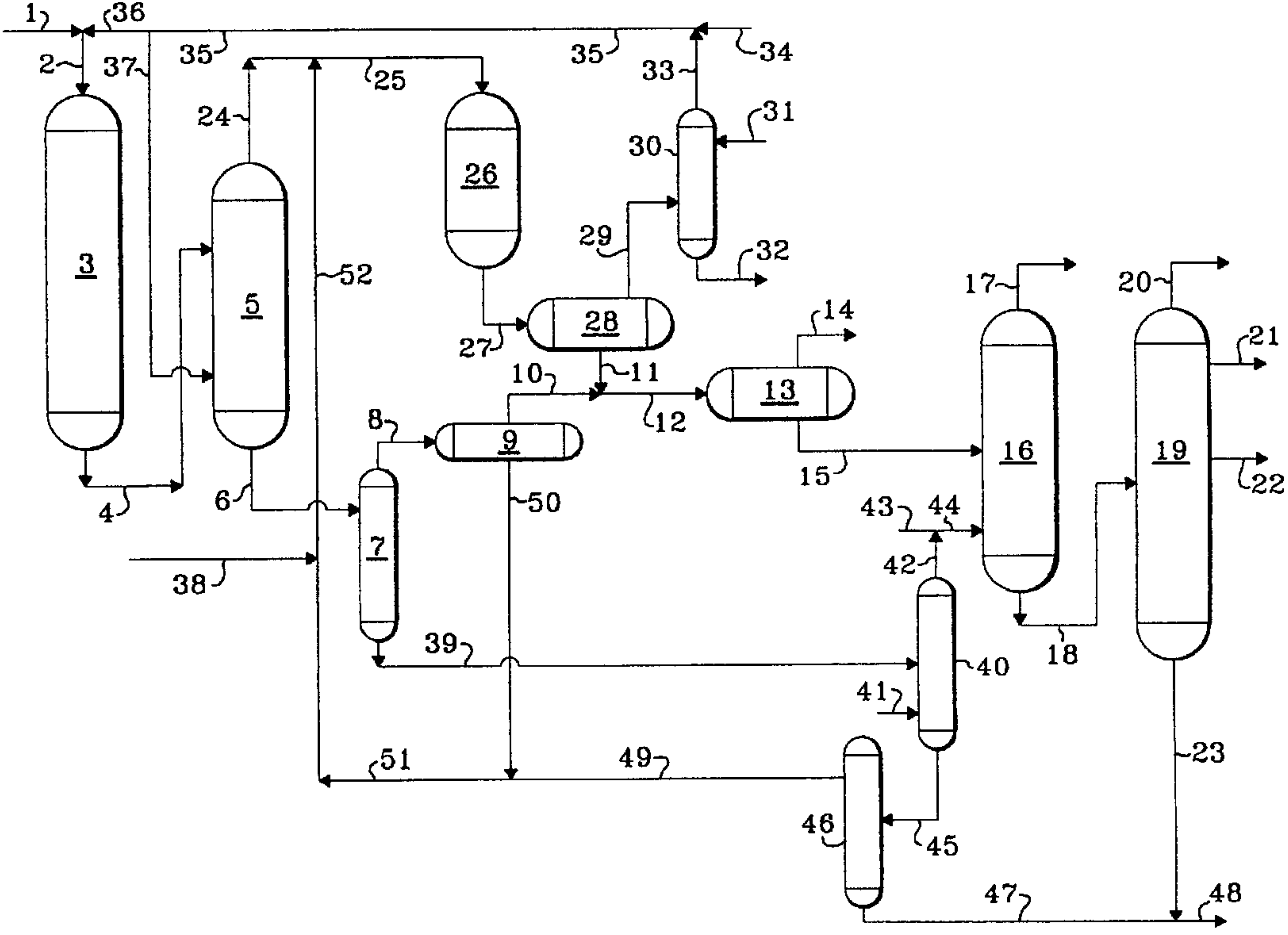

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