

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 199 347 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

15.12.2004 Bulletin 2004/51

(51) Int Cl.7: **C10G 55/02**, C10G 7/06,
C10G 9/00, C10G 55/04

(21) Application number: **00925681.9**

(86) International application number:
PCT/JP2000/003125

(22) Date of filing: **16.05.2000**

(87) International publication number:
WO 2000/069992 (23.11.2000 Gazette 2000/47)

(54) **PROCESS FOR TREATING CRUDE OIL**

VERFAHREN ZUR BEHANDLUNG VON ROHÖL

PROCEDE DE RAFFINAGE DE PETROL BRUT

(84) Designated Contracting States:
DE FR GB NL

(30) Priority: **17.05.1999 JP 13548199**

(43) Date of publication of application:
24.04.2002 Bulletin 2002/17

(73) Proprietor: **CHIYODA CORPORATION**
Yokohama-shi Kanagawa 230-8601 (JP)

(72) Inventors:
• **SHIMIZU, Shin-ichi, Chiyoda Corp.**
Yokohama-shi, Kanagawa 230-8601 (JP)

• **TAMURA, Masamichi, Chiyoda Corp.**
Yokohama-shi, Kanagawa 230-8601 (JP)
• **WADA, Yukitaka, Chiyoda Corp.**
Yokohama-shi, Kanagawa 230-8601 (JP)

(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(56) References cited:
EP-A1- 0 064 447 WO-A-96/26992
GB-A- 748 427 US-A- 3 487 006
US-A- 4 432 941 US-A- 4 441 989
US-A- 4 454 023

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 199 347 B1

DescriptionTechnical Field

[0001] The present invention relates to a method of treating a crude oil, which particularly comprises, as an essential part, a so-called upgrading method of a heavy oil, where a heavy oil content contained in a crude oil is converted into a light fraction in refining of petroleum for producing value-added petroleum products from a crude oil.

Background Art

[0002] A conventional general treating process of a crude oil will be explained with reference to Figure 3.

[0003] A crude oil 2 received by a refinery and subjected to a prescribed pretreatment is separated by distillation in an atmospheric distillation apparatus 100 to afford, downward from the top of the column, a gas content 101, a kerosene content 103, a gas oil content 105, and the like as each distillate, whereby a heavy oil content 107 is separated at the bottom of the column as a residual oil.

[0004] The gas content 101 withdrawn from the top of the column is further separated into, for example, a light, gas content (H_2 , C_1 , C_2) 111, an LPG content (C_3 , C_4) 113, a C_5 - C_6 content 115, a naphtha content 117 in a gas recovery section 110. In general, hydrogen sulfide is individually removed from the light gas content 111 and the LPG content 113 as well as the C_5 - C_6 content 115 by means of a washing apparatus, and the light gas content 111 is used for a fuel of its own consumption, and the LPG content 113 is for an LPG product. The C_5 - C_6 content 115 is used as a balancing agent for gasoline.

[0005] The naphtha content 117 is generally subjected to a treatment for removing sulfur contents and nitrogen contents by a hydrotreating apparatus 120, followed by catalytic reformation in a reforming apparatus 125 to enhance an octane value in order to form a balancing agent for gasoline.

[0006] The kerosene content 103 is subjected to hydrosulfurization and refining by a hydrotreating apparatus 130 (comprising a desulfurizing and cracking reactor R1 and a rectification part D1) to remove sulfur contents, nitrogen contents, etc., and is generally used as a kerosene product or a jet fuel.

[0007] The gas oil content 105 is also subjected to hydrosulfurization and refining by means of a hydrotreating apparatus 140 (comprising a desulfurizing and cracking reactor R2 and a rectification part D2) to remove sulfur contents, etc., and is generally used as a diesel gas oil.

[0008] The heavy oil content 107 withdrawn from the column bottom of an atmospheric distillation apparatus 100 is transferred to a vacuum distillation apparatus 200 in order to subject to a so-called upgrading treatment which converts it into a light fraction. In the apparatus, the heavy oil content 107 is separated into a vacuum gas oil 201 and a vacuum residue 205. The vacuum residue is dealt with a raw material for thermal cracking. The vacuum gas oil 201 is subjected to desulfurization, cracking, and refining and separation by means of a hydrogenating apparatus 210 (comprising a desulfurizing and cracking reactor R3 and a rectification part D3). Each fraction separated (separated into naphtha, kerosene, diesel gas oil, vacuum gas oil at the rectification part D3) is usually transferred to the above-mentioned gas recovery section 110 or combined with each line of the products such as kerosene and diesel gas oil to form products as illustrated in the drawing.

[0009] On the other hand, the vacuum residue 205 separated by means of the vacuum distillation apparatus 200 is fed to a thermal cracking section 220 (comprising a reactor R4 and a rectification part D4). In the thermal cracking section 220, a raw material for thermal cracking is thermally cracked to form thermal cracking products such as cracked gas and cracked oil, and residues such as pitch and coke. The thermally cracked oil is further subjected to secondary treatments such as hydrotreating, hydrocracking, catalytic cracking, and separation to form final products. At the secondary treatments of the thermally cracked oil, it is generally mixed with the kerosene content 103, the gas oil content 105, the vacuum gas oil fraction 201 separated in the atmospheric distillation apparatus 100 and the vacuum distillation apparatus 200 in advance. Therefore, in order to adjust to their boiling point ranges, the thermally cracked oil is further separated according to plural boiling point ranges at the rectification part (D4).

[0010] When attention is focused on the above process, especially upgrading of the heavy oil in the conventional thermal cracking section, two-step operation of distillation at the atmospheric distillation apparatus 100 and the vacuum distillation apparatus 200 is required for obtaining raw material for thermal cracking 205 (the vacuum residue 205). Moreover, in order to recover thermally cracked oil by subjecting to the secondary treatments, it is necessary to separate the oil into each fraction having a boiling point range similar to the range of each distillate oil from the atmospheric distillation apparatus 100 and the vacuum distillation apparatus 200 (for example, 101, 105, and 201) and mix it with each distillate oil. Accordingly, addition of the distillation part D4 to the thermal cracking section 220 becomes necessary and thus at least three distillation columns 100, 200, and D4 are required in total.

[0011] Therefore, the constitution of the apparatus for upgrading of a heavy oil by thermal cracking becomes complex and expensive. In addition, it is necessary to secure a wide space for the placement. Since these problems directly

connect with an increase in cost of refined each product, it is extremely difficult to introduce new facilities for the process under the present circumstances.

[0012] From the above-mentioned reasons, in order to solve the above problems, it has been desired to have a proposal for an inexpensive method of the treatment capable of simplifying the process with regard to upgrading of a heavy oil by thermal cracking.

[0013] Moreover, when whole conventional process according to Figure 3 is considered, after the crude oil 2 introduced has been separated into each component by two-times distilling operations, a similar operation of hydrodesulfurization and refining is repeatedly carried out on the separated individual component by means of a combination of a desulfurization and cracking reactor (R1 to R4), a rectification part (D1 to D4) and the like. Such conventional treating system is considered to directly result in an increase in cost of each refined product, and thus, like the above-mentioned upgrading of a heavy oil by thermal cracking, proposal of an inexpensive method of the treatment capable of simplifying the whole process has been desired.

[0014] US 4,432,941 discloses a process for the distillation and thermal cracking of a crude oil feedstock comprising: introducing the feedstock to a separation vessel; withdrawing liquid, including heavier fractions, from the separation vessel; heating at least a portion of the liquid withdrawn from the separation vessel; reacting the heated liquid in a reactor where the heavier fractions are at least partially cracked; feeding an outlet stream, including cracked products, from the reactor to the separation vessel; withdrawing gas from the separation vessel and transferring the gas to a distillation column where the gas is separated into various fractions, and cooling the cracked products prior to their being fed to the separation vessel. The process may include the further step of feeding liquid, including cracked products, to a reduced pressure column where the lighter fractions may be separated. The bottom product from the reduced pressure column may be recycled to the reactor and/or may be used to cool the cracked products. The top product from the reduced pressure column may be fed to the distillation column or may be removed as product.

[0015] WO 96/26992 describes a process for the thermal conversion of a hydrocarbon oil feed derived from a crude oil via a fractionation comprising at least an atmospheric distillation in a crude distillation unit, which process comprises the steps of (a) subjecting the hydrocarbon oil feed to a thermal conversion treatment and recovering at least one lighter oil fraction and a heavy residual fraction; and (b) feeding the lighter oil fraction(s) to a crude distillation unit for further separation.

[0016] US 4,441,989 discloses a process for the thermal cracking and fractionation of a heavy gas oil and petroleum crude oil feedstock in which the feedstock is fed to a fractionation column, light fractions are withdrawn from the column, a heavy gas oil fraction is withdrawn from the column and fed to a heater, the heated heavy gas oil and bottoms from the column are fed to a reactor where thermal cracking takes place, then the cracked vapor products are fed from the reactor to the column together with the feedstock, the cracked vapor products being quenched by the feedstock and the cracked liquid products being withdrawn from the bottom of the reactor.

[0017] The present invention is contrived under the above circumstances, and object thereof is to provide a method of treating a crude oil capable of improving the complexity of conventional constitution of the apparatus, simplifying the process and saving the space, and thereby reducing a cost for the treatment. In addition, the object is to provide a method of treating a crude oil also applicable to a small-scale refining of petroleum.

Disclosure of the Invention

[0018] For solving these problems, the present invention provides a method of treating a crude oil comprising:

a step of separating the crude oil by distillation where the crude oil is separated by distillation into a distillate oil and a heavy oil content,

a step of thermal cracking where the heavy oil content separated at said step of separating the crude oil by distillation and obtained substantially from the bottom is thermally cracked to lighten the content, and

a step of separating the thermal cracking product by distillation where the thermal cracking product obtained by lightening at said step of thermal cracking is separated by distillation; wherein

said step of separating the crude oil by distillation and said step of separating the thermal cracking product by distillation are carried out at the same time in an identical single distilling section comprising a vacuum distillation apparatus, and the distillate oil separated in the identical single distilling section contains a vacuum gas oil content, a gas oil content, a kerosene content and a naphtha content, and those contents are collectively introduced to identical one hydrotreating section without separating into each content having prescribed boiling range, where they are collectively subjected to desulfurization, cracking, and hydrogenation treatment.

[0019] In a preferred embodiment of the present invention, the distilling section in which said step of separating the crude oil by distillation and step of separating the thermal cracking product by distillation carried out at the same time comprises a pre-separation apparatus and a main separation apparatus.

[0020] In a preferred embodiment of the present invention, the heavy oil content separated in said distilling section and withdrawn from the bottom amounts 15 to 55 parts by weight relative to 100 parts by weight of a distillate oil from the distilling section.

[0021] In a preferred embodiment of the present invention, the heavy oil content separated at said step of separating the crude oil, withdrawn from the bottom, and fed to the step of thermal cracking contains substantially neither gas oil content nor vacuum gas oil content.

[0022] In a preferred embodiment of the present invention, no heavy oil content is contained in thermal cracking residue at said step of thermal cracking.

Brief Description of the Drawings

[0023]

Figure 1 is a process flow illustrating a preferred embodiment of the present invention;
Figure 2 is a detailed flowchart illustrating the distilling section 10 in Figure 1 in detail; and
Figure 3 is a process flow illustrating a conventional general mode for treating a crude oil.

Best Mode for carrying out the Invention

[0024] The following will explain a preferred mode of the present invention in detail with reference to the process flow illustrated in Figure 1.

[0025] In general, crude oil received by a refinery is permitted to stand in a crude oil tank, and water and sludge content are removed by means of desalter. The crude oil 2 subjected to such pretreatment is, as a preferred embodiment of the present invention, introduced into a distilling section 10. Figure 2 illustrates a preferred detailed flowchart of the distilling section 10.

[0026] As illustrated in Figure 2, the crude oil 2 is first introduced into a pre-separating apparatus, for example, a simple flash vessel 3 and then separated into a gas content 3a and a liquid fraction 3b. The liquid fraction 3b is introduced into a vacuum distillation apparatus 10', and then separated into an extract oil 11a extracted from the upper part of the column and a vacuum residue which is a heavy oil content 15 from the bottom of the column (the step of separating crude oil by distillation). The gas content 3a from the flash vessel 3 is cooled and further separated into a gas content 12 and a liquid fraction 11b. The liquid fraction 11b is mixed with the extract oil 11a from the vacuum distillation apparatus 10' to form a raw material oil for hydrotreating (distillate oil) 11. The distillate oil 11 contains a vacuum gas oil content, a gas oil content, a kerosene content, and a naphtha content, while the gas content 12 contains an LPG (liquefied Petroleum gas) content, a light gas content and the like.

[0027] Preferred conditions for operating the distilling section 10 including the vacuum distillation apparatus 10' are as follows: a pressure of about 1 to 10 kPa and a temperature of about 350 to 400°C. Furthermore, separation ratio of the vacuum residue (15) to the distillate oil 11 in the distilling section 10 is made 15 to 55 parts by weight relative to 100 parts by weight of the distillate oil 11. The separation ratio is determined according to kind of oil. For example, in the case of Arabian heavy crude oil, the vacuum residue (15) is preferably made 45 to 55 parts. When the vacuum residue (15) becomes less than 45 parts, a metal content and a residual carbon content contained in a heavy oil are transferred to a hydrotreating section 30 which exists downstream, and fine pores of a catalyst for desulfurization and cracking in the hydrotreating section 30 is blocked by the metal content and coke. As a result, inconveniences that activity of the catalyst is degraded and life of the catalyst is shortened occur. When the vacuum residue (15) exceeds 55 parts, owing to a decrease in the reaction rate of thermal cracking of the vacuum residue, severe conditions such as extending the residence time for reaction in the thermal cracking section or elevation of the reaction temperature are needed and, as a result, efficient cracking is inhibited. On the other hand, in the case of Arabian extra light crude oil, it is preferred to make the vacuum residue (15) 15 to 30 parts for the same reasons as above.

[0028] The crude oil to be fed to the distilling section 10 may be an ultra-heavy crude oil such as oil sand bitumen from Canada and Orinoco tar from Venezuela. In this case, separating ratio of the distillate oil 11 and the vacuum residue (15) in the distilling section 10 may be preferably adjusted so that suitable raw material can be fed to the thermal cracking section and the hydrotreating section. Moreover, the crude oil to be fed to the distilling section 10 may be an atmospheric distillation residue, and, in this case, the separating ratio may be again adjusted as mentioned above.

[0029] In addition, at the step for separating the crude oil by distillation according to the present invention, the process is operated so that the heavy oil content 15 contains substantially neither gas oil content nor vacuum gas oil content. The operation of the step for separating the crude oil by distillation is carried out so that the gas oil content and the vacuum gas oil content are withdrawn at the line of said distillate oil 11.

[0030] As illustrated in Figure 1, substantially direct introduction of the crude oil 2 to the distilling section 10 including the vacuum distillation apparatus 10' enables to fulfill the purposes of adjusting vacuum residue oil that is a raw material

oil for the thermal cracking section, and adjusting a mixed oil composed of naphtha, kerosene, gas oil and vacuum gas oil, that is a raw material oil for collective hydrotreating section. Accordingly, since it is not necessary to separate the crude oil into each fraction of naphtha, kerosene, gas oil and vacuum gas oil by distillation, the conventional large-scale atmospheric distillation apparatuses become unnecessary.

[0031] The heavy oil content 15 (vacuum residue (15)) separated at such step of separating a crude oil by distillation where the distilling section 10 is used and obtained substantially from the bottom of the distilling section 10 is introduced to the thermal cracking section 20, in which the heavy oil content 15 is thermally cracked and separated into a lightened thermal cracking product 21 and a thermal cracking residue 25 (the step of thermal cracking).

[0032] The lightened thermal cracking product 21 is returned to the above-mentioned distilling section 10, in which the product is distilled under reduced pressure to effectively recover a low-boiling content (the step of separating thermal cracking product by distillation). That is, first characteristic of the present invention is to carry out said step of separating a crude oil by distillation and step of separating a thermal cracking product by distillation in identical one distilling section 10 at the same time, and feed a suitable raw material oil to the thermal cracking section and feed a suitable raw material oil to the hydrotreating section. Namely, with regard to separated composition in the distilling section 10, a mixture of the distillate oil (containing gas content) derived from the crude oil and the thermally cracked oil (containing gas content) is withdrawn from the column top of the distilling section 10 collectively or fractionally at plural boiling ranges (symbol 11). On the other hand, a mixture of a distillation residue derived from the crude oil and a part of a cracked heavy oil is withdrawn from the column bottom of the distilling section 10 and used as a raw material for thermal cracking (15). Such first characteristic contributes to simplify the process and to minimize the apparatus.

[0033] In addition, since the present invention aims to reduce heavy oil products to zero, the thermal cracking section 20 is operated so that the thermal cracking residue 25 at the step of thermal cracking contains no heavy oil content.

[0034] In the above-mentioned thermal cracking section 20, the raw material for thermal cracking is generally pre-heated or, in some cases, pre-cracked at a tube-type heating furnace, followed by further thermal cracking by means of a reactor of vessel-type (EUREKA, delayed coker) or fluid bed-type (flexicoker, fluid coker) to form thermal cracking products such as a cracked gas and a cracked oil, and residues such as pitch and coke, which are separated from each other.

[0035] In the thermal cracking step of the present invention, although hitherto known various thermal cracking sections can be used, use of a so-called EUREKA is particularly preferable in view of the combination of downstream hydrotreating step.

[0036] EUREKA process is a process which generally produces gas, cracked oil and pitch by thermal cracking of a vacuum residue oil. The detail is shown in "Specification of Japanese Patent Publication No. 15795/1982", "Thermal and Nuclear Power Generation (Karyoku Genshiryoku Hatsuden)", Vol. 36, No. 2, pp. 151-166 (1985), "Proceedings of 17th Panel Discussion on the Petroleum Refining, Petroleum Society (Sekiyu Gakkai Dai 17 Kai Seisei Paneru Touronkai Kaigiroku)", pp. 93-102 (1992), "Catalysts in Petroleum Refining and Petrochemical Industries 1995", pp. 293-301 (1995), "Process for Petroleum Refining (Sekiyu Seisei Purosesu)", pp. 202-203 (1998, published by Petroleum Society (Sekiyu gakkai)), and the like. The reaction system of EUREKA process adopts a semi-batch method combining a tube-type cracking furnace and a vessel-type reactor, and thereby aims to cope with both production of thermo-melting pitch which has a property of homogeneous and of narrow in distribution of reaction residence time and economy of the process. The reactor is composed of two pieces of apparatus per 1 set and charge of the raw material is switched alternatively at about 90 minutes intervals by means of an automatic switching valve. It is operated at a temperature of 400°C to 450°C under a pressure of 30 to 70 kPaG, that is almost atmospheric pressure. Moreover, by blowing overheated steam of about 600 to 700°C to the bottom of the reactor, a cracked oil is purged promptly to the outside of the reaction system to suppress excessive cracking and polycondensation. Accordingly, the cracked oil has a characteristic that it contains less polycondensate molecules as compared with the product of other cracking apparatus. When the polycondensate molecules are present in the raw material oil, severer conditions are required in downstream desulfurization, cracking, or hydrogenation. In the present invention whose characteristic is combination with the hydrotreating step, it is desirable to use a method where the formation of these polycondensate molecules at the thermal cracking step is as little as possible.

[0037] As mentioned above, the distillate oil 11 separated in the distilling section 10 contains a vacuum gas oil content, a gas oil content, a kerosene content, a naphtha content and the like. These contents are collectively introduced to identical one hydrotreating section 30 without separating into each content having prescribed boiling range, where they are collectively subjected to desulfurization, cracking, and hydrogenation treatment. Since the thermally cracked oil formed at the thermal cracking step contains unsaturated hydrocarbons, quality of the oil is unsettled without further treatment. Therefore, hydrotreating is necessarily conducted in order to saturate them with hydrogen for purpose of the settlement. Accordingly, when upgrading scheme of the residual oil is carried out by thermal cracking according to a conventional technique, the thermally cracked oil is, in general, separated into each fraction by rectification and, after each fraction is mixed with each distillate oil such as naphtha, kerosene, gas oil, or vacuum gas oil, each fraction is individually subjected to hydrotreating. When attention is focused on the pressure of individual hydrotreating reaction

part of the distillate oil, the pressure is usually set up so as to increase as the fraction of a raw material oil changes from light one to heavy one in the case that the thermal cracking of the residual oil is not carried out. On the contrary, in the case that thermal cracking of the residual oil is accompanied as discussed in the present invention, the pressure is set up high even for a light oil and therefore, the pressure at hydrotreating tends to flat throughout the treatment of from a light fraction to a heavy fraction. Concretely, when the thermal cracking of the residual oil is not carried out, the pressure for hydrotreating ranges 500 to 3000 kPaG for naphtha, 1000 to 4000 kPaG for kerosene, 4000 to 7000 kPaG for gas oil, or 5000 to 7000 kPaG for vacuum gas oil, typically 2000 to 3000 kPaG for naphtha and kerosene, 5000 kPaG for gas oil, or 6000 kPaG for vacuum gas oil. On the other hand, when the thermal cracking of the residual oil is accompanied, the pressure for hydrotreating of each fraction of naphtha, kerosene, gas oil, or vacuum gas oil is set up typically the same level, i.e., 6000 kPaG. Accordingly, in the refining scheme incorporating the thermal cracking of the residual oil, there are low technical necessity of individual hydrotreating and high technical rationality of collective hydrotreating. The collective hydrotreatment in the present invention is different from that of the case not accompanying the residual oil cracking (for example, the specification of Japanese Patent Application Laid-Open No. 82573/1995 etc.) in the technical background, and is a peculiar technique in the thermal cracking scheme of the residual oil.

[0038] In addition, from the viewpoint of economy, when the distillate oil is subjected to collective hydrotreating in refining scheme without the residual oil cracking, it is especially necessary to procure a light crude oil fitting demand for heavy oil products and treat it. In this case, in order to suitably collect capital for an investment in new facilities, the profit obtainable from the difference between the cost of the crude oil, and the prices of the products must be enough. However, at the present time when the prices of the crude oil and the products are determined by market principles, it is extremely difficult to make the new facilities economically feasible without the residual oil cracking in the case of such light crude oil treatment since the price difference between the crude oil and the products is small in the case of such light crude oil treatment. On the other hand, in the case accompanying the residual oil cracking, economical advantage is enhanced by low price of the raw material heavy oil and the price difference between light oil products and heavy oil products and thus capital collecting for investment in the new facilities can be secured.

[0039] The collective hydrotreating in the present invention is different from the general technique of collective hydrotreating of the distillate oil from a crude oil, and is characterized by the technical and economical significances found in the integration with the thermal cracking of residual oil.

[0040] The reaction style is not particularly limited, and can include various embodiments such as fixed bed, fluid bed, moving bed, and the like. Generally, the composition unnecessary to treat in the hydrotreating section 30 is excluded from the compositions for collective treatment.

[0041] The refined oil 31 collectively subjected to desulfurization, cracking and hydrogenation treatment in the hydrotreating section 30 is a synthetic crude oil of low sulfur content containing no vacuum residual oil fraction and having high added value, and is treated in the downstream refining scheme according to a conventional technique.

[0042] In addition to the aforementioned first characteristic, the present invention aims to simplify whole process and reduce a cost for the treatment by collectively subjecting the distillate oil 11 including the refined product after thermal cracking to desulfurization, cracking, and hydrogenation treatment, and also collectively operating the separation by distillation after said treatment.

[0043] Part of the lightened thermal cracking product 21 may be transferred to the hydrotreating section 30 without returning to the distilling section 10.

[0044] In the above, a preferable process of the present invention has been explained with reference to Figure 1 and Figure 2. As mentioned above, the distilling section 10 to which the crude oil 2 is introduced may comprise a pre-separating apparatus and a main separating apparatus as a preferable partially transformed example. In this case, examples of the pre-separating apparatus include a flash vessel, a simple distilling column, and the like, and examples of the main separating apparatus include a vacuum distilling apparatus. Since a part of vacuum gas oil can be also separated, the placement of the pre-separating apparatus in advance affords a merit that sizes of the heating furnace and the vacuum distilling tower can be reduced.

[0045] Among the pre-separating apparatus, the flash vessel is a more preferable embodiment than the distilling column. The reasons are as follows: the treatment in the downstream hydrotreating section 30 is carried out collectively, and thus, more precise separation is not only technically unnecessary but also economically undesirable.

[0046] The following shows concrete examples, which explain the present invention in detail.

[Experimental Example 1]

(Example 1)

[0047] According to the process of the present invention as illustrated in Figure 1, an experiment of refining a crude oil was carried out as described in the following.

EP 1 199 347 B1

Kind and Properties of the crude oil used

[0048] Used crude oil: Arabian heavy oil (100% by volume)

[0049] Specific gravity: 0.896

[0050] Concentration of sulfur: 3.07% by weight

Operating conditions in the distilling section 10

[0051] Pressure: 1 to 10 kPa

[0052] Temperature: 350 to 400°C

Operating conditions in the thermal cracking section 20 (EUREKA)

[0053] Pressure: 30 to 60 kPaG

[0054] Temperature: 425 to 440°C

Operating conditions in the hydrotreating section 30

[0055] Chemical hydrogen consumption: 55 to 60 Nm³/kL

[0056] Reaction tower temperature: 340 to 380°C

[0057] Partial pressure of hydrogen: 6000 kPa

Operating conditions in the separation by distillation section 40

[0058] Pressure: 60 to 100 kPa

[0059] Temperature: 330 to 360°C

[0060] Yields and qualities of the products obtained under the above operating conditions are shown in Tables 1 and 2.

Table 1

Product Yields		
	Raw material	Products
	Arabian heavy crude oil	-
Naphtha (% by volume)	19	23
Kerosene (% by volume)	9	10
Gas oil (% by volume)	21	26
Vacuum gas oil (% by volume)	26	36
Vacuum residual oil (% by volume)	26	-
Oils in total (% by volume)	100	96
Pitch (% by weight)	-	8

Table 2

Product Qualities			
		Raw material	Products
		Arabian heavy crude oil	-
Naphtha			
	Specific gravity (-)	0.722	0.726
	Sulfur content (% by weight)	0.02	0.001
Kerosene			
	Specific gravity (-)	0.800	0.796
	Sulfur content (% by weight)	0.30	0.01

EP 1 199 347 B1

Table 2 (continued)

Product Qualities			
		Raw material	Products
Kerosene			
	Smoke point (mm)	26	22
Gas oil			
	Specific gravity (-)	0.856	0.847
	Sulfur content (% by weight)	1.54	0.05
	Cetane index (-)	51	54
Vacuum gas oil			
	Specific gravity (-)	0.941	0.925
	Sulfur content (% by weight)	3.40	0.63
Vacuum residual oil			
	Specific gravity (-)	1.053	-
	Sulfur content (% by weight)	6.00	-
	Metal content (ppm by weight)	300	-

[0061] The yields and qualities of the products shown in the above tables were confirmed to be on the same level with those of the product fractions (sulfur content of not more than 500 ppm by weight in gas oil) obtained by the conventional process illustrated in Figure 3. It was also confirmed that 15% reduction of the cost for constructing plant can be attained as compared with the conventional process. Accordingly, it was confirmed that the process of the present invention enables simplification of the process and saving of the space, and thus reduction of the treating cost without lowering the product yields and qualities.

(Example 2)

[0062] In the above Example 1, operating conditions in the hydrotreating section 30 was changed as described in the following. Except for those points, an experiment of refining a crude oil was conducted as described in Example 1.

Operating conditions in the hydrotreating section 30

[0063] Chemical hydrogen consumption: 60 to 70 Nm³/kL

[0064] Reaction tower temperature: 340 to 380°C

[0065] Partial pressure of hydrogen: 6000 kPa

[0066] Reactor volume: two times of the volume in the above Example 1

[0067] Yields and qualities of the products obtained under the above operating conditions are shown in Tables 3 and 4.

Table 3

Product Yields		
	Raw material	Products
	Arabian heavy crude oil	-
Naphtha (% by volume)	19	23
Kerosene (% by volume)	9	10
Gas oil (% by volume)	21	23
Vacuum gas oil (% by volume)	26	39
Vacuum residual oil (% by volume)	26	-
Oils in total (% by volume)	100	96
Pitch (% by weight)	-	8

Table 4

Product Qualities			
		Raw material	Products
		Arabian heavy crude oil	-
Naphtha			
	Specific gravity (-)	0.722	0.726
	Sulfur content (% by weight)	0.02	0.0005
Kerosene			
	Specific gravity (-)	0.800	0.796
	Sulfur content (% by weight)	0.30	0.001
	Smqke point (mm)	26	22
Gas oil			
	Specific gravity (-)	0.856	0.843
	Sulfur content (% by weight)	1.54	0.004
	Cetane index (-)	51	56
Vacuum gas oil			
	Specific gravity (-)	0.941	0.919
	Sulfur content (% by weight)	3.4	0.24
Vacuum residual oil			
	Specific gravity (-)	1.053	-
	Sulfur content (% by weight)	6.00	-
	Metal content (ppm by weight)	300	-

[0068] The yields and qualities of the products shown in the above tables were confirmed to be on the same level with those of the product fractions (sulfur content of not more than 50 ppm by weight in gas oil) obtained by the conventional process illustrated in Figure 3. It is also confirmed that 15% reduction of the cost for constructing plant can be attained as compared with the conventional process. Accordingly, it was confirmed that the process of the present invention enables simplification of the process and saving of the space, and thus reduction of treating cost without lowering the product yields and qualities.

[0069] The above results clearly show the effects of the present invention. Namely, the present invention provides a method of treating a crude oil comprising a step of separating the crude oil by distillation where the crude oil is separated by distillation into a distillate oil and a heavy oil content, a step of thermal cracking where the heavy oil content separated at said step of separating the crude oil by distillation and obtained substantially from the bottom is thermally cracked to lighten the content, and a step of separating the thermal cracking product by distillation where the thermal cracking product obtained by lightening at said step of thermal cracking is separated by distillation; wherein said step of separating the crude oil by distillation and said step of separating the thermal cracking product by distillation are carried out at the same time in a distilling section comprising a vacuum distillation apparatus. Furthermore, the distillate oil separated at the step of separating the crude oil by distillation and the step of separating the thermal cracking product by distillation, which are carried out at the same time in said distilling section, is collectively subjected to desulfurization, cracking, and hydrogenation treatment in identical one hydrotreating section to produce a synthetic crude oil of low sulfur content containing no vacuum residual oil fraction and having high added value, followed by treatment in the downstream refining scheme according to a conventional technique. Accordingly, it is possible to simplify the process and save the space, and thereby to reduce a cost for the treatment. In addition, the method is also applicable to a small-scale refining of petroleum.

Industrial Applicability

[0070] The method of treating a crude oil according to the present invention is especially utilized as a so-called upgrading method of a heavy oil, which converts a heavy oil content contained in a crude oil into a light oil fraction in refining of petroleum producing value-added petroleum products from a crude oil.

Claims**1.** A method of treating a crude oil comprising:

5 a step of separating the crude oil by distillation where the crude oil is separated by distillation into a distillate oil and a heavy oil content,
 a step of thermal cracking where the heavy oil content separated at said step of separating the crude oil by distillation and obtained substantially from the bottom is thermally cracked to lighten the content, and
 10 a step of separating the thermal cracking product by distillation where the thermal cracking product obtained by lightening at said step of thermal cracking is separated by distillation; wherein
 said step of separating the crude oil by distillation and said step of separating the thermal cracking product by distillation are carried out at the same time in an identical single distilling section comprising a vacuum distillation apparatus, and the distillate oil separated in the identical single distilling section contains a vacuum gas oil content, a gas oil content, a kerosene content and a naphtha content, and those contents are collectively
 15 introduced to identical one hydrotreating section without separating into each content having prescribed boiling range, where they are collectively subjected to desulfurization, cracking, and hydrogenation treatment.

2. The method of treating a crude oil according to claim 1, wherein the identical single distilling section in which said step of separating the crude oil by distillation and said step of separating the thermal cracking product by distillation
 20 carried out at the same time comprises a pre-separation apparatus and a main separation apparatus.

3. The method of treating a crude oil according to claim 1, wherein the amount of the heavy oil content separated in the identical single distilling section and withdrawn from the bottom is within a range of 15 to 55 parts by weight relative to 100 parts by weight of a distillate oil from the identical single distilling section.

4. The method of treating a crude oil according to claim 1, wherein the heavy oil content separated in said step of separating a crude oil by distillation, withdrawn from the bottom, and fed to the step of thermal cracking contains substantially neither gas oil content nor vacuum gas oil content.

5. The method of treating a crude oil according to claim 1, wherein no heavy oil content is contained in thermal cracking residue in said step of thermal cracking.

Patentansprüche**1.** Verfahren zur Behandlung von Rohöl, umfassend

35 Trennen des Rohöls durch Destillation, wobei das Rohöl durch Destillation in ein Destillatöl und ein Schweröl getrennt wird,
 thermisches Kracken, wobei das Schweröl, das beim Trennen des Rohöls durch Destillation abgetrennt und im wesentlichen vom Boden erhalten wird, thermisch gekrackt wird, um es leichter zu machen, und
 40 Trennen des thermischen Krackprodukts durch Destillation, wobei das thermische Krackprodukt, das durch Leichtermachen beim thermischen Kracken erhalten wird, durch Destillation abgetrennt wird; wobei
 das Trennen des Rohöls durch Destillation und das Trennen des thermischen Krackprodukts durch Destillation gleichzeitig in einem identischen einzelnen Destillationsabschnitt, umfassend eine Vakuumdestillationsvorrichtung, durchgeführt werden, und das Destillatöl, das im identischen einzelnen Destillationsabschnitt abgetrennt
 45 wird, ein Vakuumgasöl, ein Gasöl, Kerosin und Naphtha enthält, und diese Inhaltsstoffe gemeinsam in einen identischen Hydrotreatingabschnitt ohne Auftrennung der Inhaltsstoffe mit vorgeschriebenen Siedebereichen eingeführt werden, wo sie gemeinsam entschwefelt, gekrackt und filtriert werden.

2. Verfahren zur Behandlung von Rohöl nach Anspruch 1, wobei der identische einzelne Destillationsabschnitt, in dem das Abtrennen des Rohöls durch Destillation und das Abtrennen des thermischen Krackprodukts durch Destillation gleichzeitig durchgeführt werden, eine Vortrennvorrichtung und eine Haupttrennvorrichtung umfasst.

3. Verfahren zur Behandlung von Rohöl nach Anspruch 1, wobei der Gehalt an Schweröl, der in dem identischen einzelnen Destillationsabschnitt abgetrennt und vom Boden abgezogen wird, in einem Bereich von 15 bis 55 Gew. -Teile, in bezug auf 100 Gew.-Teile des Destillatöls aus dem identischen einzelnen Destillationsabschnitt, liegt.

4. Verfahren zur Behandlung von Rohöl nach Anspruch 1, wobei das Schweröl, das durch Trennen des Rohöls durch

Destillation abgetrennt, vom Boden abgezogen und dem thermischen Cracken zugefügt wird, im wesentlichen weder Gasöl noch Vakuumgasöl enthält.

5. Verfahren zur Behandlung von Rohöl nach Anspruch 1, wobei in dem thermischen Krackrest beim thermischen Cracken kein Schweröl enthalten ist.

Revendications

1. Procédé de traitement d'un pétrole brut comprenant :

une étape de séparation du pétrole brut par distillation où le pétrole brut est séparé par distillation en un distillat de pétrole et un contenu de pétrole lourd,
une étape de craquage thermique où le contenu en pétrole lourd séparé à ladite étape de séparation du pétrole brut par distillation est obtenu pratiquement depuis le fond est thermiquement craqué pour rendre le contenu plus léger, et
une étape consistant à séparer le produit de craquage thermique par distillation où le produit de craquage thermique obtenu en le rendant plus léger à ladite étape de craquage thermique est séparé par distillation, où ladite étape de séparation du pétrole brut par distillation et ladite étape de séparation du produit de craquage thermique par distillation sont exécutées en même temps dans une seule et même section de distillation comprenant un dispositif de distillation sous vide et le distillat de pétrole séparé dans la seule et même section de distillation contient un contenu de gaz de pétrole sous vide, un contenu de gaz de pétrole, un contenu de kérosène et un contenu de naphte, et ces contenus sont collectivement introduits dans une seule et même section d'hydrotraitement sans les séparer en chaque contenu présentant sa propre plage d'ébullition prescrite, où ils sont collectivement soumis au traitement de désulfuration, de craquage et d'hydrogénation.

2. Procédé de traitement d'un pétrole brut selon la revendication 1, où la seule et même section de distillation dans laquelle ladite étape de séparation du pétrole brut par distillation et ladite étape de séparation du produit de craquage thermique par distillation sont exécutées en même temps comprend un dispositif de pré-séparation et un dispositif de séparation principale.

3. Procédé de traitement d'un pétrole brut selon la revendication 1, dans lequel la quantité de contenu en pétrole lourd séparée dans la seule et même section de distillation et retirée du fond se situe dans une plage de 15 à 55 parties en poids par rapport à 100 parties en poids d'un distillat de pétrole provenant de la seule et même section de distillation.

4. Procédé de traitement d'un pétrole brut selon la revendication 1, dans lequel le contenu en pétrole lourd séparé dans ladite étape de séparation d'un pétrole brut par distillation, retiré du fond et fourni à l'étape de craquage thermique ne contient pratiquement ni contenu de gaz de pétrole ni contenu de gaz de pétrole sous vide.

5. Procédé de traitement d'un pétrole brut selon la revendication 1, dans lequel aucun contenu en pétrole lourd n'est contenu dans le résidu de craquage thermique de ladite étape de craquage thermique.

FIG. 1

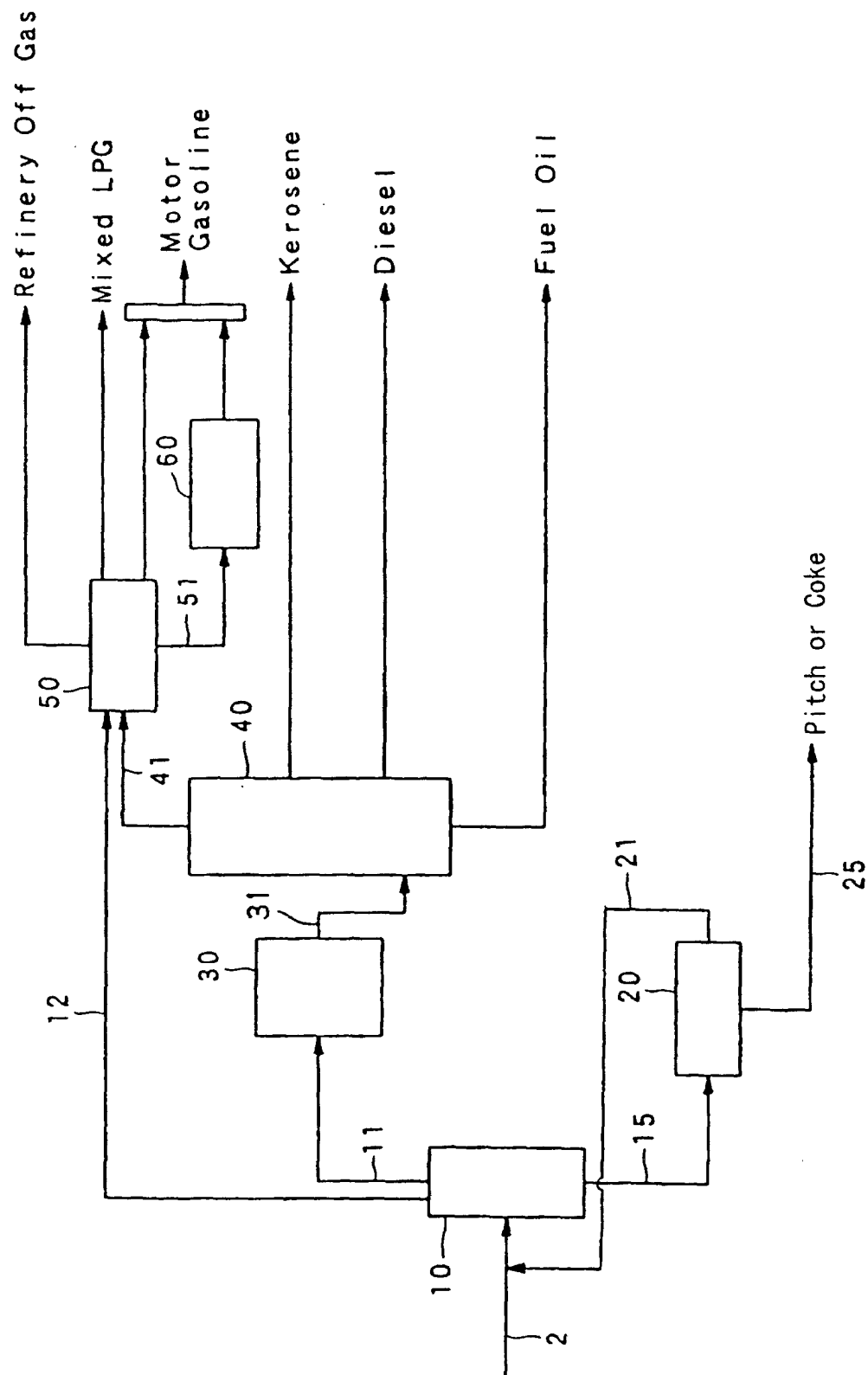


FIG. 2

