



(51) International Patent Classification:

C10G 65/12 (2006.01) C10G 49/22 (2006.01)  
C10G 47/00 (2006.01) C10G 49/12 (2006.01)

(21) International Application Number:

PCT/EP2010/006411

(22) International Filing Date:

20 October 2010 (20.10.2010)

(25) Filing Language:

English

(26) Publication Language:

English

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

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

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: PROCESS FOR HYDROCRACKING A HYDROCARBON FEEDSTOCK

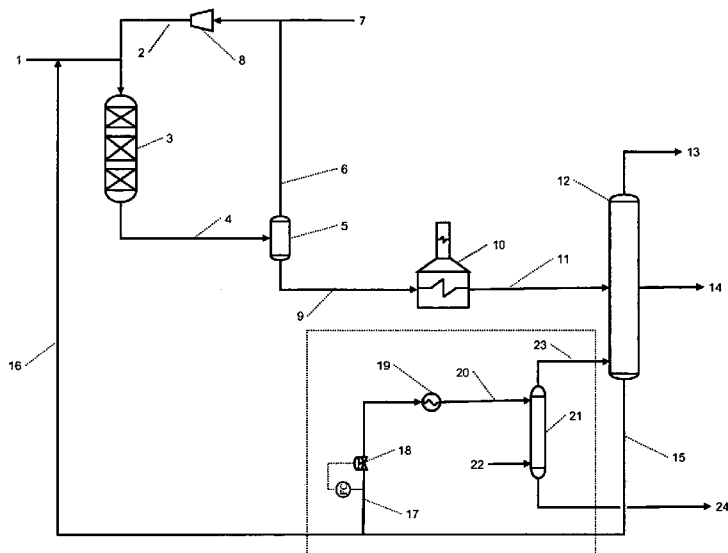


Fig. 1

(57) Abstract: A process for hydrocracking a hydrocarbonaceous feedstock comprising the steps of : (a) combining the hydrocarbonaceous feedstock with a hydrogen-rich gas to obtain a mixture comprising hydrocarbonaceous feedstock and hydrogen; (b) catalytically hydrocracking the mixture comprising hydrocarbonaceous feedstock and hydrogen in a hydrocracking zone to obtain a hydrocracked effluent; (c) separating all the hydrocracked effluent into a first vapour portion and a first liquid portion in a separation zone; (d) heating the first liquid portion to form a vapourised first liquid portion; (e) feeding the vapourised first liquid portion to a fractionation section to produce individual product fractions including a heavy bottom fraction comprising unconverted oil at the bottom zone of the fractionation section; (f) withdrawing from the fractionation column the heavy bottom fraction (g) directing a stream of heavy bottom fraction for stripping (h) stripping the stream of heavy bottom fraction for stripping with steam, in a counter current stripping column to form an overhead vapour of the heavy bottom fraction and a stripped liquid portion of the heavy bottom fraction; (i) feeding the overhead vapour of the heavy bottom fraction to the fractionation

section; and (j) removing the stripped liquid portion of the heavy bottom fraction from the bottom of the counter current stripping column as a net purge of unconverted oil.

**Title: Process for hydrocracking a hydrocarbon feedstock**

The invention relates to a process for hydrocracking a hydrocarbon feedstock to obtain a more valuable lower boiling products such as liquefied petroleum gas (LPG), naphtha, kerosene, and diesel. In particular, the invention concerns a process whereby heavy polynuclear aromatic compounds are concentrated in a portion of the unconverted oil so they can be removed resulting in increased conversion and yield of products.

The complete conversion of petroleum or synthetic heavy gas oils to distillate products such as gasoline, jet and diesel fuel in a hydrocracker is practically limited by the formation of heavy polynuclear aromatic (HPNA) compounds. These compounds, formed by undesired side reactions, are stable and virtually impossible to hydrocrack. HPNA are fused polycyclic aromatic compounds having 7+ rings for example coronenes  $C_{24}H_{12}$ , benzocoronenes  $C_{28}H_{14}$ , dibenzocoronenes  $C_{32}H_{16}$  and ovalenes  $C_{32}H_{14}$ .

HPNA with 7+ aromatic rings are byproducts of hydrocracking reactions that can potentially cause significant problems in hydrocracking units. When the solubility limit for the HPNA is exceeded, solids form in transfer lines, valves and on heat exchanger surfaces. Furthermore the HPNA can contribute to catalyst deactivation by reversible inhibition and coke formation. HPNA problems particularly occur when processing heavy feedstocks with high distillation endpoints and more aromatic cracked stocks in high conversion recycle units.

Consequently, HPNA build up to high levels in the recycle streams normally employed in high conversion processes, resulting in fouling of the catalysts and equipment.

5 The conventional solution to this problem is to remove a portion of the recycle oil stream as an unconverted oil stream to purge the HPNA compounds from the system, effectively balancing the HPNA purge rate with the rate of their formation by reactions. This approach limits the total  
10 conversion level achievable in the hydrocracker.

In a conventional high conversion hydrocracking process, a hydrocarbonaceous heavy gas oil feedstock is combined with a hydrogen-rich gas and reacted over catalyst to obtain a  
15 hydrocracked effluent comprising of less dense, lower molecular weight products. The hydrocracked effluent from the reactor is condensed and separated in a separation zone into a liquid portion comprising hydrocarbons and a vapour portion comprising un-reacted hydrogen. The vapour from  
20 this separation may be combined with hydrogen makeup to account for hydrogen consumed by reaction and may then be compressed and re-circulated back to the reactor vessel. The first liquid portion from the separation zone is then directed to a fractionation section where the lighter products are distilled from the heavy unconverted products in a  
25 fractionation section e.g. a fractionation tower or a series of fractionation towers. Heat is normally input to this recovery operation in order to provide the necessary energy for separation.

30

The conventional approach to controlling the buildup of HPNA compounds in the recycle oil is to withdraw a purge of

recycle oil product from the unit as unconverted oil. The purge rate may be adjusted so as to balance the rejection of HPNA with the net production. Such a purge essentially reduces the achievable total conversion level by hydro-  
5 cracking to less than 100 percent. Depending on the feed quality and process conditions the purge rate can be from one or two percent up to as high as 10 percent of the fresh feed rate. The yield of valuable distillate products are correspondingly reduced at substantial economic loss to the  
10 refiner.

U.S. patent no. 6,361,683 discloses a hydrocracking process whereby the hydrocracked effluent is hydrogen stripped in a stripping zone to produce a gaseous hydrocarbonaceous  
15 stream which is passed through a post-treatment hydrogenation zone to saturate aromatic compounds. The fractionation zone is associated with a stripping zone which is fed with stripped hydrocarbonaceous liquid obtained by stripping the hydrocracked effluent. Stripping to remove HPNA is also  
20 considered.

U.S. patent no. 6,858,128 discloses a hydrocracking process which utilises a fractionation zone that is divided to include sections suitable for steam stripping to concentrate  
25 HPNA.

U.S. patent no. 5,120,427 discloses a hydrocracking process in which a stripping column is provided as a stub column at the bottom of the fractionation zone, for recovering a ma-  
30 jority of light hydrocarbons, while enabling a purge of a liquid hydrocarbonaceous stream rich in HPNA.

There is substantial economic incentive to maximize the conversion of the heavy feed and a key feature of most such processes is the recycle of unconverted oil back to the re-  
action system thereby controlling the cracking severity and  
5 improving the selectivity of the hydrocracking reactions to  
more desirable end products such as gasoline, jet fuel and  
diesel fuel. All known hydrocracking processes and cata-  
lysts are, however, subject to undesirable side reactions  
leading to the formation of heavy poly-nuclear aromatic  
10 (HPNA) compounds which accumulate in the unconverted oil  
recycle stream. These compounds are virtually impossible  
to convert by hydrocracking reactions and show a strong  
tendency to build up to high concentration levels in the  
recycle oil stream. As the concentration builds up, the  
15 performance of the reactor system is continuously degraded  
leading to uneconomic conditions.

It is an objective of the invention to provide a hydro-  
cracking process whereby conversion of the heaviest and  
20 highest molecular weight materials into products is in-  
creased, resulting in reduced net yield of unconverted oil.

It is a further objective of the hydrocracking process to  
minimize the need for purge by concentrating the HPNA com-  
25 pounds in a portion of the unconverted oil stream.

These objectives are achieved by a hydrocracking process  
comprising the steps of:  
(a) combining the hydrocarbonaceous feedstock with a hy-  
30 drogen-rich gas to obtain a mixture comprising hydrocarbo-  
naceous feedstock and hydrogen;

- (b) catalytically hydrocracking the mixture comprising hydrocarbonaceous feedstock and hydrogen in a hydrocracking zone to obtain a hydrocracked effluent;
- (c) separating the hydrocracked effluent into a first vapour portion and a first liquid portion in a separation zone;
- (d) heating the first liquid portion to form a vapourised first liquid portion;
- (e) feeding the vapourised first liquid portion to a fractionation section to produce individual product fractions including a heavy bottom fraction comprising unconverted oil at the bottom zone of the fractionation section;
- (f) withdrawing from the fractionation section the heavy bottom fraction;
- (g) directing a stream of the heavy bottom fraction for stripping;
- (h) stripping the stream of the heavy bottom fraction in a counter current stripping column to form an overhead vapour of the heavy bottom fraction and a stripped liquid portion of the heavy bottom fraction;
- (i) feeding the overhead vapour of the heavy bottom fraction to the fractionation section; and
- (j) removing the stripped liquid portion of the heavy bottom fraction from the bottom of the counter current stripping column as a net purge of unconverted oil.

In a further embodiment, the stream of heavy bottom fraction for stripping is heated prior to the stripping process to raise its temperature above its bubble point concentrating the HPNA even further, by facilitating the evaporation of other constituents.

In an embodiment the first vapour portion comprises lighter low molecular weight products and unconverted hydrogen.

Another embodiment provides as the heavy bottom fraction the highest normal boiling fraction from the fractionation section, comprising hydrocarbonaceous material

In one embodiment improved separation is obtained in the counter current stripping column as it comprises multiple equilibrium stages in the form of trays or packing material.

In a further embodiment a part of the heavy bottom fraction is directed into a stream of heavy bottom fraction for recycling being combined with the hydrocarbonaceous feedstock for being input to the hydrocracking zone, to provide hydrocracking of unconverted oil.

In an embodiment the flow rate of the stream of heavy bottom fraction for stripping is controlled by a flow control unit according to a desired flow rate of the net purge of unconverted oil, such that the net purge flow may be optimised.

The hydrocarbonaceous feedstock may be hydrotreated prior to hydrocracking.

In an embodiment the energy for heating of the heavy bottom fraction for stripping is provided from heat exchange with one or more streams from the hydrocracking process e.g. a reactor effluent, or from heat exchange with an external

source of heating medium such as high pressure steam, hot flue gas from a fired heater, or by electrical heating.

5 An embodiment involves a process wherein the stripped liquid of heavy unconverted oil comprises heavy polynuclear aromatic compounds in an amount larger than the amount comprised in the heavy bottom fraction withdrawn from the fractionation column, thus reducing the share of unconverted oil in the net purge stream.

10

In a further embodiment steam output from the stripper may be added to the fractionation section, resulting in a saving of steam consumption.

15 Fig. 1 illustrates an embodiment of the process according to the invention in which flow control is employed on a heavy bottom fraction for stripping and a part of the heavy bottom fraction is recycled.

20 The disclosed process utilizes specific process steps to reduce the net purge of unconverted oil from a hydrocracker. This reduction may be accomplished by taking the bottom fraction stream from the bottom of the product fractionation section such as a fractionation column, heating  
25 it substantially above its bubble point and then stripping with steam in a counter-current column with fractionating trays or packing material. The stripping step at elevated temperature vapourizes a substantial amount of the bottom fraction stream compared to simply stripping the heavy bottom  
30 fraction at its bubble point without heating. The overhead vapour of the heavy bottom fraction may be returned to the fractionation section e.g. at the bottom.

The stripped part of the heavy bottom fraction remains a liquid and is collected in the bottom of the stripping tower. This stream is having a substantially higher boiling point than the original unconverted oil and therefore  
5 HPNA is concentrated in the heavier bottoms liquid which may then be removed as net purge from the hydrocracker.

The higher concentration of HPNA in the stripped liquid allows the removal of the required HPNA at lower purge rate.  
10 The reduced purge rate results in higher total conversion in the hydrocracker together with increased yields of valuable distillate products.

This disclosure provides a simple process for concentrating  
15 the HPNA compounds in a portion of the unconverted oil stream and thereby minimizing the required purge flow rate. The required purge flow rate is reduced substantially leading to higher conversion and better yields of final products.

20 The disclosure utilizes specific process steps to reduce the required purge of unconverted oil from the hydrocracker substantially, such as at least 25 percent and preferably by 50 percent or more. This reduction is accomplished by  
25 withdrawing a bottom fraction comprising unconverted oil in a first purge stream from the fractionation section, heating it substantially above its bubble point and then stripping with steam in a counter-current column with fractionating trays or packing material. The stripping step va-  
30 pourizes a substantial amount, such as at least 25 percent and preferably by 50 percent or more of the bottom fraction stream returning the vapour to the bottom of the fractiona-

tion section. The remainder of the bottom fraction stream remains as liquid and is collected in the bottom of the stripping tower. This liquid is substantially higher boiling than the original unconverted oil and as a consequence of the very high normal boiling point of the HPNA compounds, the physical separation concentrates the HPNA in the heavier bottoms liquid which is then removed as net purge from the hydrocracker. The higher concentration of HPNA in the stripped liquid allows the removal of the required HPNA at lower purge flow rate. The reduced purge rate results in higher total conversion in the hydrocracker together with increased yields of valuable distillate products.

By providing the stripping of the unconverted oil in a separate process step, multiple advantageous effects are obtained. An independent temperature and flow control is made possible, which allows an optimisation of the stripping conditions, and counter current flow is enabled, which has a better stripping efficiency compared to co-current flow.

Reference is made to Figure 1 which illustrates schematically the process flows and equipment configuration as embodied in this invention.

Fresh feedstock consisting of a hydrocarbonaceous feed, such as petroleum or synthetic heavy gas oils of mineral or biological origin **1** is combined with hydrogen rich gas **2** and an optional recycle stream of unconverted product **16** and fed to a hydrocracking zone **3** consisting of one or more catalysts contained in one or more reaction vessels. The

catalysts promote the hydroconversion of the hydrocarbonaceous feedstock, which may include hydrogenation to a lighter hydrocracked effluent. The hydrocracking effluent, comprising hydrocarbon products together with excess hydrogen not consumed by the reaction exits the hydrocracking zone **4** and enters a separation zone **5** consisting of one or more vessels that perform separation into a first vapour portion **6** from the separation zone may be combined with makeup hydrogen **7** to replenish the hydrogen consumed by reaction. The hydrogen rich stream may then be compressed in compressor **8** for recycle back to the hydrocracking zone.

The first liquid portion **9** from the separation step passes to a process heater **10** supplying energy for substantially vapourizing the fluid **11** before feeding the product fractionation section **12**. The fractionation section consists of one or more towers or columns with multiple equilibrium stages in the form of trays or packing material which may be operated in counter-current. The towers are normally stripped with steam or reboiled to facilitate vapourization of the products. The fractionation section performs the separation of individual product and intermediate fractions **13, 14** such as gasoline, jet fuel and diesel fuel according to differences in their normal boiling points. At the bottom zone of the fractionation section the heaviest bottom fraction, i.e. unconverted oil **15**, may be collected and withdrawn as an unconverted oil product or returned to the reactor in line **16** as a recycle oil stream for further conversion.

The aim of a hydrocracking process is to convert all or as much of the heaviest and highest molecular weight materials into products resulting in no or a minimal net yield of unconverted oil **15**. However, a first purge of unconverted oil or heavy bottom fraction **17** must be withdrawn from the hydrocracker possibly on flow control **18** in order to avoid a build-up of HPNA within the reaction system. In a heavy bottom fraction stripping system, the heavy bottom fraction stream for stripping is routed to a process heater **19** such that the temperature of the heated heavy bottom fraction stream for stripping **20** is raised substantially above the bubble point of the heavy bottom fraction stream for stripping and of the temperature of the fractionation section bottom. This heated heavy bottom fraction stream for stripping is then fed to the top of a counter-current stripping tower **21** consisting of multiple equilibrium stages in the form of trays or packing material. Steam is added to the bottom of the stripping tower **22** to facilitate vapourization of the unconverted oil. The overhead vapour from the top of the stripping tower **23** is routed to the bottom of the fractionating column **12**. The stripped heavy bottom fraction stream for stripping which is not vapourized in the stripper flows to the bottom of the tower and is then removed from the hydrocracker as a net purge (a necessary purge) of unconverted oil **24**.

The operating conditions in the heavy bottom fraction stripping system are established such that the net purge of unconverted oil **24** from the bottom of the stripper is substantially less than the heavy bottom fraction, i.e. unconverted oil **17** removed from the heavy bottom fraction stream

for stripping, while sufficiently removing the undesired HPNA.

### **EXAMPLES**

5

#### **EXAMPLE 1**

In order to test the potential split of HPNA in the proposed invention, a sample of hydrocracked unconverted oil obtained from a commercially operating hydrocracking plant with the properties shown in Table 1 was distilled in an ASTM D-1160 apparatus. Since this apparatus does not utilize reflux it generates a physical separation with substantial overlap between the overhead and bottoms product and correspond well to the vapour/liquid separation in a simple steam stripper.

10  
15

Table 1

Properties of Unconverted Oil Sample		
Specific Gravity		0.844
Heavy Poly-Nuclear Aromatics		
Coronene	wtppm	394
1-MethylCoronene	wtppm	132
NaphCoronene	wtppm	127
Ovalene	wtppm	91
Total HPNA	wtppm	744
Distillation		
Initial Boiling Point	°C	342
10%	°C	397
50%	°C	451
90%	°C	513
Final Boiling Point	°C	572

Two laboratory distillations were performed using the ASTM D-1160 method and apparatus, the first yielding a bottoms fraction of 50 volume percent of the initial charge and a second yielding a bottoms fraction of only 20 volume percent of the charge, to document how the HPNA would partition in the overhead and bottoms fractions. The results of HPNA analysis and distillation analysis on both the bottom fraction and the overhead vapour fractions are summarized in Table 2.

Table 2

Properties of Distilled Fractions					
Case Fraction		I		II	
		Bot-toms	Distil late	Bot-toms	Distil late
Yield	%vol.	50	50	20	80
Specific Gravity		0.849	0.838	0.855	0.840
Heavy Poly-Nuclear Aromatics					
Coronene	wtppm	650	105	775	245
1-MethylCoronene	wtppm	240	20	385	55
NaphCoronene	wtppm	235	<5	565	<5
Ovalene	wtppm	175	<5	475	<5
Total HPNA	wtppm	1300	130	2200	305
Initial Boiling Point	°C	406	288	440	338
10%	°C	439	380	473	391
50%	°C	479	426	510	441
90%	°C	531	463	550	483
Final Boiling Point	°C	583	511	596	529

These results clearly show that the ASTM distillation has achieved a substantial separation of HPNA between the overhead distillate and bottoms fraction. This is a consequence of the very low volatility of the HPNA compounds.

5 In a hydrocracker, it is necessary to purge sufficient HPNA from the system to balance the net production of HPNA by reaction. In this example, Case I results in an increase of the total HPNA concentration by a factor of from 744 ppmwt to 1300 ppmwt or 175 percent. Case II results in an

10 increase of total HPNA by a factor of from 744 ppmwt to 2200 ppmwt or 295 percent.

#### EXAMPLE 2

Performance of the invention was evaluated based on a steam

15 stripper under the conditions shown in Table 3 below.

Table 3

Process Conditions for Steam Stripping Column		
Theoretical Trays		4
Stripping Steam Rate	kg/hr	3243
<b>(22)</b>		
Column Top Pressure	barg	1.30
Column Bottom Pressure	barg	1.36

Process experiments were performed at two different stripper feed temperatures, 350°C and 380°C to illustrate the

20 split of overhead vapour and bottoms liquid products. Coronene HPNA molecule was also included in the experiment to show how the vapour-liquid equilibria would predict the distribution of the lightest HPNA species. The results

based on 350°C stripper feed temperature are presented in Table 4 below. At this feed temperature, 50 weight percent is distilled overhead and 50 percent is recovered in the bottoms liquid product. The coronene component has been concentrated in the stripper bottoms from 461 ppmwt in the feed to by 691 ppmwt in the bottoms corresponding to 150 percent.

Table 4

Stripper Feed and Product Rates and Properties				
Stream Description		Feed	Bottoms	Distil- late
Stream No.		<b>20</b>	<b>24</b>	<b>23</b>
Stream Temperature	°C	350	209	312
Yield (% of Feed)	%wt.	100	50	50
Heavy Poly-Nuclear Aromatics				
Coronene	Wt ppm	461	691	231
Distillation				
IBP	°C	300	340	282
10%	°C	360	393	344
50%	°C	427	447	407
90%	°C	483	505	455
FBP	°C	560	563	511

The stripper results based on 380°C stripper feed temperature are presented in Table 5 below. At this feed temperature, 64 weight percent is distilled overhead and 36 percent is recovered in the bottoms liquid product. The coronene component has been concentrated in the stripper

bottoms from 466 ppmwt in the feed to 727 ppmwt in the bottoms corresponding to 156 percent. Most of the HPNA molecules of concern in hydrocracker are in fact heavier and less volatile than coronene and can be expected to further concentrate in the stripper bottoms stream.

Table 5

Stripper Feed and Product Rates and Properties				
Stream Description		Feed	Bottoms	Distillate
Stream No.		<b>20</b>	<b>24</b>	<b>23</b>
Stream Temperature		380	195	325
Yield (% of Feed)	%wt.	100	36	64
Heavy Poly-Nuclear Aromatics				
Coronene	Wt ppm	466	727	319
Distillation				
IBP	°C	300	346	288
10%	°C	360	398	350
50%	°C	427	454	414
90%	°C	483	515	462
FBP	°C	560	554	524

These results demonstrate that under reasonable and practical conditions of temperature, pressure and flow rate, the unconverted oil stream can be split by steam stripping and result in the concentration of HPNA compounds in a bottoms liquid stream. This concentration will lead to decreased net purge rates from the hydrocracker and corre-

sponding increased conversion and yields of distillate products.

**CLAIMS**

1. A hydrocracking process comprising the steps of:
- 5 (a) combining the hydrocarbonaceous feedstock with a hydrogen-rich gas to obtain a mixture comprising hydrocarbonaceous feedstock and hydrogen;
  - (b) catalytically hydrocracking the mixture comprising hydrocarbonaceous feedstock and hydrogen in a hydrocracking zone to obtain a hydrocracked effluent;
  - 10 (c) separating the hydrocracked effluent into a first vapour portion and a first liquid portion in a separation zone;
  - (d) heating the first liquid portion to form a vapourised first liquid portion;
  - 15 (e) feeding the vapourised first liquid portion to a fractionation section to produce individual product fractions including a heavy bottom fraction comprising unconverted oil at the bottom zone of the fractionation section;
  - (f) withdrawing from the fractionation section the heavy
  - 20 bottom fraction;
  - (g) directing a stream of the heavy bottom fraction for stripping;
  - (h) stripping the stream of the heavy bottom fraction in a counter current stripping column to form an overhead vapour
  - 25 of the heavy bottom fraction and a stripped liquid portion of the heavy bottom fraction;
  - (i) feeding the overhead vapour of the heavy bottom fraction to the fractionation section; and
  - (j) removing the stripped liquid portion of the heavy bot-
  - 30 tom fraction from the bottom of the counter current stripping column as a net purge of unconverted oil.

2. Process according to claim 1, wherein the stream of heavy bottom fraction for stripping is heated prior to the stripping process to raise its temperature above its bubble point.
- 5
3. Process according to claims 1 or 2, wherein the first vapour portion comprises lighter low molecular weight products and unconverted hydrogen.
- 10
4. Process according to claims 1, 2 or 3, wherein the heavy bottom fraction is the highest normal boiling fraction from the fractionation section, comprising hydrocarbonaceous material
- 15
5. Process according to anyone of claims 1 to 4, wherein the counter current stripping column comprises multiple equilibrium stages in the form of trays or packing material.
- 20
6. Process according to anyone of claims 1 to 5, wherein a part of the heavy bottom fraction is directed into a stream of heavy bottom fraction for recycling to be combined with the hydrocarbonaceous feedstock for being input to the hydrocracking zone.
- 25
7. Process according to claim 6, wherein the flow rate of the stream of heavy bottom fraction for stripping is controlled by a flow control unit according to a desired flow rate of the net purge of unconverted oil.

8. Process according to anyone of claims 1 to 7, wherein the hydrocarbonaceous feedstock is hydrotreated prior to hydrocracking.
- 5 9. Process according to anyone of claims 2 to 8, wherein the heating of the heavy bottom fraction for stripping is provided from heat exchange with one or more streams from the hydrocracking process
- 10 10. Process according to anyone of claims 2 to 8 wherein the heating of the heavy bottom fraction for stripping is provided from heat exchange with a reactor effluent, an external source of heating medium, high pressure steam, hot flue gas from a fired heater, or by electrically heating.
- 15 11. Process according to anyone of claims 1 to 10, wherein steam output from the stripping is added to the fractionation column.

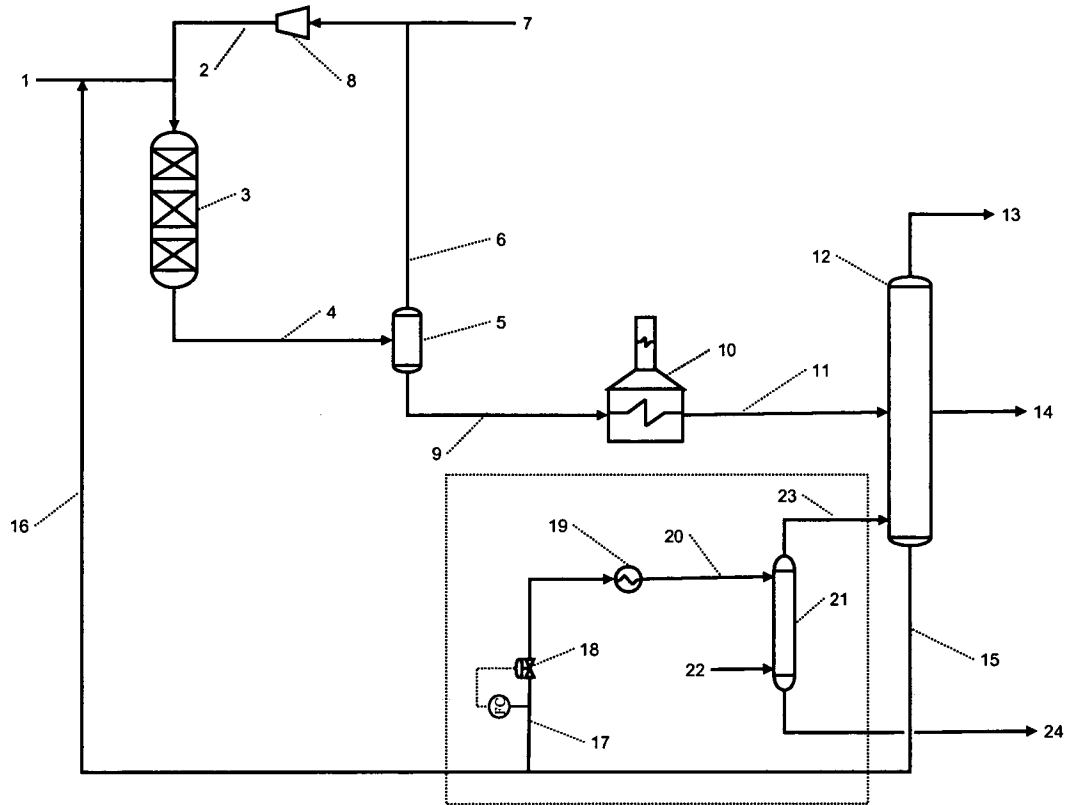


Fig.1

INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2010/006411

A. CLASSIFICATION OF SUBJECT MATTER  
INV. C10G65/12 C10G47/00 C10G49/22 C10G49/12  
ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
C10G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)  
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 961 839 A (STINE LAURENCE O [US] ET AL) 9 October 1990 (1990-10-09)	1-7,9-11
Y	* abstract figure 1 column 1, lines 7-25,46-53,57-60 column 2, lines 16-21, 25-42,52-66 column 2, line 67 - column 3, line 37 column 3, lines 40-46 column 3, line 56 - column 4, line 54 column 4, line 62 - column 5, line 18 column 5, lines 38-42,47-64 column 6, line 39 - column 7, line 44 column 7, line 63 - column 11, line 2 example 2  ----- -/--	8

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

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"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search  24 March 2011	Date of mailing of the international search report  04/04/2011
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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2010/006411

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 361 683 B1 (KALNES TOM N [US]) 26 March 2002 (2002-03-26) cited in the application	1-11
Y	* abstract figure 1 column 1, lines 1-27 column 2, line 33 - column 3, line 42 column 4, line 32 - column 5, line 3 column 6, line 28 - column 7, line 17 column 7, lines 52-64 column 8, line 28 - column 9, line 33 -----	8
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