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(54) **Title:** A PROCESS FOR SEPARATING VALUABLE PETROLEUM PRODUCTS FROM CLARIFIED SLURRY OIL

(57) **Abstract:** The present disclosure provides a process for separating valuable petroleum products from Clarified Slurry Oil by vacuum distillation with gradual increase in temperature of the distillation column. Vacuum distillation produces valuable 5 products including lighter fractions (Diesel/Light Diesel Oil), Cycle Oil, Rubber Process Oil and Petroleum Pitch. The Rubber Process Oil obtained can be further processed to reduce the asphaltene content, the polycyclic aromatic hydrocarbon (PAH) content and the ol-
efin content.



A PROCESS FOR SEPARATING VALUABLE PETROLEUM PRODUCTS FROM CLARIFIED SLURRY OIL

FIELD

The present disclosure relates to a process for separating valuable petroleum
5 products from Clarified Slurry Oil (CSO).

BACKGROUND

A fluid catalytic cracking (FCC) unit in a refinery, cracks the heavy gas oils (boiling above 360 °C) obtained from primary units and/or secondary units after pre-treatment in a fluid catalytic cracker feed hydrotreaters. The FCC process is
10 operated in a fluidized bed reactor with continuous regeneration of catalyst. The cracked product obtained is then separated through fractionation. The residual material of the fractionation section left behind after vacuum stripping and filtration (to remove the entrapped catalyst particles associated with cracked combined product from FCC reactor) is known as Clarified Slurry Oil (CSO) or
15 Carbon Black Feedstock (CBFS). CSO is normally used as carbon black feed stock or blended with a cutter stock for use as fuel oil. The CSO distills typically, between 310 °C to 610 °C (5% / 95% volume respectively).

Clarified Slurry Oil is normally filtered in a slurry settler or a Gulftronic filter to remove and recover the catalyst particles, which are recycled back into the
20 catalyst riser by combining it with the FCC feedstock oil. Thus, CSO has limited use and comparatively much lower monetary value than the actual crude oil in a refinery. CSO comprises complex mixtures of relatively high molecular weight compounds with typical molecular weight in the range of 250 to 1000. It contains greater proportions of highly condensed aromatics, asphaltenes, fewer mixed
25 aromatics, as well as non-aromatic cyclo-paraffinic compounds depending on the operating severity of the FCC unit. Thus, CSO can serve as a rich source of high value petroleum products having higher aromatic content and can be

separated into Distillate Oil (Light Diesel Oil (LDO), Diesel or Wash Oil), Cycle Oil, Rubber Process Oil (RPO), high viscosity CBFS and/or Petroleum Pitch.

The distillate fraction (LDO/Diesel) obtained by fractionation of CSO is used as boiler fuel or blended into Diesel.

- 5 Cycle Oils are used in naphtha stream crackers to quench cracked gases (as make up to the quench oil system) before further separation process. The Cycle Oil produced by conventional process has a higher amount of asphaltene, and hence, can result in precipitation of asphaltene in the Cycle Oil, which needs to be avoided. To achieve this, Cycle Oil having lower asphaltene and high aromatic
10 content is preferred.

- Rubber Process Oils (RPO) are required in rubber manufacturing and processing for improved processability and/or enhancing properties of natural as well as synthetic rubber. These applications typically use aromatic extracts obtained by solvent extraction process while producing lubricating oil from Heavy Gas Oils
15 and/or natural mineral oils for the purpose. The Rubber Process Oils are mostly in naphthenic, paraffinic or aromatic type dark colored oils. They are produced conventionally by extraction of lubricating base oil followed by secondary extraction and/or hydrogenation in refinery at high production cost.

- The distillation residue, known as 'Petroleum Pitch' obtained from CSO can be
20 used as an alternative and supplement to coal tar pitch. The polycyclic aromatic hydrocarbon (PAH) levels of the Petroleum Pitch is considerably lower than that of the coal tar pitch, however, there is no significant lowering of the carbon content of the Petroleum Pitch. Petroleum Pitch finds application in the production of refractory bricks, clay pigeons and as an impregnation pitch in
25 graphite and aluminium industry.

There is, therefore, felt need for a simple and cost efficient process for separation of petroleum products from alternative sources such as Clarified Slurry Oil.

OBJECTS

Some of the objects of the present disclosure, which at least one embodiment herein satisfies, are as follows.

5 It is an object of the present disclosure to ameliorate one or more problems of the prior art or to at least provide a useful alternative.

An object of the present disclosure is to provide a simple and efficient process for separating useful and valuable petroleum products from Clarified Slurry Oil (CSO).

10 Another object of the present disclosure is to provide valuable petroleum products from CSO which can be used in various processes, directly or with minimum treatment.

Other objects and advantages of the present disclosure will be more apparent from the following description when read in conjunction with the accompanying drawing, which is not intended to limit the scope of the present disclosure.

15 SUMMARY

The present disclosure provides a process for separating petroleum products from Clarified Slurry Oil (CSO) mixture. The process comprises the following steps: introducing a CSO mixture into a distillation unit; reducing the pressure of the distillation unit to be in the range of 0.1 mm Hg absolute to 1 mm Hg absolute;
20 and gradually raising the temperature of the CSO mixture in the distillation unit up to 500 °C. A first distillate is collected below 360 °C, a second distillate is collected below 420 °C and a third distillate is collected below 500°C, leaving behind a residue. The first distillate comprises Diesel and Light Diesel Oil (LDO), the second distillate comprises Cycle Oil, the third distillate comprises
25 Rubber Process Oil and the residue comprises Petroleum Pitch.

The third distillate obtained is further subjected to treatment with hydrogen, to convert the unsaturated olefinic content into saturated paraffinic content, and stripping to obtain Rubber Process Oil having asphaltene content ranging between 0.01 wt% to 0.1 wt% preferably, 0.05 wt% or less, and reduced
5 polycyclic aromatic hydrocarbon (PAH) content, which is lesser than the content reported in the art.

BRIEF DESCRIPTION OF ACCOMPANYING DRAWINGS

A process for separating valuable petroleum products from clarified slurry oil will now be described with the help of the accompanying drawing, in which:

- 10 FIGURE 1 illustrates a block diagram representing the steps involved in separating petroleum products in accordance with the present disclosure.

DETAILED DESCRIPTION

Clarified Slurry Oil (CSO) is rich in aromatics and hence, has a high Bureau of Mine Co-relation Index (BMCI, which effectively measures the degree of
15 aromaticity, i.e. aromatic carbons and ultimately the yield of carbon black), and high solvency power to hold asphaltene in solution. Culling out a particular fraction of CSO can facilitate availability of Distillate Aromatic Extract (DAE) type oil (with excellent viscosity-gravity constant (VGC)), which can be used more effectively as compared to the current industry practice of using lubricating
20 oil extracts for the same purpose. Hence, it is preferred that high cost/low BMCI lubricating extracts are replaced with the Rubber Process Oil fractions derived from Clarified Slurry Oil.

Accordingly, the present disclosure provides a simple and a cost effective process for separating valuable petroleum products such as Diesel, Light Diesel Oil,
25 Cycle Oil, Rubber Process Oil and the like, from Clarified Slurry Oil using vacuum distillation.

In an aspect of the present disclosure, the process comprises the following steps:

The CSO mixture is introduced into a distillation unit. The pressure in the distillation unit is reduced, typically with the help of a vacuum pump to ensure that the pressure therein lies in the range of 0.1 mm Hg absolute to 1 mm Hg absolute. Thereafter, the temperature of the CSO mixture in the distillation unit is
5 raised gradually up to 500 °C in a graded manner, to collect a first distillate below 360 °C, a second distillate below 420 °C, a third distillate below 500 °C, leaving behind a residue (known as pitch).

In an embodiment of the present disclosure, the first distillate comprises Diesel and Light Diesel Oil, the second distillate comprises Cycle Oil, the third distillate
10 comprises Rubber Process Oil (RPO) and the residue comprises Petroleum Pitch.

The process of the present disclosure is described hereinafter. The bulk temperature of the CSO mixture (process fluid) in accordance with the present disclosure does not exceed 350 °C especially in the first step of the vacuum distillation and has the lowest possible residence time, in order to minimize the
15 undesired side reactions/cracking of the process fluid. The process temperatures mentioned in the present disclosure have been converted from temperatures under vacuum conditions to those at normal pressure conditions. Therefore, the actual process temperatures under vacuum conditions of 1 mm Hg to 0.1 mm Hg are much lower and hence, the distillation can be carried out using a thermic fluid
20 having a bulk temperature of up to 350 °C .

The first distillate comprising the Diesel and the Light Diesel Oil is used as a fuel in boilers and furnaces or blended with Diesel. In an embodiment of the present disclosure, the first distillate comprising Diesel and Light Diesel Oil (LDO) is collected at a temperature above 180 °C and below 360 °C.

25 The second distillate comprising the Cycle Oil is mainly used in Naphtha crackers. Cycle Oil, is collected up to 420 °C, preferably at a temperature above 360 °C and below 420 °C. The Cycle Oil obtained typically has very low

asphaltene content ranging between 0.01 wt% to 0.1 wt%, more preferably, 0.05 wt% or less (see example-1, table-3 and table- 6).

The third distillate comprising the Rubber Process Oil is collected up to 500 °C. In an embodiment of the present disclosure the third distillate is collected at a
5 temperature above 420 °C and below 500 °C. A mild hydrogenation step is generally carried out for the third distillate collected below 500 °C, to impart product stability as well as compliance with the volatility specification of the Rubber Process Oil (RPO). The hydrogenated Rubber Process Oil typically has an asphaltene content ranging between 0.01 wt% to 0.1 wt%, more preferably,
10 0.05 wt% or less.

A residue comprising Petroleum Pitch is obtained after collection of the third distillate. The Quinoline Insolubles (QI) of the residue comprising Petroleum Pitch obtained by the process of the present disclosure is in the range of 0.1 % to 0.4 % and has softening point in the temperature range of 90 °C to 115 °C. The
15 residue obtained from the vacuum distillation - Petroleum Pitch, can be used as a precursor for obtaining high value Mesophase Pitch therefrom. Mesophase pitch can be used to produce carbon fibers, carbon foam and the like. Petroleum Pitch can also be used as 'Binder Pitch' or 'Impregnating Pitch' in the Aluminum and Graphite Industry.

20 The process in accordance with the present disclosure is carried out in a unit having vacuum distillation facilities including degassers, falling film evaporators (FFE), thin film evaporators (TFE), short path distillation units (SPDU), condensers, coolers product receivers and the like.

While, the light ends (Diesel/LDO) and Cycle Oil can be used directly in various
25 applications, the Rubber Process Oil fraction of CSO is either used directly in the untreated form or further treated to obtain treated Rubber Process Oil. Treatment of the untreated Rubber Process Oil comprises mild hydrogenation to achieve

olefin saturation followed by stripping of the light ends to attain appropriate flash point of the final product.

The hydrogenation step is mild and is sufficient to saturate the olefins present in the CSO fractions and impart stability on long term storage as well. An optional
5 step of blending with other types of Rubber Process Oil can also be carried out to improve the quality of the Rubber Process Oil based on specific end application.

In one of the embodiment of the present disclosure, the third distillate obtained is subjected to treatment with hydrogen in the temperature range of 280 °C to 320 °C and in the pressure range of 28 bars to 30 bars using 430 to 470 nm³ of
10 hydrogen gas per m³ of the third distillate at 1 to 2 hour⁻¹ liquid hourly space velocity of untreated Rubber Process Oil, in the presence of a catalyst.

In an embodiment of the present disclosure, the catalyst for the hydrogenation (treatment with hydrogen gas) step is at least one selected from the group consisting of cobalt-molybdenum (Co-Mo) and nickel-molybdenum (Ni-Mo). In
15 a preferred embodiment of the present disclosure, the commercially available Co-Mo catalyst, TK-562-BRIM 1/10" (Halder Topsoe) is used for the hydrogenation of the Rubber Process Oil.

The light saturated hydrocarbons evolved during the hydrogenation step are separated either by stripping or distillation to impart product stability as well as
20 compliance with the volatility specification of the Rubber Process Oil (RPO).

In an embodiment of the present disclosure, the stripping of the hydrogenated Rubber Process Oil is carried out in the temperature range of 200 °C to 300 °C and in the pressure range of 4 bars to 8 bars.

In an embodiment of the present disclosure the hydrogenated and stripped Rubber
25 Process Oil is optionally blended.

The treated Rubber Process Oil obtained after hydrogenation, stripping and optionally, blending contains reduced polycyclic aromatic hydrocarbon (PAH) content which is less than the content reported in the art.

Petroleum Pitch fractions, obtained after separation of the Cycle Oil fraction from the CSO, is found to be suitable as high BMCI grade Carbon Black Feed Stock (CBFS).

The present disclosure is further described in light of the following non-limiting examples which are set forth for illustration purpose only and are not to be construed for limiting the scope of the disclosure.

10 **Example 1: Fractional Distillation of Clarified Slurry Oil**

Figure-1 is a block diagram that depicts a process for separating petroleum products from Clarified Slurry Oil (CSO). The feed CSO was transferred from a feed tank (1) to a surge tank (2). The surge tank (2) was pre-heated up to 130 °C to adjust the viscosity of the feed CSO. The feed CSO from the surge tank (2) at 130 °C was fed to the main pre-heater (3), where the feed CSO was heated up to 240 °C. The feed from the main pre-heater (3) at 240 °C was then fed to Degasser-1 (4). Degasser-1 (4) was operated at a temperature of 250 °C and the pressure of Degasser-1 (4) was maintained at 100 mmHg. The bottom feed from Degasser-1 (4) was fed to Degasser-2 (5). Degasser-2 (5) was operated at a temperature of 270 °C and the pressure of Degasser-2 (5) was maintained at 1 mmHg. Overhead streams from both Degasser-1 (4) and Degasser-2 (5) were condensed and collected in the respective receivers. The condensate collected from Degasser-1 (4) and Degasser-2 (5) was the first distillate (D1) (lighter fraction comprising Diesel, Light Diesel Oil) having boiling points typically below 360 °C.

The bottom feed from Degasser-2 (5) was fed to a Thin Film Evaporator (TFE) (6). The TFE (6) was operated at a temperature of 310 °C and 1 mm Hg pressure. The overhead stream from the TFE (6) was condensed and collected in a receiver

as the second distillate (**D2**) (Cycle Oil). The bottom stream from TFE (**6**) was collected as the TFE residue. The lighter fraction and the TFE residue can be blended, if required, to obtain fuel oil.

The TFE Residue was the feed to another distillation column working under vacuum-Short Path Distillation Unit (SPDU) (**7**). SPDU (**7**) operates at a much lower vacuum of up to 0.1 mm Hg and a temperature of 340 °C. The overhead from SPDU (**7**) is collected in a receiver as the third distillate (**D3**) (Rubber Process Oil). The residue left behind in the SPDU is the pitch (**P**).

The yield of different cuts obtained by the process of the present disclosure is given below in **Table-1**, 100 % feed was processed.

Table-1

S. No.	Distillation products	Yield (Vol %)
1	Lighter Ends	13
2	Cycle Oil	37
3	Rubber Process Oil	32
4	Pitch	18

The properties of the different cuts obtained are given below in **Tables 2 to 5**. **Table-2** summarizes the properties of the light fraction (Diesel, Light Diesel Oil) obtained from the vacuum distillation.

Table-2

Analysis	Results
Sample: Lighter Fraction (Initial Boiling Point (IBP) up to 360 °C fraction)	
Density @15 °C (g/cc)	0.9848

Sulphur (wt%)	0.45
Flash Point (°C)	98
Kinematic Viscosity (KV) @ 40 °C (cSt)	7.193
Pour point (°C)	-18
SimDist	
5 % distillation at (°C)	194.6
90 % distillation at (°C)	355

Simulated Distillation (SimDist) is a gas chromatographic technique used to simulate the results of a distillation tower, separating crudes or other multicomponent blends into component fractions by boiling points.

Table-3 summarizes the properties of the second distillate (Cycle Oil) obtained from the vacuum distillation.

Table-3

Analysis	Results
Sample: Cycle Oil (360 °C to 420 °C fraction)	
Density (g/cc)	1.034
Flash Point (°C)	189
KV @ 40 °C (cSt)	60
Pour Point (°C)	+9
Asphaltenes (wt%)	<0.05
Sulphur (wt%)	0.6
Bromine Number	24
SimDist	

5 % distillation at (°C)	331.0
90 % distillation at (°C)	415.0

Simulated Distillation (SimDist) is a gas chromatographic technique used to simulate the results of a distillation tower, separating crudes or other multicomponent blends into component fractions by boiling points.

- 5 **Table-4** summarizes the properties of the third distillate (Rubber Process Oil) obtained from the vacuum distillation.

Table-4

Analysis	Results
Sample: Rubber Process Oil (without hydrogenation)	
Density @15 °C (g/cc)	1.07
Flash Point (°C)	>200°C
KV @ 40 °C (cSt)	1150
Viscosity Gravity Constant (VGC)	<30
Sulphur content (wt%)	1.6
Pour Point (°C)	>20
SimDist	
5 % distillation at (°C)	380
90 % distillation at (°C)	470

- 10 **Table-5** summarizes the properties of the residue (pitch) left behind after the vacuum distillation.

Table-5

Analysis	Results
Sample: Pitch	
Density @ 15 °C (g/cc)	1.1699
Flash Point (°C)	250°C
Softening Point (°C)	105
KV @ 176°C (cSt)	450
Quinoline Insolubles (%)	0.240
Toluene Insolubles	1.30
Coking value	45.17
Moisture content	nil

Example 2: Hydrogenation of the third distillate (RPO)

- The third distillate of the CSO mixture collected from the vacuum distillation unit
- 5 was cooled to a temperature of 280 °C and then subjected to a hydro-treating process using a cobalt-molybdenum catalyst (TK-562-BRIM-1/10"). Hydrogen gas was purged into the third distillate and heated to a temperature of 320 °C at 30 bars pressure. Hydrogen gas was supplied in an amount of 450 nm³ per m³ and the liquid hourly space velocity of the third distillate was maintained at 1 hour⁻¹.
- 10 The physico-chemical properties of the hydrogenated Rubber Process Oil are summarized in **Table-6** below.

Table-6

Analysis	Results
Sample: Rubber Process Oil (After hydrogenation)	
Density @ 29.5 °C (g/cc)	1.045
KV @ 40 °C (cSt)	720
Pour Point (°C)	18
Sulphur (wt%)	0.40
Flash Point (°C)	233
Viscosity Gravity Constant	1.015
Aniline Point (°C)	< 30
Asphaltenes (ppm)	207

The asphaltene content of the Rubber Process Oil and the Cycle Oil obtained by the process of the present disclosure is very low, typically, 0.05 wt% or less.

- 5 The blend of Lighter ends (Diesel/LDO), Rubber Process Oil (RPO) and Petroleum Pitch fractions, obtained after separation of the Cycle Oil fraction from the CSO, is found to be suitable as high BMCI grade Carbon Black Feed Stock (CBFS).

TECHNICAL ADVANCES AND ECONOMICAL SIGNIFICANCE

- 10 The process of the present disclosure described herein above has several technical advantages including, but not limited, to the realization of:

- a simple and economic process for the separation of petroleum products from CSO using vacuum distillation with gradual increase in temperature of the distillation column;

- Rubber Process Oil and Cycle Oil comprising less than 0.05 wt% asphaltene content; and
- carrying out the process in the absence of expensive conventional solvent extraction processes conventionally used for the separation of Rubber Process Oil and Cycle Oil from lubricating oil.

The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific
10 embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments
15 herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

Throughout this specification the word “comprise”, or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a
20 stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The use of the expression “at least” or “at least one” suggests the use of one or more elements or ingredients or quantities, as the use may be in the embodiment
25 of the disclosure to achieve one or more of the desired objects or results.

Any discussion of documents, acts, materials, devices, articles or the like that has been included in this specification is solely for the purpose of providing a context for the disclosure. It is not to be taken as an admission that any or all of these

matters form a part of the prior art base or were common general knowledge in the field relevant to the disclosure as it existed anywhere before the priority date of this application.

5 The numerical values mentioned for the various physical parameters, dimensions or quantities are only approximations and it is envisaged that the values ten percent higher/lower than the numerical values assigned to the parameters, dimensions or quantities fall within the scope of the disclosure, unless there is a statement in the specification specific to the contrary.

10 While considerable emphasis has been placed herein on the components and component parts of the preferred embodiments, it will be appreciated that many embodiments can be made and that many changes can be made in the preferred embodiments without departing from the principles of the disclosure. These and other changes in the preferred embodiment as well as other embodiments of the disclosure will be apparent to those skilled in the art from the disclosure herein,
15 whereby it is to be distinctly understood that the foregoing descriptive matter is to be interpreted merely as illustrative of the disclosure and not as a limitation

CLAIMS

1. A process for separating petroleum products from Clarified Slurry Oil (CSO) mixture, the process comprising the following steps:
 - a. introducing the CSO mixture into a distillation unit;
 - 5 b. reducing the pressure of the distillation unit to lie in the range of 0.1 mm Hg absolute to 1 mm Hg absolute; and
 - c. gradually raising the temperature of the CSO mixture in the distillation unit up to 500 °C to collect a first distillate below 360 °C, a second distillate below 420 °C, and a third distillate below
10 500 °C, leaving behind a residue;

wherein, the first distillate comprises Diesel and Light Diesel Oil (LDO), the second distillate comprises Cycle Oil, the third distillate comprises Rubber Process Oil and the residue left behind comprises Petroleum Pitch.
- 15 2. The process as claimed in claim 1, wherein the first distillate is collected at a temperature above 270 °C and below 360 °C, the second distillate is collected at a temperature above 360 °C and below 420 °C and the third distillate is collected at a temperature above 420 °C and below 500 °C.
- 20 3. The process as claimed in claim 1, wherein the third distillate is reacted with hydrogen in the presence of at least one catalyst at a pre-determined temperature and at a pre-determined pressure using 430 to 470 nm³ of hydrogen gas per m³ of third distillate at 1 to 2 hour⁻¹ liquid hourly space velocity of the untreated third distillate to obtain a treated third distillate.
25
4. The process as claimed in claim 3, wherein the catalyst is at least one selected from the group consisting of cobalt-molybdenum (Co-Mo) and nickel-molybdenum (Ni-Mo).

5. The process as claimed in claim 3, wherein the reaction is carried out in the temperature range of 280 °C to 320 °C and in the pressure range of 28 bars to 30 bars.
- 5 6. The process as claimed in claim 3, further includes the step of subjecting the treated third distillate to a temperature range of 200 °C to 300 °C and to a pressure range of 4 bars to 8 bars to obtain Rubber Process Oil having an asphaltene content in the range of 0.01 wt% to 0.1 wt%.
- 10 7. The process as claimed in claim 6, wherein the Rubber Processing Oil has an asphaltene content of 0.05 wt% or less.
8. The process as claimed in claim 1, wherein the Cycle Oil has an asphaltene content of 0.05 wt% or less.
- 15 9. The process as claimed in claim 1, wherein the Petroleum Pitch has Quinoline Insolubles (QI) in the range of 0.1 % to 0.4 % and a softening point in the temperature range of 90 °C to 115 °C.

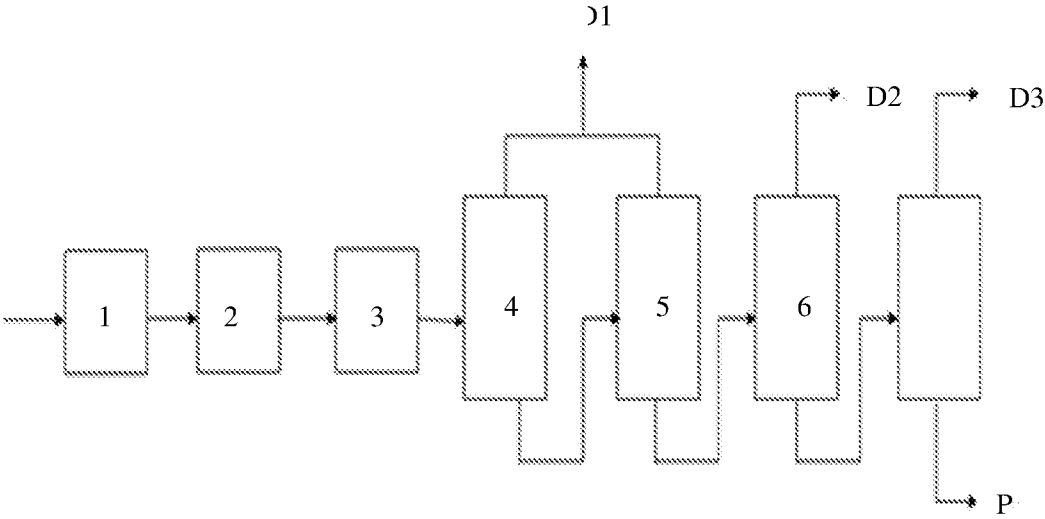


FIGURE 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2015/055084

A. CLASSIFICATION OF SUBJECT MATTER
C10G1/02, C10G21/00, C10G9/06 Version=2015.01

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 practicable, search terms used)

IPO INTERNAL DATABASE, PATSEER

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4192734 A, MOBIL OIL CORPORATION, Pub.dt.11 MARCH 1980. PAGE 4, LINE 5-65 -----	1-9
Y	EP 0436253 A1, SHELL INTERNATIONALE RESEARCH MAATSCHAPPII B.V., Pub.dt. 10 JULY 1991. ABSTRACT, CLAIM 1. -----	1-9
Y	EP 2688983 A1, SAUDI ARABIAN OIL COMPANY , Pub.dt. 29 JANUARY 2014. ABSTRACT, CLAIM 1.	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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