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(54) Hydrotreating process

Hydrobehandlungsverfahren

Procédé d'hydrotraitement

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Description

HYDROTREATING PROCESS

The present invention relates to a process for hydrotreating in a single reactor vessel comprising at least an upper and a lower catalyst bed a hydrocarbon oil which is substantially liquid at process conditions and to a reactor vessel suitable for carrying out such process.

It is foreseen that the amount of contaminating compounds, such as sulphur and aromatics, allowed to be present in hydrocarbon oils according to environmental legislation, will continuously decrease in the future. Therefore, there is much interest in processes with the help of which the content of such compounds in hydrocarbon oils can be reduced to a low level in a commercially attractive way.

In some catalytic desulphurization processes, such as described in e.g. British patent specification 1420248, use is made of two or more fixed-bed catalytic reaction systems, each consisting of one or more reaction vessels. The capital investment needed for such processes utilizing several reaction vessels, is higher than the capital investment needed for the present single reactor vessel process.

The present invention relates to a process for hydrotreating in a single reactor vessel comprising at least an upper and a lower catalyst bed, a hydrocarbon oil which is substantially liquid at process conditions, which process comprises:

(i) contacting partly hydrotreated hydrocarbon oil obtained in step (iv) described hereinbelow, at elevated temperature and pressure in the upper catalyst bed with a hydrotreating catalyst in the presence of clean hydrogen containing gas,
(ii) separating the effluent of step (i) into hydrotreated hydrocarbon oil and used hydrogen containing gas, which hydrotreated hydrocarbon oil is removed from the process,
(iii) contacting fresh hydrocarbon oil at elevated temperature and pressure with a hydrotreating catalyst in the lower catalyst bed in the presence of used hydrogen containing gas obtained in step (ii),
(iv) separating the effluent of step (iii) into partly hydrotreated hydrocarbon oil and contaminated hydrogen containing gas, which contaminated hydrogen containing gas is removed from the process, and
(v) transporting partly hydrotreated hydrocarbon oil obtained in step (iv) to step (i),

whereby the hydrogen partial pressure in the upper catalyst bed is higher than in the lower catalyst bed.

In the process according to the present invention, the final hydrotreating step is carried out in the presence of hydrogen which may contain a relatively small amount of hydrogen sulphide, which leads to good hydrotreating results.

The present hydrotreating process differs from conventional hydrotreating processes, such as described in US patent specification 4,243,519, in the sequence of the process steps. In the process according to the present invention the final hydrotreating step is carried out in the upper catalyst bed. Whereas, on the contrary, in the conventional process, the final hydrotreating step is carried out in a lower catalyst bed, which is situated further downstream the hydrogen gas flow. By operating the final hydrotreating step in the upper catalyst bed, one has the advantage of operating it at the highest hydrogen partial pressure maintained in the vessel, due to the pressure drop over a reactor. A higher hydrogen partial pressure gives better hydrotreating results.

Further, the use of a feedstock which is substantially liquid at process conditions makes that the separation of hydrocarbon oil and hydrogen containing gas can be attained without the need to cool down the partly hydrotreated oil, separate gas from liquid and to heat the partly hydrotreated oil up again, which is disadvantageous from an economical point of view.

It is now possible to obtain the same good results as in a countercurrent mode of operation without suffering from the inherent disadvantages of countercurrent operation, such as restrictions on the gas and liquid space velocity.

The present invention relates furthermore to a reactor vessel suitable for hydrotreating a hydrocarbon oil according to the invention, in which vessel:

(a) above the upper zone for retaining a catalyst bed is situated an inlet for gas and an inlet for liquid,
(b) between the upper and lower zones for retaining a catalyst bed is situated a separating means for separating liquid and gas,
(c) between the upper zone for retaining a catalyst bed and the separating means is situated an outlet for liquid,
(d) between the separating means and the lower zone for retaining a catalyst bed is situated an inlet for liquid,
(e) below the lower zone for retaining a catalyst bed is present an outlet for gas and an outlet for liquid, or an outlet for liquid and gas,

to which vessel a means is attached for transporting liquid obtained from the outlet for liquid situated below the lower zone for retaining a catalyst bed to the inlet for liquid situated above the upper zone for retaining a catalyst bed.

The process according to the present invention suitably comprises a hydrodesulphurization process in step (iii) followed by a further hydrodesulphurization process in step (i). In this way a very low sulphur level can be attained in a commercially attractive way. Other contaminants, such as nitrogen containing compounds, can also to a certain extent be removed in a hydrodesulphurization process. Further, the process suitably involves a hydrodesulphurization process in step (iii) followed by a hydrogenation process in step (i). In that way both the sulphur and the aromatics content of the fresh hydrocarbon oil can be diminished in a commercially attractive way.

The hydrocarbon oil subjected to the present process is substantially liquid at process conditions. The liquid phase of the hydrocarbon oil makes that the separation of the hydrotreated hydrocarbon oil from the hydrogen containing gas in step (ii) can be attained in a simple way. Suitably this separation is carried out with the help of one or more separating trays consisting of a conventional liquid draw-off tray as used in distillation units.

The separation of step (iv) can be carried out outside or inside the reactor vessel. In the first case, the hydrocarbon oil will usually be cooled down and needs heating up before it can be used in step (i). Therefore, separation inside the reactor, preferably with the help of a separating tray as described above, is preferred.

The pressure drop over the reactor vessel will generally be between 0.2 and 10 bar, more specifically between 0.5 and 5 bar. It is possible to add hydrogen to the lower catalyst bed. However, in general the hydrogen partial pressure will be higher in the upper catalyst bed than in the lower catalyst bed. The pressure drop will generally make that the hydrogen partial pressure in the upper catalyst bed is between 0.1 and 9 bar, more specifically between 0.4 and 4.5 bar higher than in the lower catalyst bed.

With the expression "clean hydrogen containing gas" is meant a gas containing less than 3% by volume of hydrogen sulphide, preferably less than 1% by volume, more preferably less than 0.5 % by volume, most preferably less than 0.1 % by volume. Suitably, contaminated hydrogen containing gas obtained in step (iv) is cleaned, e.g. by treating it with an amine, and subsequently used in step (i) as clean hydrogen containing gas.

A hydrocarbon oil which is substantially liquid at process conditions, is understood to comprise a hydrocarbon oil of which a major amount, for example more than 70 % by weight suitably more than 80 % by weight, and preferably more than 95 % by weight, is in the liquid phase. Hydrocarbon oils which can be suitably treated in the process according to the present invention, comprise any hydrocarbon which is substantially liquid at process conditions, for example kerosene fractions. A hydrocarbon oil which could be suitably treated in the process would be a gas oil, as the environmental constraints on this oil fraction have become quite strict. A suitable gas oil would be a gas oil substantially, e.g. more than 75% by weight, boiling in the range between 150 and 400 °C.

If a gas oil is hydrotreated in the process according to the present invention, steps (i) and (iii) are suitably carried out at a temperature of between 150 and 450 °C, suitably between 300 and 400 °C, preferably between 325 and 390 °C, more preferably between 340 and 385 °C, and step (i) is suitably carried out at a pressure of between 20 and 85 bar, preferably between 30 and 65 bar, and step (iii) is suitably carried out at a pressure of between 15 and 80 bar, preferably between 25 and 60 bar.

Further, in the present process suitably a lubricating oil can be hydrotreated, such as a lubricating oil substantially, e.g. more than 95% by weight, boiling in the range between 320 and 600 °C.

If a lubricating oil is hydrotreated in the process according to the present invention, steps (i) and (iii) are suitably carried out at a temperature of between 300 and 400 °C, preferably between 325 and 390 °C, more preferably between 340 and 385 °C, and a pressure of less than 250 bar, preferably less than 200 bar, more preferably less than 175 bar.

The hydrotreating catalyst employed in the process according to the present invention, suitably comprises one or more metals from Group 1b, 2a, 4b, 5b, 6b, 7b and 8 of the Periodic Table of the Elements in the Handbook of Chemistry and Physics, 63rd edition, on a solid carrier. The carrier can optionally comprise a zeolite.

As described above, the hydrotreating process according to the present invention preferably involves in step (i) a hydrogenation process and in step (iii) a hydrodesulphurization process, or in both steps a hydrodesulphurization process.

In the first mode, in step (i) a hydrogenation catalyst is applied at hydrogenation conditions which include a temperature of between 150 and 350 °C, and in step (iii) a hydrodesulphurization catalyst is applied at hydrodesulphurization conditions. In such case, the hydrodesulphurization of step (iii) must in general be carried out such that a sulphur content is attained which is such that the specification on the sulphur tolerance of the hydrogenation catalyst of step (i) is met, as otherwise this hydrogenation catalyst could be poisoned. Suitably, the hydrocarbon oil obtained in step (iv) contains not more than 15% by volume of sulphur containing compounds, based on volume of sulphur containing compounds present in the fresh hydrocarbon oil, preferably not more than 10%.

In the second mode, in both step (i) and (iii) a hydrodesulphurization catalyst is applied at hydrodesulphurization conditions. In that case, the partly hydrotreated hydrocarbon oil obtained in step (iv) suitably contains between 1 and 30% by volume of sulphur containing compounds, based on volume of sulphur containing compounds present in the fresh hydrocarbon oil.

The present invention can suitably be carried out in a reactor vessel as shown in Figure 1.

The upper catalyst bed can contain either a hydrodesulphurization or a hydrogenation catalyst; the lower catalyst

bed contains a hydrodesulphurization catalyst. Clean hydrogen containing gas is fed to the reactor via line 2, while partly hydrotreated hydrocarbon oil is introduced in the upper part of the reactor via line 1. The inlet for gas and the inlet for liquid can be combined. However, it is preferred to have separate inlets. The hydrotreated effluent from the upper catalyst bed is separated from gas with the help of a draw-off tray. The separated hydrotreated hydrocarbon effluent is removed from the reactor via line 3, while used hydrogen containing gas passes the separating tray and reaches the lower catalyst bed. Via line 4 fresh hydrocarbon oil is introduced between the separating tray and the lower catalyst bed. The partly hydrotreated effluent obtained after passing the fresh hydrocarbon oil over the lower catalyst bed, is removed from the reactor via line 5 and separated into partly hydrotreated hydrocarbon oil which is sent to line 1, and contaminated hydrogen containing gas. The contaminated hydrogen containing gas is suitably cleaned by treating it with an amine, so-called scrubbing. The cleaned gas obtained can then, optionally together with make-up hydrogen, be recycled to line 2 and be used again.

The advantages of the present invention will be illustrated by the following example.

EXAMPLE

The process was carried out in a set-up as described in Figure 1. The catalyst present both in the upper and the lower catalyst bed was a hydrodesulphurization catalyst, comprising 3.1% by weight of cobalt and 12.4% by weight of molybdenum, based on total amount of catalyst, on alumina. The catalyst particles were in the shape of 1.2 mm trilobes.

A gas oil feedstock of which according to the ASTM distillation curve more than 78% by volume is in the gaseous phase at 383 °C, more than 50% by volume is in the gaseous phase at 345 °C and more than 20% is in the gaseous phase at 300 °C was led to the reactor via line 4. The overall process conditions comprise a temperature of 360 °C and a weight hourly space velocity of 2.0 kg/l.h and a hydrogen to oil ratio of 200 Nl/kg. The hydrogen partial pressure at the outlet of the upper catalyst bed was 24.4 bar, while the hydrogen partial pressure at the outlet of the lower catalyst bed was 23.1 bar. At these process conditions about 7 % by weight of the gas oil feedstock was in the gaseous phase. The sulphur content of the feed, the partly hydrotreated feed and the hydrotreated feed are shown in Table 1, in amount of elemental sulphur on total amount of feed.

Table 1

	feed	partly hydrotreated feed	hydrotreated feed
Sulphur content (% by weight)	1.64	0.21	0.06

Not according to the invention, fresh feedstock as described hereinabove was processed in a set-up similar to the one of Figure 1, at process conditions substantially as described hereinabove. No intermittent hydrogen separation took place between the catalyst beds; no hydrocarbon oil was added or removed between the catalyst beds. The hydrogen partial pressure at the reactor outlet was 23.1 bar. The hydrotreated hydrocarbon oil obtained had a sulphur content of 0.11%wt.

Claims

1. Process for hydrotreating in a single reactor vessel comprising at least an upper and a lower catalyst bed, a hydrocarbon oil which is substantially liquid at process conditions, which process comprises:

   (i) contacting partly hydrotreated hydrocarbon oil obtained in step (iv) described hereinbelow, at elevated temperature and pressure in the upper catalyst bed with a hydrotreating catalyst in the presence of clean hydrogen containing gas,
   (ii) separating the effluent of step (i) into hydrotreated hydrocarbon oil and used hydrogen containing gas, which hydrotreated hydrocarbon oil is removed from the process,
   (iii) contacting fresh hydrocarbon oil at elevated temperature and pressure with a hydrotreating catalyst in the lower catalyst bed in the presence of used hydrogen containing gas obtained in step (ii),
   (iv) separating the effluent of step (iii) into partly hydrotreated hydrocarbon oil and contaminated hydrogen containing gas, which contaminated hydrogen containing gas is removed from the process, and
   (v) transporting partly hydrotreated hydrocarbon oil obtained in step (iv) to step (i),

   whereby the hydrogen partial pressure in the upper catalyst bed is higher than in the lower catalyst bed.

2. Process according to claim 1, in which contaminated hydrogen containing gas obtained in step (iv) is cleaned and

used in step (i).

3. Process according to claim 2, in which the contaminated hydrogen containing gas is cleaned by treating with an amine.

4. Process according to any one of claims 1-3, in which the clean hydrogen containing gas contains less than 3% by volume of hydrogen sulphide.

5. Process according to any one of claims 1-4, in which the hydrocarbon oil is a gas oil substantially boiling in the range between 150 and 400 °C.

6. Process according to claim 5, in which steps (i) and (iii) are carried out at a temperature of between 325 and 390 °C and step (i) is carried out at a pressure of between 20 and 85 bar, and step (iii) is carried out at a pressure of between 15 and 80 bar, whereby the pressure in step (i) is higher than the pressure in step (iii).

7. Process according to any one of claims 1-4, in which the hydrocarbon oil is a lubricating oil substantially boiling in the range between 320 and 600 °C.

8. Process according to claim 7, in which steps (i) and (iii) are carried out at a temperature of between 325 and 390 °C and a pressure of less than 200 bar.

9. Process according to any one of claims 1-8, in which the catalyst comprises one or more metals from Group 1b, 2a, 4b, 5b, 6b, 7b and 8 of the Periodic Table of the Elements, on a solid carrier.

10. Process according to any one of claims 1-9, in which in step (i) a hydrogenation catalyst is applied at hydrogenation conditions, and in step (iii) a hydrodesulphurization catalyst is applied at hydrodesulphurization conditions.

11. Process according to claim 10, in which the hydrocarbon oil obtained in step (iv) contains not more than 10% by volume of sulphur containing compounds, based on volume of sulphur containing compounds present in the fresh hydrocarbon oil.

12. Process according to any one of claims 1-9, wherein in step (i) and (iii) a hydrodesulphurization catalyst is applied at hydrodesulphurization conditions.

13. Process according to claim 12, in which the hydrocarbon oil obtained in step (iv) contains between 1 and 30% by volume of sulphur containing compounds, based on volume of sulphur containing compounds present in the fresh hydrocarbon oil.

14. Reactor vessel suitable for hydrotreating a hydrocarbon oil according to any one of claims 1-13, in which vessel:

(a) above the upper zone for retaining a catalyst bed is situated an inlet for gas and an inlet for liquid,
(b) between the upper and lower zone for retaining a catalyst bed is situated a separating means for separating liquid and gas, (c) between the upper zone for retaining a catalyst bed and the separating means is situated an outlet for liquid,
(d) between the separating means and the lower zone for retaining a catalyst bed is situated an inlet for liquid,
(e) below the lower zone for retaining a catalyst bed is present an outlet for gas and an outlet for liquid, or an outlet for liquid and gas,

to which vessel a means is attached for transporting liquid obtained from the outlet for liquid situated below the lower zone for retaining a catalyst bed to the inlet for liquid situated above the upper zone for retaining a catalyst bed.

Patentansprüche

1. Verfahren zur Hydrierbehandlung eines Kohlenwasserstofföls, das unter den Verfahrensbedingungen weitgehend flüssig ist, in einem einzigen Reaktor, der mindestens eine obere und eine untere Katalysatorschüttung enthält, bei dem man:

(i) in der oberen Katalysatorschüttung teilweise hydrierbehandeltes Kohlenwasserstofföl aus dem im folgenden beschriebenen Schritt (iv) bei erhöhter Temperatur und erhöhtem Druck in Gegenwart von reinem wasserstoffhaltigem Gas mit einem Hydrierbehandlungskatalysator in Berührung bringt,
(ii) den Austragsstrom des Schritts (i) in hydrierbehandeltes Kohlenwasserstofföl und gebrauchtes wasserstoffhaltiges Gas auftrennt und das hydrierbehandelte Kohlenwasserstofföl aus dem Verfahren ausschleust,
(iii) in der unteren Katalysatorschüttung frisches Kohlenwasserstofföl bei erhöhter Temperatur und erhöhtem Druck in Gegenwart von gebrauchtem wasserstoffhaltigem Gas aus Schritt (ii) mit einem Hydrierbehandlungskatalysator in Berührung bringt,
(iv) den Austragsstrom des Schritts (iii) in teilweise hydrierbehandeltes Kohlenwasserstofföl und verunreinigtes wasserstoffhaltiges Gas auftrennt und das verunreinigte wasserstoffhaltige Gas aus dem Verfahren ausschleust, und
(v) teilweise hydrierbehandeltes Kohlenwasserstofföl aus Schritt (iv) dem Schritt (i) zuführt,

wobei der Wasserstoffpartialdruck in der oberen Katalysatorschüttung höher ist als in der unteren Katalysatorschüttung.

2. Verfahren nach Anspruch 1, bei dem man das verunreinigte wasserstoffhaltige Gas aus Schritt (iv) reinigt und in Schritt (i) wiederverwendet.

3. Verfahren nach Anspruch 2, bei dem man das verunreinigte wasserstoffhaltige Gas durch Behandeln mit einem Amin reinigt.

4. Verfahren nach einem der Ansprüche 1-3, bei dem das reine wasserstoffhaltige Gas weniger als 3 Vol.-% Schwefelwasserstoff enthält.

5. Verfahren nach einem der Ansprüche 1-4, bei dem man als Kohlenwasserstofföl ein im wesentlichen im Bereich von 150 bis 400°C siedendes Gasöl einsetzt.

6. Verfahren nach Anspruch 5, bei dem man die Schritte (i) und (iii) bei einer Temperatur von 325 bis 390°C, Schritt (i) bei einem Druck von 20 bis 85 bar und Schritt (iii) bei einem Druck von 15 bis 80 bar durchführt, wobei der Druck in Schritt (i) höher ist als der Druck in Schritt (iii).

7. Verfahren nach einem der Ansprüche 1-4, bei dem man als Kohlenwasserstofföl ein im wesentlichen im Bereich von 320 bis 600°C siedendes Schmieröl einsetzt.

8. Verfahren nach Anspruch 7, bei dem man die Schritte (i) und (iii) bei einer Temperatur von 325 bis 390°C und einem Druck unter 200 bar durchführt.

9. Verfahren nach einem der Ansprüche 1-8, bei dem man einen Katalysator, der ein oder mehrere Metalle der Gruppe 1b, 2a, 4b, 5b, 6b, 7b und 8 des Periodensystems der Elemente auf einem festen Träger enthält, einsetzt.

10. Verfahren nach einem der Ansprüche 1-9, bei dem man in Schritt (i) unter Hydrierbedingungen einen Hydrierkatalysator und in Schritt (iii) unter Hydrierentschwefelungsbedingungen einen Hydrierentschwefelungskatalysator einsetzt.

11. Verfahren nach Anspruch 10, bei dem das in Schritt (iv) erhaltene Kohlenwasserstofföl nicht mehr als 10 Vol.-% schwefelhaltige Verbindungen, bezogen auf das Volumen an schwefelhaltigen Verbindungen im frischen Kohlenwasserstofföl, enthält.

12. Verfahren nach einem der Ansprüche 1-9, bei dem man in Schritt (i) und in Schritt (iii) unter Hydrierentschwefelungsbedingungen einen Hydrierentschwefelungskatalysator einsetzt.

13. Verfahren nach Anspruch 12, bei dem das in Schritt (iv) erhaltene Kohlenwasserstofföl 1 bis 30 Vol.-% schwefelhaltige Verbindungen, bezogen auf das Volumen an schwefelhaltigen Verbindungen im frischen Kohlenwasserstofföl, enthält.

14. Reaktor, der sich zur Hydrierbehandlung eines Kohlenwasserstofföls gemäß einem der Ansprüche 1-13 eignet, in welchem:

(a) über der oberen Zone zum Zurückhalten einer Katalysatorschüttung ein Einlaß für Gas und ein Einlaß für Flüssigkeit,
(b) zwischen der oberen und unteren Zone zum Zurückhalten einer Katalysatorschüttung ein Trennmittel zum Auftrennen von Flüssigkeit und Gas,
(c) zwischen der oberen Zone zum Zurückhalten einer Katalysatorschüttung und dem Trennmittel ein Auslaß für Flüssigkeit,
(d) zwischen dem Trennmittel und der unteren Zone zum Zurückhalten einer Katalysatorschüttung ein Einlaß für Flüssigkeit und
(e) unter der unteren Zone zum Zurückhalten einer Katalysatorschüttung ein Auslaß für Gas und ein Auslaß für Flüssigkeit bzw. ein Auslaß für Flüssigkeit und Gas angeordnet sind,

an dem ein Mittel zum Zuführen von Flüssigkeit aus dem unter der unteren Zone zum Zurückhalten einer Katalysatorschüttung angeordneten Auslaß für Flüssigkeit zum über der oberen Zone zum Zurückhalten einer Katalysatorschüttung angeordneten Einlaß angebracht ist.

Revendications

1. Procédé d'hydrotraitement, dans un seul récipient de réaction ou réacteur comprenant au moins un lit de catalyseur supérieur et un lit de catalyseur inférieur, d'une huile hydrocarbonée qui est sensiblement liquide dans les conditions opératoires, caractérisé en ce que :

   (i) on met en contact l'huile hydrocarbonée partiellement hydrotraitée, obtenue au cours de l'étape (iv) décrite ci-dessous, à température et pression élevées, dans un lit de catalyseur supérieur, avec un catalyseur d'hydrotraitement, en présence d'un gaz contenant de l'hydrogène propre,
   (ii) on sépare l'effluent de l'étape (i) en huile hydrocarbonée hydrotraitée et en gaz contenant de l'hydrogène usé, laquelle huile hydrocarbonée hydrotraitée est prélevée du procédé,
   (iii) on met en contact de l'huile hydrocarbonée fraîche à température et pression élevées avec un catalyseur d'hydrotraitement dans le lit de catalyseur inférieur, en présence de gaz contenant de l'hydrogène usé, obtenu dans l'étape (ii),
   (iv) on sépare l'effluent de l'étape (iii) en huile hydrocarbonée partiellement hydrogénée et en gaz contenant de l'hydrogène contaminé, lequel gaz contenant de l'hydrogène contaminé est évacué du procédé, et
   (v) on envoie l'huile hydrocarbonée partiellement hydrotraitée obtenue dans l'étape (iv) à l'étape (i),

   en une manière telle que la pression partielle d'hydrogène dans le lit de catalyseur supérieur soit plus élevée que celle dans le lit de catalyseur inférieur.

2. Procédé suivant la revendication 1, caractérisé en ce que le gaz contenant de l'hydrogène contaminé obtenu dans l'étape (iv) est nettoyé et utilisé dans l'étape (i).

3. Procédé suivant la revendication 2, caractérisé en ce que le gaz contenant l'hydrogène contaminé est nettoyé par traitement avec une amine.

4. Procédé suivant l'une quelconque des revendications 1 à 3, caractérisé en ce que le gaz contenant de l'hydrogène propre contient moins de 3% en volume de sulfure d'hydrogène.

5. Procédé suivant l'une quelconque des revendications 1 à 4, caractérisé en ce que l'huile hydrocarbonée est un gazole bouillant sensiblement dans la plage comprise entre 150 et 400°C.

6. Procédé suivant la revendication 5, caractérisé en ce que l'on entreprend les étapes (i) et (iii) à une température comprise entre 325 et 390°C et on entreprend l'étape (i) à une pression comprise entre 20 et 85 bars, et on entreprend l'étape (iii) à une pression comprise entre 15 et 80 bars, en une manière telle que la pression dans l'étape (i) soit supérieure à la pression dans l'étape (iii).

7. Procédé suivant l'une quelconque des revendications 1 à 4, caractérisé en ce que l'huile hydrocarbonée est une huile lubrifiante bouillant sensiblement dans la plage comprise entre 320 et 600°C.

8. Procédé suivant la revendication 7, caractérisé en ce que l'on entreprend les étapes (i) et (iii) à une température

comprise entre 325 et 390°C et sous une pression inférieure à 200 bars.

9. Procédé suivant l'une quelconque des revendications 1 à 8, caractérisé en ce que le catalyseur comprend un ou plusieurs métaux choisis parmi ceux des groupes 1b, 2a, 4b, 5b, 6b, 7b et 8 du tableau périodique des éléments, sur un support solide.

10. Procédé suivant l'une quelconque des revendications 1 à 9, caractérisé en ce que, dans l'étape (i), on applique un catalyseur d'hydrogénation dans des conditions d'hydrogénation et, dans l'étape (iii), on applique un catalyseur d'hydrodésulfuration dans des conditions d'hydrodésulfuration.

11. Procédé suivant la revendication 10, caractérisé en ce que l'huile hydrocarbonée obtenue dans l'étape (iv) ne contient pas plus de 10% en volume de composés contenant du soufre, sur base du volume des composés contenant du soufre présents dans l'huile hydrocarbonée fraîche.

12. Procédé suivant l'une quelconque des revendications 1 à 9, caractérisé en ce que, dans l'étape (i) et l'étape (iii), on applique un catalyseur d'hydrodésulfuration dans des conditions d'hydrodésulfuration.

13. Procédé suivant la revendication 12, caractérisé en ce que l'huile hydrocarbonée obtenue dans l'étape (iv) contient entre 1 et 30% en volume de composés contenant du soufre, sur base du volume des composés contenant du soufre présents dans l'huile hydrocarbonée fraîche.

14. Récipient de réaction ou réacteur convenant à l'hydrotraitement d'une huile hydrocarbonée suivant l'une quelconque des revendications 1 à 13, dans lequel récipient ou réacteur :

(a) au-dessus de la zone supérieure destinée à retenir un lit de catalyseur, se situe une entrée de gaz et une entrée de liquide,
(b) entre les zones supérieure et inférieure destinées à retenir un lit de catalyseur est situé un moyen séparateur destiné à séparer liquide et gaz,
(c) entre la zone supérieure destinée à retenir un lit de catalyseur et le moyen séparateur est située une sortie de liquide,
(d) entre le moyen séparateur et la zone inférieure destinée à retenir un lit de catalyseur est située une entrée de liquide,
(e) en dessous de la zone inférieure destinée à retenir un lit de catalyseur, sont présentes une entrée de gaz et une entrée de liquide, ou une entrée de liquide et de gaz,

récipient ou réacteur auquel est attaché un moyen pour transporter du liquide obtenu à partir de la sortie de liquide située en dessous de la zone inférieure destinée à retenir un lit de catalyseur vers l'entrée de liquide située au-dessous de la zone supérieure destinée à retenir un lit de catalyseur.

FIG.1

