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(71) Applicant: **NESTE CORPORATION** [FI/FI]; Keilaranta 21, 02150 Espoo (FI).

(72) Inventors: **MAKKONEN, Jaana**; Neste Corporation, Keilaranta 21, 02150 Espoo (FI). **KETTUNEN, Mika P.**; Neste Corporation, Keilaranta 21, 02150 Espoo (FI).

(74) Agent: **PITKÄNEN, Kirsi-Marja**; KOLSTER OY AB, European Patent Attorney, (Iso Roobertinkatu 23), P.O.Box 148, 00121 Helsinki (FI).

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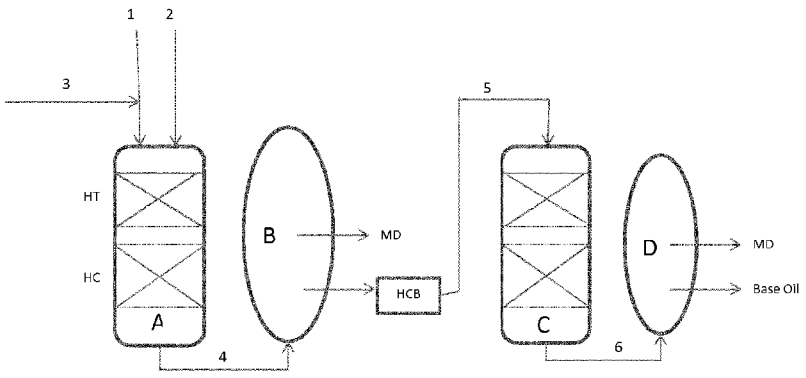

Fig. 1

(57) Abstract: The invention provides a method of producing oil-based components, comprising the steps of: providing VGO and slack wax; combining the VGO as a major component and the slack wax as a minor component to provide a feedstock; subjecting the feedstock to a hydrocracking step to provide a first effluent; fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction; recovering the bottom fraction and the middle distillate fraction. The invention further provides a method for improving the viscosity index of base oil, comprising the steps of: providing VGO and slack wax; combining the VGO as a major component and the slack wax as a minor component to provide a feedstock; subjecting the feedstock to a hydrocracking step to provide a first effluent; fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction; subjecting the bottom fraction to a dewaxing step to provide a second effluent; fractionating the second effluent to provide at least a middle distillate and base oil; recovering the middle distillate and the base oil.

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A method for producing oil-based components

Field of the invention

The present invention relates to the field of producing traffic fuels and base oil components. More particularly, the invention relates to a method including hydrocracking and dewaxing of waxy feedstock for producing middle distillate fuel and lubricant base oil.

Background of the invention

Cracking, and especially hydrocracking, is a well-known process in refinery used for cleaving larger hydrocarbon components into smaller short-chain hydrocarbons which are usable as traffic fuel components. Cracking is achieved by breaking the carbon-carbon bonds in the hydrocarbon chain of C15 to C45 typically in the presence of a cracking catalyst. The nature of the end products is dependent on the nature of the feed and on the process conditions under which the process is carried out, such as temperature, pressure and the nature of the catalyst.

A widely used method for carrying out catalytic cracking of high-boiling, high-molecular weight hydrocarbon fractions of petroleum crude oils is a fluid catalytic cracking (FCC) process, in which a powdered catalyst is employed. The catalyst particles are suspended in a rising flow of a heavy gas oil feed to form a fluidized bed. The feed is typically pre-heated and then sprayed into the base of the riser via feed nozzles to bring the feed in contact with the hot fluidized catalyst. The temperature of a FCC cracker is typically between 500°C and 800°C.

Hydrocracking of heavy hydrocarbons can also be achieved in a fixed bed hydrocracker. In this hydrocracker, the feedstock is fed downward through the catalyst bed together with hydrogen gas. In a fixed bed reactor, the catalyst is fixed onto particles, which can be of various sizes and forms providing an even and homogenous distribution of the feedstock and hydrogen gas and, further, maximum contact with the active catalyst. The catalyst containing particles are fixed in layer or bed and the feedstock and hydrogen gas run through the layer. Typically, fixed bed reactors contain several catalyst layers.

A commonly used feedstock for hydrocracking is vacuum gas oil (VGO) which is heavy oils left-over from petroleum distillation. VGO contains a large quantity of cyclic and aromatic compounds as well as heteroatoms, such as sulphur and nitrogen, and other heavier compounds, depending on the crude source and VGO cut.

Hydrocarbon cracking is usually accompanied by a hydrogenation process, also called as hydrotreatment process. The purpose of the hydrogenation is to remove heteroatoms, such as oxygen, sulphur and/or nitrogen, and also to saturate aromatics typically present in the hydrocarbon feed. The hydrogenation process is typically performed before the actual hydrocracking process in order to ensure removal of heteroatoms and saturation of aromatics. In some cases hydrogenation also includes ring-opening functions. However, no substantial cleavage of hydrocarbons takes place in the hydrogenation step. The preceding hydrogenation of the feedstock before hydrocracking ensures good hydrocracking performance and improves the yield of the products produced in the hydrocracking.

Waxes and slack waxes is a general term for feedstock comprising mainly paraffins. The paraffins in waxes are typically saturated C15-C45 linear hydrocarbons (normal or n-paraffins). Waxes may also contain to some extent branched (isomerized or i-paraffins) and cyclic hydrocarbons. Slack waxes are typically formed by a solvent dewaxing process of a waxy petroleum feed, such as a VGO stream. The solvent dewaxing process is typically performed by mixing a suitable solvent with the waxy petroleum feed, then cooling the mixture and separating the waxes as solid wax crystals, for example by filtration. Waxes can also be produced by Fischer-Tropsch (F-T) process, in which gas containing carbon monoxide and hydrogen is reacted to form hydrocarbon of various chain lengths. F-T process is widely used in gas-to-liquid (GTL) technologies where natural gas is used as a carbon source. Biomass can also be used as the carbon source in the F-T process and it is then generally called biomass-to-liquid (BTL) technology. Slack wax produced by solvent dewaxing contains varied amounts of impurities which makes the slack wax a low value product.

A catalytic dewaxing (cat-dewaxing) unit is a device where hydrocarbon feedstock is catalytically dewaxed, i.e. selectively cracked and isomerized. A cat-dewaxing unit is generally called as VHVI (Very High Viscosity Index) unit, since base oils with very high viscosity index are obtained in said unit. In the VHVI unit, in order to improve the cold properties of a base oil, linear paraffins are isomerized to form branched paraffins (iso-paraffins). Also, cracking of hydrocarbons takes place to some extent.

There is an ever increasing demand for high quality traffic fuels and base oil components in terms of purity, emissions, cold flow properties and lubricity of petroleum products. For example, the demand for middle distillates used as basic components in diesel fuel production is increasing in terms of cold flow properties and cetane number. Cetane number is an indicator of combustion

speed of diesel fuel. The most important characteristic for a base oil component is the viscosity index, i.e. the measure for the change of viscosity with variations of temperature. High viscosity index of base oil component indicates that its lubricating ability is maintained over a large temperature range.

Various new technological developments have tried to meet the increasing demand for improved petroleum based product. US 2004/0256287 A1 discloses a process of hydrocracking a waxy hydrocarbon feedstock, such as Fischer-Tropsch waxy hydrocarbons, in the presence of a hydrocracking catalyst. The hydrocracking effluent is hydroisomerized in the presence of a hydroisomerization catalyst. The hydroisomerization effluent is fractioned to provide a heavy fraction and a middle distillate fuel, and the heavy fraction is dewaxed to provide a lubricant base oil having a viscosity index greater than 130.

US 2009/0065393 A1 discloses a method for obtaining a petroleum distillate in which a paraffin-based wax such Fischer-Tropsch wax and/or slack wax, is subjected to a cracking process in the presence of a catalyst, followed by hydrogenating the olefinic intermediate obtained in the presence of a catalyst, and recovering the distillate.

There remains a need for an efficient, simple and economic method of producing high quality middle distillates and very high viscosity index lubricant base oils in high yields from available feasible feeds and yet upgrading the product quality. The middle distillates and base oils desirably have high cetane number and high viscosity index, respectively.

Brief description of the invention

In as aspect, the present invention provides a method of producing oil-based components, comprising the steps of:

- providing VGO and slack wax;
- combining the VGO as a major component and the slack wax as a minor component to provide a feedstock;
- subjecting the feedstock to a hydrocracking step to provide a first effluent;
- fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction;
-recovering the bottom fraction and the middle distillate fraction.

In another aspect, the invention provides a method for improving the viscosity index of base oil, comprising the steps of:

- providing VGO and slack wax;
- combining the VGO as a major component and the slack wax as a minor compo-

nent to provide a feedstock;

- subjecting the feedstock to a hydrocracking step to provide a first effluent;
- fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction;
- subjecting the bottom fraction to a dewaxing step to provide a second effluent;
- fractionating the second effluent to provide at least a middle distillate and base oil;
- recovering the middle distillate and the base oil.

In a further aspect, the invention provides an arrangement for producing oil-based components, the apparatus comprising:

- a hydrocracking reactor A for cracking a waxy feed to provide a first effluent 4, said hydrocracking reactor A comprising at least one inlet for supplying a feedstock to the hydrocracking reactor A and an outlet for discharging the first effluent 4 from the hydrocracking reactor A;
- a first distiller B in a flow connection with the hydrocracking reactor A for fractioning the first effluent 4 to provide at least a bottom fraction HCB and a middle distillate fraction MD, the first distiller B being arranged downstream of the hydrocracking reactor A;
- a dewaxing unit C in a flow connection with the first distiller B for dewaxing the bottom fraction HCB to provide a second effluent 6, the dewaxing unit C being arranged downstream of the first distiller B; and
- a second distiller D in a flow connection with the dewaxing unit C for fractioning the second effluent 6 to provide at least a middle distillate MD and base oil, the second distiller D being arranged downstream of the dewaxing unit C and comprises at least one outlet for discharging the middle distillate MD and the base oil.

Vacuum gas oil is a petroleum based heavy hydrocarbon distillate which is widely used as a feedstock in fluid catalytic crackers to produce a wide range of valuable products for various applications, such as gasoline, diesel fuel and base oil. VGO contains a large quantity of cyclic and aromatic compounds as well as sulphur and nitrogen which impede its conversion to high quality valuable end products. As a rule, VGO quality influences on the quality of the end products. High quality Group III base oils with high viscosity index can be produced from suitable VGO in good yields. However, further increase of the viscosity index inevitably results in undesired lower yields.

It was surprisingly found in the present invention that high quality middle distillates and lubricant base oils in high yields can be produced when a feedstock for the overall refining process of hydrocracking and catalytic dewaxing comprises VGO and slack wax. Also, it was surprisingly found that the viscosity index of a base oil was increased without compromising the yield, when slack wax in combination with VGO was used in the production of the base oil, compared to the viscosity index of a base oil produced from VGO only. It was further found that by introducing slack wax together with VGO to a hydrocracker, the performance of the hydrocracker catalyst was improved. In addition, the life time of the hydrocracking catalyst was prolonged. Further, middle distillate with improved cetane number and base oil with increased viscosity index were produced in good yields.

A beneficial advantage of the method of the invention is that strict quality requirements of VGO as an adequate feedstock can be bargained when slack wax is introduced to the feedstock. In general, the adequate quality of the feedstock is adjusted by means of the VGO and slack wax. This means in practice that lower quality VGO with higher quality slack wax including a minor amount of impurities, and vice versa, can be used in the method of the invention and still high quality products are produced. This feature allows to employ VGO and slack waxes in a larger quality range and provides an economic advantage.

The method is efficient, simple and economic.

Brief description of the drawings

Figure 1 shows schematically an embodiment of the method of the invention.

Figure 2 shows an effect of slack wax to the viscosity index (VI) of base oil as a function of kinematic viscosity (KV).

Detailed description of the invention

In an aspect, the present invention provides a method of producing oil-based components, comprising the steps of:

- providing VGO and slack wax;
- combining the VGO as a major component and the slack wax as a minor component to provide a feedstock;
- subjecting the feedstock to a hydrocracking step to provide a first effluent;
- fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction;

-recovering the bottom fraction and the middle distillate fraction.

In the present invention,

the term "slack wax" means a crude wax produced by chilling and solvent filter-pressing wax distillate;

the term "vacuum gas oil (VGO)" means a hydrocarbon product obtained from crude oil vacuum distillation;

the term "Group III Base oil" means paraffinic base stock which contains sulphur ≤ 0.03 wt.%, saturates ≥ 90 wt.% and has a viscosity index of ≥ 120.

Viscosity index (VI) is typically calculated from kinematic viscosities at 40°C and at 100°C according to standard ASTM D 2270. A high VI means that base oil has similar viscosity properties at 40°C and at 100°C, which is a highly desired property. Low VI is not desired; it means that base oil has high viscosity at 40°C but low at 100°C.

The feedstock suitable for use in the method of the invention typically comprises at most about 0.18 wt.% nitrogen, at most about 2 wt.% sulphur, and about 45 wt.% aromatic compounds.

The boiling range of the feedstock comprising VGO and slack wax can vary and is determined by the desired final base oil. In an embodiment, the boiling range of the feedstock is substantially in the same range as that of VGO.

Typically, slack wax contains quantities of aromatics, nitrogen and sulphur as impurities. In an embodiment of the invention, slack wax is provided as unpurified slack wax obtained from solvent dewaxing of a waxy petroleum feed.

Slack wax is combined with VGO to provide a feedstock comprising the VGO a major component and the slack wax as a minor component. Besides slack wax, the feedstock can contain minor amounts of additional wax(es). The additional wax(es) can be any kind of waxes, including synthetic wax, such as Fischer-Tropsch wax.

In an embodiment, the feedstock comprises at most about 30 wt.% slack wax. In another embodiment, the feedstock comprises at most about 25 wt.% slack wax. In still another embodiment, the feedstock comprises at most about 20 wt.% slack wax. In an embodiment, the feedstock comprises 1-25 wt.% slack wax. In another embodiment, the feedstock comprises 10-20 wt.% slack wax. In an embodiment, in each of the above separate embodiments the balance is VGO.

The feedstock comprising slack wax is subjected to a hydrocracking step. In the hydrocracking step, heteroatoms such as N and S are removed, larger long-chain hydrocarbons are cleaved into smaller short-chain hydrocarbons and/or some cyclic hydrocarbons are ring-opened to form linear and/or branched hydrocarbons. Also, dearomatization of the aromatic compounds and isomerization of the hydrocracked molecules may also occur to some extent in the process. However, the cleavage of the hydrocarbons of the wax in the hydrocracking step is not as extensive as that of VGO.

The hydrocracking is typically performed in the presence of a hydrocracking catalyst. Hydrocracking catalysts suitable for use in this step are well known to a skilled person in the art. The hydrocracking catalyst may be arranged in one or more layers in a fixed bed. The catalyst may also be arranged in graded catalyst bed. Alternatives for suitable arrangement of the catalyst are well known to a skilled person in the art.

In an embodiment, the feedstock is first subjected to a hydrotreatment step before the hydrocracking step to remove impurities. The hydrotreatment step is carried out under conditions where any heteroatoms, such as oxygen, sulphur and/or nitrogen present in the feedstock are removed. Also aromatic compounds are typically saturated in this step. No substantial cracking of the hydrocarbons in the feedstock takes place in this step. The hydrotreatment step before hydrocracking ensures good hydrocracking performance and improves the yield of the products produced in the subsequent hydrocracking. The hydrotreatment is typically performed in the presence of a catalyst. Catalysts suitable for use in this step are well known to a skilled person in the art. The catalyst may be arranged in one or more layers in a fixed bed. The catalyst may also be arranged in graded catalyst bed. Alternatives for suitable arrangement of the catalyst are well known to a skilled person in the art.

The hydrotreatment and hydrocracking steps can be conducted in a single reactor or separate reactors. When the two steps are conducted in separate reactors, the hydrotreatment reactor is arranged upstream of the hydrocracking reactor.

The feed rate of hydrogen per feedstock in the hydrocracking step, optionally including a hydrotreatment step, is about more than 1000 L/L.

The hydrocracking is typically carried out at a pressure in the range from about 120 to about 170 bar. In an embodiment, the pressure is about 150 bar. In another embodiment, the pressure is about 132 bar.

The temperature in the hydrocracking is in the range of about 350°C to

about 450°C. In an embodiment, the temperature is 400°C.

The conversion level in the hydrocracking step is in the range of about 50% to about 80%. In an embodiment, the conversion level is about 56%. The conversion level is calculated as follows:

Conversion % = 100 – [100 * (product boiling > 343°C/a fraction in the feed, boiling > 343°C)]

The feedstock comprising VGO and slack wax can be fed to the hydrocracking reactor as separate streams or combined into a single stream which is fed to the reactor.

The first effluent obtained from the hydrocracking step is fractionated by distillation whereby at least a bottom fraction and a middle distillate fraction are obtained. Adequate fuel oil quality for the middle distillate fraction boiling in the range of about 300°C to about 370°C is achieved and it is suitable for use as a component in diesel fuel. The bottom fraction is mainly composed of linear paraffins and naphtenes and boils above 370°C. Fractionation of the first effluent also produces a quantity of light gaseous hydrocarbons.

In an embodiment, for further refining, the bottom fraction is subjected to a dewaxing step. In the dewaxing step, waxy n-paraffins are isomerized to provide branched iso-paraffins. Isomerization of hydrocarbons is desired and generally improves the cold flow properties of a base oil. The dewaxing is typically performed in the presence of a dewaxing catalyst. Dewaxing catalysts suitable for use in this step are well known to a skilled person in the art.

The dewaxing step provides a second effluent which is fractionated in a distiller to high quality middle distillate and base oil. Also lighter gaseous hydrocarbons are obtained. Group III Base oil having desirably a high viscosity index of >130 and middle distillate boiling in the range of about 300°C to about 370°C with high cetane number and improved cold flow properties are achieved. The middle distillate obtained from the dewaxing step can be used as diesel fuel as such or as a blending component.

The present invention can be a batch process or a continuous process.

In another aspect, the invention provides a method for improving the viscosity index of base oil, comprising the steps of:

- providing VGO and slack wax;
- combining the VGO as a major component and the slack wax as a minor component to provide a feedstock;

- subjecting the feedstock to a hydrocracking step to provide a first effluent;
- fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction;
- subjecting the bottom fraction to a dewaxing step to provide a second effluent;
- fractionating the second effluent to provide at least a middle distillate and base oil;
- recovering the middle distillate and the base oil.

All the information relating to the feedstock, process conditions etc. described above also apply in the latter method.

An example of an arrangement which can be used for conducting the method of the invention is shown in Figure 1. Referring to the figure, the arrangement for producing oil-based components comprises a hydrocracking reactor A for cracking a waxy feed to provide a first effluent 4, a first distiller B, a dewaxing unit C and a second distiller D. The hydrocracking reactor A comprises at least one inlet for supplying a feedstock into the hydrocracking reactor A and an outlet for discharging the first effluent 4 from the hydrocracking reactor A. In an embodiment of the invention, the hydrocracking reactor A comprises at least two inlets, one for slack wax 2 and one for combined hydrogen 1 and VGO 3. In the figure, the hydrocracking reactor A comprises a catalytic hydrotreatment zone HT and a catalytic hydrocracking zone HC, the hydrotreatment zone lying upstream of the hydrocracking zone. The catalysts in each of the two zones can be arranged in one or more beds. Further, the beds can be graded in respect to the amount of the catalyst employed. A suitable arrangement and grading of the catalyst are well known to a skilled person in the art. Alternatively, the hydrotreatment zone and the hydrocracking zone can be arranged in individual reactors, the hydrotreatment reactor lying upstream of the hydrocracking reactor (not shown in Fig. 1).

The first distiller B is in a flow connection with the hydrocracking reactor A for fractioning the first effluent 4 to provide at least a bottom fraction HCB and a middle distillate fraction MD. The first distiller B comprises an inlet for supplying the first effluent 4 into the first distiller B and at least one outlet for discharging the bottom fraction HCB and a middle distillate fraction MD. The flow connection between the hydrocracking reactor A and the first distiller B is arranged through a pipe connection between the outlet of the hydrocracking reactor A and the inlet of the first distiller B. The first distiller B is arranged downstream of the hydrocracking reactor A. The dewaxing unit C is in a flow connection with the first distiller B for dewaxing the bottom fraction HCB to provide a

second effluent 6. In an embodiment, unit C is a solvent dewaxing reactor. The dewaxing unit C comprises an inlet for supplying the bottom fraction HCB into the dewaxing unit C and an outlet for discharging the second effluent 6. The flow connection between the first distiller B and the dewaxing unit C is arranged through a pipe connection between the outlet of the first distiller B discharging the bottom fraction HCB and the inlet of the dewaxing unit C. The dewaxing unit C is arranged downstream of the first distiller B. The second distiller D is in a flow connection with the dewaxing unit C for fractioning the second effluent 6 to provide at least a middle distillate fraction MD and base oil. The second distiller D comprises an inlet for supplying second effluent 6 into the second distiller D and at least one outlet, but preferably two outlets, for discharging the middle distillate MD and base oil. The flow connection between the dewaxing unit C and the second distiller D is arranged through a pipe connection between the outlet of dewaxing unit C and the inlet of the second distiller D. The second distiller D is arranged downstream of the dewaxing unit C and comprises at least one outlet for discharging the middle distillate MD and base oil.

In a further aspect, the invention provides an arrangement for producing oil-based components, the apparatus comprising:

- a hydrocracking reactor A for cracking a waxy feed to provide a first effluent 4, said hydrocracking reactor A comprising at least one inlet for supplying a feedstock to the hydrocracking reactor A and an outlet for discharging the first effluent 4 from the hydrocracking reactor A;
- a first distiller B in a flow connection with the hydrocracking reactor A for fractioning the first effluent 4 to provide at least a bottom fraction HCB and a middle distillate fraction MD, the first distiller B being arranged downstream of the hydrocracking reactor A;
- a dewaxing unit C in a flow connection with the first distiller B for dewaxing the bottom fraction HCB to provide a second effluent 6, the dewaxing unit C being arranged downstream of the first distiller B; and
- a second distiller D in a flow connection with the dewaxing unit C for fractioning the second effluent 6 to provide at least a middle distillate MD and base oil, the second distiller D being arranged downstream of the dewaxing unit C and comprises at least one outlet for discharging the middle distillate MD and the base oil.

The following examples are given for further illustration of the invention without limiting the invention thereto.

Example

Feedstock comprising 20 wt.% slack wax and a balance of VGO was introduced to a hydrocracking reactor comprising a hydrotreatment zone and a hydrocracking zone. The content of sulphur and nitrogen of the feedstock was 1.3 wt.% and 0.079 wt.%, respectively. The viscosity index of the feedstock was 106. The conversion level was about 56%.

The feedstock was introduced to the hydrocracking reactor at a temperature of about 400°C and at a pressure of about 132 bar. The feed of hydrogen per feedstock was 1.1 L/L.

As a reference, 100% VGO feedstock was introduced to the hydrocracking reactor under the same conditions.

The effluent from the hydrocracking reactor was fed to a distiller. A bottom fraction (HCB) boiling above 370°C, and a middle distillate fraction boiling in the range of about 300°C to about 370°C were obtained. The yield of the bottom fraction with 20 wt.% slack wax addition to VGO was surprisingly increased, at low conversion level of about 56%, from 31% to 35% as compared to a VGO feed without slack wax. The cetane number of a middle distillate fraction was increased from 60 (100% VGO) to 64 (80% VGO/20% slack wax).

The bottom fraction was solvent dewaxed (SDW) to provide base oil with a viscosity index of >130 and additional middle distillate having a cetane number of 64. Catalytic dewaxing processes are especially developed to improve the cold properties of the base oil products without sacrificing the viscosity index. Therefore, SDW can be used as an indicator of the viscosity index also of the catalytically dewaxed product. SDW is also a generally accepted and used method in the field and correlates well with catalytic dewaxing.

Figure 2 shows that the viscosity index of base oil at a conversion level of about 56% was remarkable higher with 20 wt.% slack wax addition than that of pure VGO feed. Base oil obtained from the solvent dewaxing, having a viscosity index of at least 130 was achieved even with 4 cSt product. Figure 2 further shows that the viscosity index of the base oil is increased by more than about 10 units compared to that of base oil which is prepared from VGO without wax.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. A method of producing oil-based components, comprising the steps of:
- providing VGO and slack wax;
- combining the VGO as a major component and the slack wax as a minor component to provide a feedstock;
- subjecting the feedstock to a hydrocracking step to provide a first effluent;
- fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction;
-recovering the bottom fraction and the middle distillate fraction.

2. The method of claim 1, wherein
- the bottom fraction is subjected to a dewaxing step to provide a second effluent;
- the second effluent is fractionated to provide at least a middle distillate and base oil;
- recovering the middle distillate and the base oil.

3. A method for improving the viscosity index of base oil, comprising the steps of:
- providing VGO and slack wax;
- combining the VGO as a major component and the slack wax as a minor component to provide a feedstock;
- subjecting the feedstock to a hydrocracking step to provide a first effluent;
- fractionating the first effluent to provide at least a bottom fraction and a middle distillate fraction;
- subjecting the bottom fraction to a dewaxing step to provide a second effluent;
- fractionating the second effluent to provide at least a middle distillate and base oil;
- recovering the middle distillate and the base oil.

4. The method of any one of the preceding claims, wherein the feedstock comprises at most about 30 wt.% slack wax, specifically at most about 25 wt.%, more specifically at most about 20 wt.%, even more specifically 1-25 wt.%, still even more specifically 10-20 wt.%, the balance being the VGO.

5. The method of any of the preceding claims, wherein the slack wax is provided as unpurified slack wax obtained from solvent dewaxing of a waxy petroleum feed.

6. The method of any one of the preceding claims, wherein the feedstock comprises at most about 0.18 wt.% nitrogen, at most about 2 wt.% sulphur, and about 45 wt.% aromatic compounds.

7. The method of any one of the preceding claims, wherein the feedstock is subjected to a hydrotreatment step before the hydrocracking step.

8. The method of any one of the preceding claims, wherein the conversion level in the hydrocracking step is in the range of about 55% to about 75%, specifically about 56%.

9. The method of any one of the preceding claims, wherein the bottom fraction has a boiling temperature above 370°C.

10. The method of any one of the preceding claims, wherein the boiling range of the middle distillate fraction and the middle distillate is about 300°C to about 370°C.

11. The method of any one of claims 2 to 10, wherein the viscosity index of the base oil is increased by more than about 10 units compared to that of base oil prepared from VGO without wax.

12. An arrangement for producing oil-based components, the apparatus comprising:

- a hydrocracking reactor (A) for cracking a waxy feed to provide a first effluent (4), said hydrocracking reactor (A) comprising at least one inlet for supplying a feedstock to the hydrocracking reactor (A) and an outlet for discharging the first effluent (4) from the hydrocracking reactor (A);
- a first distiller (B) in a flow connection with the hydrocracking reactor (A) for fractioning the first effluent (4) to provide at least a bottom fraction (HCB) and a middle distillate fraction (MD), the first distiller (B) being arranged downstream of the hydrocracking reactor (A);
- a dewaxing unit (C) in a flow connection with the first distiller (B) for dewaxing the bottom fraction (HCB) to provide a second effluent (6), the dewaxing unit (C) being arranged downstream of the first distiller (B); and
- a second distiller (D) in a flow connection with the dewaxing unit (C) for fractioning the second effluent (6) to provide at least a middle distillate (MD) and base oil, the second distiller (D) being arranged downstream of the dewaxing unit (C) and comprises at least one outlet for discharging the middle distillate (MD) and the base oil.

13. The arrangement of claim 12, wherein the hydrocracker reactor is a fixed bed hydrocracker.

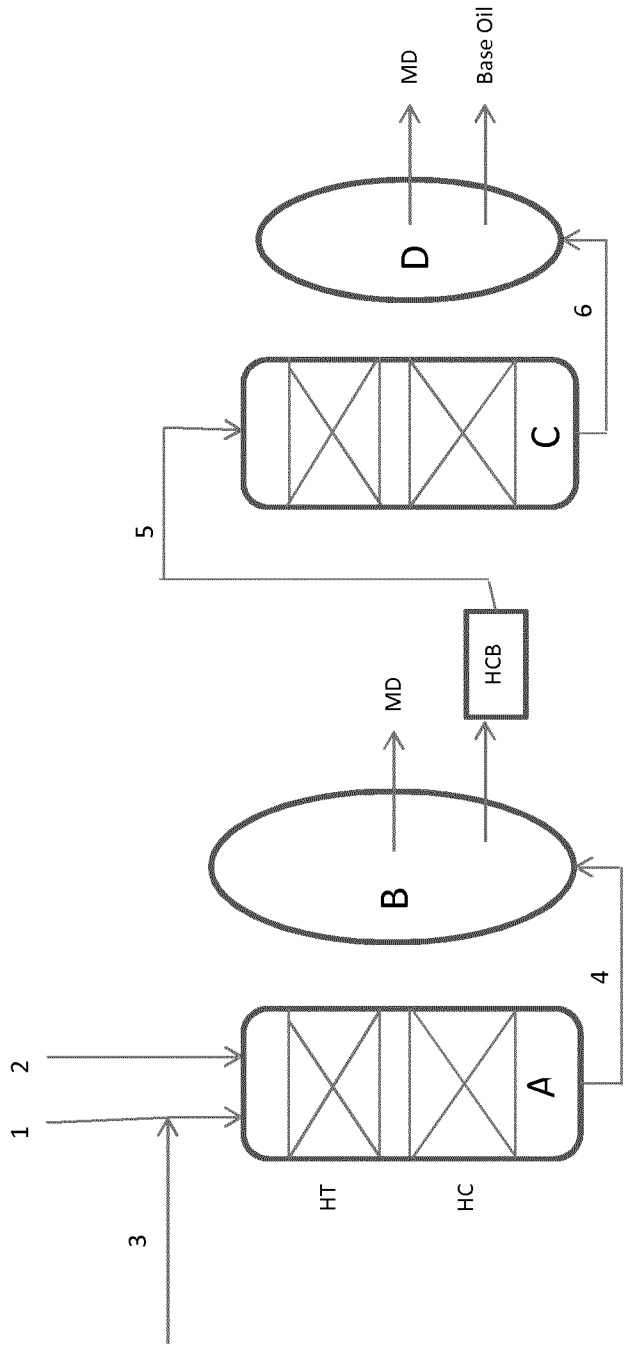

Fig. 1

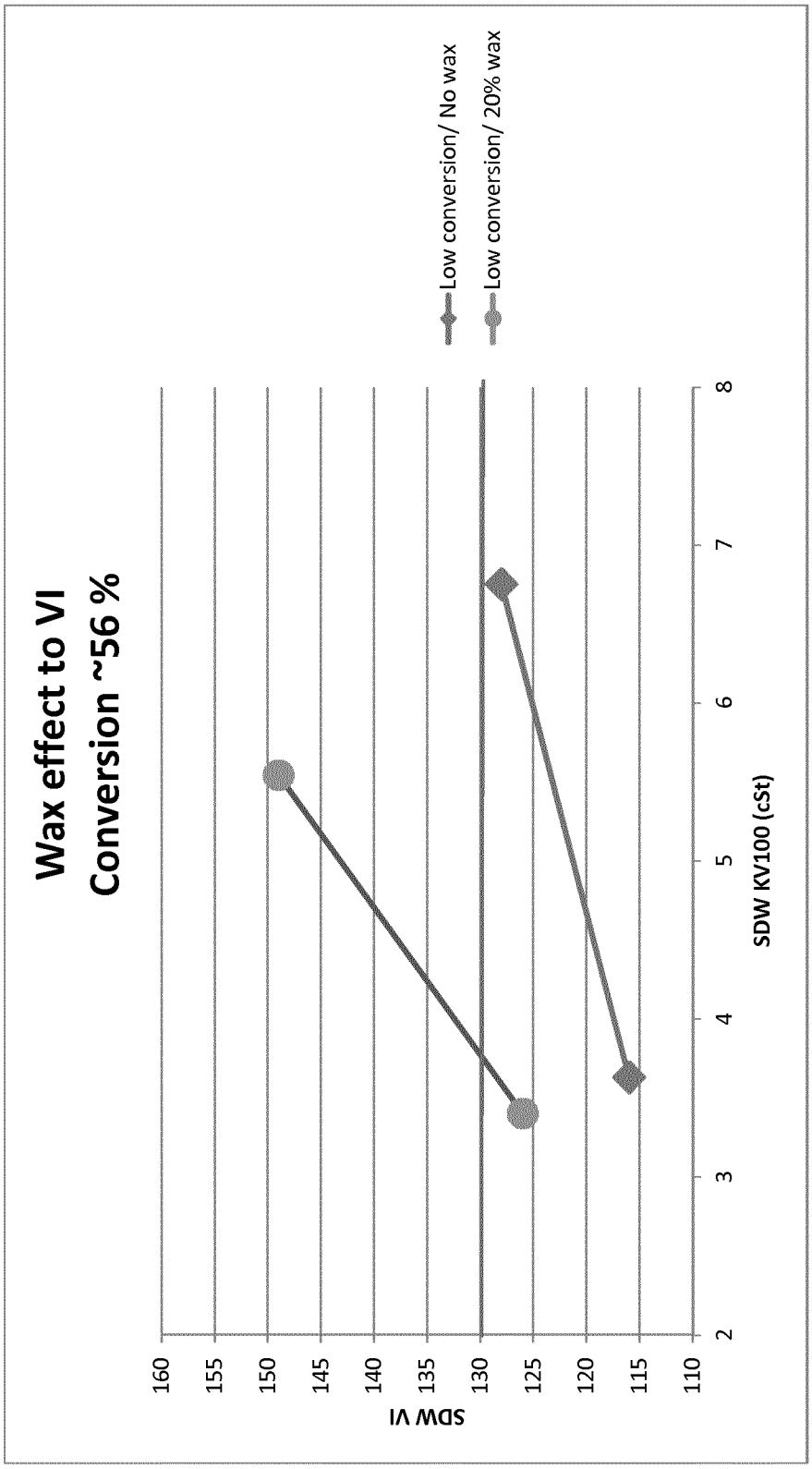
Wax effect to VI
Conversion ~56 %
Low conversion/ No wax
Low conversion/ 20% wax
SDW VI
160
155
150
145
140
135
130
125
120
115
110
SDW KV100 (cSt)
2
3
4
5
6
7
8

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/058365

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10G49/00 C10G47/00 C10G45/58 C10G73/06 C10G65/12 C10G67/04
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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/175794 A1 (DUININCK JAKOB W [FR] ET AL) 2 August 2007 (2007-08-02) paragraphs [0001], [0013] - [0019] paragraph [0021] paragraph [0055]; figure 1 -----	1-13
A	US 8 404 912 B1 (MILLER STEPHEN JOSEPH [US]) 26 March 2013 (2013-03-26) column 1, lines 6-10 column 2, lines 20-29 column 4, lines 4-6 column 4, line 62 - column 5, line 14 column 8, lines 5-14 claims 1,14 ----- -/--	1-13

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 2016	07/06/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Vaz, Miguel

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/058365

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 315 891 B1 (RICHTER FERDINAND [DE] ET AL) 13 November 2001 (2001-11-13) drawing; column 3, line 47 - column 4, line 63 column 2, lines 11-13 column 4, lines 37-40; table 3 column 6, line 17	1-13
A	US 2004/245147 A1 (BOUCHER ASHE HEATHER A [CA]) 9 December 2004 (2004-12-09) paragraphs [0016], [0018] paragraphs [0021], [0029], [0030], [0032] paragraph [0017]	1-13
A	US 2014/042056 A1 (DAAGE MICHEL [US] ET AL) 13 February 2014 (2014-02-13) paragraphs [0042], [0045]	1-13
A	US 2007/278134 A1 (TIMKEN HYE KYUNG [US] ET AL) 6 December 2007 (2007-12-06) paragraph [0008]	1-13

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/058365

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007175794 A1	02-08-2007	CN 1926220 A	07-03-2007
		EP 1733008 A1	20-12-2006
		JP 2007526380 A	13-09-2007
		KR 20060130675 A	19-12-2006
		US 2007175794 A1	02-08-2007
		WO 2005085393 A1	15-09-2005
US 8404912 B1	26-03-2013	CA 2862652 A1	14-11-2013
		CN 104080891 A	01-10-2014
		EP 2847302 A1	18-03-2015
		JP 2015519443 A	09-07-2015
		KR 20150018761 A	24-02-2015
		SG 11201404569R A	28-08-2014
		US 8404912 B1	26-03-2013
		WO 2013169367 A1	14-11-2013
US 6315891 B1	13-11-2001	EP 0921184 A1	09-06-1999
		JP 4020521 B2	12-12-2007
		JP H11269470 A	05-10-1999
		SG 75901 A1	24-10-2000
		US 6315891 B1	13-11-2001
		ZA 9809528 A	19-04-2000
US 2004245147 A1	09-12-2004	CA 2526088 A1	06-01-2005
		EP 1633833 A1	15-03-2006
		JP 2006527275 A	30-11-2006
		KR 20060005007 A	16-01-2006
		US 2004245147 A1	09-12-2004
		WO 2005001001 A1	06-01-2005
US 2014042056 A1	13-02-2014	CA 2879867 A1	13-02-2014
		EP 2882831 A1	17-06-2015
		US 2014042056 A1	13-02-2014
		WO 2014025598 A1	13-02-2014
US 2007278134 A1	06-12-2007	US 2007278134 A1	06-12-2007
		WO 2007143435 A2	13-12-2007