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PROCESS FOR THE PRODUCTION OF HIGH VISCOSITY INDEX LUBRICATING OILS

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ABSTRACT OF THE DISCLOSURE

A process for the production of a wide range of high viscosity index lubricating oils by hydrocracking a first feed, separating a light oil fraction from the hydrocrackate, hydrocracking a second feed and the light oil fraction together, and recovering high viscosity index lubricating oils, including a 100–150 neutral oil with a viscosity index of at least 100 and an 800+ neutral oil with a viscosity index of at least 95. The second feed is no heavier than the first feed, and preferably is lighter. Reaction conditions and oil cut points are specified. Stabilization and dewaxing may follow the two hydrocracking steps.

BACKGROUND OF THE INVENTION

This invention relates to the production of lubricating oils. More particularly, it relates to the production of high viscosity index oils by hydrocracking.

Viscosity index (VI) is a measure of an oil's rate of of change of viscosity with temperature. A higher viscosity index indicates that the oil's viscosity change is small over a wide range of temperatures. Thus a high VI oil is one that does not thin out at high temperatures nor become viscous at low temperatures. Because of this property, high VI oils are considered premium oils. The best light oils are those with VI's of at least 100; and the best heavy oils are those with VI's of at least 95.

Many lubricating oils as produced do not have particularly high VI's. Consequently, a number of processes have been proposed in the art for increasing the VI of oils. These have included processes in which high VI components are added to a low VI oil or in which a low VI oil is hydroprocessed to raise the VI. Solvent extraction has also been used to improve VI; the low VI components are extracted from the oil leaving only the high VI components. It is apparent that each of these processes has some disadvantageous features; either foreign materials must be added to the oil or some oil yield is lost through extraction, or additional processing steps are required.

In recent years, hydroprocessing has been actively investigated as a means for producing lubricating oils with high VI's. These investigations have centered around two basic types of hydroprocesses, hydrocracking and hydrogenation. In general, hydrogenation has been used as a finishing step in lubricating oil manufacture. The raw oils, either straight-run or produced by solvent extraction or some similar type of separation process, are hydrogenated at relatively mild conditions. A typical such process is disclosed in U.S. Patent 2,967,144, in which oxidation stability of an oil is improved by hydrogenation. Hydrocracking, which has been considerably less prominent in the lubricating oil area, has been used primarily to produce certain types of lubricating oils. A typical single stage process is disclosed in U.S. Patent 2,960,458. Occasionally the two processes have been combined with the hydroegnation step being used to upgrade the oil produced by hydrocracking. Typical examples of this combination will be found in U.S. Patents 2,779,713; 2,787,582; and 2,917,448.

Until now, however, the existing hydrotreating processes have not been capable of producing high VI oils with a wide range of viscosities. When hydrocrackers were operated to produce high VI light neutral oils (as defined below), there would be a very poor yield of the heavy neutral oils. Conversely, when hydrocracking under conditions to produce good yields of heavy neutral oils, the VI's of the light neutral oils would be seriously affected.

SUMMARY OF THE INVENTION

We have now discovered a novel process for the production of high viscosity index lubricating oils with a wide range of viscosities which comprises: hydrocracking in a first hydrocracking zone, at a temperature of 700°–850° F., to a conversion of at least 20 percent to materials boiling below its initial boiling point, a first hydrocarbon oil feed, boiling in the range of 800°–1,200° F. and containing less than 5 weight percent asphaltenes; separating from the effluent of the first zone a plurality of hydrocarbon fractions including at least one light oil fraction boiling in the range of 700–900° F.; hydrocracking in a second hydrocracking zone, to a conversion of at least 20 percent to materials below the second feed initial boiling range and at a temperature of 700°–850° F., the light oil fraction and a second hydrocarbon oil feed boiling in the range of 700°–1,100° F., having an average boiling point no higher than the average boiling point of the first oil feed, and containing less than 5 weight percent asphaltenes and finally recovering from the effluents of both zones a plurality of lubricating oils, including from the effluent of said first zone at least one 800+ neutral oil having a viscosity index of at least 95 and from the effluent of said second zone at least one 100–150 neutral oil having a viscosity index of at least 100. Preferably each oil feed contains less than 1 weight percent asphaltenes, because oils with high alphaltenes contents tend to foul the hydrcracking catalysts. The hydrocracked effluents of each zone may be wholly or partially dewaxed and/or stabilized to ultraviolet light.

DETAILED DESCRIPTION OF THE INVENTION

In its broadest embodiment, the process of this invention comprises hydrocracking in a first hydrocracking zone at a temperature of 700°–850° F., to a conversion of at least 20 percent to materials boiling below its initial boiling point, a first hydrocarbon oil feed, boiling in the range of 800°–1,200° F. and containing less than 5 weight percent asphaltenes; separating from the effluent of said first zone a plurality of fractions, including at least one light oil fraction boiling in the range of 700°–900° F.; hydrocracking in a second zone, at a temperature of 700°–850° F., to a conversion of at least 20 percent to materials boiling below the second feed initial boiling point, the light oil fraction and a second hydrocarbon oil feed boiling in the range of 700°–1,100° F., having an average boiling point no higher than the average boiling point of said first oil feed, and containing less than 5 weight percent asphaltenes; and finally recovering from the effluents of both zones a plurality of lubricating oils, including from the effluent of said first zone at least one 800+ neutral oil having a viscosity index of at least 95 and from the effluent of said second zone at least one 100–150 neutral oil having a viscosity index of at least 100. Preferred forms of the process of this invention will be described below.

The two hydrocracking zones are principal features of the process of this invention. They are conventional hydrocracking zones, comprising catalyst-containing vessels in which the lubricating oil stocks are converted to the desired products in the presence of hydrogen and a catalyst. Suitable hydrocracking catalysts for use in the

process of this invention are those solid contact materials having the properties of accelerating scission of carbon-carbon bonds and of accelerating hydrogenation of cracked hydrocarbon fragments so produced. For purposes of the present invention in its preferred aspects, is is highly advantageous to employ a catalyst which maintains high activity throughout continuous operation for periods of time of at least 600 hours, and more preferably in the neighborhood of from two to several thousand hours, without regeneration. These requirements are met by many known catalysts, which usually are composed of a refractory oxide in combination with an active hydrogenating metal component of Group VIII of the Periodic Table and a hydrogenating metal component of Group VI of the Periodic Table. It is generally desirable to convert the metal components to the sulfides to develop their maximum catalytic activity for hydrocracking oils containing nitrogen compounds.

Particularly good refractory oxides are the high surface porous oxide cogels or coprecipitates of silica with alumina or magnesia, wherein the silica and the alumina or magnesia are each present to the extent of at least 10 percent. Other high surface area cogels with materials such as zirconia, titania, or boria can also be used. The single ingredients alumina, silica, or magnesia do not themselves appear to have sufficient cracking activity to be considered within the preferred refractory oxides. Preferred Group VIII components are the oxides and sulfides of the iron group and noble metals, cobalt, nickel, platinum, and palladium, and especially nickel. Preferred Group VI components are the oxides and sulfides of molybdenum and tungsten. Thus examples of hydrocracking catalysts which would be preferred for use in the process are the combinations nickel-tungsten-silica-magnesia, nickel-tungsten-silica-alumina, nickel-molybdenum-silica-alumina, and nickel-molybdenum-silica-magnesia. Such catalysts may vary greatly in their activities for hydrogenation and for cracking and in their ability to sustain high activity during long periods of use depending on their compositions and methods of prepaation. Obviously, the best proven catalyst available is selected, taking into consideration all of the above factors and also price.

Numerous schemes can be devised for bringing together the oils, hydrogen, and the catalyst at the temperature and pressure conditions for catalytic hydrocracking. Thus, the catalyst may be suspended in the oil as finely divided particles, or it may gravitate through the oil as relatively large particles. The oil and hydrogen may be passed upwards or downwards concurrently or countercurrently in one or more parallel or series-connected reaction chambers. Probably the most suitable commercial method for carrying out the process continuously, however, comprises preheating the oil and hydrogen under pressure and then passing them downward through one or more stationary beds of catalyst particles contained in a high pressure reactor. The amount of hydrogen passed through the reactor is in substantial excess of the amount consumed in hydrogenation reaction occurring therein, and the gas used is sufficiently pure, so that the hydrogen partial pressure at all times constitutes the major portion of the total pressure. Hydrogen consumption in each zone is in excess of 500 standard cubic feet per barrel of fresh feed, and a particularly preferred range of hydrogen consumption is 1200–3000 standard cubic feet of hydrogen per barrel of fresh feed. If desired, excess hydrogen from the first zone may be passed into the second zone.

The hydrocarbon oil feed to the first zone, referred to as the "first feed," is a hydrocarbon oil boiling in the range of 800°–1,200° F. It may be a heavy straight-run gas oil, a deasphalted oil, or the like. It may previously have been desulfurized or denitrified. Preferred first feeds are those boiling at 900° F. or higher. The hydrocarbon oil feed to the second reaction zone, referred to as the "second feed," is a hydrocarbon oil boiling in the range of 700°–1,100° F. and is no heavier than the first stock (i.e., has an average boiling point no higher than the average boiling point of the first stock). Preferably, the second feed is somewhat lighter than the first feed, for the former is primarily intended to be a source of the lighter neutral oils, while the latter is primarily intended to be a source of the heavy neutral oils. The second feed may also be a straight-run gas oil or any other hydrocarbon oil boiling within the proper range. Because of poisoning effect on the catalysts caused by cracking of asphaltenes to coke, it is required that the stocks each contain less than 5 percent, by weight, of asphaltenes. Preferably, in order to minimize poisoning, the asphaltene content is below 1 percent, by weight.

Reaction conditions in the first zone are temperatures within the range of 700°–850° F., hydrogen pressures between 1,000–5,000 p.s.i.g., and liquid hourly space velocities between 0.1–10.0. At these conditions there is at least 20 percent conversion of the feed material to products boiling below the feed initial boiling point. Under these conditions a variety of reaction products will be formed as the high boiling first stock is cracked to lower boiling products. The effluent of this zone will contain, among other products, a light oil fraction boiling between 700°–850° F. This product is separated from the reaction zone effluent and passed to the second zone for further hydrocracking, this time simultaneously with the second stock. Reaction conditions in the second zone are within the same ranges as in the first zone; but, because the feed to the second zone contains lighter materials, the precise reaction conditions are somewhat milder. It is preferred to obtain these milder conditions by holding temperature and pressure approximately by the same in both reaction zones, but permitting a higher liquid hourly space velocity in the second zone. Particularly preferred is a space velocity 1.5–3.0 times greater than that in the first zone.

The effluents of the two hydrocracking zones contain a wide variety of products. Some are light gases and other products boiling below the lubricating oil range, and these are separated and recovered as products or passed on to further processing. The various lubricating oil fractions are separated according to their "neutral oil" ratings. A neutral oil rating is simply the viscosity of a given oil fraction at 100° F.; thus, a "100 neutral oil" is an oil fraction which has a viscosity of 100 S.U.S. at 100° F.

The advantages of the process over those of the prior art lie in the ability of this process to produce a wide viscosity range of oils, all of which have high VI's. Consequently, it is required that included among the lubricating oils recovered from the effluents of the zones be at least one oil having a neutral oil rating between 100 and 150 (i.e., a 100–150 neutral oil) and a VI of at least 100, and at least one oil having a neutral oil rating of at least 800 (i.e., an 800+ neutral oil) and a VI of at least 95. In a typical operation of the process of this invention, a 130 neutral oil, a 300 neutral oil, and an 800 neutral oil would be separated and recovered. Other combinations are often used and can be adjusted to meet the processor's needs.

Occasionally the oils as produced, especially the heavier neutral oils, do not have sufficiently low pour points to meet a particular specification. In this case, it is preferred to dewax that portion of the zone effluents, which is to be separated into the lubricating oils (as e.g., by distillation), prior to that separation. Dewaxing may be by conventional methods, such as solvent dewaxing. A preferred method is the novel catalytic dewaxing process claimed in copending application Ser. No. 704,556.

In the past it has been noticed that some oils produced by hydrocracking show a degree of instability in the presence of ultraviolet light This instability is evidenced by the formation of a dark precipitate when the oil is

exposed to natural or artificial ultraviolet light. The light neutral oils tend to show a higher degree of instability (e.g., by forming a precipitate more rapidly) than do the heavier neutral oils. This instability can be overcome by conventional stabilization processes, the most common of which is solvent extraction with a solvent such as phenol or furfural.

The following example will illustrate the process of this invention. In the first reaction zone, a 900°–1,150° F. straight-run gas oil having a gravity of 19.0° API, a sulfur content of 0.7 percent, and nitrogen content of 0.22 percent was hydrocracked over a catalyst comprising nickel and tungsten on an active cracking support. The reaction temperature was 790° F., the hydrogen partial pressure was 2,200 p.s.i.g., and the liquid hourly space velocity of the feed was 0.85. Hydrogen throughput was 8,000 s.c.f./bbl. of which 1,200 s.c.f./bbl. was consumed. The reaction products of the first zone were a 50 percent yield of 750° F.— hydrocarbons, a 9 percent yield of 750°–840° F. light lubricating oil, a 9 percent yield of an 840°–910° F. heavy lubricating oil, and a 32 percent yield of a 910° F.+ heavy oil. The products were nitrogen- and sulfur-free, the nitrogen and sulfur having been converted to ammonia and H_2S, respectively. On dewaxing, the 840°–910° F. cut produced a 300 neutral oil having a VI of 97 while the 910° F.+ cut produced an 800 neutral oil having a VI of 98.

The light lubricating oil boiling between 750°–840° F. and having a VI below 90, was passed to a second reaction zone in which it was combined as one part in ten with a straight-run gas oil to make a feed boiling in the range of 670° F.–1,095° F. This feed had a gravity of 22.3° API, a sulfur content of 0.4 percent, and a nitrogen content of 0.19 percent. This feed was hydrocracked over the same type of catalyst as that in the first reaction zone at a temperature of 790° F., a liquid hourly space velocity of 1.25, and a hydrogen partial pressure of 2,200 p.s.i.g. The hydrogen throughput rate was 8,000 s.c.f./bbl. of which 1,000 s.c.f./bbl. was consumed. The products of this second reaction zone were a 64 percent yield of 750° F.— hydrocarbons, a 19 percent yield of a 750°–850° F. oil which, when dewaxed, produced a 130 neutral oil having a VI of 100, and a 17 percent yield of an 850° F.+ oil which, on dewaxing, produced a 300 neutral oil having a VI of 106.

The individual oil samples and VI measurements were made on samples of the separate effluents. The effluents of both reaction zones (except for the test samples removed) were combined for dewaxing and stabilizing and then were distilled into the respective cuts: a 750° F. light hydrocarbon cut, the 130 neutral oil with a VI of 100, a combined 300 neutral oil having a VI of 103, and the 800 neutral oil with a VI of 98.

The example and data above are given for illustrative purposes and are not meant to limit the scope of the process of this invention. The invention is to be limited only in accordance with the appended claims.

We claim:

1. A process for producing a lubricating oil stock comprised of high viscosity index fractions having a wide range of viscosities, which comprises contacting, in a first hydrocracking step, a first hydrocarbon oil feed having as asphaltene content below 5% by weight and boiling in the range about 800° to 1200° F. and hydrogen with a solid hydrocracking catalyst under hydrocracking conditions to convert the feed to a product having a substantial proportion, not less than 20% by volume of the feed, to products boiling below the initial boiling point of the feed and a substantial content of 800 neutral oil having a viscosity index above 95, separating from the product of the first hydrocracking step a fraction boiling in the range about 700° to 900° F., contacting in a

second hydrocracking step a combined feed comprising said separated fraction and a second hydrocarbon oil feed having an asphaltene content below 5% by weight and boiling in the range about 700° to 1100° F. and hydrogen with a solid hydrocracking catalyst under hydrocracking conditions to convert a substantial proportion at least 20% by volume of said combined feed to products boiling below the initial boiling point of the combined feed, the catalyst in both hydrocracking steps being comprised of a hydrogenation component and a refractory oxide cracking component.

2. The process of claim 1, wherein the asphaltene content of each of said hydrocarbon oil feeds is below 1% by weight.

3. The process of claim 1, wherein the average boiling point of the second hydrocarbon oil feed is below the average boiling point of the first hydrocarbon oil feed.

4. The process of claim 1, wherein the hydrocracking catalyst in both hydrocracking steps is comprised of a Group VI metal or metal compound and a Group VIII metal or metal compound supported on an acidic carrier, the temperature in both of said hydrocracking steps is maintained in the range 750° to 820° F., the pressure in both hydrocracking steps is maintained in the range 1200 to 3000 p.s.i.g., the liquid hourly space velocity in both hydrocracking steps is in the range 0.3 to 5.0, and the hydrogen consumption in both hydrocracking steps is in excess of 500 standard cubic feet per barrel of feed.

5. A process for producing a lubricating oil stock comprised of high viscosity index fractions having a wide range of viscosities, which comprises contacting, in a first hydrocracking step, a first hydrocarbon oil feed having an asphaltene content below 5% by weight and boiling in the range about 800° to 1200° F. and hydrogen with a solid hydrocracking catalyst under hydrocracking conditions to convert the feed to a product having a substantial proportion, not less than 20% by volume of the feed, to products boiling below the initial boiling point of the feed and a substantial content of 800 neutral oil having a viscosity index above 95, separating from the product of the first hydrocracking step a fraction boiling in the range about 700° to 900° F., contacting in a second hydrocracking step a combined feed comprising said separated fraction and a second hydrocarbon oil feed having an asphaltene content below 5% by weight and boiling in the range 700° to 1100° F. and hydrogen with a solid hydrocracking catalyst under hydrocracking conditions to convert a substantial proportion at least 20% by volume of said combined feed to products boiling below the initial boiling point of the combined feed, the catalyst in both hydrocracking steps being comprised by a hydrogenation component and a refractory oxide cracking component, dewaxing the remainder of the product of the first hydrocracking step and the product of the second hydrocracking step and recovering from the dewaxed products a light lubricating oil fraction about 100–150 neutral having a viscosity index above 100 and a heavy lubricating oil fraction about 800 neutral having a viscosity index above about 95.

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