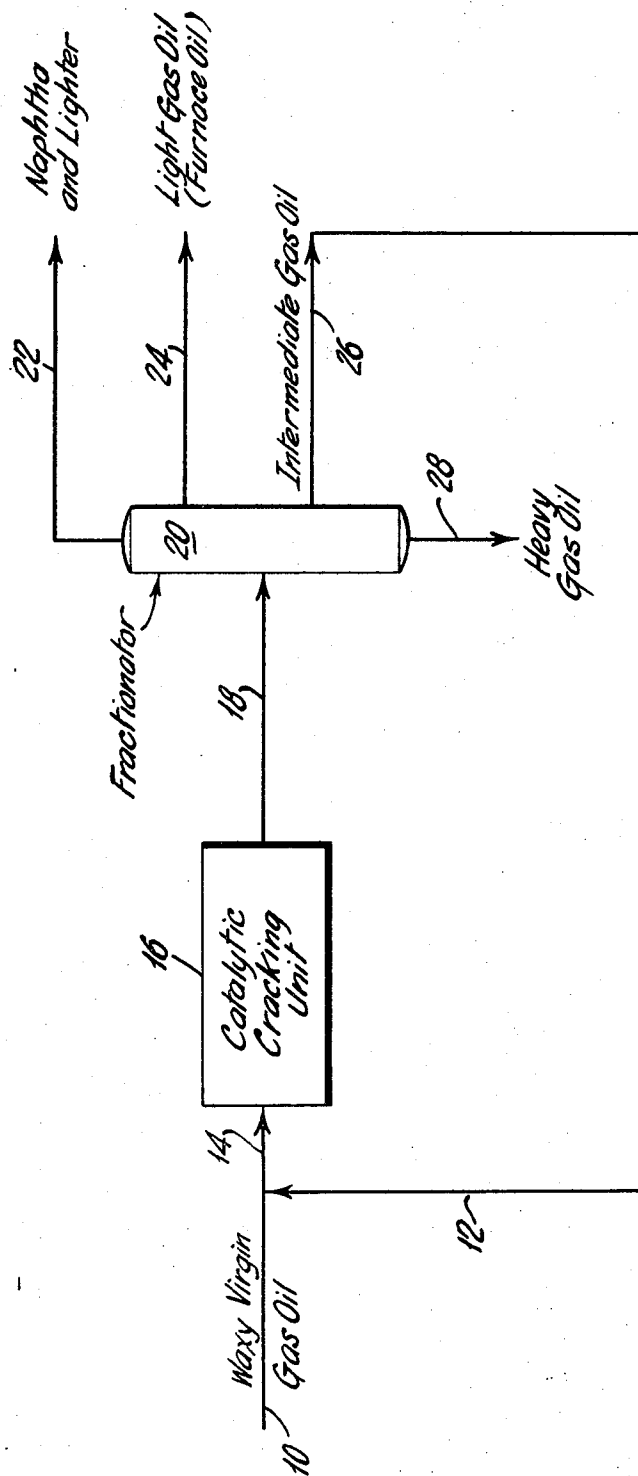


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FURNACE OIL FROM WAXY GAS OILS
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FURNACE OIL FROM WAXY GAS OILS

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8 Claims

ABSTRACT OF THE DISCLOSURE

Low pour point light cycle gas oil for use as furnace oil may be obtained when catalytically cracking a waxy gas oil if the light gas oil fraction from the catalytic cracking unit is limited to a boiling range of about 430–550° F. while an intermediate gas oil fraction therefrom having an initial boiling point of about 550 and an end point in the range of 650 to 750° F. is recycled to extinction back to the feed to the catalytic cracker. The virgin gas oil to the catalytic cracker may have an IBP of about 430 or about 550° F. To maximize furnace oil production when the IBP of the waxy gas oil feed to the catalytic cracker is about 550° F., the light gas oil fraction from the catalytic cracker is admixed with a virgin waxy gas oil having a boiling range of about 430–550° F.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of application Ser. No. 793,643, filed Jan. 15, 1969 and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to the production of furnace oil. More particularly, this invention relates to a process whereby a waxy gas oil serving as feed to a catalytic cracking unit for the production of gasoline and gasoline blending components may simultaneously produce cycle gas oils useful as low pour point furnace oils. Specifically, this invention relates to a method of (a) segregating that portion of waxy virgin gas oils and/or cycle gas oils therefrom which contains the normal paraffins most detrimental to low pour furnace oils, (b) catalytically cracking a waxy gas oil having a particular boiling range and (c) recycling to extinction that portion of the cycle gas oil containing the undesirable, high-pour-producing, normal paraffins.

The catalytic cracking of gas oils is well known. The production of gasoline from crude oil is substantially increased by the catalytic cracking processes presently in use. The light and intermediate cycle gas oil from the catalytic cracker may serve as the feed stock for preparation of furnace oil. Furnace oil is also known as fuel oil No. 1, fuel oil No. 2 or heating oil. These fuel oils are particularly useful for home and industrial heating purposes. These uses require that the oil have a low pour point of about 0° F. or lower. With the advent of processing low sulfur crudes to meet minimum air pollution standards for the combustible products obtained therefrom, a concomitant problem arises. The low sulfur crudes often are highly paraffinic which imparts a high pour point to the gas oils therefrom with the result that furnace oils prepared from these crudes will not meet the pour point specification without additional processing or substantial modifications to present processing techniques. Although dewaxing the waxy gas oil to reduce its pour point is an obvious solution to the problem, the utilization of solvent dewaxing, urea dewaxing or other dewaxing processes increases significantly the cost of producing furnace oil. Processing schemes which eliminate the need for

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dewaxing or which reduce the quantity of the material which must be dewaxed to produce satisfactory furnace oils will find use in modern petroleum refineries.

SUMMARY OF THE INVENTION

In the process of our invention, furnace oils having low pour point characteristics are obtained from the cycle gas oil of a catalytic cracking unit processing waxy gas oils. Specifically, the catalytic cracker cycle gas oil is separated into a light gas oil fraction having a boiling range of about 430–550° F. and a pour point of about 0° F. and an intermediate gas oil fraction having an initial boiling point of about 550° F. and an end point in the range of 650 to 750° F. Broadly, the gas oil from the catalytic cracking unit is separated into a light gas oil fraction having a pour point of 0° F. or lower and an intermediate gas oil fraction having an initial boiling point corresponding to the end point of the light gas oil fraction and an end point in the range of 650 to 750° F. The intermediate gas oil is recycled to the catalytic cracking unit as part of the feed thereto. The light cycle gas oil is suitable for use as furnace oil. In this process the initial boiling point, IBP, of the feed to the catalytic cracking unit is usually above 400° F., i.e., approximately 430° F. Alternately, we find that the furnace oil production can be maximized by limiting the IBP of the gas oil feed to the catalytic cracking unit to about 550° F. The 430–550° F. gas oil cut from the virgin gas oil is not introduced to the catalytic cracker but is admixed with the 430°–550° F. fraction from the cycle gas oil to produce the desired low pour point furnace oil. Broadly, this alternative embodiment may be described as removing from the virgin gas oil fuel that portion thereof having a pour point of 0° F. or lower and catalytically cracking the remaining portion. The gas oil from the catalytic cracking unit is separated into a light gas oil fraction having a pour point of 0° F. or lower and an intermediate gas oil fraction which is recycled and having an initial boiling point corresponding to the end point of the light gas oil fraction and an end point in the range of 650 to 750° F. The light gas oil fraction is admixed with the 0° F. or lower pour point fraction cut from the virgin gas oil to produce the desired low pour point furnace oil.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing is a schematic flow diagram of an embodiment of the process units and flow systems suitable for carrying out the process of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the present invention, a waxy gas oil is catalytically cracked and then fractionated to produce a light gas oil suitable for use as a furnace oil having a low pour point. Cycle gas oil fractions having a high pour point are separated from the catalytic cracker effluent in the fractionator and are recycled to extinction back to the feed to the catalytic cracking unit.

The term "waxy gas oil" as used herein when referring to the feed to the catalytic cracker is defined as one where the pour point of the 430–650° F. boiling range material in the gas oil has a pour point above about 5° F. Further, as used herein the term "low pour point" furnace oil or "low pour point" heating oil refers to a furnace oil or heating oil having a pour point of about 0° F. or lower.

Our invention may be understood from the following detailed description, taken with reference to the accompanying drawing which illustrates diagrammatically an embodiment for practicing the method of our invention.

A waxy gas oil charge stock, such as an Amal Nafoora gas oil, introduced into the system through line 10 is com-

bined with a recycled stream entering from line 12 and passes through line 14 into catalytic cracking unit 16 where it is contacted with a bed of cracking catalyst. The fresh feed to the catalytic cracker is a virgin waxy gas oil having a boiling range above about 400° F., e.g., approximately 430–850° F. The catalytic cracking unit 16 may comprise either a fluidized catalytic cracking unit or a moving bed type catalytic cracking unit, both of which are well known. Fluidized catalyst units may be of either bed cracking or riser cracking design.

Effluent from the catalytic cracking unit 16 is passed via line 18 to fractionator system 20 where it is separated into a plurality of fractions. As illustrated in the specific embodiment of the drawing, the catalytic cracking unit product is separated into (a) a fraction boiling below about 430° F. at atmospheric pressure e.g., naphtha and lighter, which is discharged through line 22; (b) a light gas oil fraction, having a boiling range of about 430–550° F. discharged through line 24; (c) an intermediate gas oil having an initial boiling point of about 550° F. and an end point in the range of 650 to 750° F. discharged through line 26; and (d) a heavy gas oil, e.g. the bottoms from the fractionator having a 650 to 750° F. plus boiling range discharged through line 28.

The light gas oil recovered from the fractionator and having a boiling range of about 430 to about 550° F. is a principal product of the process and is used as a feed stock for the production of low pour point furnace oil. Conventional caustic washing, a process well known in the art, may be and usually is required to produce a saleable product. Since a waxy gas oil is being cracked, a 550–650° F. intermediate gas oil cut from the fractionator has too high a pour point to permit its inclusion in the furnace oil. Accordingly, this cut from the fractionator is recycled through lines 26 and 12 back to line 10 where it is admixed with virgin waxy gas oil to serve as the feed to the catalytic cracker. This cycle gas oil is recycled to extinction with no net make of intermediate gas oil being included in the furnace oil feed stock. The waxy gas oil bottoms from the reactor passes through line 28 and may be recycled for inclusion in the gas oil feed to the catalytic cracker if of proper quality. However, this particular stream normally contains a high concentration of polycyclic aromatics making it a highly refractory stream. It may be desirable to hydrogenate this heavy gas oil to reduce the concentration of aromatic and polycyclic aromatics in this stream. Upon hydrogenation the heavy cycle gas oil has many of the qualities of fresh feed making it a desirable component to be recycled for admixing with the virgin gas oil feed to catalytic cracker 16.

The process of this invention is related to the production of furnace oil. In domestic U.S. refineries a significant quantity of furnace oil is normally produced from light or intermediate cycle gas oils or mixtures thereof which are produced in a catalytic cracking unit. Furnace oil (also fuel oil No. 2, or heating oil), has a pour point requirement of 0° F. and a boiling range of about 430–650° F. A 430–550° F. boiling range will satisfy the specifications for fuel oil No. 1 if the pour point is about –30° F.

Recent concern over the potential hazards of air pollution has lead to studies which identify sulfur compounds in the atmosphere as being particularly troublesome and suggest that a major reduction in the emission of sulfur products into the atmosphere is desirable. One means offered for achieving this result is to reduce the sulfur content of fossil fuels used in stationary power, electric generating plants and home heating units. Among the methods suggested to achieve the desired result of reducing the sulfur content of fuel oil is the substitution of low sulfur content crude oils for the high sulfur crudes being used in the production of fuel oils. Not all of the low sulfur crude oils can be substituted directly for the higher sulfur-containing crude oils being processed currently. For example, some of the low sulfur crude oils are highly paraffinic, i.e., waxy, in nature. Thus, a Libyan crude, hav-

ing a low sulfur content and therefore very desirable for fuel oil production, yields fuel oils having pour points above specification where conventional or prior art processing techniques are employed. To handle increasing quantities of waxy crudes in a given refinery it is necessary to resort to alternative processing schemes to reduce the pour point of the furnace oils. Perhaps one obvious processing scheme is to dewax that portion of the low sulfur crude oil which is ultimately used in furnace oil production. However, alternate schemes which avoid the use of expensive dewaxing processes would be particularly desirable.

We have found that the pour point of a 430–550° F. virgin Libyan crude (Amna) gas oil is 0° F. However, if a significant amount of a heavier virgin gas oil, i.e., having an IBP greater than 550° F., is combined with the light virgin gas oil, a pour point in the range of +10 to +35° F. is obtained. We further found that the higher the carbon number of the normal paraffin present in a gas oil the greater its influence on increasing the pour point of the gas oil. Thus, for example, 1% of a C₂₀ normal paraffin will raise the pour point of a 430–650° F. gas oil 50° F. while 1% of a C₁₅ normal paraffin will increase the pour point of that same gas oil only about 17° F. It is apparent that normal paraffin content alone does not determine the pour point, but in addition the carbon number distribution of the normal paraffins is significant. A C₂₀ normal paraffin has a boiling point of 651° F. which means that because of distillation overlap a significant amount of this particular normal paraffin will be present in a 650° F. end point gas oil. Since it is the quality of the wax in addition to the quantity present which influences the pour point of the gas oil and the furnace oil produced therefrom, we found that the wax in a 550–650° F. gas oil increases the pour point substantially more than the same amount of wax in the corresponding 430–550° F. gas oil. For example, in a 430–550° F. virgin gas oil containing 1.7 to 2.1 wt. percent normal paraffins, based on whole crude, the pour point was 0° F. as compared to a 550–650° F. virgin gas oil containing 1.0 to 1.7 wt. percent normal paraffins, based on whole crude, wherein the pour point was +45° F.

The process of our invention relates to the processing of waxy gas oil by a combination of catalytic cracking and fractionation to produce low pour point-low cloud point cycle gas oils useful as furnace oils. Any of the normally low sulfur, highly paraffinic gas oils may be employed in this process, for example, low-sulfur, waxy gas oils obtained from such crude oils as Amal Nafuora (Amna), Libyan, Minas and Nigerian crude. The waxy gas oils serving as feed to the catalytic cracking unit in our process have a boiling range above about 400° F., usually having about a 430° F. IBP and an end point of about 850–1000° F. In some instances the initial boiling point of the gas oil may be about 550° F.

The catalytic cracking units employed in the process of our invention may be any of the well known catalytic cracking units currently in service and may comprise either a fluidized catalyst bed or a moving catalyst bed. A fluidized catalytic cracking unit may be of either bed cracking or riser cracking design.

The operating conditions employed in the catalytic cracker are those well known to one skilled in the art and include, for example, an operating temperature in the range of 800 to 1100° F., preferably 850 to 1000° F., with a space velocity, based on the total feed to the catalytic cracking unit, of 0.2 to 300 lbs. of hydrocarbon feed stock per hour per pound of catalyst and a reactor pressure within the range of 0 to 200 p.s.i.g., preferably of the order of 25 p.s.i.g. The reaction conditions, particularly temperature and space velocity, are variable and are controlled to produce a per pass conversion of fresh feed of 30 to 80 vol. percent. Percent conversion is defined as 100 minus the volume percent of effluent from the catalytic cracker boiling above 430° F.

The catalyst employed in the catalytic cracking unit preferably comprises a molecular sieve or crystalline aluminosilicate base carrying catalytic metal additives, for example, rare earth metals, particularly cerium and lanthanum, their oxides or sulfides. Preferred catalysts are molecular sieve cracking catalyst of the well known commercial varieties e.g., Davison XZ-25, Aerocat Triple S-4, Nalcat KSF, Houdry HZ-1, etc. These catalysts are made up of a silica-alumina-zeolite base impregnated with or containing rare earth metal oxides.

The catalysts used in the catalytic cracking unit of this process are not limited to the molecular sieve type. The well known and commercially-proven acidic catalysts used heretofore may also be employed. These include the natural clay catalysts comprising silica-alumina as well as the synthetic silica-alumina catalysts of high or low alumina content and the silica-magnesia catalysts.

Fractionation of the effluent from the catalytic cracking unit may be performed in any conventional fractionation system well known in the art wherein the catalytic cracker effluent is separated into a plurality of fractions. The fractionator must be capable of separating the effluent into fractions such as the following, for example: a naphtha and lighter stream, a light gas oil having a boiling range of about 430-550° F., an intermediate gas oil having an initial boiling point of about 550° F. and an end point in the range of 650-750° F. and a heavy gas oil having a boiling range above 650-750° F.

In one embodiment of our invention a virgin waxy gas oil having an IBP of about 430° F. is introduced into a catalytic cracker. The effluent obtained therefrom is fractionated into cuts comprising a 430-550° F. gas oil which serves as the feed stock for the production of furnace oil and a cycle gas oil having an IBP of 550° F. and an end point in the range of 650 to 750° F. which is recycled and admixed with the feed to the catalytic cracker. This embodiment may be more broadly described as separating from the catalytic cracker effluent a light gas oil having a pour point of 0° F. or lower and an intermediate gas oil fraction having an initial boiling point corresponding to the end point of the light gas oil fraction and an end point in the range of 650 to 750° F. The light gas oil is suitable for use as furnace oil and the intermediate gas oil is recycled as feed to the catalytic cracker.

Alternatively, in another embodiment of our invention, the waxy gas oil is initially separated into a 430-550° F. cut and a 550° F. +cut. The 550° F. IBP waxy gas oil serves as the feed to the catalytic cracker as in the above embodiment. The fractions obtained from the fractionator are handled in a similar fashion; i.e., the 430-550° F. gas oil serves as the furnace oil feed stock and the 550° F. IBP, 650-750° F. end point cycle gas oil is recycled to extinction to the catalytic cracker. The 430-550° F. virgin gas oil bypasses the processing units and is admixed with the 430-550° F. cycle gas oil obtained from the fractionator to produce the low pour point furnace oil. This alternative may be broadly described as removing from the virgin gas oil feed that portion thereof having a pour point of 0° F. or lower which bypasses the catalytic cracker for subsequent admixing with similar material present in the catalytic cracker effluent. The remaining portion of the virgin gas oil is catalytically cracked producing an effluent which is separated into a light gas oil fraction having a pour point of 0° F. or lower and an intermediate gas oil fraction having an initial boiling point corresponding to the end point of the light gas oil fraction and an end point in the range of 650 to 750° F. The intermediate gas oil is recycled to extinction as feed to the catalytic cracker while the light gas oil is admixed with the 0° F. or lower pour point fraction of the virgin gas oil to produce the desired low pour point furnace oil.

The following specific examples demonstrate the ability of the process of this invention to produce low pour point

furnace oil from waxy gas oils by the combination of catalytic cracking and fractionation.

Examples I-IV

A series of four test runs illustrating the process of this invention and alternate processing sequences was made. In all instances the virgin gas oil feed to the catalytic cracker having the properties set forth below was obtained from a Amal Nafoora crude oil.

TABLE I.—FRESH CHARGE STOCK

Description	Virgin gas oil, at—	
	430-850° F.	550-850° F.
Yield, vol. percent whole crude.....	45.3	33.4
Gravity, ° API.....	36.7	34.1
Viscosity, cs. at 100° F.....	7.42	12.3
Pour point, ° F.....	65	75
Sulfur, wt. percent.....	0.16	0.18
Distillation, ° F.: ¹		
IBP.....	458	533
10.....	521	619
30.....	592	675
50.....	680	730
70.....	763	799
90.....	841	845

¹ 10 mm. vacuum distillation. Temperatures have been converted to atmospheric equivalent.

These runs were performed in a fluid catalytic cracking pilot unit together with fractionation equipment, as required. The catalyst used in these tests was an equilibrium catalyst composed of Davison XZ-25, which is a mixed silica-alumina-zeolite cracking catalyst containing about 30-35 wt. percent alumina. In addition, the catalyst had a mesh size of 60-200, a surface area of 118 m.²/g., a pore volume of 42 cc./g. and a settled density of 45.9 lb./ft.³. The equilibrium catalyst had the following activity as measured by bench tests: Texaco D+L activity (McReynolds, H. Petroleum Refiner, vol. 26, No. 12, 94 (1947)) of 36; volume percent conversion, based on fresh feed, of 46; a gas producing factor of 0.9 and a carbon producing factor of 0.6.

The catalytic cracking unit was operated under the following conditions:

TABLE II.—CATALYTIC CRACKER OPERATING CONDITIONS

Space velocity, wt./hr./wt.	3.0
Catalyst/oil ratio	3.0
Reactor temperature	920
Regenerator temperature	1050
Pressure, p.s.i.g.	0
430° F. conversion, vol. percent, per pass	65

Details on the individual tests follow:

Example I

A 430° F. IBP Amna virgin gas oil having properties set forth in Table I was introduced into the catalytic cracker pilot unit operating under the conditions of Table II. The effluent from the cracker was fractionated producing a 430-650° F. gas oil cut having a pour point of +10° F. after reducing the pour point by urea dewaxing the pour point is 0° F. at a yield, based on whole crude, of 10.4 wt. percent. The yield of furnace oil plus debutanized gasoline is 34.5 wt. percent, based on whole crude.

Example II

In a similar fashion, a 430° F. IBP Amna virgin gas oil was catalytically cracked and the effluent fractionated to produce a 430-550° F. gas oil cut having a pour point of -30° F. and a 550-650° F. gas oil cut having a pour point of +30° F. After urea dewaxing the pour point of the 550-650° F. gas oil is +15° F. Admixing these two gas oils produces a 430-650° F. furnace oil having a pour point of 0° F. at a yield, based on whole crude, of 12.6 wt. percent. The yield of furnace oil plus debutanized gasoline is 36.7 wt. percent, based on whole crude.

Example III

To exemplify the process of this invention, a 430° F. IBP Amna virgin gas oil having the properties listed in Table I was subjected to catalytic cracking as in Examples I and II. Upon fractionation, the 430–550° F. gas oil cut having a pour point of –30° F. was withdrawn as the product furnace oil. The 550–650° F. gas oil fraction was recycled for admixture with the feed to the catalytic cracker. This intermediate gas oil was recycled to extinction. The 430–550° F. gas oil was produced at a yield, based on whole crude, of 8.9, wt. percent. The yield of furnace oil plus debutanized gasoline is 36.9 wt. percent based on whole crude.

Example IV

As another example of this invention, a 430–850° F. Amna virgin gas oil having the above properties was fractionated to produce a 430–550° F. virgin gas oil and a 550–850° F. virgin gas oil having the above properties. The 550–850° F. gas oil was subjected to catalytic cracking and fractionation, as in the above examples, producing a 430–550° F. gas oil having a –30° F. pour and a 550–650° F. gas oil having a pour point of +30° F. which was recycled back to the feed to the catalytic cracker. The 430–550° F. cycle gas oil from the fractionator and the 430–550° F. virgin gas oil were admixed to produce a furnace oil product having a pour point of –5° F. at a yield, based on whole crude, of 17.5 wt. percent. The yield of furnace oil plus debutanized gasoline is 39.4 wt. percent, based on whole crude.

Examples III and IV, illustrating the process of this invention, have an advantage over Examples I and II in that no dewaxing facilities are required to produce low pour furnace oil. Further, the process of this invention produces these furnace oils at yields which are comparable to alternate processing techniques and actually produce higher yields of debutanized gasoline plus furnace oil than schemes employing dewaxing.

Obviously, many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

We claim:

1. A process of producing, from a waxy gas oil, a petroleum fraction having a maximum pour point of 0° F. and suitable for use as a furnace oil which comprises:
 - (a) separating a waxy gas oil into a first fraction having a pour point of 0° F. maximum and a second fraction consisting of the remaining waxy gas oil,
 - (b) subjecting the second fraction to catalytic cracking conditions in a catalytic cracking zone effecting conversion of not less than 30 volume percent based on fresh feed,
 - (c) recovering from the catalytic cracking effluent a third fraction having a pour point of 0° F. maximum,
 - (d) recovering from the catalytic cracking effluent a fourth fraction having an initial boiling point corresponding to the end point of the third fraction and an end point in the range of 650 to 750° F.,
 - (e) passing a portion of said fourth fraction to said catalytic cracking zone as part of the feed thereto thereby converting said portion to additional quantities of said third fraction, and
 - (f) combining the first fraction and the third fraction

to produce as a product of said process a fifth fraction having a pour point of 0° F. maximum.

2. A process according to claim 1 wherein all of said fourth fraction is passed to said catalytic cracking zone.

3. A process according to claim 1 wherein the waxy gas oil has a boiling range of about 430–850° F.

4. A process according to claim 1 including the following additional steps:

- (g) passing a portion of said fourth fraction to a dewaxing zone under dewaxing conditions effecting a reduction in the pour point of said fourth fraction,
- (h) recovering from said dewaxing zone a sixth fraction having a pour point of 0° F. maximum, and
- (i) combining said sixth fraction with said fifth fraction producing a product having a pour point of 0° F. maximum.

5. A process of producing, from a waxy gas oil, a petroleum fraction having a maximum pour point of 0° F. and suitable for use as a furnace oil which comprises:

- (a) separating a waxy gas oil into a first fraction having boiling range between 430 and 550° F. and a pour point of 0° F. maximum and a second fraction consisting of the remaining gas oil,

- (b) subjecting said second fraction to catalytic cracking conditions in a catalytic cracking zone effecting conversion of not less than 30 volume percent based on fresh feed,

- (c) recovering from the catalytic cracking effluent a third fraction having a boiling range between 430 and 550° F. and a pour point of 0° F. maximum,

- (d) recovering from the catalytic cracking effluent a fourth fraction having a boiling range between 550 and 650° F.,

- (e) passing a portion of said fourth fraction to said catalytic cracking zone as part of the feed thereto thereby converting said portion to additional quantities of said third fraction, and

- (f) combining the first fraction and the third fraction to produce as a product of said process a fifth fraction having a pour point of 0° F. maximum.

6. A process according to claim 5 wherein all of said fourth fraction is passed to said catalytic cracking zone.

7. A process according to claim 5 wherein the waxy gas oil has a boiling range of about 430–850° F.

8. A process according to claim 5 including the following additional steps:

- (g) passing a portion of said fourth fraction to a dewaxing zone under dewaxing conditions producing a sixth fraction having a pour point of 0° F. maximum, and

- (h) combining the fifth fraction and the sixth fraction producing a product of said process having a pour point of 0° F. maximum.

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