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CONVERSION OF HYDROCARBON OILS

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3 Claims. (Cl. 196—52)

This invention relates to the conversion of hydrocarbon oils and has to do particularly with a combination unit involving thermal and catalytic cracking.

5 In accordance with the invention, a hydrocarbon oil, which may be unsuitable for catalytic cracking due to excess carbon formation, is subjected to thermal cracking, the cracked products separated into a residuum, an intermediate gas oil fraction and gasoline. The intermediate gas oil fraction may be subjected to solvent extraction with a selective solvent, to separate an extract and raffinate. The raffinate is subjected to catalytic cracking to form gasoline and a recycle stock which may be recycled to the thermal cracking operation. The residuum from the thermal cracking operation may be subjected to flash distillation to form a cycle gas oil which may be charged to the solvent refining operation or recycled to the thermal cracking operation, or both. The invention is particularly adapted to a clean circulation operation wherein the fresh charge may be contacted with the cracked vapors from the thermal cracking operation to form a mixture of reflux condensate and unvaporized charging stock which is charged to the thermal cracking operation and a superclean recycle stock which is charged to the solvent extraction operation. The extract from the solvent extraction operation may advantageously be charged to the thermal cracking operation.

According to a modification of the invention, a hydrocarbon oil which may be suitable for catalytic cracking, may be subjected to catalytic cracking and a gasoline and a recycle stock separated from the cracked products. The recycle stock may be subjected to solvent extraction to produce a raffinate and an extract. The raffinate is returned to the catalytic cracking operation. The extract is subjected to thermal cracking and a gasoline fraction and a recycle stock separated from the thermally cracked products. The last mentioned recycle stock may be passed to the solvent extraction operation. Instead of subjecting the recycle stock from the catalytic cracking operation to solvent extraction, this recycle stock may be charged directly to the thermal cracking operation, and the recycle stock from the thermal cracking operation subjected to the solvent extraction to produce a raffinate, which is charged to the catalytic cracking operation, and an extract which is returned to the thermal cracking operation.

The invention will be more fully understood from the following description read in connection with the accompanying drawing which shows one form of apparatus for carrying out the process of the invention.

Referring to the drawing, a fresh charge stock such as crude oil, reduced crude or heavy gas oil

is charged through the line 1 by the pump 2 to a fractionator 3. The charge is contacted with cracked vapors introduced through line 4, thereby forming a mixture, comprising unvaporized fresh charge and reflux condensate. The mixture is collected in the bottom of fractionator 3 from whence it is withdrawn through the line 5 and pump 6, for recycling to the system. The vapors pass overhead from fractionator 3 through the line 7 to a secondary fractionator 8. In the latter, fractionation takes place to separate gasoline vapors which are passed overhead from the fractionator through the line 9 and condenser 10 to an accumulator 12 wherein a gasoline distillate is collected.

A secondary or superclean condensate is collected in the lower portion of the fractionator 8 and drawn off through the line 14. The superclean condensate is passed through a cooler 18, pump 19 and line 20 to a mixer 21 wherein it is intimately contacted with a solvent introduced through line 23 by the pump 24. The solvent is intended to be one which will cause separation of the more paraffinic constituents from the less paraffinic constituents. The solvents contemplated are SO₂, furfural, nitrobenzene, phenol, and the like. A mixture of solvent and oil is transferred from the mixer through line 25 to a separator 26 wherein raffinate and extract layers settle out.

The raffinate layer collecting in the upper portion of the settler, comprising largely paraffinic hydrocarbons, and substantially free from solvent, is drawn from the top of the settler through the line 28 by the pump 29 and charged to a heating coil 30 located in a furnace 31. In case it is necessary to make a further separation of solvent from the raffinate, a still may be installed in the line 28 for stripping the solvent from the hydrocarbons. A clean charging stock, suitable for catalytic cracking, such as virgin gas oil, may be introduced through the line 32 by the pump 33. In the heating coil the oil is raised to temperatures sufficiently high for purposes of catalytic cracking. This temperature may be about 750° to 950° F. Pressures are preferably about atmospheric or slightly above. The hot oil is transferred from the heating coil through the line 34 to a catalyst chamber 35. In passing through the catalyst chamber the oil is contacted with a suitable cracking catalyst, such as active alumina, acid-treated clays, synthetic aluminum silicates, silica gel and the like. The cracked products are transferred from the catalyst chamber 35 through the line 36 to fractionator 38. In the fractionator, hydrocarbons of gasoline boiling range are separated as vapors and passed overhead through the line 39 and condenser 40 to a receiver 42.

A recycle stock of higher boiling range than

gasoline is collected in the lower portion of the fractionator 38 and withdrawn through the line 44. This recycle stock may be passed through the line 45 by the pump 46 to the mixer 21 to undergo solvent extraction. The recycle stock may, however, be passed through the line 48, pump 50, line 51 and line 52 to the heating coil 53 located in a furnace 54. In the coil 53, the oil is subjected to cracking conditions of temperature and pressure, such as about 800° to 1000° F. and 200 to 1000 pounds. The products from the coil 53 are passed through the transfer line 55 together with admixed reflux condensate and unvaporized charging stock from the line 5 to a soaker or reaction chamber 56. The cracked products are passed from the soaker 56 through line 58 to separator 60 wherein a separation between vapors and unvaporized oil occurs. The vapors are passed overhead through the line 4 to the fractionator 3, referred to heretofore.

A residuum or tar is drawn from the bottom of the separator 60 and conducted through line 63 to a tar stripper 64 wherein the tar is flashed by reduction of pressure through valve 65 in the line 63. Fuel oil is drawn from the bottom of the tar stripper through the line 67. Vapors comprising cycle gas oil are passed overhead through the vapor line 68 and condenser 70. The condensate is then pumped by the pump 71 through the line 52 back to the heating coil 53. Any portion or all of the oil may be discharged from the system through the line 73, or passed through the line 75 to the mixer 21.

The extract layer, comprising naphthenes, aromatics, olefinic hydrocarbons and solvent, collected in the lower portion of the settler 26, is passed through the line 78 by the pump 79 to a still 80. In the still the solvent is vaporized and passed overhead through the vapor line 81 and condenser 82. The condensate is then pumped by the pump 84 through the line 85 to the mixer 21 for reuse. The extract portion remaining in the still 80 is drawn off from the bottom thereof through the line 86 and may be discharged from the system or passed through the line 88 by the pump 90 for charging through the line 52 to the heating coil 53 of the thermal cracking system.

As an example of the operation of the invention, a reduced crude is charged to the primary fractionator of a thermal cracking unit. The resulting mixture of unvaporized charge and heavy reflux condensate, collected as a so-called black oil in the lower portion of the fractionator, is withdrawn and passed to a soaker. The uncondensed vapors from the fractionator are passed to a secondary fractionator wherein a gasoline fraction and a superclean recycle stock are separated. The superclean recycle stock is subjected to solvent extraction with furfural. The raffinate is subjected to catalytic cracking at temperatures of about 900° F and about atmospheric pressure, in the presence of a silica-alumina catalyst. The cracked products are fractionated to separate a gasoline fraction and a recycle stock. The recycle stock is subjected to thermal cracking at a temperature of about 930° F. and 400 pounds pressure in a coil and soaking drum. The cracked products are separated into vapors and residuum, and the vapors discharged into the primary fractionator referred to heretofore. The residuum is flash distilled to produce a fuel oil

and a cycle gas oil which is returned to the coil of the thermal cracking system. The solvent and extracted hydrocarbons are subjected to distillation to separate the solvent which is returned to the solvent extraction system. The extract separated from the solvent is charged to the thermal cracking operation. The thermally and catalytically cracked gasolines when blended together show an octane number of about 78 and a yield of about 70%.

As another example of the operation of the invention, a virgin gas oil is subjected to catalytic cracking at temperatures of about 930° F and about atmospheric pressure in the presence of an acid treated clay catalyst. The cracked products are separated into a gasoline fraction and a recycle stock. The recycle stock is subjected to thermal cracking at temperatures of about 950° F. and about 300 pounds pressure. The thermally cracked products are separated into residuum, clean recycle stock and a gasoline fraction. The clean recycle stock is subjected to solvent extraction with SO₂ to produce a raffinate and an extract. The raffinate is charged to the catalytic cracking operation and the extract is returned to the thermal cracking operation. The total gasoline yield is about 75% and shows an octane number of about 80.

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 for the conversion of hydrocarbon oils which comprises subjecting the oil to thermal cracking wherein high boiling oils are converted into gasoline by heat and pressure, separating the cracked products into gasoline, residuum and a clean gas oil recycle stock, subjecting said residuum to flash distillation to separate a cycle gas oil, subjecting said cycle gas oil and said clean gas oil recycle stock to solvent extraction to separate a raffinate and an extract fraction, subjecting said raffinate fraction to catalytic cracking, separating from the reaction products of the catalytic cracking operation gasoline and a recycle stock, and passing said recycle stock to the thermal cracking operation.

2. A process for the conversion of hydrocarbon oils which comprises contacting fresh charging stock with cracked vapors from a thermal cracking operation thereby forming a mixture of unvaporized fresh charge and reflux condensate, recycling said mixture to said thermal cracking operation, further fractionating the vapors to form a reflux condensate, subjecting said reflux condensate to solvent extraction to separate a raffinate and an extract portion, charging the raffinate portion to a catalytic cracking operation, recovering from the catalytic cracking operation gasoline and a recycle stock and passing said last mentioned recycle stock to said thermal cracking operation.

3. A process according to claim 2 in which said extract portion is returned to the thermal cracking operation.

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