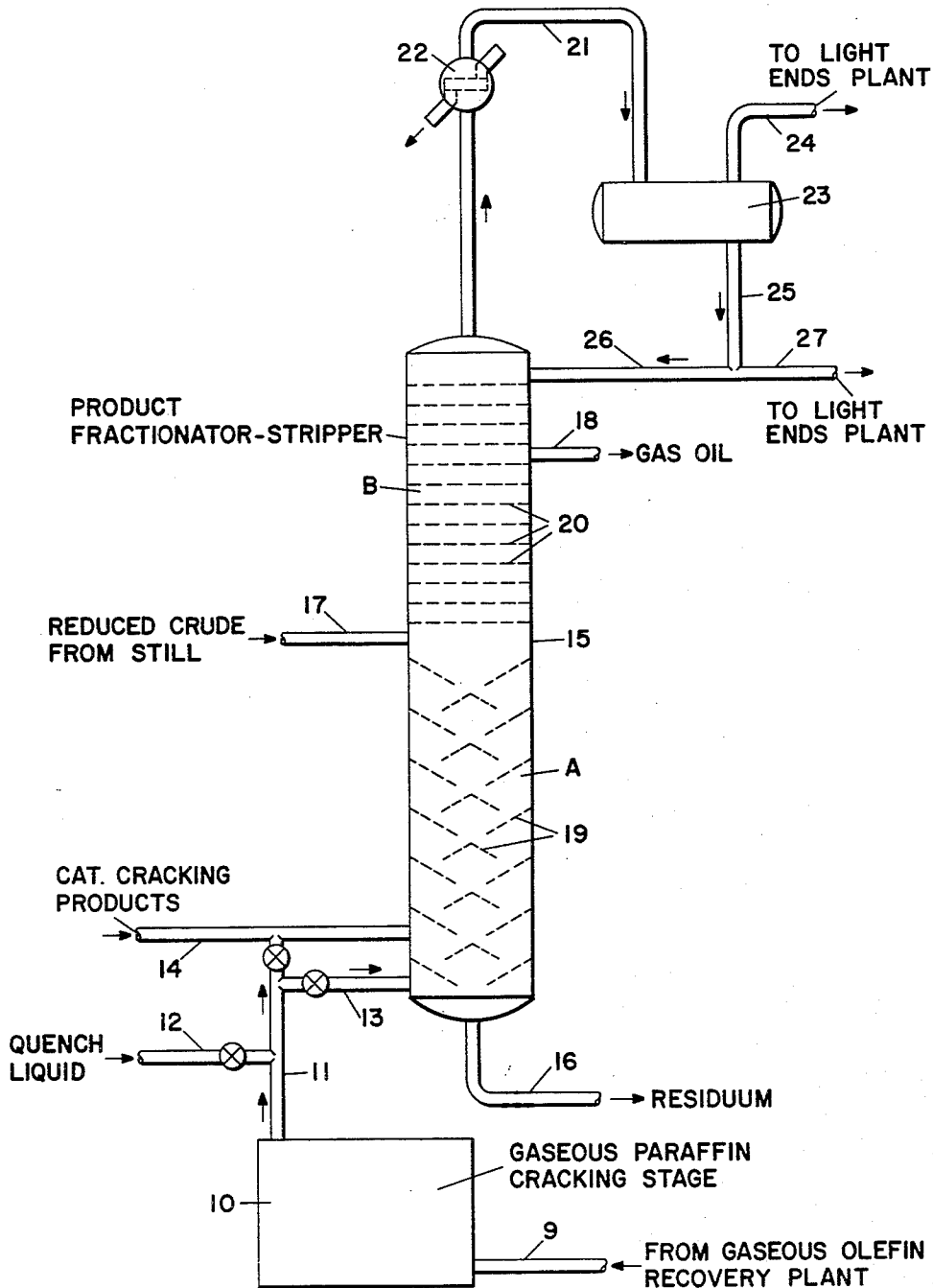


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OLEFIN PRODUCTION PROCESS
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COMBINATION CRUDE DISTILLATION AND
OLEFIN PRODUCTION PROCESS

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The present invention relates to an improved method for the conversion of crude petroleum into more valuable hydrocarbon oil products. More specifically, it is concerned with obtaining maximum yields of low boiling products of the motor fuel and gas oil ranges and minimum yields of heavy products such as fuel oils and tars, while at the same time producing high quality ethylene or propylene with a minimum of processing steps and a substantially reduced investment and operating cost.

In its broadest aspect, the present invention involves a series of integrated distillation, catalytic and thermal conversion stages wherein products from these stages are conducted to a single product fractionation step and treated therein in a manner such that reduced crude obtained as liquid residue of a crude distillation is stripped of relatively low boiling constituents. More particularly, the invention pertains to a combination process of the type wherein one of the conversion stages is high temperature cracking of ethane or propane.

In conventional combination crude oil distillation and conversion processes, the recovery of maximum yields of motor fuel and heating oil products has been usually accomplished by subjecting light and heavy naphtha fractions from a crude still to further fractionation and, if desired, to suitable thermal or catalytic refining treatments such as reformation, isomerization, hydroforming, alkylation, etc. A gas oil fraction from the crude still is subjected to thermal or catalytic cracking to obtain lower boiling products which are subsequently fractionated. The reduced crude is generally subjected to a further distillation at reduced pressures to produce tar and additional low boiling products, principally gas oil to be processed with the gas oil fraction from the crude still as mentioned above. These processes normally require as many product fractionators as there are stripping and conversion stages, yielding a plurality of streams of products of desirable boiling range. For economical heat recovery, much heat exchange apparatus is required both within each unit and in combination between units. Vast tank facilities must be provided to permit storage of the various products prior to blending in desired proportions. The vacuum distillation equipment normally used for working up the reduced crude is expensive with respect to investment, operation and maintenance. As a result of these complications, conventional type combination processes must be operated on a relatively large scale to be economical. Normally, refining capacities in excess of, say, about 20,000 bbls. per day of crude are required to make operations of this type pay, while smaller refineries must be designed on the basis of an often undesirably high output of heavy fuel oil and other products of a relatively low commercial value.

The present invention utilizes effluent from an ethane or propane cracker, together with effluent from a catalytic cracker or other conversion unit, in a combination fractionator for furnishing the partial pressure effect and heat to help strip heavy gas oil from the reduced crude without need of vacuum equipment.

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The present invention also provides an improved method for the integrated production of ethylene or propylene in a combination unit type refinery. These olefins are currently manufactured principally by one of two methods. They can be recovered from existing refinery gas streams, for example, from the gas from a fluid catalytic cracker or steam cracking unit. They can be obtained by cracking ethane or propane.

The method of recovering C_2 to C_3 olefins from the cracked gases is similar in both of these cases. Where ethylene is recovered from the effluent of steam cracking or from ethane or propane cracking, the very hot reactor effluent has to be quenched quickly. The quenching requires circulation of large amounts of quenching liquid, e.g. water and oil.

In normal operation of the combination unit, reduced crude has been passed generally to an intermediate part of a fractionating column. In some of these units, naphtha conversion effluent has been fed to the fractionating column at a point below the feed point of the reduced crude, substantially at the temperature of the conversion stage. In some instances a light virgin naphtha has been supplied to the fractionating column likewise at a point below the reduced crude feed point after suitable additional heating, if desired. Various final product streams have been recovered from the fractionator which would include a fuel gas overhead, a low boiling fraction of motor fuel boiling range, a heating oil fraction, a gas oil fraction, and a heavy bottoms fraction of the fuel oil range. The gas oil fraction is sent to a catalytic cracking stage to be converted into additional amounts of motor fuel, diesel oil, gas oil range cycle stock, and heavy bottoms. It has been considered desirable to pass the catalytically cracked gas oil products to a point below the reduced crude feed. In this manner, the reduced crude or equivalent thereof was intended to be subjected to countercurrent heating, vaporization and stripping actions with vapors from the gas oil cracking process as well as with the virgin and reformed naphtha vapors.

When operating substantially as described above, extremely large volumes of process vapors are required and heat has to be supplied for the reduced crude stripping in order to keep the volume of heavy residuum finally produced at a minimum. Also for ethylene recovery the light gases from ethane cracking and catalytic cracking are combined before the recovery operation.

The present invention affords certain advantages that will be apparent from the description following.

In the present invention, ethane or propane cracking is integrated into a combination reduced crude and catalytic cracked gas oil product fractionator. A partially quenched effluent from such an ethane or propane cracking operation is introduced into the bottom of a combination product fractionator for reduced crude stripping and catalytic cracked product fractionation. More specifically, the partially quenched effluent from the ethane or propane cracking serves to help vaporize gas oil from the reduced crude and is itself at the same time further quenched and cooled by contact with the residual portions of the reduced crude. The ethylene or propylene produced in the ethane or propane cracking step is passed through the fractionation zone, may be separated from condensable vapors of higher boiling hydrocarbons and may be then sent to a light ends separation plant wherein absorber dry gas is separated from other hydrocarbons. The absorber dry gas, e.g. ethylene or propylene, may be subjected to an operation wherein the olefins produced in the ethane or propane cracking step are recovered along with a similar olefin product formed in the catalytic cracking step. It is also a function of the olefin recovery process to separate out any methane

and lighter gases present. Ethane and propane separated and recovered in the catalytic light ends separation and olefin purification stages are recycled to provide feed for the C_2 to C_3 paraffin cracking operation. The light ends separation and olefin recovery processes, which are both well known to one skilled in the art, combine gas compression, gas absorption, and low temperature fractionation. Other well known selective adsorption steps may be used in separating the desired C_2 to C_3 paraffins from the olefins and other gaseous components.

Having set forth its general nature and objects, the invention will be best understood from the more detailed description hereinafter which refers to the accompanying drawing, wherein a schematic flow diagram of the steps and means used in the present invention is shown.

Referring to the drawing, the reduced crude is passed from a conventional atmospheric still outlet 17 to the lower portion of a combined product fractionator-stripper 15. The reduced crude enters the combination unit substantially at the conditions of the still, that is at a temperature of about 650° to 700° F. and a pressure of about 5 to 15 p.s.i.g. The effluent from an ethane or propane gas cracker 10, said effluent leaving the cracking stage at about 1450° to 1550° F. and about 5 to 15 p.s.i.g., is passed through line 11 wherein at least a portion of the effluent is contacted with a quenching liquid introduced by means of line 12 in order to lower the temperature of the cracking effluent to about 900° to 1000° F. The stream is then passed by means of lines 11, 13 or 14, or both 13 and 14, to the combination fractionator 15. Line 13 leads directly from line 11 to the combination unit 15 at a point below the feed point of the reduced crude 17. Line 14 passes an effluent stream of reaction products from a catalytic cracking process, the vapors of which are substantially at the catalytic cracking conditions 900° to 1000° F. and about 5 to 15 p.s.i.g. and which enter fractionator 15 below the feed point of the reduced crude. The relative proportion of the effluent from 10 that is passed through line 13 directly to the combination unit 15 depends primarily on the amount of stream 11 that has been contacted with the quench liquid from line 12. If desired, all the effluent from 10 may be subjected to quenching via line 12 and then passed via line 13 to the fractionator 15. Alternatively, a major portion of the effluent from 10 may be passed via line 11 directly to line 14 without quenching, and the combined stream added to the combination unit 15. The vapors in line 14 have a much greater volume than those in line 11, up to 100 times as great, so that the addition of line 11 to 14 will cause only a few degrees rise in temperature. The purpose of using the quench liquid 12 and the addition of the cracker effluent 11 to line 14 rather than having the cracked gases from line 11 pass directly to the combination unit 15 is to lower the temperature of the cracked gases from about 1450° to about 1550° F. as it leaves the gas cracking stage to about 900° to 1000° F. as it enters the fractionator 15. An indirect heat exchange means may be provided for this purpose also, if desired.

The cracked gases and vapors supplied through lines 13 and 14 pass upwardly through fractionator 15 against the downwardly flowing reduced crude to strip the latter of vaporizable constituents. Fractionator 15 comprises a lower stripping section A and an upper combined fractionation section B. Both sections are provided with suitable known means for improving the countercurrent contact between downflowing liquid and upwardly flowing vapors. For the purpose of stripping, a disc-and-doughnut baffle arrangement has been found to be most efficient and such is shown schematically for section A by elements 19. Section B is illustrated to contain a number of bubble cap plates 20 to enhance the efficiency of the fractionation.

The details of operation of the combination fractionator are well known to one skilled in the art. Reference

may be made to U.S. 2,644,785 and U.S. 2,777,801 for operation of the unit and other details of the process. In the present invention, the partial pressure effect of the stream from the ethane or propane cracker 10 and the heat content thereof are sufficient to cause the gas oil constituents of the reduced crude to vaporize. A side stream of gas oil range hydrocarbons boiling in the range of 600° to 700° F. which is suitable as a catalytic cracking stock is withdrawn from an intermediate section of fractionator 15 via line 18. This side stream product may serve as a quench liquid sent to line 12. A heavy material containing non-distillable constituents of the crude charged collects in the bottom zone of section A of the combination unit 15 from which it is withdrawn via line 16.

It will be understood that although in the operation of a conventional combination fractionator other streams may be introduced or withdrawn, such as a heating oil, a low boiling fraction of the motor fuel boiling range, steam, etc.; for the purposes of the present invention, the simplified drawing does not show all of these.

The gas and naphtha vapors leave the top of fractionator 15 through line 21 at about 50° to 100° F. and 10 to 15 p.s.i.g. After passing through condenser 22, the fractionator effluent stream passes to a liquid and gas separator 23. From separator 23, the gaseous stream containing the olefins is withdrawn by line 24 and the liquid containing naphtha hydrocarbon is withdrawn by line 25. At least a portion of the liquid is refluxed by line 26 to the combination unit 15 at a point near the top of section B. The remaining liquid is passed on to the light ends plant by line 27.

The gas stream in line 24 is also passed to a light ends separation plant in which the absorber dry gas containing C_2 and C_3 and lighter hydrocarbons are separated from C_4 and higher hydrocarbons. The absorber dry gas containing C_2 or C_3 and lighter hydrocarbons is next passed to a recovery system similar to a conventional ethylene recovery plant in which the ethylene or other gaseous olefins produced in the ethane or propane cracker 10 are recovered along with any olefins produced in the catalytic cracking step, the outlet of which is 14. Methane and lighter gases are separated out in this recovery plant and any ethane and/or propane present is recovered, separated, and recycled via line 9 to provide feed for the ethane or propane cracking operation.

Representative operating data in demonstrating a preferred embodiment are given in the following example:

EXAMPLE 1

The combination fractionator was operated under the following tabulated conditions:

Combination fractionator

Atmospheric reduced crude feed, 685° F.	B/D--	13,858
Feed as effluent from catalytic cracking stage, 900° F.	-----#/hr--	147,000
Feed as effluent from an ethane cracker, 1530° F.	-----#/hr--	4,750
Gas oil vaporized from reduced crude, 650° F.	B/D--	10,745
Overhead stripped product, 85° F.	-----#/hr--	8,655
Heavy residuum, 650° F.	-----B/D--	8,248
Stripping zone conditions, 800° F. and 8 p.s.i.g.		

It is to be noted from the above that 10,745 barrels per day of gas oil constituents were recovered. If this process were operated without utilizing the product vapors from the ethane cracking unit, only approximately 5,000 to 6,000 barrels per day of gas oil constituent would be recovered.

In the plant to which the above data pertain, a reduced crude enters the combination unit at a temperature of about 650° to 700° F., preferably about 680° to 690°

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F., a feed from a catalytic cracking stage enters the fractionation zone at a point below the feed point of the reduced crude at a temperature of about 900° to 1000° F., preferably about 940° to 950° F., an effluent from a C₂ to C₃ paraffin high temperature cracking step which leaves the ethane or propane cracking stage at about 1450° to 1550° F., and preferably about 1530° to 1540° F. when cracking ethane after being partially quenched by contacting said effluent with either a gas oil product stream from the combination unit or with a catalytic cracking feed, enters the fractionation zone at a point below the reduced crude feed point at a temperature of about 900° to 1000° F., preferably about 940° to 950° F., a stream of gas oil stripped from the reduced crude is withdrawn from the fractionation zone at about 600° to 700° F., and preferably about 640° to 650° F., a stream of heavy residuum leaves the bottom of the combination unit at a temperature of about 580° to 650° F., preferably about 600° F., and the absorber overhead product vapors leave the combination unit at a temperature of about 75° to 120° F., and preferably about 80° to 90° F. Suitable conditions for the stripping zone are temperatures in the range of 750° to 850° F. and preferably 790° to 820° F., and pressures in the range of 5 to 15 p.s.i.g., and preferably 8 to 12 p.s.i.g.

The process of the present invention secures efficient heat recovery and the elimination of the need for separate quenching equipment.

What is claimed is:

1. In a combination distillation and catalytic hydrocarbon conversion process the improvement which comprises passing a reduced crude oil containing a substantial quantity of hydrocarbon components boiling in the gas oil boiling range into an intermediate part of a product

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fractionation zone operated at elevated temperatures and greater than atmospheric pressure, passing a major portion of the effluent vapors from a C₂ to C₃ paraffin cracking zone operated at temperatures of 1450° to 1550° F. directly to join a much greater volume of vapors supplied from a catalytic cracking zone operated at temperatures of 900 to 1000° F. thus rapidly quenching the high temperature effluent from the paraffin cracking process to a temperature in the range of 900° to 1000° F., supplying the combined stream of hydrocarbon vapors from said quenching operation into a lower part of the product fractionation zone, stripping gas oil components from said reduced crude, segregating and removing a gas oil fraction from said fractionation zone and removing overhead products from said fractionation zone containing olefins produced in said C₂ to C₃ cracking operation and naphtha from said catalytic cracking process.

2. The process of claim 1 in which said stripping of gas oil components from the reduced crude is conducted at temperatures of about 750° to 850° F. and pressures of about 5 to 15 p.s.i.g. and in which said gas oil product removed from the fractionation zone boils in the range of 600° to 700° F.

3. A process according to claim 1 wherein a feed stream for said C₂ to C₃ paraffin cracking operation is composed principally of ethane.

4. A process according to claim 1 wherein a feed stream for said C₂ to C₃ paraffin cracking operation is composed principally of propane.

References Cited in the file of this patent

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