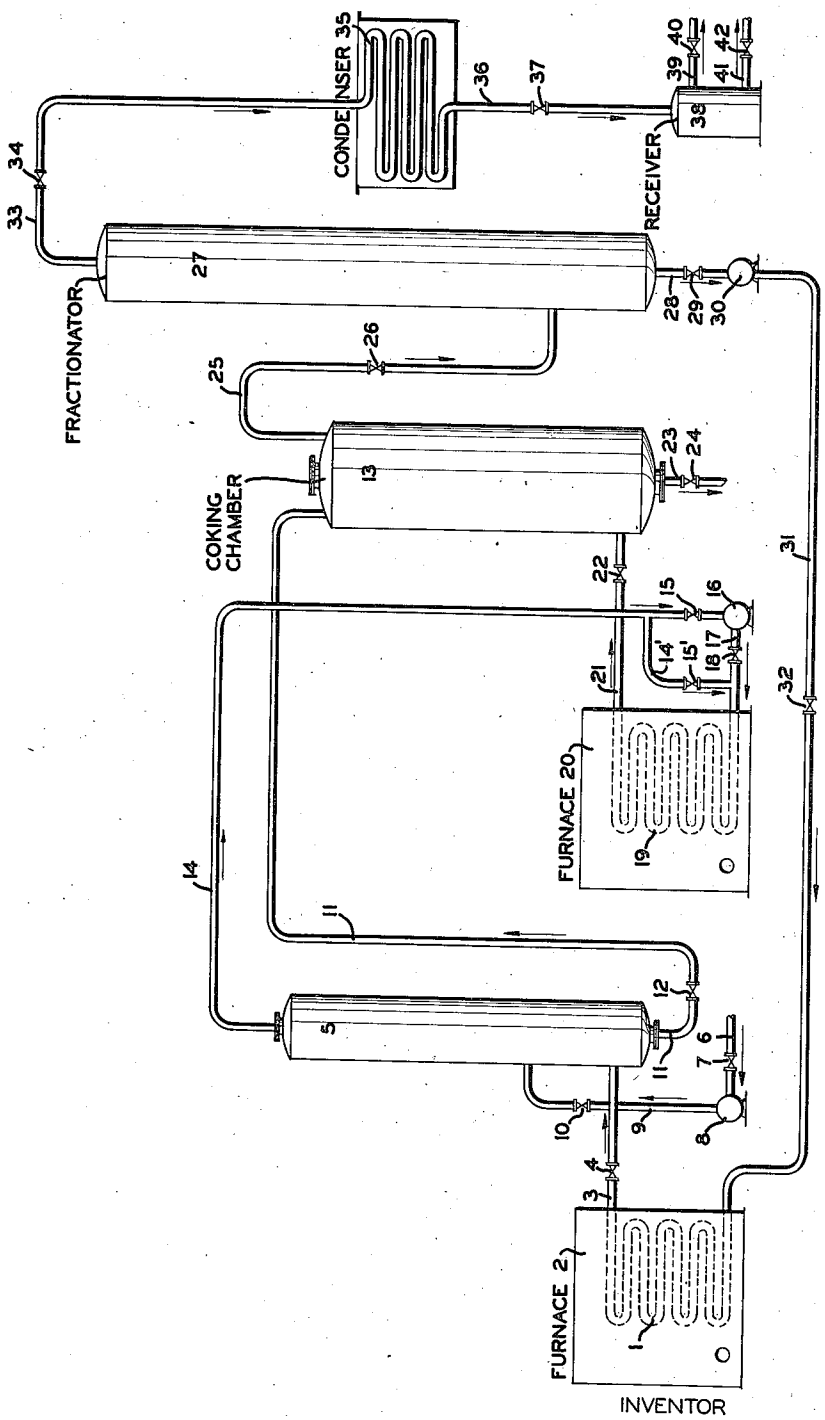
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CONVERSION AND COKING OF HYDROCARBON OILS

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CONVERSION AND COKING OF HYDROCARBON OILS

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3 Claims. (Cl. 196—60)

The invention particularly refers to an improved process and apparatus for the treatment of crude petroleum, or other hydrocarbon oil containing motor fuel or motor fuel fractions, wherein said motor fuel fractions of the charging stock are subjected to reforming to improve their anti-knock value, the heavier components of the charging stock as well as intermediate products of the operation are subjected to conversion for the production of high yields of good quality motor fuel and the residual conversion products of the process are reduced to coke. In the present invention all of these operations are accomplished simultaneously in a unified system of simplified design, the arrangement of the process being such that each operation is complementary to the others.

In one of its specific embodiments the invention comprises subjecting insufficiently converted intermediate conversion products of a cracking operation to further conversion in a heating coil and communicating reaction chamber maintained at superatmospheric pressure, simultaneously introducing into the reaction chamber raw oil charging stock for the process, comprising a hydrocarbon oil containing a substantial proportion of material within the boiling range of motor fuel; wherein it is substantially vaporized and subjected to mild conversion, withdrawing non-vaporous residual liquid from the reaction chamber and introducing it into a reduced pressure coking chamber, separately withdrawing the vaporous products from the reaction chamber, subjecting them to continued conversion under independently controlled conversion conditions in a separate heating coil and then introducing them into direct contact with the residual material in the coking chamber, whereby to assist its reduction to coke, subjecting vaporous products from the coking chamber to fractionation, whereby their insufficiently converted components are condensed as reflux condensate to be returned to the first mentioned heating coil, as already described, for further conversion, subjecting the fractionated vapors to condensation and collecting the resulting products.

It will be apparent that the features of the invention are not a mere aggregation or obvious combination of topping, cracking, reforming and coking operations but that in the present process these operations are so related and interdependent that the elimination of any of the principal features of the invention tends to obviate the advantages of the others. By introducing the raw oil charging stock for the process directly into the reaction chamber it comes into intimate contact with the hot conversion products from the heating coil to which the reflux condensate is supplied, being thereby substantially vaporized and subjected to relatively mild conversion conditions. This same feature serves as a means of partially cooling the hot conversion products supplied to the reaction chamber thereby permitting more severe conversion conditions in the heating coil to which the reflux condensate is supplied than would be otherwise advantageous and serving as a means of preventing excessive conversion of the residual liquid products in the reaction chamber by cooling as well as by dilution with unvaporized portions of the raw oil. Further conversion of the vaporous products from the reaction chamber in a separate heating coil under independently controlled conversion conditions permits the treatment of these products, which contain high percentages of material within the boiling range of motor fuel, under conditions which will reform or improve the anti-knock value of said motor fuel components and also serves as a means of subjecting to relatively severe conversion conditions any vaporous components of the crude which may escape the desired degree of conversion in the reaction chamber. The temperature of the reheated vapors from the reaction chamber and their low boiling nature makes them desirable for use as a heat carrying medium to assist coking of the residual conversion products from the reaction chamber, with which the heated vapors are commingled in the reduced pressure coking chamber. By introducing the crude oil directly into the reaction chamber, separating its relatively light and relatively heavy components by vaporization of the former and subjecting each to separate treatment, as provided by the present invention, instead of subjecting the entire charging stock to conversion conditions in the heating coil, excessive conversion of its heavy components, with the consequent formation of coke and gas, or excessively mild conversion of its relatively light components, with the consequent low yields and poor anti-knock value of motor fuel products, is avoided and this also permits separate treatment of the reflux condensate under the conversion conditions to which it is best suited with all of its well known advantages.

The attached diagrammatic drawing illustrates one specific form of apparatus incorporating the features of the present invention and in which the process of the invention may be practiced.

Referring to the drawing, reflux condensate from the fractionator of the system is supplied, by means which will be later more fully described, to heating coil 1, which is located within a furnace 2, of any suitable form capable of supplying the required heat to the reflux condensate to insure its subjection to the desired conversion temperature, preferably at a substantial superatmospheric pressure in the heating coil. The heated oil is discharged through line 3 and valve 4 into reaction chamber 5, also preferably maintained at a substantial superatmospheric pressure, and wherein the vaporous and residual liquid conversion products are separated.

Simultaneous with the introduction of hot conversion products from heating coil 1 into the reaction chamber, raw oil charging stock for the system, comprising crude petroleum or other hydrocarbon oil comprising a substantial proportion of materials within the boiling range of motor fuel, is supplied through line 6 and valve 7 to pump 8 and fed therefrom through line 9 and valve 10 into reaction chamber 5. It will be understood that the raw oil may, of course, be preheated by means of heat recovered from within the system or in any well known manner not illustrated in the drawing, prior to its introduction into the reaction chamber. By direct contact with the heated conversion products from heating coil 1 in chamber 5, the raw oil is substantially vaporized, serving at the same time to partially cool the hot conversion products from the heating coil, while the vaporized portion of the raw oil as well as the vaporous conversion products are subjected to continued relatively mild conversion in the reaction chamber.

Residual liquid, including any unvaporized components of the raw oil as well as residual liquid conversion products, is removed from the reaction chamber through line 11 and valve 12 to coking chamber 13, which is preferably operated at substantially reduced pressure relative to that employed in the reaction chamber, by means of which pressure reduction further vaporization of the residual oil is effected and, with the assistance of other means, which will be later more fully described, the unvaporized residual oil is reduced to petroleum coke.

Vaporous products including mildly converted vaporous components of the raw oil charging stock as well as vaporous conversion products from heating coil 1 are withdrawn from reaction chamber 5 through line 14 and may pass through valve 15 to pump or compressor 16 by means of which they are fed through line 17 and valve 18 to heating coil 19 for continued or further conversion. It is within the scope of the invention to employ substantially the same, increased or decreased pressure in heating coil 19 relative to that in the reaction chamber and, when substantially the same or somewhat decreased pressure is employed in the heating coil, the use of pump or compressor 16 may be unnecessary and it may be by-passed by means of line 14' and valve 15'. Furnace 20 of any suitable form furnishes the heat required to effect the desired degree of conversion of the vaporous products from chamber 5 in heating coil 19. Preferably they are subjected to a higher conversion temperature in heating coil 19 than that to which they are subjected in reaction chamber 5 and the highly heated relatively light material is discharged from the heating coil through line 21 and valve 22 into coking chamber 13, preferably entering this zone below the level of residual material or at least below the level of unvaporized residual oil in the coking chamber so that the heated vapors come into direct contact with the residual oil and serve to assist its reduction to coke.

Coke may be allowed to accumulate in chamber 13 to be removed therefrom after the operation of the chamber is completed and preferably, although not illustrated in the drawing, a plurality of coking chambers are employed and may be operated either alternately or simultaneously to permit prolonged operation of the process. Alternate operation of a plurality of coking chambers is preferred, one or more being in operation while another or others are being cleaned and prepared for further operation. Coking chamber 13 is provided with a drain-line 23 controlled by valve 24, which may also serve as a means of introducing steam, water or other suitable cooling medium to assist cooling and facilitate cleaning of the chamber.

Vaporous products are withdrawn from chamber 13 through line 25 and valve 26 to fractionation in fractionator 27. It is preferable in an operation of this character, wherein coke is produced at low pressure, to remove heavy components such as tars and similar high coke-forming materials from the vaporous products withdrawn from the coking chamber, prior to their fractionation for the separation of lower boiling insufficiently converted components (reflux condensate) therefrom, returning such heavy materials to the coking chamber for further treatment. For the sake of simplicity, means for accomplishing this are not illustrated in the drawing, but any well known method of separating heavy, high coke-forming materials from the vapors may be employed. Insufficiently converted components of the vapors supplied to fractionator 27 are condensed in this zone as reflux condensate, collecting in the lower portion of the fractionator from which they are withdrawn through line 28 and valve 29 to pump 30. Pump 30 supplies the reflux condensate through line 31 and valve 32 to heating coil 1 for further conversion, as previously indicated.

Fractionated vapors of the desired end boiling point are withdrawn from the upper portion of the fractionator through line 33 and valve 34 and are subjected to condensation and cooling in condenser 35, from which the resulting distillate and uncondensable gas is withdrawn through line 36 and valve 37 to collection in receiver 38. Uncondensable gas may be released from the receiver through line 39 and valve 40. Distillate may be withdrawn from the receiver to storage or elsewhere, as desired, through line 41 and valve 42.

Conversion temperatures employed in the heating coil to which the reflux condensate from the fractionator of the system is supplied, are preferably within the range of 900 to 1,000° F., or thereabouts, preferably with a superatmospheric pressure, measured at the outlet from the heating coil, of from 100 to 500 pounds, or more, per square inch. A pressure within substantially this same range is preferably employed in the reaction chamber although the reaction chamber may be maintained at a pressure substantially equalized with or lower than that employed at the outlet from the heating coil. The heating coil to which the vaporous products from the reaction chamber are subjected to continued conversion preferably utilizes a conversion temperature within the range of 900 to 1,100° F., or thereabouts, and any desired pressure may be employed

in this zone ranging, for example, from substantially atmospheric to 800 pounds, or more, per square inch. The preferred range of conditions in this zone is 950 to 1,000° F., and 300 to 500 pounds per square inch superatmospheric pressure, or thereabouts. A substantially reduced pressure relative to that employed in the reaction chamber is preferably utilized in the coking chamber and may range, for example, from 100 pounds, or thereabouts, per square inch down to substantially atmospheric pressure. Pressures substantially equalized with or somewhat reduced, relative to that in the coking chamber may be employed in the fractionating, condensing and collecting portions of the system.

As an example of one specific type of operation which may be practiced in accordance with the process of the present invention in an apparatus such as illustrated and above described, the raw oil charging stock is a crude oil of about 38° A. P. I. gravity containing approximately 40% of material boiling up to approximately 437° F. Reflux condensate from the fractionator of the system is subjected to a temperature of about 950° F., at a superatmospheric pressure of approximately 500 pounds per square inch and then introduced into the reaction chamber to which the raw oil charging stock is supplied and directly contacted therewith. The residual oil from the reaction chamber is introduced into a coking chamber operated at a pressure of about 30 pounds per square inch while vaporous products from the reaction chamber are subjected to continued conversion at a pressure of about 500 pounds per square inch and a temperature of about 970° F., and are then introduced into direct contact with the residual material in the coking chamber. This operation may yield, per barrel of charging stock, about 75% of motor fuel having an anti-knock value equivalent to an octane number of approximately 80, about 53 pounds of low volatile petroleum coke and about 600 cubic feet of uncondensable gas.

To better illustrate the advantages obtained by use of the features of the present invention, the above operation may be compared with one of the best type of operations now in practice, not employing the features of the present invention, using the same grade of charging stock. In this latter operation the charging stock and total reflux condensate are subjected in a single heating coil to a temperature of approximately 950° F., at a superatmospheric pressure of about 350 pounds per square inch, the heated products pass through a reaction chamber maintained at substantially the same pressure into a reduced pressure vaporizing chamber wherein residual liquid is separated from the vaporous products, the unvaporized residual oil being withdrawn from the system and the vapors subjected to fractionation. This latter operation may yield, per barrel of charging stock, about 69% of motor fuel having an octane number of about 70, and about 22% of residual oil of low gravity, leaving about 10% by volume of the charging stock which is chargeable to coke, gas and loss.

I claim as my invention:

1. A cracking process which comprises heating reflux condensate, formed as hereinafter set forth, to cracking temperature under pressure while flowing in a restricted stream through a heating zone, discharging the heated condensate into a vapor separating zone and commingling the same with relatively cool charging oil for the process thereby vaporizing a substantial portion of the charging oil by the heat of the reflux condensate, separating the commingled oils into vapors and unvaporized oil in the separating zone, removing the unvaporized oil from the separating zone and flash distilling the same in a flashing zone by pressure reduction, separately removing vapors from the separating zone and heating the same directly and without prior condensation thereof to vapor phase cracking temperature in a second heating zone, introducing the thus heated vapors to the flashing zone to assist the distillation of the unvaporized oil therein, removing the commingled vapors from the flashing zone and fractionating the same to condense heavier fractions thereof, supplying such condensed fractions to the first-mentioned heating zone as said reflux condensate, and finally condensing the fractionated vapors.

2. A cracking process which comprises heating hydrocarbon oil to a cracking temperature under pressure while flowing in a restricted stream through a heating zone, discharging the heated oil into an enlarged zone and commingling the same with a cooler oil containing a substantial quantity of hydrocarbons within the gasoline boiling range and vaporizing a substantial portion of the cooler oil by contact with the first-mentioned oil, removing vapors, including vapors of said gasoline hydrocarbons, from the enlarged zone and heating the same sufficiently to enhance the anti-knock value of the gasoline hydrocarbons, separately removing unvaporized oil from the enlarged zone and flash distilling the same in a flashing zone by pressure reduction, introducing the heated vapors from the second-mentioned heating step to the flashing zone to assist the distillation of the unvaporized oil therein, and removing the commingled vapors from the flashing zone for dephlegmation and condensation.

3. The process as defined in claim 1 further characterized in that such charging oil comprises crude oil containing natural gasoline.

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