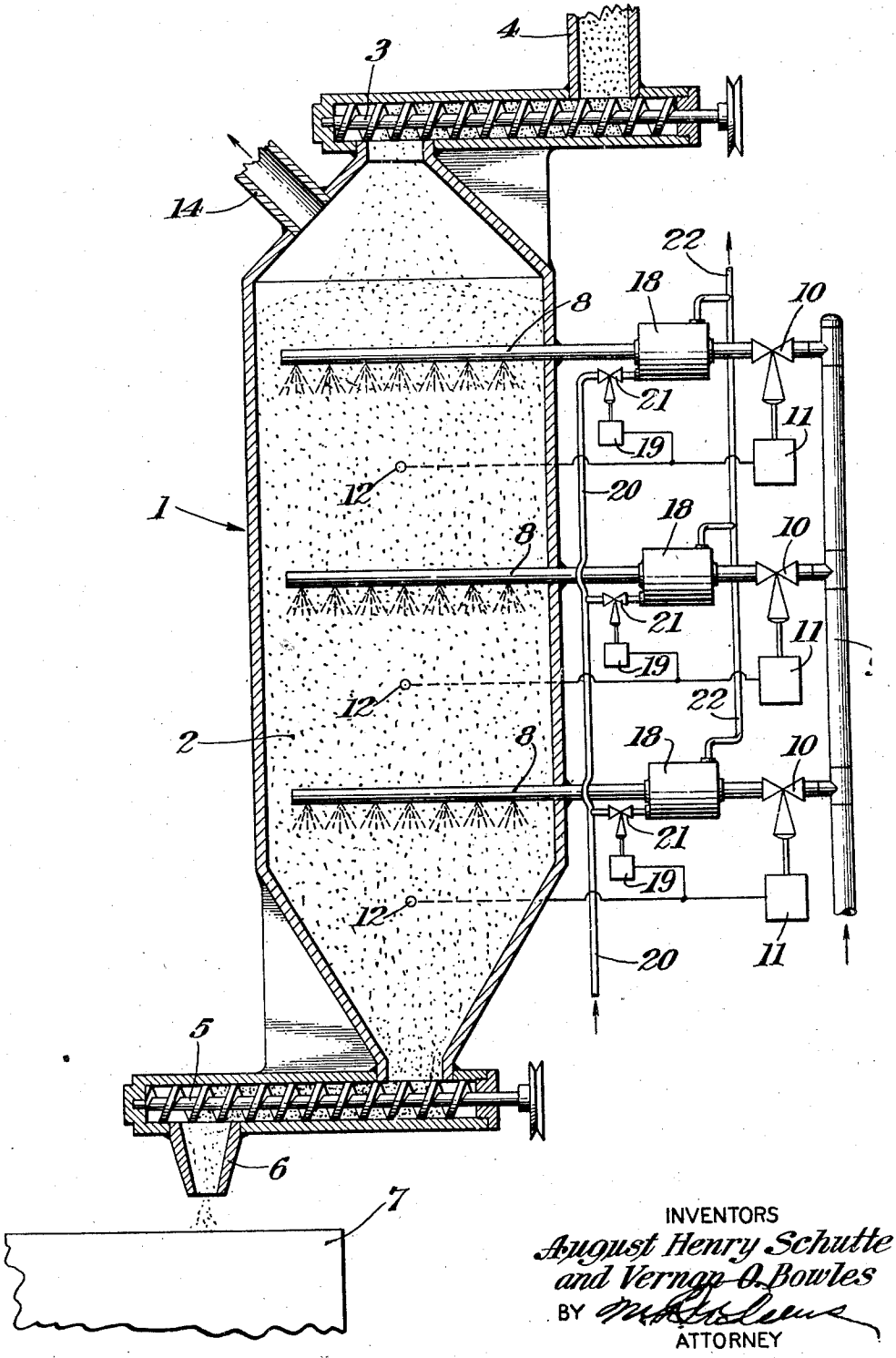
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HYDROCARBON CONVERSION

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HYDROCARBON CONVERSION

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This invention relates to treating hydrocarbons and, in particular, to the provision of a new and improved method for treatment of heavy hydrocarbons and tars, etc., especially those which are residues of various commercial processes.

It is a particular object of this invention to provide a new and improved method of treating such heavy hydrocarbons, residual oils, etc., whereby to secure or recover the ultimate value of their components or fractions by thermally cracking, distilling and/or converting them to take off and collect the lighter components in vaporous or gaseous form, while forming coke as an additional valuable and useful product.

It is a particular object of this invention to provide such a method wherein improved returns from the conversion of heavy hydrocarbon residuals is secured by the production of coke in addition to the production, for instance, of condensible vapors containing gasoline and gas oil and non-condensible gases and apparatus particularly adapted to achievement of the aforesaid objects.

It is a further object of this invention to provide a new and improved continuous coking method wherein particles of contact material provided with coatings or envelopes of deposited coke which coke may be burned off the particles for the production of thermal energy and for regeneration of the particles for re-use as coke deposit receiving media or as a catalyst.

These and other objects and advantages of the invention will clearly appear from the following description taken with the accompanying drawing and the appended claims.

The term "bed" as herein used refers to a mass of solid particles (of contact material) either porous or non-porous, in substantial contact, as distinguished from dispersed particles floated in, or in suspension in, a stream or volume of liquid, gas, or vapor.

In various cracking methods of the prior art utilizing a moving catalyst bed, it is a primary object to supply the cracking or distillation charge to the reaction chamber in vapor phase of selected boiling range to avoid coking so far as is possible. The production of condensible vapors and non-condensible gases has been the sole end of such conversion methods and the production of coke has been considered undesirable, being, for that reason, purposely avoided. The vapor phase charges of such methods were so selected as to avoid the inclusion of heavily coke forming, higher boiling vapors therein.

In our method, on the contrary, the charge is admitted in liquid phase, or in mixed phase, and the production of coke is a desired object and end of the process, since the coke formed in the process may be used, thereafter, for the production of thermal energy, as will clearly appear hereinafter. For example, we may use as a charge a heavy hydrocarbon residual, such as a reduced crude which is a residue of a crude oil topping operation or a vacuum reduction operation, or a cracked residual from a cracking operation.

Referring to the drawing, illustrating diagrammatically, and partly in section, apparatus adapted to the accomplishment of this invention, the casing 1 forms a chamber 2. In this chamber 2 (which may be termed the "reaction chamber"), a heavy hydrocarbon charge is injected into and concurrent with a moving bed of heated solid particles (either porous or substantially impervious) of contact material (such as inert refractory, cracking catalyst or coke) or spread upon the particle surfaces thereof to produce condensible vapors and non-condensible gases which are removed from the upper end of the reaction chamber 2 above the bed, while the bed particles are coated with dry coke. The coke-coated bed particles are removed continuously from the lower end of the reaction chamber 2 and replaced by new or regenerated bed particles introduced into the upper end of the reaction chamber 2, as will hereinafter most clearly appear.

A conveyor of suitable type, such as the screw conveyor 3, is connected with the inlet 4 whence it receives heated bed material or contact material which is conveyed and introduced by the conveyor 3 into the upper end of the reaction chamber 2 at a rate determined by the speed at which the conveyor is driven. The contact material thus introduced into the chamber 2 passes by gravity downwardly therethrough at a predetermined rate from the point of introduction at the upper end of the chamber to the lower end of the chamber.

A similar conveyor 5 communicates with the lower end of the chamber 2 whence it receives coke-coated bed material or contact material which is conveyed by it to the outlet or spout 6 at a rate determined by the rate at which the conveyor 5 is driven.

Since coke coatings are deposited on the bed particles of contact material during their travel through the chamber 2, their bulk is increased by the amount of the bulk of the coatings; for this reason, the rate of removal by the conveyor

5 should exceed the rate of introduction by the conveyor 3. This is accomplished by varying the capacities of the conveyors 3 and 5 accordingly, in order that the quantity of contact material in the moving bed in the chamber 2 shall be maintained substantially constant and unvarying. Any suitable known means (not shown) may be provided for driving the conveyor screws of the conveyors 3 and 5 at desired speeds, for this purpose.

The coke-coated bed particles issuing from the outlet 6 are received by any suitable collecting and/or conveying means such as a chain grate, link elevator, rail conveyors, track cars or the like, designated 7 in the drawing.

Disposed in the reaction chamber 2 in the path of the bed of contact material is one or more charge distributing members such as the spargers 8 which receive the heated hydrocarbon charge from the charge inlet 9 leading from any suitable supply as, for instance, a heating furnace fed from a storage tank or reservoir.

Each of the spargers 8 is provided with a control valve 10 for controlling the rate at which the charge is supplied and spread thereby upon the bed material. This rate of injection or supply of the charge and the speed of the bed determine the spread density, i. e., amount of spread charge per unit of volume of the bed.

The speed of the bed is controllable through variation of the speeds of conveyors 3 and 5 and the injection or supply rate (and spread density) through the valves 10.

While the feed control valves 10 may be manually controlled, if desired, means responsive to the temperature in the coking zone adjacent each sparger 8 may be provided. As shown, this means comprises thermostatic valve control units or members 11 responsive to the thermostatic elements 12 each suitably arranged in the path of the moving bed to control the respective valves in accordance with the temperature of the bed material in that coking zone adjacent the sparger controlled through the valve which is responsive to that element 12.

Since the initial temperature of the bed material decreases progressively throughout its travel through the chamber 2, in the absence of compensatory heating devices, the spread density or charge feed rate must decrease accordingly in such cases in order to prevent incomplete coke production or, in other words, in order that coke produced will be dry, thus avoiding cementing, chunking or sticking together of the coke-coated bed particles. By proper adjustment of the control units or members 11, this may be automatically accomplished.

While we have, herein, illustrated the provision of three spaced spargers 8, forming three coking zones in the chamber 2 and substantially equidistantly spaced, any number and any spacing may be provided, where desired.

With proper control of the variables, it is contemplated that the coke produced in the chamber be applied in superposed layers or laminae. For example, in the illustrated apparatus, an innermost coating, layer, or envelope may be applied directly to the bed particles or nuclei in the first or uppermost coking zone supplied by the uppermost sparger 8, an intermediate coating or layer in that controlled by the second sparger 8, and a third or outer coating or envelope in the lowermost zone controlled by the third or lower sparger 8.

The vaporous products are drawn off from the upper end of the chamber 2 through the vapor outlet 14. These vaporous products comprise condensible vapors and incondensible gas or gases. These products may be carried off for separation and processing in any known manner, as, for instance, for removal of gasoline and gas oil by condensation and separation off of the incondensible gas or gases.

While such vaporous products and their treatment are known in the art, it is the case, however, that their production concurrently with the continuous production of coke, as described above, has not heretofore been practiced.

A specific example is as follows:

Charge:

Mid-Continent reduced oil, with A. P. I. gravity @ 60° F. of 18.0.

Flash point, C. O. C	°F	330
Fire point, C. O. C	°F	435
Pour point	°F	80

Bed material:

Round stone gravel, (inert refractory).

Size	Average approx. 5 mesh (U. S. Std. sieve size)	
Density	g/cc	1.549
Voids	percent	41.0

Procedure:

6.7 lbs. of (oil) charge was introduced at 840° F. to the coking chamber; spread upon 24 lbs. of bed material at 970° F. Contact time 8 minutes, 36 seconds.

Temperature of the bed material fell from 970° F. to 870° F.

The products comprised:

Gas	0.188 lb. or 2.8%
Distillate	5.750 lb. or 86.9%
Coke	0.500 lb. or 7.5%

Alternative bed material:

Calcined coke particles.

Size	Approx. 5 mesh (average)
Voids	40% (approx.)

The products are approximately as above, i. e., 2.8% gas, 86.9% distillate, and 7.5% deposited coke.

Further investigation indicated the preferred range for the same (oil) charge to be as follows:

Charge (oil) introduced into the coking chamber at 800° F. to 950° F. and contacted with a bed of contact material comprising chemically inert refractory particles, or coke (as above), at 900° F. to 1100° F. (providing the main portion of the coking heat or thermal energy) with a charge spread density of 5 lb. to 50 lb. of (oil) charge per 100 lb. of bed material and contact time of 5 min. to 30 min. will produce a coke yield of 3 lb. to 30 lb. of coke per 100 lb. of (oil) charge introduced.

It follows that where the bed material comprises calcined coke particles, the coke deposit thereon will be approximately the same and will represent increase in grain or particle size.

Particularly where the bed material is a chemically inert refractory material, it is advantageous to employ as the collecting means 7 a chain grate or other means for using the heated output of the outlet 6, before the heat thereof is dissipated. Where such immediate use is possible, the latent heat of this output is additive to the heat energy or thermal energy produced, or liberated, by combustion of the coke coatings in the material.

The provision of close control of the variables such as initial heat of charge and bed, and spread density (through regulation of bed speed and rate of charge injection or feed), makes possible wide variation in the operative cycle whereby commensurate variation in the type, properties, and quantities of the end products, may be secured as desired.

The contact time is, of course, a function of the speed of movement of the bed through the chamber or coking zone and may be varied according to the nature of the charge, the temperature of admission of the charge, and of the bed material, and the rate of feed, or charge spread density, all of which may be varied to suit the properties of the charge as well as the types and relative quantities of the end products desired, in a manner well known in the art.

The nature of the bed material likewise may vary with consequent effect on the above mentioned variables. It may comprise a chemically inert refractory material, a known cracking catalyst material, or calcined coke particles which are enlarged by the deposit of coke coatings or envelopes thereon according to the principles of this invention. Therefore, the inclusive or comprehensive term "contact material" as used herein is of substantial scope since it covers these three rather divergent types of coke deposit receiving media.

The term "calcined" as herein applied to the coke comprising the bed particles refers to coke particles from which volatile matter has been removed.

According to the method of this invention, the contact time, i. e., speed of the moving bed, is so chosen, according to the spread density, type and temperature of the charge and of the bed material, that the coke deposited on the bed particles is dry and non-tacky in order that the formation of clumps in the bed, i. e., cementing together of the bed particles, is prevented.

Since the above described examples represent the results secured in a coking chamber having but a single coking zone, wherein but a single coating was deposited on the bed particles, the yield may be greatly increased by applying the coke produced in the chamber as a multiplicity of coatings or superimposed envelopes, each individually relatively thin but collectively of substantial thickness. This "multiple coating" is effected, according to this invention by dividing the coking chamber into a multiplicity of coking zones wherein the charge feeds and/or spread densities are independently controlled, according to the temperature of the bed material in each zone.

Optionally, means may be provided for independently controlling the charge temperature according to the bed temperature, independently, in each zone. This means may comprise independent heat exchangers or heaters 18 for each sparger 8 controlled either by the control means 11, 12 of each sparger or by functionally similar heat responsive means comprising individual, independent valve control units or members 19 responsive to the above described thermostatic elements 12, as shown. Independent thermostatic elements (not shown) may be provided and located if desired.

As shown, the heat exchangers 18 may comprise elements of conventional form to which heating gas or fluid is supplied by conventional feed pipe 20, having common connection therewith, under control of valves 21 operated by the above described control units 19, a suitable exhaust 22 being provided, in conventional manner, for the heat exchangers or heaters 18.

Since it is much easier to secure a dry coating when the thickness thereof is slight, and since the dryness or non-tacky nature of the deposited coke is important in preventing the formation of lumps, clumps and cementing in the bed, the above described "multiple coating" principle is an important feature of this invention. The coatings secured on the bed particles or nuclei are dry, non-tacky, brittle, and frangible whereby the movement of the bed is sufficient to maintain the coated particles separate from one another, or discrete within the bed, without necessity for the provision of mechanical agitation or stirring.

The above described independent control of the temperature of charge admission for each coking zone makes it possible to compensate for progressive drop in the bed temperature as the bed passes through the chamber 2. In other words, the loss of bed temperature is compensated for by increase in admission temperature of the charge. For instance, since the bed temperature is highest in the first or upper coking zone, the charge admission temperature would be lowest while the charge admission temperature should be highest in the final coking zone or lowest coking zone where the bed temperature is lowest. Also, in apparatus provided with multiple coking or reaction zones, by use of the above described compensatory means, the spread density in each zone may be maintained equal.

It is, of course, to be understood that the above description is merely illustrative and in nowise limiting and that we desire to comprehend within our invention such modifications as are included within the scope of the appended claims.

Having thus fully described our invention, what we claim as new and desire to secure by Letters Patent is:

1. In a method of recovering usable thermal energy from heavy hydrocarbons, passing by gravity through a sealed chamber including a plurality of coking zones at predetermined speed, a preheated bed comprising particles of solid contact material, spreading on said moving bed in each coking zone a heated heavy hydrocarbon charge at predetermined spread density and at predetermined admission temperature, while independently controlling the temperatures of admission of said charge to said chamber and the spread density of said charge in each of said coking zones to compensate for temperature drop in said bed in its passage through said zones, whereby to form on said bed particles in each coking zone coatings of dry non-adhesive coke capable of combustion for generating thermal energy upon use of said coated bed particles as fuel.

2. In apparatus for converting hydrocarbons, means forming a reaction chamber, means for conveying a bed comprising heated particles of contact material introduced at a predetermined temperature through said chamber at predetermined speed, means for injecting a heated hydrocarbon charge at predetermined spread density into said bed at a plurality of points in its path of travel through said chamber for forming vaporous hydrocarbon conversion products and depositing a plurality of superposed dry coke coatings on said bed particles, and means responsive to the bed temperature for independently controlling the charge injection rate at each of said points of charge injection to compensate for variation in bed temperature by varying the spread density directly with the bed temperature

whereby to prevent incomplete coke production throughout said chamber.

3. In apparatus for converting hydrocarbons, means forming a reaction chamber, means for conveying a bed comprising heated particles of contact material introduced at a predetermined temperature through said chamber at a predetermined rate, means for injecting a heated hydrocarbon charge at predetermined spread density into said bed at a plurality of points in its path of travel through said chamber for forming vaporous hydrocarbon conversion products and depositing a plurality of superposed dry coke coatings on said bed particles, and means responsive to the bed temperature for independently controlling the charge injection rate and the charge injection temperature at each of said points by varying the charge injection temperature inversely with the bed temperature and the charge spread density directly therewith whereby to secure uniform coke coatings and compensate for variations in bed temperature.

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