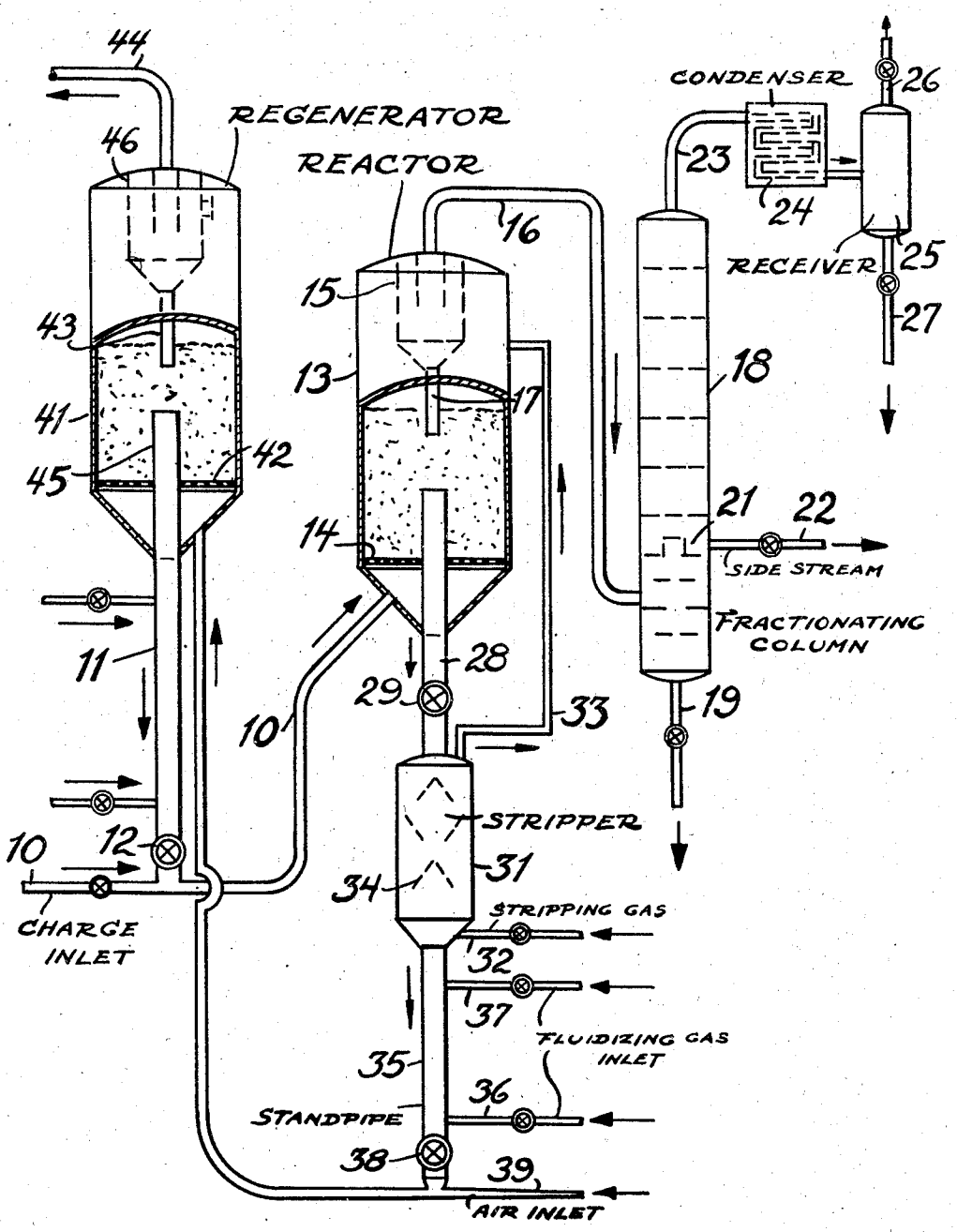
June 3, 1947. C. E. HEMMINGER ET AL 2,421,616

CATALYTIC TREATMENT OF HYDROCARBON OILS

Filed Dec. 28, 1944



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Patented June 3, 1947 2,421,616

UNITED STATES PATENT OFFICE

2,421,616

CATALYTIC TREATMENT OF HYDROCARBON OILS

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Application December 28, 1944, Serial No. 570,188

7 Claims. (Cl. 196—52)

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This invention relates to the cracking of hydrocarbon oils and pertains more particularly to the cracking of oils in the presence of a finely-divided cracking catalyst.

It has heretofore been the practice to crack oils in the presence of a finely-divided cracking catalyst which is continuously circulated through a cracking zone and a regenerating zone and in which the catalyst is maintained in a fluid state throughout its circulation between the cracking and regenerating zones by maintaining a small amount of fluidizing gas in admixture with said catalyst. It has previously been known that the presence of a small amount of such aerating gas causes the finely-divided catalyst to behave in many respects as a liquid, such as being capable of generating a hydrostatic pressure. When operating according to previous practices, the pressure lost during circulation of the catalyst powder is restored by providing one or more standpipes in the circulating circuit. For example, one standpipe may be positioned in the transfer line for passing the catalyst from the cracking zone to the regenerating zone and another standpipe may be positioned in the transfer line leading from the regenerating zone back to the cracking zone. This type of process is generally known as the fluid cracking process.

When operating the fluid catalyst process, and also other types of catalytic processes, it has been the practice heretofore to regulate the cracking conditions to convert a relatively uniform and predetermined amount of the charging oil into gasoline, irrespective of the coke-forming characteristics of the charging oil. This means that there is a variation in the amount of coke formed during the cracking operation from a given amount of feed, depending upon the coking characteristics of the charging oil. Because of the variation in the amount of coke produced, according to prior practices it was necessary to design the regeneration chamber of sufficient capacity to burn the maximum amount of coke which would be produced from the various types of charging oils passed to the equipment. In view of this, the regenerating equipment was operated at design capacity only in cases where the charging stock produced a relatively high percentage of coke. In other cases, such as when employing a relatively clean condensate stock which produced relatively low amounts of coke, the regenerating equipment was not operated at maximum capacity or efficiency.

One of the important objects of the present invention is to provide an improved method of operating a cracking process capable of more efficiently utilizing the cracking equipment.

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Another main object of the invention is to utilize more effectively the heat liberated during the burning of combustible deposits from the catalyst during the regenerative treatment.

Other more detailed objects of the invention will be apparent from the description hereinafter in which reference will be made to the accompanying drawing which is a partly diagrammatic and partly schematic illustration of an apparatus capable of carrying the invention into effect.

In accordance with the present invention, the oil to be cracked is passed upwardly through a vertical reaction chamber into which a stream of finely-divided powder is continuously introduced and the velocity of the vapors rising through the chamber is controlled by the rate of feed of the charging oil to maintain a relatively dense, turbulent layer or phase of catalyst in the bottom portion of the cracking chamber. Under properly regulated conditions, this relatively dense layer will be superimposed by a relatively dilute phase containing oil vapors and a small amount of entrained catalyst. The level of the dense, turbulent phase of catalyst in the cracking chamber is independently controlled by separately withdrawing a stream from the dense phase at a controlled rate.

Further in accordance with the present invention, the level of the dense, turbulent phase within the cracking chamber is regulated to convert a substantially uniform amount of the charging oil into coke or combustible deposits, irrespective of the coke-forming characteristics of the charging oil.

According to a more specific phase of the invention, the amount of coke formed is controlled so that the heat liberated during the burning thereof is sufficient to supply the major portion of the heat requirements for the cracking process. This involves supplying the heat required to preheat the oil from incipient cracking temperature or below up to the final cracking temperature and to supply the necessary heat for the endothermic reaction. When operating according to the present invention, the amount of charging stock converted into gasoline will vary with the coke-forming characteristics of the charge. Expressed in another way, instead of carrying out the cracking process to convert a uniform amount of charging oil into gasoline, according to present practices, the cracking conditions are controlled to convert a uniform and predetermined amount of the oil

into coke, the amount of coke formed being sufficient to supply the necessary fuel for the cracking process. This is accomplished according to a specific phase of the invention by regulating the level of the dense, turbulent phase of catalyst within the cracking zone.

Having set forth the general nature and objects, the invention will be best understood by the more detailed description hereinafter and reference will now be made to the accompanying drawing.

Referring to the drawing, the reference character 10 designates a charge line for introducing the oil to be processed into the system. This oil may comprise any higher boiling hydrocarbon oil fraction which is desired to be converted into gasoline or motor fuel constituents, including gas oils and crude residuums. The oil prior to being introduced into the system through line 10 may be partially preheated from room temperature even up to incipient cracking temperature, such as from 500° F. to 750° F. The oil passing through line 10 intermingles with a stream of hot, finely-divided cracking catalyst introduced through vertical conduit 11 having a control valve 12 for regulating the amount of powder introduced into the oil. The temperature of the catalyst powder introduced into the oil is preferably materially above the desired cracking temperature and the amount introduced is sufficient to preheat the oil from the initial preheat temperature to the final desired cracking temperature and also to supply the necessary heat for the cracking reaction. The amount of catalyst so introduced will normally range between 5 and 50 parts of catalyst per part of oil by weight. The finely-divided catalyst may consist of any of the cracking catalysts, such as activated clays and synthetic gels of silica-alumina, silica-magnesia, boron oxide-alumina, silica-zirconia, and the like.

The suspension of oil and catalyst formed in the line 10 is transferred into the bottom of a reaction chamber 13. The bottom of the reaction chamber 13 may be in the form of an inverted cone superimposed by a grid 14 forming a distributing zone for distributing the oil vapors and catalyst into the main body of the cracking chamber. The size of the cracking chamber is designed to permit the velocity of the oil vapors to be reduced to a point which will cause the finely-divided powder to separate into a relatively dense phase in the bottom section of the reaction chamber, as illustrated. This layer of catalyst will be maintained in a highly turbulent condition by the oil vapors rising therethrough and a substantially uniform temperature may therefore be maintained throughout the body of catalytic material therein.

The oil vapors pass upwardly through the layer of catalytic material maintained in the cracking chamber and are removed overhead into a cyclone separator 15 wherein entrained catalyst is separated from the gaseous reaction products. The superficial velocity of the oil vapors rising through the reaction chamber may be of the order of from 0.5 to 5 feet per second, depending upon the size and density of the catalyst particles.

The reaction vapors are removed from cyclone separator 15 through line 16 and the catalyst separated in the cyclone is returned to the cracking chamber through conduit 17. The cracked vapors may be passed to a conventional fractionating column 18 in which the vapors are subjected to fractional condensation to separate the cracked products into a plurality of fractions. The initial fraction formed in the bottom portion of the fractionating tower 18 will normally contain a relatively small amount of catalytic material. The initial condensate, containing the powdered material is withdrawn from the bottom of the fractionating tower 18 through line 19 and may be rejected from the system or it may be recycled to the reaction chamber for further cracking, if desired. Condensate formed in the upper section of the fractionating tower may be separately collected in one or more trap-out trays, such as trap-out tray 21, and separately withdrawn as a side stream through line 22.

Vapors remaining uncondensed in the fractionating tower 18 are removed overhead through line 23 which leads to a condenser 24 in which the motor fuel constituents formed during the cracking process may be condensed. The products then continue from the condenser 24 into a receiver 25 in which the liquid distillate separates from uncondensed vapors and gases. The vapors and gases are removed from the receiver 25 through line 26 and may be passed to suitable recovery equipment which, for purposes of simplicity, has not been illustrated in the drawing. The raw distillate separated in the receiver 25 is withdrawn through line 27 and may be subjected to any further finishing treatment required for the production of the final market product.

Referring again to the reaction chamber 13, a separate conduit 28 extends upwardly through the bottom of the reaction chamber into the main body of the chamber and preferably terminates at an intermediate point therein. The conduit 28 serves for separately withdrawing a stream of catalytic material containing absorbed reaction products from the reaction chamber. This stream discharges through a control valve 29 into a stripping zone 31 in which the powder is subjected to thorough stripping by an inert gas such as combustion gas or steam to remove the volatile hydrocarbon products therefrom. The gas used for stripping is introduced into the bottom of the stripping zone 31 through line 32 and the volatile hydrocarbons together with the stripping gas are removed overhead through line 33 and may be introduced into the reaction chamber 13 above the level of catalyst therein and become intermingled with the main vapor product stream.

The stripper 31 may be provided with suitable baffle 34 for improving the contact between the stripping gas and the powder. The catalyst passes from the bottom of the stripper 31 into a vertical conduit 35 which forms a standpipe for restoring at least a portion of the pressure lost on the powder during circulation through the reaction chamber. A fluidizing gas may be introduced at one or more spaced points through lines 36 and 37 for maintaining the powder in the vertical standpipe 35 in a fluid state capable of behaving as a liquid and thereby generating a hydrostatic pressure at the base of the standpipe. The powder discharges from the base of the standpipe 35 through a control valve 38 at a controlled rate into a stream of air passing through line 39. The suspension of air and catalyst passes from line 39 into the bottom of a regenerator 41 below a grid plate 42. The regeneration chamber 41 is constructed similarly to the cracking chamber 13 and the diameter of the chamber is preferably such that the velocity of the air rising through the regenerator is reduced to a point which permits the powder to separate into a relatively dense layer, as pre-

viously described in connection with the reaction chamber 13.

The catalyst is subjected to regeneration within the regenerating chamber 41 for burning combustible deposits formed on the catalyst during the cracking operation. The spent combustion gases are removed overhead from the regenerator 41 through a cyclone 46 which effects further removal of catalyst powder from the spent combustion gases. The catalyst separated in the cyclone 46 discharges back into the regenerator through conduit 43 and the spent combustion gases are removed overhead through line 44. These combustion gases may be passed to additional recovery equipment such as Cottrell separators, filter bags, and the like for further separation of the catalyst from the regeneration gas. As illustrated, the conduit 11 which discharges the catalyst into the main feed stream passing through line 10 has an extension 45 projecting through the grid plate 42 and upwardly into the intermediate section of the regenerator 41. This conduit serves to remove hot, regenerated catalyst directly from the regenerator and returning it directly into the oil streams. If desired, a small amount of fluidizing gas may be introduced at one or more spaced points in the conduit 11 to maintain the powder in a fluid state and the conduit 11 may function as conduit 35 for generating additional pressure to restore pressure lost during passage through the regenerating equipment.

In accordance with the present invention, the amount of coke formed from a given amount of feed during the cracking process is maintained substantially uniform irrespective of the coke-forming characteristics of the charge by varying the depth of the catalyst layer within the reaction chamber 13. The depth of the catalyst layer in the reaction chamber may be regulated by controlling the rate of withdrawal of the catalyst through control valves 29 and 38. The extent of cracking in the cracking chamber 13 will depend upon the depth of the catalyst layer through which the oil vapors pass, and when it is desired to reduce the amount of cracking which is taking place the level in the reactor is maintained relatively low, whereas when it is desired to increase the degree of cracking a greater depth of catalyst is maintained within the reaction chamber. The minimum level maintained in the reaction chamber 13 will be fixed by the height of the conduit 28 projecting into the reaction chamber, and the maximum level will depend upon the height of the reaction chamber.

It will therefore be evident that the amount of catalyst maintained in the reaction chamber through which the oil vapors pass may be controlled over a relatively wide range and thus provides an excellent means of regulating the amount of coke formed during the cracking operation. The amount of coke formed from a given amount of feed is preferably sufficient to supply the major portion of the heat requirements for the cracking process, as previously set forth. This may range from 2% to 9% coke, depending upon the preheat temperature of the oil and the cracking temperature desired. When operating at temperatures of about 950° F. in the cracking chamber and 1100° F. in the regenerator, the amount of coke formed should be about 6% when an oil preheat temperature of 400° F. to 500° F. is employed.

This application forms a continuation-in-part of our earlier application Serial No. 363,867, filed November 1, 1940.

Having set forth the general nature and objects of the invention, it will be understood that it embraces such other variations and modifications as come within the spirit and scope thereof.

What is desired to be protected by Letters Patent is:

1. In a process for cracking hydrocarbon oils wherein the oil is cracked in the presence of a catalyst which continuously circulates through a cracking zone and wherein oils of different coking characteristics are passed through said cracking zone at different times, the improvement which comprises controlling the amount of catalyst in said cracking zone to convert a substantially uniform and predetermined amount of the oil into coke irrespective of the coke-forming characteristics of said oil.

2. In a process for cracking hydrocarbon oils wherein the oil is cracked in the presence of a catalyst which continuously circulates through a cracking zone and thereafter through a regenerating zone in which coke deposits formed on the catalyst during the cracking operation are removed by burning and wherein oils of different coke-forming characteristics are passed through said cracking zone at different times, the improvement which comprises controlling the amount of catalyst in said cracking zone to convert a substantially uniform and predetermined amount of the oil into coke irrespective of the coke-forming characteristics of said oil, the amount of coke formed being sufficient when burned in said regenerating zone to supply the major portion of the heat requirements for the cracking process, burning the coke formed during the cracking process in said regenerating zone to heat the catalyst to a temperature materially above the temperature existing in the cracking zone and thereafter returning the heated catalyst directly from the regenerating zone to the cracking zone.

3. A process for cracking hydrocarbon oils which comprises passing the oils of different coke-forming characteristics in vapor form at different times upwardly through an enlarged vertical cracking zone containing finely-divided cracking catalyst, regulating the velocity of the vapors rising through said cracking zone to maintain a relatively dense, turbulent layer of catalyst in the bottom portion of the cracking zone, withdrawing vaporous cracked products from the upper end of said zone, continuously introducing a stream of hot, finely-divided catalyst into said cracking zone, withdrawing a stream of finely-divided catalyst from the lower portion of said cracking zone below the level of said dense, turbulent layer of catalyst and varying the amount of catalyst contained in said zone to convert a uniform amount of said oils into coke irrespective of the coke-forming characteristics of said oils during the cracking process.

4. A process for cracking hydrocarbon oils of different coke-forming characteristics which comprises preheating the oils to a temperature below active cracking temperature, passing the oils so heated in vapor form at different times upwardly through an enlarged vertical cracking zone containing finely-divided cracking catalyst, regulating the velocity of the vapors rising through said cracking zone to maintain a relatively dense, turbulent layer of catalyst in the bottom portion of said zone, withdrawing vaporous cracked products from the upper end of said zone, separately withdrawing a stream of finely-divided catalyst from the lower portion of said cracking

zone below the level of said layer, passing the catalyst so withdrawn to a regenerating zone, burning coke deposits from said catalyst within said regenerating zone to thereby heat said catalyst, returning the heated catalyst to the cracking zone and varying the amount of catalyst within said cracking zone to convert a uniform and predetermined amount of oils into said coke deposits irrespective of the coke-forming characteristics of said oils, the amount of coke deposits being sufficient to supply the remaining heat requirements for the cracking process.

5. In the process defined by claim 4, the improvement which comprises varying the amount of catalyst in said zone to convert from 3% to 9% of said oil into coke deposits.

6. A process for cracking hydrocarbon oils of different coke-forming characteristics which comprises preheating the oils to a temperature below incipient cracking temperature, passing the heated oils in vapor form at different times upwardly through an enlarged vertical cracking zone containing finely-divided cracking catalyst, regulating the velocity of the vapors rising through said cracking zone to maintain a relatively dense, turbulent layer of said catalyst in the bottom portion of said zone, withdrawing vaporous cracked products from the upper end of said zone, separately withdrawing a stream of finely-divided catalyst containing coke deposits from the lower portion of the cracking zone, passing the catalyst so withdrawn to a regenerating zone, burning coke deposits from said catalyst in the regenerating zone to thereby heat said catalyst, returning the heated catalyst to the cracking zone and regulating the level of the layer within said cracking zone to convert a uniform and predetermined amount of said oils into coke irrespective of the coke-forming characteristics thereof, the amount of said coke being sufficient when burned in said regenerating zone to supply the remaining heat requirements for the cracking process.

7. In a fluid catalyst cracking process for cracking oils of different coke-forming characteristics wherein finely-divided cracking catalyst maintained in a fluid state is continuously circulated through a cracking zone and thereafter through a regenerating zone in which coke deposits formed on the catalyst during the cracking operation are burned with the liberation of heat and wherein the loss in pressure on the catalyst during circulation is restored by passing the catalyst downwardly through a vertical standpipe capable of generating a hydrostatic pressure; the improvement which comprises passing the oils in vapor form at different times upwardly through a cracking zone containing said catalyst at a velocity controlled to form a relatively dense layer of catalyst in the bottom section of the cracking zone, removing vaporous reaction products from the upper end of the cracking zone, separately withdrawing finely-divided catalyst containing coke deposits from the lower portion of the cracking zone below the level of said catalyst layer, passing the catalyst so withdrawn to a regenerating zone, passing an oxidizing gas upwardly through said regenerating zone at a velocity controlled to maintain a relatively dense layer of catalyst in said regenerating zone, removing spent regenerating gas from the upper portion of said regenerating zone, heating said catalyst within said regenerating zone, withdrawing catalyst from the lower portion of said regenerating zone beneath the layer of said catalyst therein, returning the regenerated catalyst while in said heated condition to said cracking zone and varying the level of the catalyst within said cracking zone to convert a substantially uniform and predetermined amount of said oils into coke irrespective of the coke-forming characteristics thereof.

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