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2,982,717

CATALYTIC CRACKING PROCESS

Filed Aug. 2, 1957

3 Sheets-Sheet 1

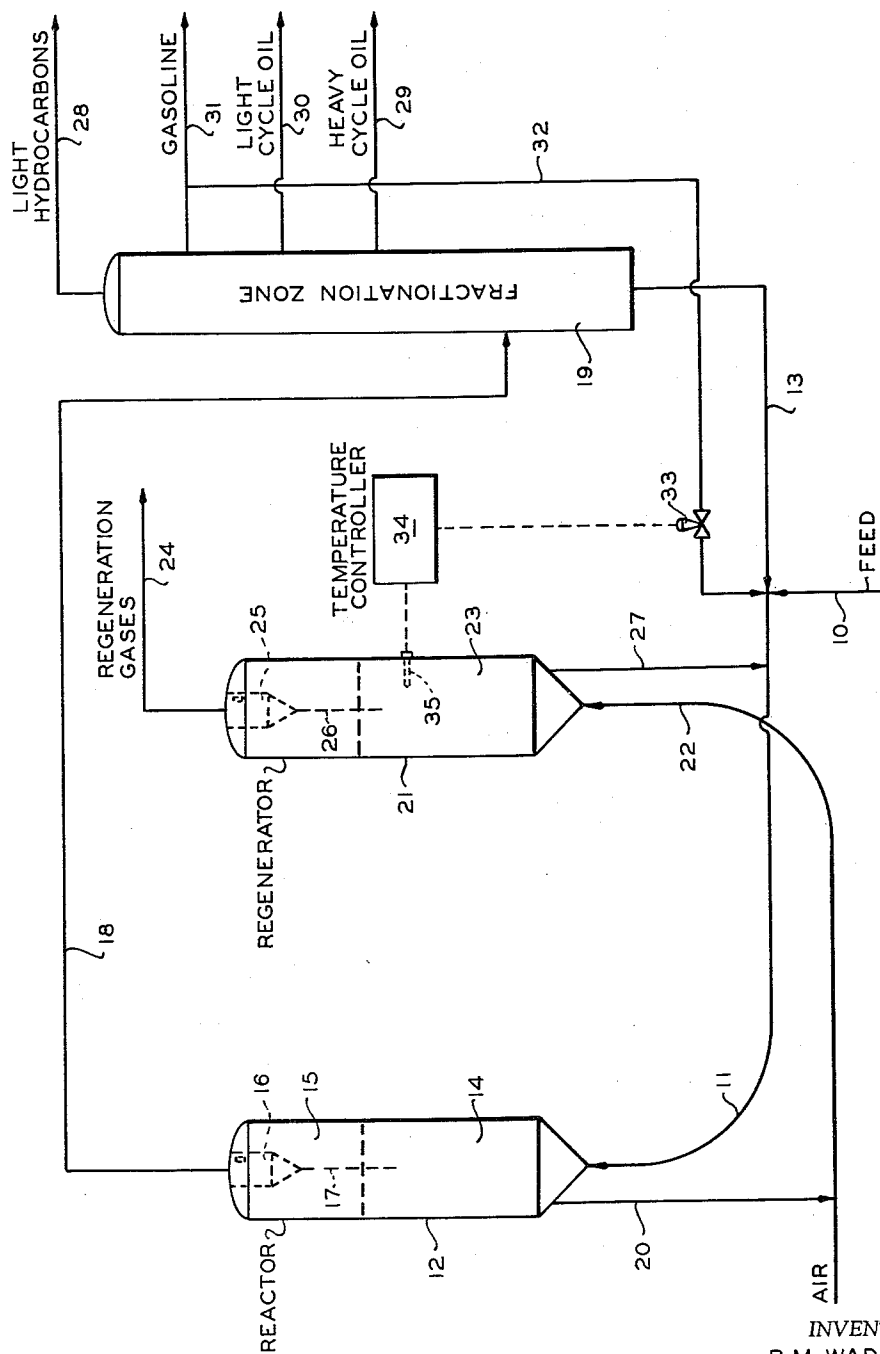


FIG. 1.

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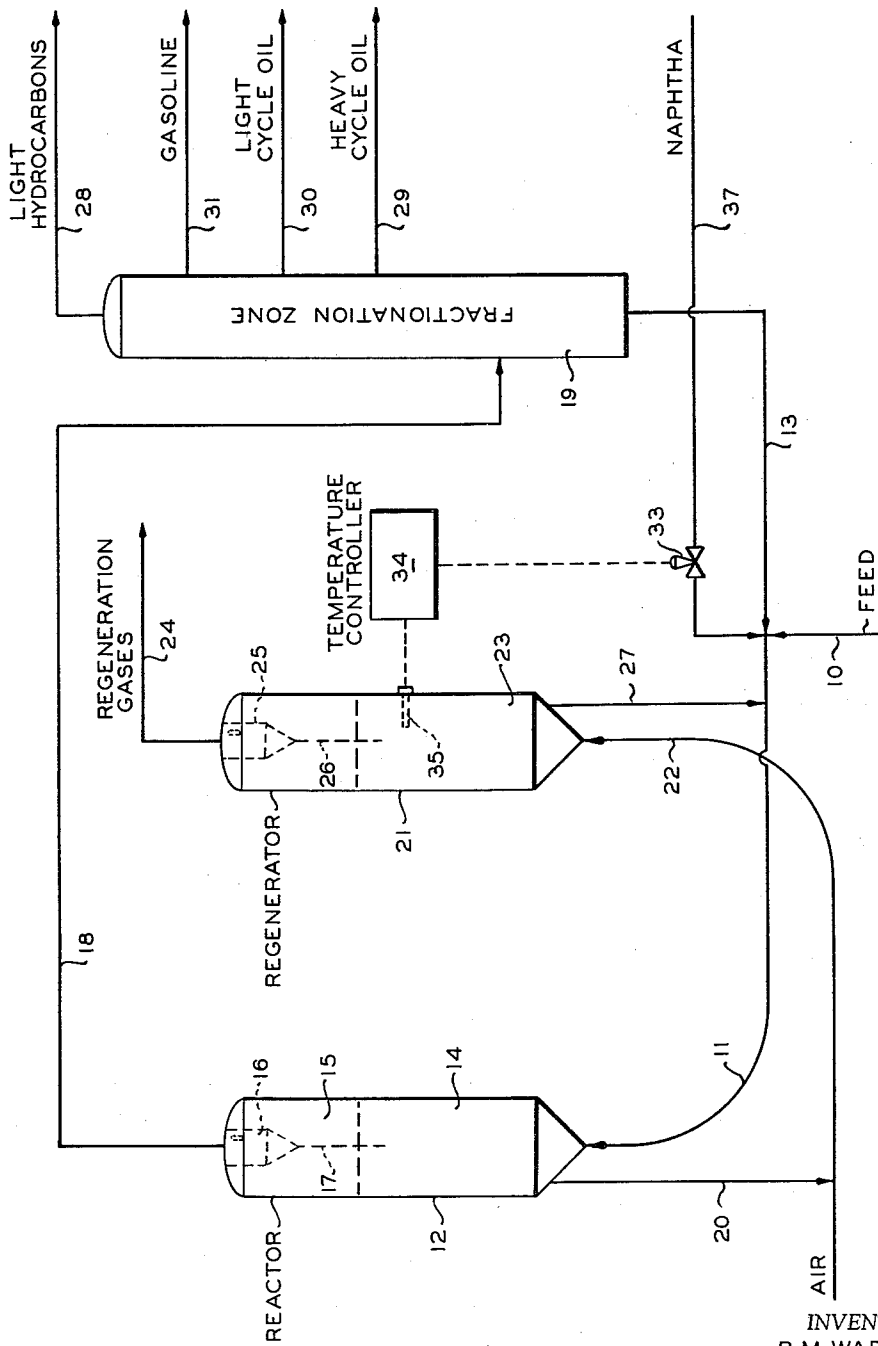


FIG. 2.

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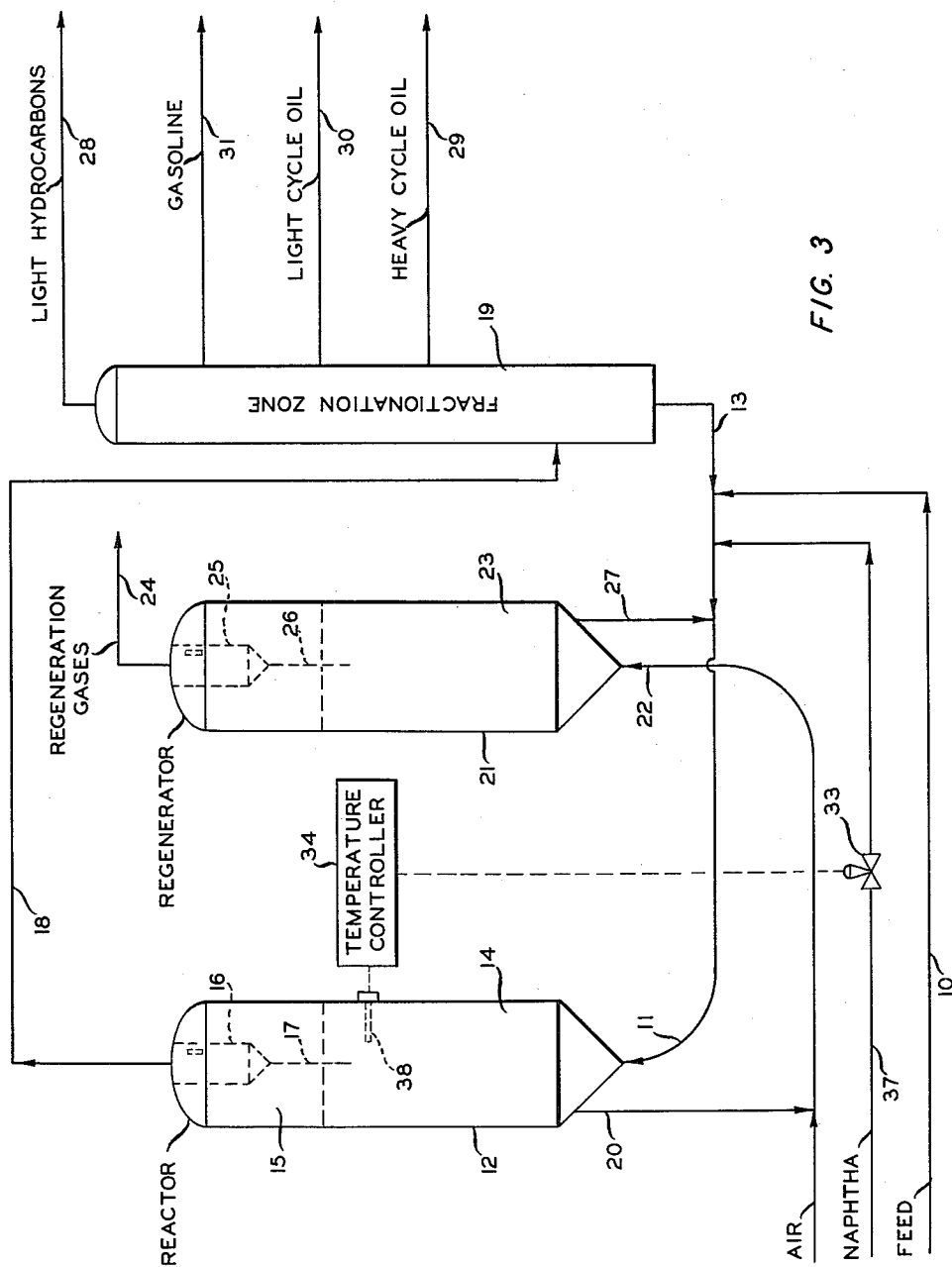
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CATALYTIC CRACKING PROCESS

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8 Claims. (Cl. 208—108)

This invention relates to the catalytic treatment of hydrocarbon oils to produce lower boiling products including gasoline. In one aspect, this invention relates to the catalytic cracking of hydrocarbon oils in a thermally balanced system. In another aspect, this invention relates to the catalytic conversion of a relatively heavy hydrocarbon under controlled conditions of deposition of coke or carbonaceous material on the catalyst. In another aspect, this invention relates to regeneration of hydrocarbon conversion catalyst under regulated temperature conditions and to an apparatus suitable for said conversion.

It is well known that hydrocarbon oils, such as crude oil, virgin gas oil, vacuum gas oil, topped crude and the like, can be catalytically cracked by contact with a solid catalyst under catalytic cracking conditions to produce gasoline and other desirable products. During these catalytic cracking reactions, coke or carbonaceous material is deposited on the surface of the catalyst, resulting in a decrease in the activity of the catalyst. In general, all hydrocarbon oils do not have the same coke or carbonaceous material deposition tendency but hydrocarbon oils from different sources or oils having different previous treatments show different coking properties under conversion conditions. The varying minute quantities of metals in the hydrocarbon oils also affects the carbon deposition tendency of the oil. Periodically, the deposits of coke and carbonaceous material which have developed on the catalyst must be removed in order to maintain the catalyst activity and such reactivation of the catalyst is accomplished by transferring the contaminated catalyst to a regeneration vessel where at least a portion of such deposits are burned off the catalyst. Thereafter, the regenerated catalyst at an elevated temperature developed in the regeneration vessel is returned to the reaction vessel.

The catalytic cracking reaction is an endothermic one and the heat required is customarily supplied by the combustion of the coke and carbonaceous material on the catalyst in the exothermic regeneration step. It is very desirable to not produce excessive amounts of carbonaceous deposits on the catalyst in the cracking step because an excessive amount of heat will be developed in the regeneration step and this excessive heat must be removed from the catalyst before the regenerated catalyst is returned to the cracking vessel in order to maintain the desired temperature level in that vessel. One way to cool the regenerated catalyst is by circulation of a coolant through tubes located in the regenerator in contact with the catalyst. Another means of cooling the regenerated catalyst is by recycling cooled catalyst through the regenerator in direct contact with the catalyst being regenerated.

In ordinary process operation an equilibrium level of coke deposition on the catalyst is established by employing a constant catalyst to oil ratio in the cracking zone. This equilibrium coke level is periodically reduced in the regeneration when the catalyst is regenerated in the regenerator with the development of the necessary quantity of heat to obtain the regenerated catalyst at the proper

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temperature level for use in the cracking zone. When the heat developed in the exothermic reaction step exactly supplies the heat required for the endothermic cracking step, the system is said to be thermally balanced.

Unfortunately, the thermal balance cannot be maintained in the system over long periods of time. During a process upset, a contaminant in the hydrocarbon oil, such as heavy components having higher carbon deposition tendencies or various minute quantities of metals, causes additional quantities of coke and carbonaceous material to be deposited on the catalyst during the cracking step. When this catalyst containing a greater amount of carbonaceous material is regenerated, the greater quantity of carbonaceous material burned raises the temperature of the regenerated catalyst. The return of this catalyst at a more elevated temperature to the cracking zone results in still more carbonaceous material being deposited on the catalyst. Thereafter, the regeneration of this catalyst containing a still greater amount of carbonaceous material results in a still higher temperature being developed in the regenerated catalyst. Thus, the temperature of the process is "snowballing" and such operation cannot be tolerated in a system where a thermal balance between the cracking and regeneration steps must be maintained.

I have now discovered that substantially thermal balance can be established and maintained between the cracking step and the regeneration step in a catalytic cracking process by the introduction of a highly refractory fluid, such as naphtha, gasoline or the like, into the catalytic cracking zone as required by the temperature of the catalyst taken at any suitable point in the system.

An object of this invention is to provide an improved catalytic cracking process and apparatus wherein improved yield of motor fuel boiling range products is obtained. Another object of this invention is to provide an improved catalytic cracking process and apparatus wherein the deposition of coke and carbonaceous material on the catalyst is regulated under controlled conditions. Another object of this invention is to provide an improved catalytic cracking process and apparatus wherein the temperature in the regeneration zone is maintained at a predetermined level. Another object of this invention is to provide an improved catalytic cracking process and apparatus wherein the temperature in the reaction zone is maintained at a predetermined level. Another object of this invention is to provide an improved catalytic cracking process and apparatus wherein the cracking step is established and maintained in substantially thermal balance with the regeneration step. Another object of this invention is to provide an improved catalytic cracking process wherein a less refractory feed stream is contacted with a catalyst under cracking conversion conditions in admixture with a more refractory hydrocarbon stream.

Other aspects, objects and advantages of this invention are apparent from a consideration of the accompanying disclosure, drawing and the appended claims.

In accordance with this invention, there is provided a catalytic cracking process and apparatus for performing said process wherein substantial thermal balance is established and maintained between the cracking step and the regeneration step by the introduction of a highly refractory stream, such as naphtha, gasoline, or the like, into the cracking zone in a controlled amount in accordance with the temperature of the catalyst measured at some point in the system.

More specifically, there is provided a catalytic cracking conversion process, and apparatus for performing said process, wherein the amount of coke or carbonaceous material deposited on the catalyst in the cracking zone is automatically controlled by regulating the introduction of a diluent or highly refractory stream, such as gasoline,

naphtha or the like, into the catalytic cracking conversion zone in accordance with the temperature of the catalyst measured at some point in the system.

In one embodiment, this invention comprises introducing a feed stream into a cracking zone, contacting said feed stream with a cracking catalyst in said cracking zone maintained under catalytic cracking conditions, recovering the effluent from said cracking zone, transferring the contaminated catalyst to a regeneration zone, contacting said catalyst with air under regeneration conditions to regenerate catalyst and elevate its temperature, detecting the temperature of the catalyst in said regeneration zone, introducing a naphtha boiling range fraction into said cracking zone, automatically controlling the amount of said naphtha boiling range fraction introduced into said cracking zone in accordance with the temperature of the catalyst in the regeneration zone, and transferring the regenerated catalyst into said cracking zone at a temperature so as to result in the temperature desired in said cracking zone.

An alternative further inventive concept is found in a non-equivalent embodiment of another concept of the invention which can be viewed as a narrower or independent sub-concept under the broader aspect of the invention. In this embodiment, this invention comprises introducing a feed stream into a cracking zone, contacting said feed stream with a cracking catalyst in said cracking zone maintained under catalytic cracking conditions, recovering the effluent from said cracking zone, transferring the contaminated catalyst to a regeneration zone, contacting said catalyst with air under regeneration conditions to regenerate catalyst and elevate its temperature, detecting the temperature of the catalyst in said cracking zone, introducing a naphtha boiling range fraction into said cracking zone, automatically controlling the amount of said naphtha boiling range fraction introduced into said cracking zone in accordance with the temperature of the catalyst in said cracking zone, and transferring the regenerated catalyst into said cracking zone at a temperature so as to result in the temperature desired in said cracking zone.

It is to be appreciated that thermal balance between the reaction and regeneration steps is maintained in this process without a provision for abstracting excess heat or supplying additional heat to the system. Thus, heat for the inherent thermal balance which should exist between the cracking and regeneration steps is stored in the catalyst during its regeneration and automatically supplied therewith to the cracking zone so as to correspond to the heat required for conducting the endothermic catalytic cracking reaction in the latter zone. Ordinarily, this condition of inherent thermal balance does not exist because the quantity of combustible contaminants accumulated by the catalyst in promoting the cracking of most hydrocarbon oils to produce a satisfactory high yield of gasoline is usually more than that which is necessary for thermal balance between the cracking and regeneration steps. In some operations, a natural thermal balance will exist and in these operations the highly refractory stream or the diluent is not introduced into the cracking zone. However, whenever there is an upset in the operating conditions such that the temperature in the regeneration zone increases to above a predetermined value, highly refractory hydrocarbon or diluent is automatically introduced into the cracking zone to effect the lowering of the temperature to within the desired operating range. When the temperature in the cracking zone has been corrected so that thermal balance again exists in the system, the temperature in the regenerator reaches a predetermined minimum value and the flow of highly refractory hydrocarbon or diluent into the cracking zone is automatically reduced, or stopped, by the temperature controller so that stable operation is obtained.

The novel features of the invention are particularly advantageous to operations of the fluid type in which a

relatively dense and turbulent fluid-like bed of finely-divided catalyst particles is maintained in the cracking and regeneration zones. However, the invention is also applicable to an operation of the type in which a relatively compact bed of moving granular catalyst particles is maintained in the cracking and regeneration zones. Of course, the conditions of the catalyst bed in the regeneration zone may be similar to that maintained in the cracking zone or, when desired, relatively compact beds of catalyst may be maintained in the cracking zone and a fluid-like bed maintained in the regeneration zone or vice versa.

The accompanying drawings are diagrammatic illustrations of specific forms of apparatus in which the improved method of operation provided by the invention may be successfully conducted. In the drawings, Figure 1 is a partial schematic flow diagram of a fluid-type process showing an embodiment of the invention wherein the temperature of the catalyst in the regeneration zone is detected and a gasoline boiling range fraction, which is separated from the effluent of the cracking zone, is recycled to the cracking zone. Figure 2 is a partial schematic flow diagram of a fluid-type catalytic cracking process showing another embodiment of the invention wherein the temperature of the catalyst in the regeneration zone is detected and the highly refractory stream or diluent is a naphtha obtained from some source other than the cracking process. Figure 3 is a partial schematic flow diagram of a fluid-type catalytic cracking process showing another embodiment of the invention wherein the temperature of the catalyst in the cracking zone is detected and the highly refractory stream or diluent is a naphtha obtained from some source other than the cracking process.

Referring to Fig. 1, feed hydrocarbon, in this embodiment, a gas-oil, is introduced by line 10 and thence through line 11 into reactor 12 together with heavy hydrocarbon containing a small amount of catalyst introduced through recycle line 13. In reactor 12, the hydrocarbon is contacted with a dense phase bed of fluidized cracking catalyst 14 under hydrocarbon conversion conditions, including the temperature of about 900° F. Above the dense phase catalyst bed 14 and reactor 12 is a dilute phase 15 which comprises a relatively dilute suspension of entrained solid particles in vaporous reaction products. The vaporous reaction products are passed through a separating means 16 arranged in the upper portion of reactor 12 to separate most of the entrained catalyst particles from the vaporous reaction products. The separated catalyst particles are returned to the dense phase bed 14 through line 17 which dips below the uppermost level of the dense phase bed of catalyst 14. The separated vaporous reaction products pass overhead through line 18 into the lower part of fractionating tower 19, wherein the vapors are fractionated as will be presently described.

During the cracking operation, the catalyst particles become contaminated by the deposition of coke or carbonaceous material thereon and this contaminated catalyst is removed from reactor 12 through downleg 20 and transported to regenerator 21 through line 22 by means of air or oxygen containing combustion gas introduced into line 22. In regenerator 21, the contaminated catalyst is maintained in a fluidized bed 23 by the combustion gas introduced through line 22. The catalyst is regenerated by the combustion of the coke and carbonaceous deposits from the surface of the catalyst by the oxygen containing gas as it passes through the fluidized bed of catalyst. The regeneration step is carried out at a temperature of about 1050° F. and the endothermic heat of reaction necessary in the cracking step is thereby imparted to the regenerated catalyst. The regeneration gases pass overhead and are removed from regenerator 21 through line 24. Any entrained catalyst particles in the regeneration gases are removed by sepa-

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ration means 25 arranged in the upper part of regenerator 21 and returned into the bed 23 of dense phase catalyst by line 26. The hot regenerated catalyst particles then flow through standpipe 27 into line 11 through which they are transported to reactor 12 by the steam of hydrocarbon feed passing therethrough.

Returning now to the fractionating tower 19, the vaporous reaction products introduced into the fractionating tower through line 18 are fractionated into several fractions. The light hydrocarbons pass overhead by means of line 28 and are recovered for use in other processes. The bottoms from fractionating tower 19 contain some catalyst particles which were carried over with the vaporous reaction products from line 18 and also contain some heavier cracked constituents. These bottoms are withdrawn from fractionating tower 19 through line 13 and returned to regenerator 12 through line 11, as previously noted. Higher up in fractionating tower 19 a side stream is withdrawn through line 29 and this side stream comprises a heavy cycle oil boiling in the range of about 550–740° F. This heavy cycle oil can either be withdrawn from the system as a product of the process or is recycled to the cracking zone for further hydrocarbon conversion. In this embodiment it is entirely removed from the operation. Higher up in fractionating tower 19, another side stream is withdrawn through line 30 and this side stream comprises a light cycle oil boiling in the range of about 450–610° F. This light cycle oil may also be either withdrawn from the process as a product or returned to the cracking zone for further hydrocarbon conversion. Still higher up in the fractionating tower 19, another side stream comprising gasoline boiling range products having a boiling range from about 100–425° F., is withdrawn through line 31. This gasoline boiling range material constitutes the substantial portion of the product of the process; however, a portion of this gasoline boiling range material is recycled through line 32 and line 11 into reactor 12 in a manner now to be described. It is noted that the bottoms 13 from the fractionation zone 19, in most operations, are passed to a settling zone, or Dorr thickener (not shown), to produce a decant oil product and a slurry stream of oil and catalyst which latter stream is returned to reactor 12.

The flow of gasoline boiling range products recycled to reactor 12 is controlled by valve 33 in line 32, the position of valve 33 being controlled by temperature controller 34 in accordance with the temperature measured in catalyst bed 23 and regenerator 21 by thermocouple 35.

In operation, a relationship between the hydrocarbon conversion conditions in reactor 12 and the regeneration conditions in regenerator 21 is established so that the exothermic heat of regeneration absorbed by the regenerated catalyst is equal to the endothermic heat of reaction required in the cracking step in reactor 12, thus resulting in the system being in a state of thermal balance. When the system is in a state of thermal balance, substantially no gasoline boiling range product is recycled from fractionating tower 19 through line 32 into reactor 12. Whenever the thermal balance is upset, as for example, by the presence of a less refractory hydrocarbon fraction in the feed, an excessive amount of coke and carbonaceous material is deposited on the catalyst in reactor 12 and the combustion of this coke and carbonaceous material from the catalyst and regenerator 21 results in a higher temperature being developed in the bed 23 of regenerated catalyst. Before the practice of this invention, the return of this regenerated catalyst at a higher temperature from regenerator 21 into reactor 12 resulted in still further deposition of coke and carbonaceous material on the catalyst. Thus, the system is in a state of snowballing, as previously described. In the improved process of this invention, this state of snowballing is never reached because the increase of temperature in bed 23 of the regenerated catalyst is detected by

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thermocouple 35 located therein and the operation of temperature controller 34 opens valve 33 to recycle a gasoline boiling range fraction from fractionating tower 19 into reactor 12. This gasoline boiling range fraction, being more refractory than the hydrocarbon feed stream, acts as a diluent in reactor 12 so that there is less coke and carbonaceous material deposited on the catalyst in reactor 12. A reduction in the amount of coke and carbonaceous material deposited on the catalyst results in a lower temperature being developed in the regenerator 21 and the system again comes back into thermal balance. The presence of thermal balance in the system is detected by thermocouple 35 in regenerator 21 and temperature controller 34 operates to stop the flow of gasoline boiling range fraction from fractionating tower 19 through recycle line 32 into reactor 12. Not shown, for sake of simplicity, there is provided a control system which lowers the rate of feed in pipe 10 whenever the rate of feed of the gasoline containing fraction in pipe 32 is increased and vice versa so that, in this embodiment, the total hydrocarbon to catalyst ratio is maintained substantially constant.

In the embodiment of Figure 2 of the drawings, where the same reference characters of Figure 1 are used to identify similar elements of the process in Figure 2, a naphtha fraction boiling in the range of 200–400° F. is used in place of the gasoline boiling range fraction shown in the embodiment in Figure 1 to regulate the deposition of coke and carbonaceous material on the catalyst and thereby maintain the thermal balance between the reactor and regenerator. In this embodiment, the naphtha fraction is introduced through line 37 and line 11 to reactor 12 in accordance with the degree of opening of valve 33 in line 37. Ordinarily, and so long as thermal balance is maintained, valve 33 will remain substantially closed and no naphtha is introduced into the system. However, whenever there is an excessive deposition of coke or carbonaceous material on the catalyst in reactor 12 resulting in an increase in temperature in the bed of regenerated catalyst 23 in regenerator 21, the increase in temperature is detected by thermocouple 35 and temperature controller 34 operates to open valve 33 and introduce naphtha into the system. The naphtha fraction, being a less refractory fraction than the hydrocarbon feed, acts as a diluent in the reaction zone so that less coke and carbonaceous material is deposited on the catalyst. With a decrease in the deposition of coke and carbonaceous material on the catalyst, the temperature of the catalyst in regenerator 21 decreases and whenever the temperature decreases to a minimum value where the system is again in thermal balance, the flow of naphtha into the system is discontinued.

In the embodiment of Figure 3 of the drawings, where the same reference characters of Figures 1 and 2 are used to identify similar elements of the process in Figure 3, the temperature of the catalyst is detected in the cracking zone, instead of in the regeneration zone as shown in Figures 1 and 2, and a naphtha fraction boiling in the range of 200–400° F. is introduced into the cracking zone to regulate the deposition of coke and carbonaceous material on the catalyst and thereby maintain the thermal balance between the reactor and regenerator. In this embodiment, thermocouple 38 is located in reactor 12. Naphtha is introduced through line 37 and line 11 into reactor 12 in accordance with the degree of opening of valve 33 in line 37. Valve 33 ordinarily remains substantially closed and no naphtha is introduced into the system; however, whenever there is an excessive deposition of coke or carbonaceous material on the catalyst in reactor 12, there is a resulting increase of temperature in regenerator 21 and this increase in temperature is detected by thermocouple 38 which is operatively connected to temperature controller 34 and which operates to open valve 33 and introduce naphtha into the system. The less refractory naphtha fraction acts as a

diluent in the cracking zone so that less coke and carbonaceous material is deposited on the catalyst. This decrease in coke and carbonaceous material deposited on the catalyst results in a lower temperature being developed in regenerator 21 and when the temperature decreases to a minimum value where the system is again in thermal balance, the flow of naphtha into the system is discontinued. In this embodiment, increases in temperature in regenerator 21 do not effect the introduction of naphtha into the system unless the increase in temperature is either sufficiently high or for a sufficient period of time to cause an increase in temperature in reactor 12. Thus, ordinary fluctuations of temperature not caused by excessive coke and carbonaceous deposits on the catalyst do not actuate valve 33 for the introduction of naphtha into reactor 12.

It is also within the scope of this invention to locate the temperature sensing means at other places in the system besides in the reactor and the regenerator, as shown in the drawings. For example, the temperature sensing means can also be located in the conduits carrying the regenerated catalyst, such as in lines 27 and 11, shown in Figure 1.

The recycle of gasoline boiling range fraction or the introduction of a naphtha fraction into the cracking zone results in the conversion of some of the higher boiling constituents of these fractions and an upgrading of the material being introduced. This upgrading of the recycled or introduced fraction is, of course, an advantageous feature of the invention. Although one of these fractions can be introduced or recycled continuously with advantageous results, such continuous recycling or introduction is not within the scope of this invention. Thus, the gasoline boiling range fraction or naphtha fraction is recycled or introduced only at times when the thermal balance in the system has been upset.

It is within the scope of this invention to introduce any highly refractory hydrocarbon fluid, of which a gasoline boiling range fraction and a naphtha fraction are merely examples, into the cracking zone to regulate the deposition of coke and carbonaceous material on the catalyst. In effect, the introduced fraction serves as a diluent for the hydrocarbon feed stream being cracked. Preferably, the highly refractory fluid is a gasoline boiling range fraction obtained from the cracking process and having an initial boiling point within the range of about 50–150° F. and an end point in the range of about 325–425° F. Of course, other gasoline boiling range fractions having different boiling ranges can be employed. If the highly refractory hydrocarbon fluid is a naphtha fraction, preferably this naphtha fraction will have an initial boiling point within the range of 125–250° F. and an end point in the range of 350–450° F.

In the practice of the invention, any hydrocarbon stream which is normally subjected to a cracking step can be treated in the process of this invention. Such hydrocarbon streams are well known to those skilled in the art and some such streams include crude oil, virgin gas oil, vacuum gas oil, topped crude and the like. If desired, mixtures of these hydrocarbon streams also can be treated in the process of this invention.

The cracking catalyst suitable for the present process are those having activity in promoting the cracking of gas oil and the like and particularly those minerals or natural and synthetic mixtures thereof comprising bauxite, brucite, various clay-type minerals and active aluminum silicates. These natural catalysts may be used after activation by various means such as acid treating and/or may be promoted with minor amounts of active metals or metal salts or oxides. Also useful are natural materials comprising zirconia, titania, and synthetic preparations comprising zirconia, titania, magnesia, alumina and various silica-alumina combinations. These latter materials may be promoted with minor quantities of metal oxides.

The conditions maintained in the cracking zone and

the regeneration zone in the process of this invention are those conventionally used in operations of this type. Thus, in the cracking zone, the process conditions generally comprise a temperature in the range of 870–1050° F., a catalyst to oil ratio in the range of from about 1:1 to 20:1, a catalyst residence time in the range of from about 5 seconds to about 10 minutes, a weight space velocity in the range of from about 1 to about 20 pounds of oil per hour per pound of catalyst, and a pressure in the range of from about 3 to 20 p.s.i.g. In the regeneration zone, the conditions usually comprise a temperature in the range of from about 1025–1170° F., a pressure in the range of from 10 to 25 p.s.i.g., and a regenerating gas velocity between about 0.5 and 5 feet per second. The particular choice of cracking and reaction conditions will, of course, depend to a substantial extent on the particular hydrocarbon stream being treated and the products desired, but the particular conditions chosen must permit thermal balance to be established between the cracking zone and the regeneration zone. These conditions will ordinarily be within the ranges specified.

Specific example

Charge material (10):

Virgin gas oil, b./d. -----	2,400
API @ 60/60° F. -----	29
Preheat temp., ° F. -----	700

Catalyst (27):

Synthetic silica-alumina, microns -----	10–150
Temperature, ° F. -----	1,096
Tons per hour -----	92
Coke, wt. percent -----	0.40

Diluent (32):

Catalytically cracked gasoline (untab.) --	(1)
Preheat temp., ° F. -----	700
API @ 60/60° F. -----	56

Reactor (12):

Temperature, ° F. -----	900
Pressure p.s.i.g. -----	8
Cat./oil wt. ratio -----	26:1

Regenerator (21):

Temperature, ° F. -----	1,100
Pressure, p.s.i.g. -----	16

* The amount of diluent added depends on the regenerator catalyst temperature. That is, it is desired to maintain, in this example, the 1100–5° F. temperature of the catalyst in the regenerator to maintain thermal balance of the process. When the regenerator temperature increases to above 1105° F., the thermocouple, or equivalent means, by way of the temperature controller, actuates opening of valve 33 to admit, in this example, unstabilized catalytically cracked gasoline produced by the process. When the added diluent causes the regenerator temperature to fall below the preset minimum of 1095° F., the thermocouple, by way of the temperature controller, actuates closing down on valve 33 to decrease, or stop, the flow of diluent. Upset in the operation effecting a rise in regenerator catalyst temperature above the preset maximum, e.g., 1105° F., caused by virgin gas oil being contaminated with topped crude, metal compounds, or other materials which cause an increase in coke laydown on catalyst in the reactor, is prevented in accordance with this invention by automatic addition of a diluent as above-described. The diluent may be fed to the reactor feed prior to or subsequent the feed preheater. In the specific example, an unstabilized catalytically cracked gasoline, produced by the process, is used. However, in some instances a stabilized product may be used. Also, in some operations, there is always a small quantity of diluent added to the feed to the reactor. This quantity may be about 5 barrels per hour for control purposes. When the regenerator temperature rises to the preset maximum, additional diluent flows to the reactor; and when the regenerator temperature falls to the preset minimum, less quantity of diluent is added to bring the regenerator back to the desired temperature by controlling the amount of coke laydown in the reactor, and thus maintaining the desired thermal balance of the process.

* 60 percent conversion is effected in this specific example: the used catalyst contains 1.4 weight percent coke and the regenerated catalyst has 0.4 weight percent coke.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, drawings, and the appended claims to the invention, the essence of which is that there have been provided a method and apparatus for establishing and maintaining thermal balance between the cracking zone and the regeneration zone in a catalytic cracking process wherein a highly refrac-

tory hydrocarbon fluid, such as a gasoline boiling range fraction or a naphtha fraction, is automatically introduced into the cracking zone whenever the system has become unbalanced as detected by the temperature of the catalyst measured at some point in the system.

I claim:

1. In a process for the catalytic conversion of a hydrocarbon feed stream wherein said hydrocarbon feed stream is contacted with an active cracking catalyst in a single-stage cracking zone maintained under catalytic conversion conditions, said catalyst being contaminated by the deposition of coke and carbonaceous material on the surface thereof, and said contaminated catalyst is circulated directly from said cracking zone through a regeneration zone in which said coke and carbonaceous material is reduced by combustion, thereby elevating the temperature of said catalyst before its return to said cracking zone as an undivided stream, the improvement comprising maintaining the thermal balance between said cracking zone and said regeneration zone by introducing a highly refractory hydrocarbon stream as a diluent into said hydrocarbon stream upstream of said cracking zone whenever a state of thermal unbalance develops due to an increase in said deposition of coke and carbonaceous material in said cracking zone, as detected by a temperature sensing means located in the catalyst system, said introduced highly refractory hydrocarbon stream having a boiling range in the range of about 50° to 450° F. and serving to decrease said deposition of coke and carbonaceous material, and discontinuing said introduction of said highly refractory hydrocarbon stream when said thermal balance is restored and said deposition of coke and carbonaceous material is decreased.

2. A process of claim 1 wherein said highly refractory hydrocarbon stream is a gasoline boiling range fraction having an initial boiling point within the range of about 50° to 150° F. and an end point in the range of about 325° to 425° F.

3. A process of claim 1 wherein said highly refractory hydrocarbon stream is a gasoline boiling range fraction having an initial boiling point within the range of about 125° to 250° F. and an end point in the range of about 350° to 450° F.

4. A catalytic cracking process comprising introducing a feed stream into a single-stage cracking zone, contacting said feed stream with a cracking catalyst in said cracking zone maintained under catalytic cracking conditions, fractionating the effluents obtained from said cracking zone to thereby obtain a gasoline boiling range fraction having an initial boiling point within the range of about 50° to 150° F. and an end point in the range of about 325° to 425° F., transferring the catalyst contaminated by deposition of coke and carbonaceous material thereon directly from said cracking zone to a regeneration zone, contacting said catalyst with air under regeneration conditions to regenerate said catalyst and elevate its temperature, detecting the temperature of the catalyst at

some point in the system, recycling as a diluent a portion of said gasoline boiling range fraction to said feed stream at a point upstream of said cracking zone to decrease said deposition of coke and carbonaceous material, automatically controlling the recycle of said gasoline boiling range fraction to said cracking zone in accordance with said detected temperature of the catalyst, the introduction of said gasoline boiling range fraction into said feed stream taking place during thermal unbalance of said process due to an increase in said deposition of coke and carbonaceous material on the catalyst in said cracking zone as indicated by said detected temperature, said introduction of said gasoline boiling range fraction being discontinued when the thermal unbalance of said process is restored and said deposition of coke and carbonaceous material on the catalyst in said cracking zone is decreased, and transferring the regenerated catalyst as an undivided stream to said cracking zone at a temperature so as to result in the temperature desired in said cracking zone.

5. The process of claim 4 wherein the temperature of the catalyst is detected in said regeneration zone.

6. The process of claim 4 wherein the temperature of the catalyst is detected in said cracking zone.

7. The process of claim 4 wherein said gasoline boiling range fraction boils in the range of 100–425° F.

8. The process of claim 7 wherein said catalytic cracking conditions comprise a temperature in the range of 870–1050° F., a catalyst to oil ratio in the range of from about 1:1 to 20:1, a catalyst residence time in the range of from about 5 seconds to about 10 minutes, a weight space velocity in the range of from about 1 to 20 pounds of oil per hour per pound of catalyst, and a pressure in the range of from about 3 to 20 p.s.i.g., and said regeneration zone conditions comprise a temperature in the range of 1025–1170° F., a pressure in the range of 10–25 p.s.i.g., and a regeneration gas velocity of from about 0.5 to 5 feet per second.

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