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(54) **Fluidized catalytic cracking process.**

(57) A fluidized catalytic process preferably cracking of heavy oils, operating with equilibrium fluidized catalyst is operated with an entrainable catalyst which is removed by reactor effluent vapours. Preferred is addition of entrainable catalyst containing 10 to 40 weight % of ZSM-5 and having an average particle size of 4 to 10 microns. The entrainable catalyst is removed from the FCC reactor with reactor effluent, and preferably recycled to the reactor.

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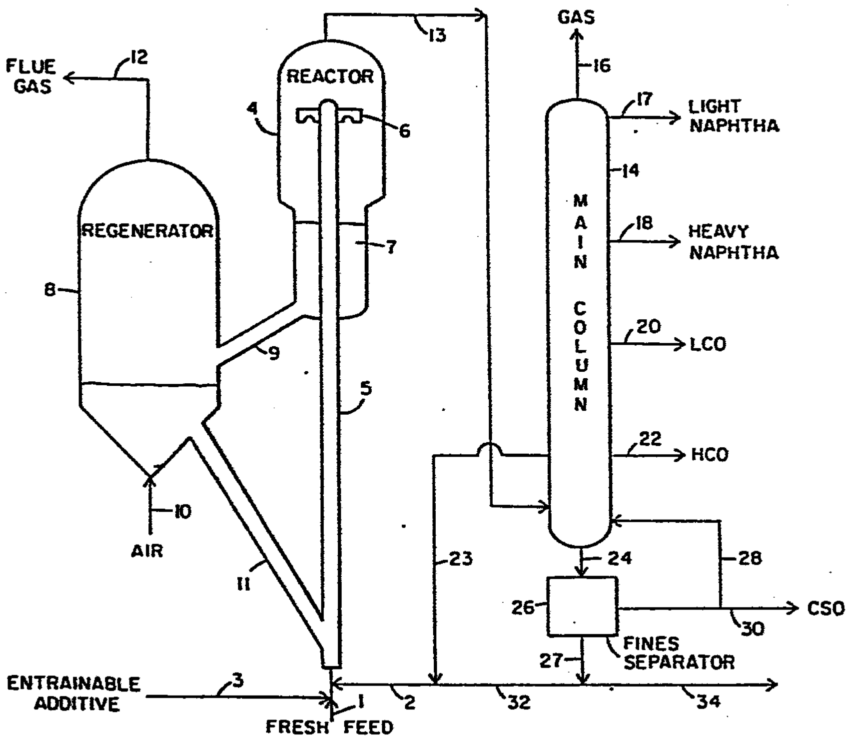
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ENTRAINABLE ADDITIVE
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FLUIDIZED CATALYTIC CRACKING PROCESS

This invention relates to an improvement in hydrocarbon conversion processes wherein a catalyst is contacted with a hydrocarbon feedstock in a fluidized bed reactor.

The fluidized catalytic cracking process is well known. Cracked hydrocarbon vapours from the reactor pass to various product fractionators wherein the hydrocarbon mixture is separated into fractions. Some catalyst is usually carried along with the hydrocarbon vapours into the fractionator. This catalyst tends to accumulate in the fractionator with the heaviest hydrocarbon fraction contained in the reactor effluent.

It is known to simply recycle this heavy oil, commonly called a slurry oil, back to the reactor to reduce the loss of relatively expensive FCC catalyst from the plant. Unfortunately this slurry oil is highly aromatic, and relatively refractory or inert to the conditions which produced it in the FCC reactor. Recycling of slurry oil to minimize catalyst losses will cause this slurry stream to grow in size because the highly aromatic slurry oil passes through the FCC reactor unscathed, and tends to accumulate.

The separation and recycle of catalyst fines from slurry oil is by now a standard technique, as described in US-A-3,338,821; 4,022,675; 4,285,805; and 4,345,991. All of these patents taught recovery of catalyst fines generated in the FCC reactor, and recycle of the fines to the reactor to minimize catalyst loss.

It is known that the slurry oils can be cleaned by passing these oils through an electrofilter, as disclosed in US-A-3,928,158.

US-A-4,059,498 teaches an improved device in which a central tubular electrode extends downwardly through the filter bed. An outer vertical perforated cylindrical electrode is concentric with the central electrode. Radial liquid flow is provided, permitting increased flow rate as compared to longitudinal flow.

Improvements in process efficiency have been made available to FCC operators by the development of zeolites characterised by a Constraint Index in the range 1 to 12 (the significance and manner of determination of which term is set forth in our GB 1,446,522). The term "zeolite" as here used denotes the class of porotectosilicates, i.e., porous crystalline silicates that contain silicon and oxygen atoms as the major components. Other components may be present in minor amounts, usually less than 14 mole % and preferably less than 4 mole %. These components include aluminium, gallium, iron, chromium, boron and the like with aluminium being preferred and used herein for illustration purposes. The minor components may be present separately or in mixtures.

Constraint Index (CI) values for some typical materials are:

	CI
ZSM-4	0.5
ZSM-5	8.3
ZSM-11	8.7
ZSM-12	2
ZSM-23	9.1
ZSM-35	4.5
ZSM-38	2
TMA Offretite	3.7
Clinoptilolite	3.4
H-Zeolon (mordenite)	0.4
REY	0.4
Amorphous Silica-Alumina	0.6
Erionite	38

A crystalline zeolite when identified by any combination of conditions within the testing definition set forth in the aforesaid GB 1,446,522 as having a Constraint Index in the approximate range of 1 to 12 is intended to be included in the instant zeolite definition whether or not the identical zeolite, when tested under other of the defined conditions, may give a Constraint Index value outside of the approximate range of 1 to 12.

The novel class of zeolites defined herein is exemplified by ZSM-5, ZSM-11, ZSM-5/ZSM-11 intermediate, ZSM-12, ZSM-23, ZSM-35, ZSM-38 and ZSM-48, defined respectively by the x-ray data set forth in UA-A-3,702,886; 3,709,979; 4,229,424; 3,832,449; 4,076,842; 4,016,245; 4,046,859; and 4,377,497.

The present invention contemplates utilization of such zeolites wherein the mole ratio of silica to alumina is essentially unbounded. Reference to the above-identified patents should not be construed as limiting the disclosed crystalline zeolites to those having the specific silica-alumina mole ratios discussed therein, it now being known that such zeolites may be substantially aluminium-free and yet, having the same crystal structure as the disclosed materials, may be useful or even preferred in some applications, as may zeolites which contain trivalent lattice elements other than aluminium.

ZSM-5 is a preferred catalyst because it is exceedingly active. Successful FCC processes may use catalysts containing relatively small amounts of ZSM-5 in an amorphous base such as silica, alumina, or silica-alumina.

One of the virtues of the ZSM-5 material, its great activity, causes some operations problems. When its high activity is tempered by incorporation of the ZSM-5 in an amorphous base, the ratio of ZSM-5 to amorphous material is fixed. It is possible to augment somewhat the ZSM-5 content of an operating FCC reactor by addition of additional particulate material containing neat ZSM-5 or enriched amounts of ZSM-5, as compared to the equilibrium catalyst in the FCC reactor. Unfortunately there is no way to remove the ZSM-5 catalyst without removing the catalyst inventory from the reactor and replacing it with a different FCC catalyst.

Another problem with operation of ZSM-5 embedded in an amorphous matrix, is that the deactivation/reactivation characteristics of the ZSM-5 and amorphous material are different. The ZSM-5 material is relatively stable, as regards activity, in the FCC reactor. The ZSM-5 needs very little regeneration. The amorphous material rapidly deactivates after only a few minutes of operation due to coke deposition. The only way to restore the activity of the amorphous material is to burn the coke therefrom in an FCC regenerator. Regeneration of the amorphous material tends to age, prematurely, the ZSM-5 catalyst passing through the regenerator, necessitating a continuing program of ZSM-5 addition to the FCC reactor to replace that ZSM-5 damaged by the regeneration process.

US-A-4,309,280 teaches adding a finely divided powder of zeolite additive promoter to coat the surface of FCC catalyst. This reference discloses that "the additive promoter can also be introduced to and/or recycled through the recycle feed". See column 3, lines 28/29.

As the additive is of such a size as to coat the catalyst, the additive is locked onto the FCC catalyst, and behaves as FCC catalyst. Recycle of FCC catalyst from the main column bottoms will result in additive recycle, plus recycle of a refractory slurry oil.

Petroleum refiners have had no economical and efficient means of reducing the ZSM-5 content of an FCC reactor. It was possible to add ZSM-5 quickly, but not to remove it. It was possible to allow the ZSM-5 to naturally deactivate in the regenerator, but premature aging of the catalyst is an expensive way to remove its catalytic activity. Thus there has been no completely satisfactory way to adjust the ZSM-5 content of an FCC reactor. Operation with ZSM-5 amorphous mixtures usually resulted in premature aging of the ZSM-5.

We have now discovered that it is possible to increase or decrease the amount of the ZSM-5 catalyst contained within the fluidized catalytic cracking reactor. We have also discovered a way to keep the active ZSM-5 catalyst out of the deleterious environment of the catalyst regenerator.

According to the present invention a fluidised catalytic cracking process of the cyclic, regenerative kind in which a cracking feed contacts in a reactor a cracking catalyst having an average particle size of 30 to 80 μm and a pore size sufficient to provide access to cracking sites for at least the majority of feed components, the catalyst being continuously withdrawn from the reactor, regenerated, and returned to the reactor, hydrocarbon effluent being continuously withdrawn from the reactor and subjected to fractionation, is characterised in that a catalyst comprising a crystalline zeolite having a constraint index in the range 1 to 12 and of average particle size 3 to 30 μm is continuously added to said reactor and is withdrawn in entrainment in said effluent at at least 50% of the rate of its addition.

In a preferred embodiment added catalyst is withdrawn in entrainment in said effluent at at least 90% of the rate of its addition, and the quantity of said added catalyst in the reactor is 0.1 to 5% wt. of the quantity of said cracking catalyst in the reactor. Usually the added catalyst is recovered from entrainment in said effluent and recycled to the reactor, and at least 99% wt. of said added catalyst present in the reactor can be recycled added catalyst.

The cracking catalyst usually comprises from 5 to 50% wt. of a synthetic faujasite suspended within and distributed throughout an inorganic oxide matrix, whilst the added catalyst usually comprises from 10 to 40% wt. of a zeolite having the structure of zeolite ZSM-5 composited with an amorphous binder.

Accordingly the present invention provides a fluidized catalytic conversion process wherein a feedstream is charged to a fluidized bed reactor containing a fluidized bed of equilibrium catalyst to produce cracked product, and a converted feedstream is removed as a product from the process, wherein the improvement comprises addition of an entrainable catalyst additive to said fluid bed, and removing a majority of said entrainable additive with said product removed from the fluid bed reaction zone.

In another embodiment the present invention provides a process for fluidized catalytic conversion of a hydrocarbon feed comprising charging to a fluidized bed reactor containing equilibrium fluid cat cracking catalyst a hydrocarbon feed and an entrainable catalyst additive to produce vapourized cat cracking products; removing said vapourized products containing at least 90 % wt. of said entrainable catalyst additive from said FCC reactor; recovering from said vapourized product at least a portion of said entrainable catalyst additive; and recycling at least a portion of said entrainable catalyst additive to said reactor.

In a more limited embodiment the present invention provides a process for fluidized catalytic cracking of hydrocarbons comprising charging to a fluidized bed reactor a hydrocarbon feed and hot regenerated equilibrium catalyst from a source hereafter specified; adding to said reactor fresh entrainable catalyst additive and recycle entrainable catalyst additive from a source hereafter specified; converting in said fluid bed reactor said hydrocarbon feed to hydrocarbon products; removing from said reactor equilibrium catalyst, regenerating same in an oxygen-containing regeneration zone to to produce regenerated catalyst, and recycling said regenerated catalyst to said FCC reactor as said hot regenerated catalyst; removing from said reactor a reactor effluent vapour stream comprising hydrocarbon products and at least 50% wt. of said entrainable catalyst additive; separating and fractionating said reactor effluent vapour to produce a plurality of relatively light hydrocarbon products and a relatively heavy liquid product stream containing said entrainable catalyst additive; recovering from said relatively heavy liquid stream at least 90% wt. of said entrainable catalyst additive contained therein and recycling said additive to said FCC reactor.

BRIEF DESCRIPTION OF THE DRAWING

The single figure is a simplified diagram representing an FCC unit with a reactor, regenerator and main fractionator.

The present invention solves two independent problems. The first problem solved is the fact that ZSM-5 catalyst, or other entrainable catalyst additive, can be continuously added to the catalyst contained in a fluid bed reactor, and quickly removed from the reactor independently of the equilibrium catalyst. The effect of catalyst additive addition can be made permanent by continuing to add it.

The second problem solved by this invention is the ability to recover the ZSM-5 catalyst or other entrainable catalyst additive, and recycle it to the reactor, without passing through the high temperature FCC regenerator. Avoiding the FCC catalyst regenerator prevents premature aging of the catalyst additive.

Each of the important process parameters will be discussed in turn.

REACTOR/REGENERATOR

These are conventional. The FCC reactor may be an entirely dense phase fluid bed, or may operate with all riser cracking, with a dilute phase bed, or some mixture of both modes of operation. The FCC regenerator can be a single dense bed, or two dense beds connected by a dilute phase transport riser connected to a second dense bed within the regenerator. The regenerator can operate in a CO afterburning mode, or may be operated to produce substantial amounts of CO. The practice of the present invention will be most beneficial when the regenerator is run relatively hot; usually this is associated with a CO afterburning type of operation. Hot catalyst regeneration promotes rapid deactivation of the ZSM-5 materials.

EQUILIBRIUM CATALYST

The equilibrium catalyst, which will comprise the bulk of the catalyst within the fluid bed reactor, may be any conventional fluid bed, or FCC catalyst, either amorphous or crystalline, or a mixture of both. Catalysts having an average particle size of 10 to 100 micrometers diameter are commonly used in fluidized beds. The particle size distribution of the catalyst will be that required for good fluidization characteristics in the reactor. By way of illustration, but not limitation, a good FCC equilibrium catalyst will have the following properties:

Particle Density, g/cc	1.42
Packed Density, g/cc	.99
Average Particle Size, mm	74
Size Distribution	

Diameter micro-meters	wt %
0-20	-
20-40	4
40-60	15
60-80	45
80+	37

ENTRAINABLE CATALYST

An acceptable catalyst additive is any which can be added to the fluid bed reactor and removed with the vapourised reactor effluent. The exact size of the entrainable catalyst additive will vary with operating conditions within the reactor, and will be affected to some extent by the size of the equilibrium catalyst and by the efficiency of the cyclones used to return the bulk of the equilibrium catalyst to the reactor.

A preferred additive is ZSM-5, either neat or dispersed in an amorphous base. The practice of the present invention is most advantageous when a relatively concentrated ZSM-5 material, e.g., typically 10 to 50% wt. ZSM-5, is added as an entrainable catalyst additive. In most conventional FCC reactors containing conventional equilibrium catalysts, an entrainable catalyst additive with an average particle size of 3 to 30, and preferably 5 to 20 micrometers will give good results.

The retention time of the entrainable catalyst additive will vary from the residence time of the gas to about ten times as long as the gas residence time. Usually the entrainable catalyst particles will be swept along with the gas, so the entrainable catalyst particle residence time will be on the order of 100 to 200 percent of the gas residence time within the reactor.

One additional benefit from the practice of the present invention is that the entrainable catalyst additive is disproportionately effective within, e.g., the FCC reactor because of its small particle size. Even operating in a throwaway mode of operation, in the absence of recycle, the practice of our invention makes better use of the ZSM-5 because the ZSM-5 is in a highly divided state.

When ZSM-5 is the entrainable additive, it should have the following composition and properties.

	Preferred	Acceptable
ZSM-5 Content	25%	5-100%
Chemical Composition		
SiO_2	94%	10-100%
Al_2O_3	6%	0-10%
Particle Density	1.40 g/cc	
Particle Size Distribution		
0-20 mm	78.6%	
20-40 mm	21.4%	
Average Particle Size	4.2 mm	3-30 mm

MAIN FRACTIONATOR

The fractionation facilities are conventional. Any commonly used method of recovering valuable products from material contained in the reactor effluent can be used. Usually the reactor effluent vapours are cooled and compressed and sent through a variety of absorber and fractionators. The heaviest material contained in the reactor effluent is usually removed as the bottom stream from a large fractionator, typically called the main fractionator.

ENTRAINABLE CATALYST RECOVERY

We prefer to recycle all or a portion of the entrainable catalyst back to the reactor, or to mix with reactor feed. It is acceptable, and may be preferred, based upon the economics of a given location, to recycle only the catalyst, or a liquid stream containing an enriched catalyst concentration.

The catalyst can be recovered from the slurry oil by filtration, settling, addition of an antisolvent, or any other known means of separating a finely divided powder from a liquid.

It is preferred not to simply recycle, e.g., the main column bottoms back to the reactor. Such a recycle operation tends to produce a refractory slurry oil which is difficult to crack in the FCC unit. Such an operation also recycles both entrainable additive and FCC catalyst carried out of the FCC, and sometimes it is preferred to recycle, preferentially, the entrainable additive.

It is also within the scope of the present invention to fractionate the recycled catalyst, i.e., separate large fines from small fines by using staged filtration, or other conventional means. In this manner the fraction most enriched in ZSM-5, or other desired catalyst additive, can be recycled to the reactor, without sending other catalyst fines or the entire stream from the main column bottoms back to the reactor.

It is also possible to recover ZSM-5 catalyst, or other entrainable catalyst additive, using staged cyclone separators, a baghouse, electrostatic precipitators, or equivalent means. In this mode of operation the entrainable catalyst additive recovery and recycle would occur upstream of the product fractionator. The disadvantage of this type of operation is that it requires some additional capital expense, but it may be cheaper on the new unit to install staged cyclones to recover and recycle to the reactor entrainable particles of ZSM-5 that would otherwise be removed from the reactor, rather than tolerate the problems introduced with a large slurry oil recycle. Staged cyclonic separation of fine particles contained in reactor effluent vapour could also accomplish the desired goal, namely recycle of entrainable ZSM-5 to the reactor without sending the ZSM-5 material or other entrainable additive through the regenerator.

Once the additive has been recovered it could additionally be treated to recover any lost activity, such as by combustion of coke deposits under milder conditions than those prevailing in the main regenerator.

ELECTROSTATIC FILTER

The preferred method of recovering entrainable catalyst involves use of an electrostatic filter, such as the ones disclosed in US-A-3,928,158 and 4,059,498, the entire contents of which are incorporated herein by reference.

UA-A-3,928,158 describes an electrostatic filter in which an electrostatic gradient is imposed across a bed of glass beads. Liquid flows through the bed while the electrical gradient is imposed across the bed. Solids are deposited in the filter bed at the point of contact of the glass beads. The filter can be repeatedly and readily reconditioned for further use by backflushing.

DETAILED DESCRIPTION OF THE DRAWING

The invention is now further illustrated in connection with the drawing.

Fresh feed enters reactor 4 via line 1. The feed is mixed with a heavy recycle stream contained in line 2. Catalyst additive may be added from two sources, fresh in line 3, recycled along with the heavy recycle stream in line 2, or both. Catalyst additive may also be added in other parts of the plant, so long as the additive eventually enters the reactor. Regenerated equilibrium catalyst in line 11 is mixed with the incoming feed in the base of the riser 5 of reactor 4. Catalyst and reactor effluent vapours are discharged from riser reactor 5 via discharge means 6, shown schematically as a short length of pipe with a downfacing discharge, although cyclones may also be used. The equilibrium catalyst falls to the bottom of reactor 4 to form a dense bed of catalyst 7, while the entrainable catalyst additive is removed along with the reactor effluent vapour via line 13. The riser reactor shown is merely illustrative of one suitable reactor. A single dense bed reactor, a series of fluid bed reactors, and ebullating bed reactor, or a moving bed reactor may also be used. All of these reactors operate with an equilibrium catalyst, and all may benefit by adding an entrainable catalyst additive.

Spent equilibrium catalyst is removed from dense bed 7 via line 9 and charged to conventional catalyst regenerator 8. Air, or oxygen containing gas or other regeneration fluid is added to the bottom of regenerator 8 via line 10. Flue gas is removed via line 12. Regenerated catalyst is removed via line 11.

The reactor effluent vapour in line 13 is charged to main column 14. Depending on the feed and catalyst, different products will be recovered. A typical product mix obtained by charging oil to an FCC unit is shown, but should not be limiting. Removed overhead from main column 14 is a wet gas via line 16, a light naphtha via line 17 and a heavy naphtha stream via line 18. A light cycle oil is removed via line 20. Heavy cycle oil is removed via line 22 or via line 23 if it is to be recycled to the reactor mixed with the recycled additive. A main column bottom stream is withdrawn via line 24 and charged to electrofilter 26 wherein a heavy fraction enriched in catalyst fines and entrainable catalyst additive is recovered via line 27 and recycled via line 32 to line 23 containing heavy cycle oil, and from there it is charged via line 2 to mix with the fresh feed.

A portion of the main column bottom steam is withdrawn from the process via line 30 as clarified slurry oil, while the remaining portion of it is recycled via line 28 to the bottom of the main column. A portion of the catalyst fines and entrainable catalyst additive is removed from the process via line 34.

Although a recycle operation is shown in the drawing, wherein entrainable catalyst additive is recycled, it is possible to operate with once through operation wherein there is no flow in line 32. The optimum amount of recycle versus fresh addition of entrainable catalyst additive can be determined based on local economics. In general, a large slurry stream is undesirable because this brings a great deal of refractory material into the reactor. Operation with once through entrainable additive addition results in higher costs for catalyst additive. In general, recycle will be most attractive when the cost of the entrainable catalyst additive is relatively high, the amount of catalyst fines produced during normal operation is relatively low, and the size of the slurry oil stream produced is relatively small.

BEST MODE

When practicing this invention in an FCC plant designed to process 100,000 barrels (158,987 m^3) per day of feed, and containing 400 tons (406,420 kg) of catalyst with an average particle size of 74 µm we would operate with addition of 200 pounds (90.72 kg) per day of catalyst additive. The catalyst additive would have the following physical properties:

	Preferred
ZSM-5 Content	25%
Chemical Composition	
SiO_2	94%
Al_2O_3	6%
Particle Density	1.40 g/cc
Particle Size Distribution	
0-20 mm	78.6%
20-40 mm	21.4%
Average Particle Size	4.2

and would be added to the plant by pumping it in as a slurry in a light cycle oil stream. The amount of recycle additive present in the recycle catalyst stream from the main column bottoms would be 12,500 pounds (5,670 kg) per hour. An electrofilter would be used to separate recycle additive from slurry oil so that recycle of the refractory slurry oil can be minimized. Preferably at least 90% of the slurry oil is removed from the process, while at least 90-99% of the additive is recycled.

The riser feed would see a catalyst composition containing 0.25 weight percent ZSM-5 almost entirely due to recycle from the main column bottoms. The amount of ZSM-5 going to the regenerator should of course be minimized, but a small amount will pass through the regenerator.

ILLUSTRATIVE EMBODIMENT

Listed in the following table are estimates of product distributions that would be obtained in a prior art process, i.e., with no entrainable ZSM-5, as compared to the process described above in the description of best mode.

	Prior Art		Invention	
	Wt %	Vol %	Wt %	Vol %
Conversion	63.2	67.0	63.5	67.3
MCB	12.9	10.8	12.7	10.6
LCO (680°F @ 90%)(360°C)	23.9	22.2	23.8	22.1
C_5+ Gasoline (385°F @ 90%)(196°C)	43.1	51.4	41.8	49.8
Total C_4	7.5	11.6	8.0	12.3
Total C_3	4.4	7.7	5.0	8.7
C_2 and Lighter	3.5	3.9	4.0	4.5
Coke	4.7		4.7	
Total	100.0	107.6	100.0	108.0
Potential Alkylate		20.5		23.3
Outside IC_4 Required		11.0		13.0

	Prior Art		Invention	
	Wt %	Vol %	Wt %	Vol %
Light Hydrocarbons				
H_2	0.03	0.09	0.04	0.12
H_2S	0.12	0.04	0.12	0.04
C_1	1.18	1.36	1.36	1.57
C_2	1.23	1.48	1.48	1.70
C_2-	0.89	0.97	1.03	1.12
C_3	1.08	1.93	1.18	2.11
C_3-	3.32	5.75	3.81	6.59
NC_4	1.20	1.86	1.23	1.91
IC_4	2.10	3.37	2.03	3.25
C_4-	4.20	6.33	4.71	7.10
Gasoline Octane R+O		89.8		90.8
M+O		79.5		79.9
Gasoline + Alkylate R+O		90.9		91.7
M+O		83.1		83.8
Wt % ZSM-5 Present	0.00		0.25	

The significance of the present invention is that it gives refiners a way to change the catalyst characteristics in the FCC reactor without changing the catalyst inventory and without subjecting the entire catalyst inventory to the FCC regenerator. In the case of the ZSM-5 additive, it is possible to take advantage of the high activity and coke resistance of ZSM-5 without subjecting the ZSM-5 to the harsh conditions experienced in the modern CO afterburing regenerators associated with FCC units. If the ZSM-5 catalyst were added in a form where it behaved exactly as the equilibrium, the ZSM-5 would be subjected to high temperature regeneration every 3-10 minutes, and would lose most of its cracking activity within a few days, requiring very high ZSM-5 makeup rates to achieve the octane gains and gasoline plus alkylate yield gains described in the illustrative embodiment above.

In contrast, by the practice of the present invention, it is possible to operate the FCC reactor with a very large presence of ZSM-5 catalyst, while adding only about one-tenth or one-hundredth the amount of ZSM-5 catalyst that would otherwise be needed to make up for the rapid deactivation of ZSM-5 in the FCC regenerator.

CLAIMS

1. A fluidised catalytic cracking process of the cyclic, regenerative kind in which a cracking feed contacts in a reactor a cracking catalyst having an average particle size of 30 to 80 μm and a pore size sufficient to provide access to cracking sites for at least the majority of feed components, the catalyst being continuously withdrawn from the reactor, regenerated, and returned to the reactor, hydrocarbon effluent being continuously withdrawn from the reactor and subjected to fractionation, characterised in that a catalyst comprising a crystalline zeolite having a constraint index in the range 1 to 12 and of average particle size 3 to 30 μm is continuously added to said reactor and is withdrawn in entrainment in said effluent at at least 50% of the rate of its addition.

2. A process according to claim 1 wherein said added catalyst is withdrawn in entrainment in said effluent at at least 90% of the rate of its addition.

3. A process according to claim 1 or claim 2 wherein the quantity of said added catalyst in the reactor is 0.1 to 5% wt. of the quantity of said cracking catalyst in the reactor.

4. A process according to any preceding claim wherein said added catalyst is recovered from entrainment in said effluent and recycled to the reactor.

5. A process according to claim 4 wherein at least 99% wt. of said added catalyst present in the reactor is recycled added catalyst.

6. A process according to any preceding claim wherein one of the products of said fractionation is a relatively heavy liquid stream containing the majority of the catalyst entrained in said effluent.

7. A process according to claim 6 wherein said stream is a slurry oil.

8. A process according to claim 6 or claim 7 wherein said stream containing said catalyst is recycled.

9. A process according to any of claims 4 to 7 wherein catalyst is recovered by separation from hydrocarbon product.

10. A process according to claim 9 wherein the separation is effected by an electrostatic filter.

11. A process according to claim 9 wherein the separation is effected by passing said effluent through staged cyclones.

12. A process according to claim 9 wherein the separation is effected by filtration, settling or use of an antisolvent.

13. A process according to claim 12 in which the filtration is staged and separates said added catalyst in preference to said cracking catalyst.

14. A process according to any of claims 4 to 7 and 9 to 13 wherein said recovered catalyst is regenerated before being recycled.

15. A process according to claim 6 wherein at least 90% wt. of said added catalyst contained in said stream is recycled.

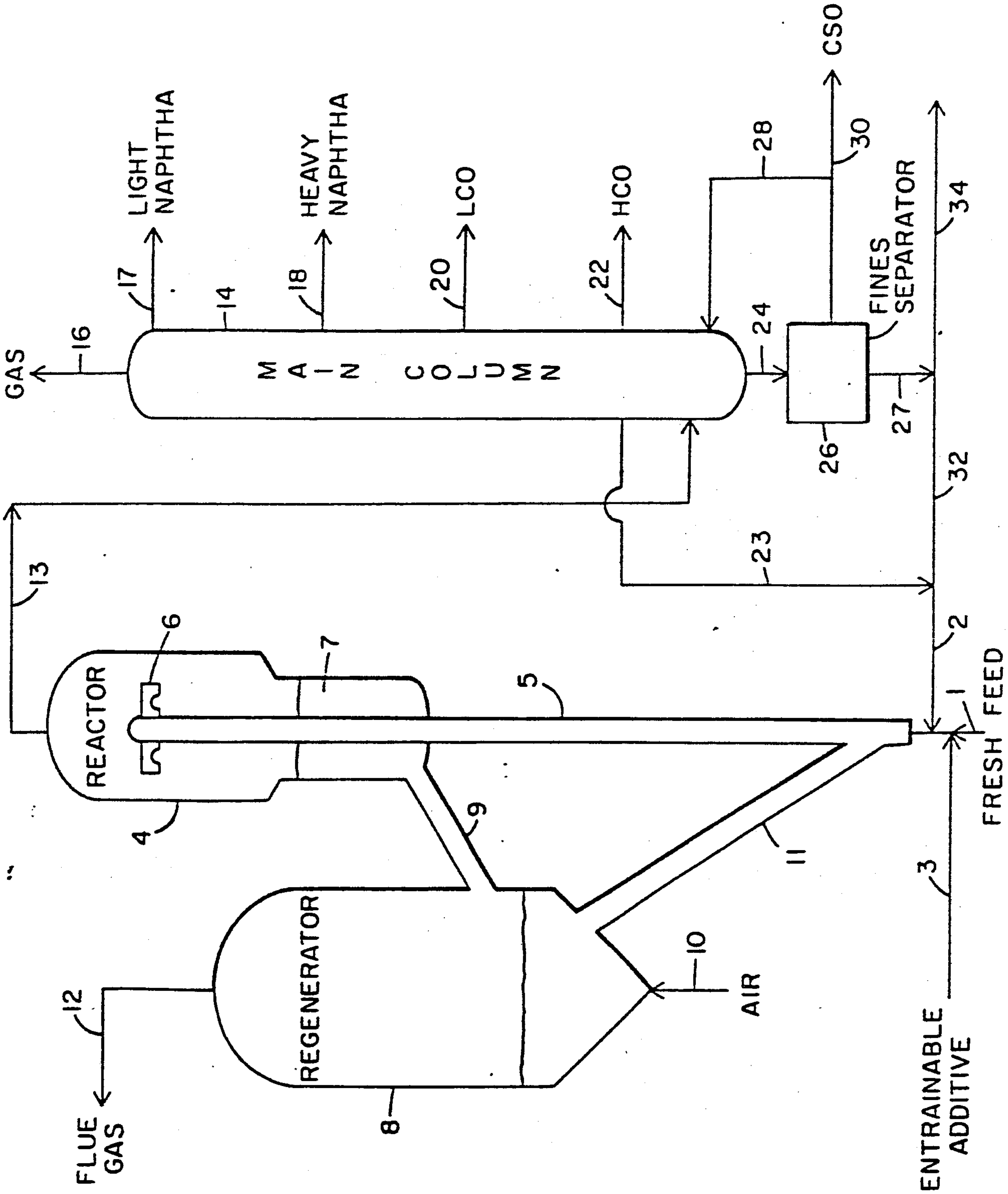
16. A process according to any preceding claim wherein the reactor is a riser reactor.

17. A process according to any preceding claim wherein the cracking feed is a heavy oil.

18. A process according to any preceding claim wherein said cracking catalyst comprises from 5 to 50% wt. of a synthetic faujasite suspended within and distributed throughout an inorganic oxide matrix.

19. A process according to any preceding claim

wherein said added catalyst comprises from 10 to 40% wt. of a zeolite having the structure of zeolite ZSM-5 composited with an amorphous binder.


FLUE GAS
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REACTOR
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FRESH FEED
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