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Owen et al.

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[54] **CONVERSION OF SULFUR CONTAMINATED HYDROCARBONS**

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[51] **Int. Cl.** **B01j 9/04,** C10g 11/04

[58] **Field of Search** 208/72, 75, 150, 151, 153, 208/164, 113, 120, 127; 252/417, 419

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[57] **ABSTRACT**

A fluid catalytic cracking catalyst regeneration operation is described which is directed to reducing sulfur in the flue gases. Riser cracking initially with low sulfur feed followed by high sulfur feed in combination with high temperature stripping with regenerated catalyst retains desorbed sulfur compounds in hydrocarbon phase. Separate recovery of regeneration flue gases from a two stage operation reduces flue gas sulfur treating.

10 Claims, 2 Drawing Figures

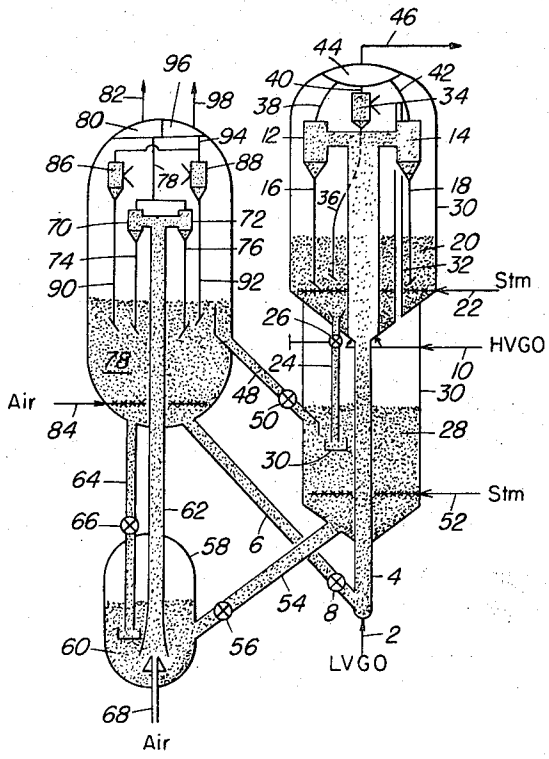


FIGURE I

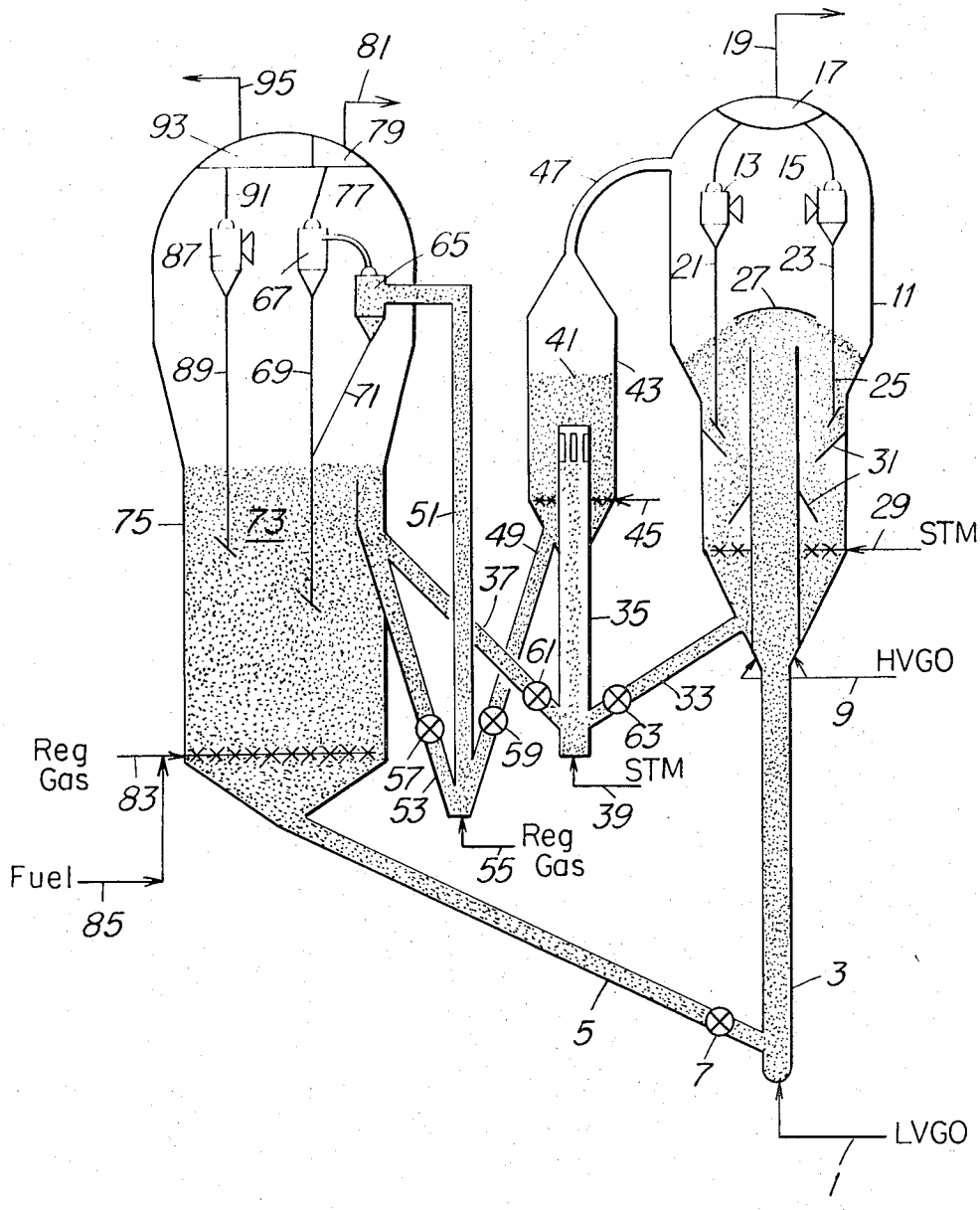
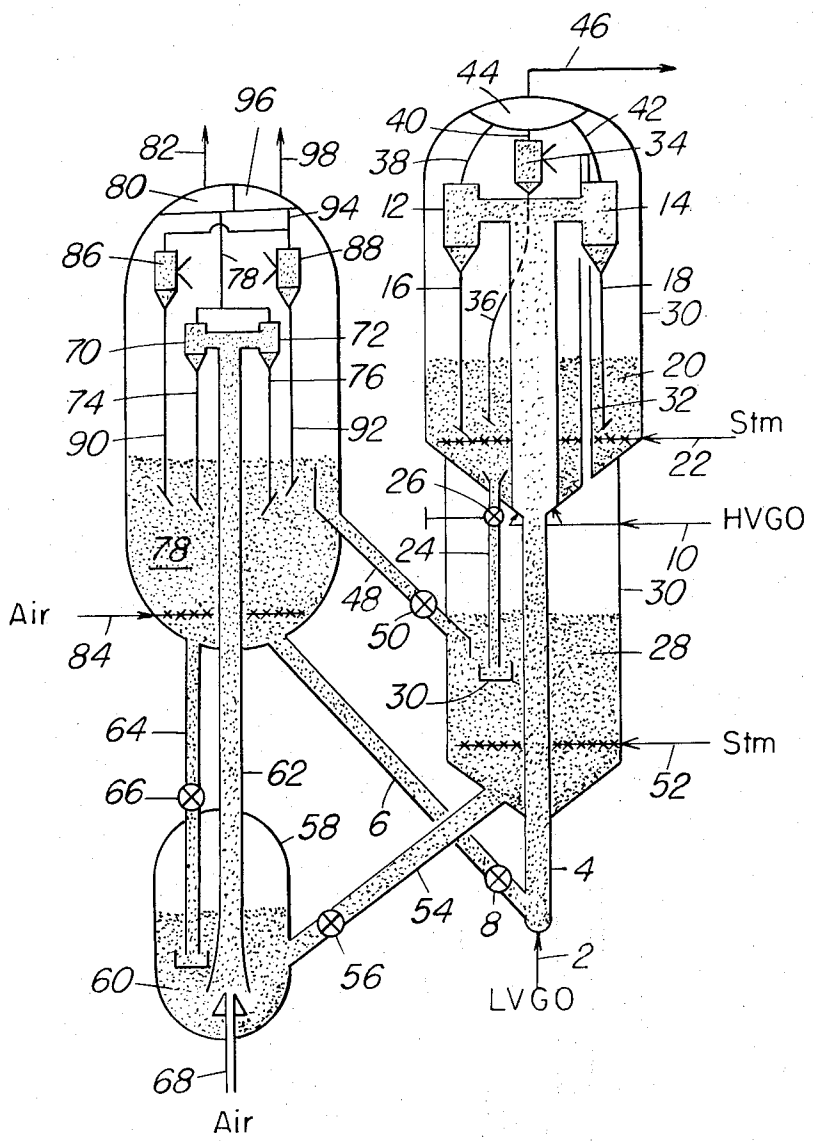

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59
57
53
55
39
41
43
47
19
17
13
15
21
27
23
11
25
31
29
STM
HVGO
9
Reg Gas
83
Fuel
85
Reg Gas
STM
3
5
7
LVGO
1

FIGURE II


46
44
96
42
40
82
98
34
38
80
94
12
14
86
88
78
16
36
18
30
70
72
20
74
76
32
Stm
90
92
22
26
HVGO
24
10
78
48
30
Air
50
28
84
30
64
Stm
62
52
66
58
6
4
54
8
56
2
60
LVGO
68
Air

CONVERSION OF SULFUR CONTAMINATED HYDROCARBONS

BACKGROUND OF THE INVENTION

Fluid catalytic cracking has been known and commercially employed for a number of years. During this time a number of useful and economic process variations and vessel designs have been made which particularly rely upon a combination of dispersed and dense catalyst phase operations. In all of these process variations a cracking catalyst is contacted with fresh and recycle hydrocarbon streams varying considerably in composition and derived from sour and sweet crudes. The charge materials are often also contaminated with metal contaminates, the extent of which is dependent upon the crude source. Thus, in such operations the catalyst used becomes contaminated with metals which readily adsorb sulfur or decomposed sulfur compounds that concentrate in the catalyst coke deposits of hydrocarbon conversion. During reactivation of the catalyst by burning with air or oxygen containing gases, the sulfur compounds are converted and are carried off by the hot regeneration combustion flue gases. An object of this invention is to severely restrict or limit the level of sulfur in the bulk of the regenerator flue gases and the combination of the present invention is directed to accomplishing this purpose.

SUMMARY OF THE INVENTION

The present invention is concerned with a combination of operating parameters for transferring sulfur compounds normally found in regenerator flue gases so that they are recovered separately or in the hydrocarbon product recovery system. In a more particular aspect the present invention is concerned with reducing sulfur in the regeneration flue gases to less than about 250 ppm. by a relationship of operating conditions in the hydrocarbon conversion step and its associated catalyst stripping operation which will substantially retain sulfur and its compounds within the hydrocarbon product recovery system.

The combination operation of the present invention is pursued on the premise that compounds of sulfur and conversion products thereof may be confined substantially to surface hydrocarbonaceous deposits of contaminated catalyst and this may be accomplished by a combination of sequential catalyst contacts in which a low sulfur and nitrogen containing hydrocarbon feed initially contacts the catalyst under elevated temperature hydrocarbon conversion conditions to deposit carbonaceous material and then the coked catalyst is contacted with a sulfur and nitrogen contaminated hydrocarbon feed under lower temperature hydrocarbon conversion conditions. Conversion of the separate hydrocarbon feeds of different levels of sulfur and nitrogen compounds is preferably at an elevated temperature of at least 1,000° F. during a hydrocarbon residence time in the conversion zone of less than about 10 seconds, more usually less than about 8 but above about 0.5 or 1 seconds. This sequence of hydrocarbon feed contact coupled with short contact time high temperature conversion operation seems to be effective in confining sulfur compounds to the surface carbonaceous material deposits. This phenomenon is coupled with a multi-stage stripping operation in which the first stage of stripping is carried out under conditions selected for the removal of entrained vaporous hydrocarbons and a second stage of stripping is preferably carried out at much higher temperatures providing a high temperature catalyst soaking operation in the presence of hot regenerated catalyst added, for example, in an amount to raise the temperature of the contaminated catalyst to at least about 1,050° F. and preferably up to about 1,200° F. This high temperature stripping operation in the presence of added hot regenerated catalyst combines to provide high temperature stripping of sulfur compounds from the catalyst before the catalyst passes to oxygen regeneration. During this second stage high temperature stripping operation, it has been found that a major portion, if not all, of the adsorbed sulfur compounds are effectively removed from the catalyst and are carried off with hydrocarbon product and stripping gases. A third operating parameter contributing to the results desired by the present combination but not necessarily required with some charge stocks is concerned with restricting the level of coke on the catalyst passed to the regenerator. In one particular aspect, it is proposed to operate the process in a coke deficient manner in an order of magnitude which will maintain as low as about 1.0 weight percent of feed as coke on the catalyst passed to regeneration. Such an operation is promoted by using high activity crystalline aluminosilicate conversion catalysts at high temperatures and short contact times during the hydrocarbon conversion sequence of the process. Thus, in such an operating concept, it is contemplated burning supplementary fuel in the regeneration sequence as make-up for a heat balanced operation of at least about 3.5 wt. percent coke on the catalyst.

The combination operation of the present invention may be further improved by using a high metals containing matrix catalyst to assist with sulfur adsorption.

The regeneration sequence of the processing combination of the present invention is a segregated operation relying upon dispersed phase catalyst regeneration of limited duration in the range of 1 to 10 seconds for initially contacting the catalyst to remove particularly surface carbonaceous deposits by burning in the presence of an oxygen containing regeneration gas followed by a second stage of catalyst regeneration in, for example, a more dense fluid catalyst bed phase to accomplish a further removal of carbonaceous deposits. Supplemental fuel burning may be promoted in the second regeneration stage to make up for the heat requirements of the coke deficient operation. Flue gases are separately removed from each stage of regeneration so that those higher in sulfur content may be passed to a treating process step for their removal.

It will be readily apparent to those skilled in the art from the above brief description that the present invention relies upon a particular relationship and combination of operating parameters to accomplish the results desired.

Cracking catalyst compositions which may be used with considerable success in the processing scheme of this invention include the various crystalline aluminosilicate conversion catalysts of the "X" and "Y" faujasite type or zeolite "L" developed in recent years and now known in the industry. These materials may be combined with a porous mixture material and used alone or in combination with a ZSM-5 type of material disclosed in U.S. Pat. No. 3,702,886 and related co-

pending application. The present invention may also be employed with amorphous type of hydrocarbon conversion catalyst used alone or in combination with a ZSM-5 type of material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. I presents diagrammatically in elevation a side-by-side hydrocarbon conversion — catalyst regeneration system in which regenerated catalyst is passed to a second stage of stripping and a first stage of regeneration for admixture with spent catalyst used for hydrocarbon conversion. Separate stages of catalyst regeneration permit the separate recovery of flue gases from each stage.

FIG. II presents diagrammatically in elevation an arrangement of apparatus combining the operating features of FIG. I in a more compact arrangement of contact vessels.

DISCUSSION OF SPECIFIC EMBODIMENTS

Referring now to FIG. I there is shown diagrammatically in side-by-side relationship a hydrocarbon conversion system, a catalytic stripping system and a catalyst regeneration system with interconnecting catalyst transfer conduits therebetween. In this arrangement an oil feed substantially sulfur free or, for example, a gas oil feed boiling in the range of about 500° to about 750° F. such as a light virgin gas oil fraction of low sulfur and nitrogen content is introduced by conduit **1** to the bottom portion of riser reactor **3** wherein it is mixed with hot regenerated catalyst at a temperature within the range of 1,300° to 1,400° F. introduced by conduit **5** to form a catalyst-oil suspension at a temperature in the range of about 1,000° F. up to about 1,100° or 1,150° F. A catalyst flow control valve **7** is provided in conduit **5.** The catalyst-oil suspension thus formed at an elevated cracking temperature is passed upwardly through an initial portion of a riser reactor zone **3** under velocity conditions selected to provide a hydrocarbon residence time within the range of 1 to about 4 seconds before the suspension passes into an expanded section of the riser reactor. At substantially the juncture of the expanded riser reactor section, conduit means **9** is provided for introducing an oil fraction of relatively high sulfur and nitrogen content such as a heavy vacuum gas oil boiling in the range of about 700° to about 1,100° F. The sulfur containing gas oil fraction is usually heated to an elevated temperature in the range of 350° to about 800° F. before introduction to the riser for admixture with the upflowing suspension formed in the lower portion of the riser reactor. In the expanded portion of the riser reactor, the hydrocarbon conversion temperatures will usually be from about 50° to about 200° lower than the suspension temperature entering the expanded riser reactor section. Catalyst to oil ratios employed in the riser will be selected from within the range of from about 4 to about 10.

The hydrocarbon feed introduced to the bottom of riser **3** may be any low sulfur containing hydrocarbon feed and thus the invention is not restricted to processing only a light virgin gas oil. Also any high sulfur containing feed may be substituted for the heavy vacuum gas oil specifically described.

The hydrocarbon-catalyst suspension passed upwardly through the riser reactor is discharged from the upper end thereof into a larger vessel **11** wherein the catalyst is separated from hydrocarbon vapors by a reduction in velocity promoting hindered settling and by cyclonic separation means **13** and **15** positioned in an upper portion of the vessel **11.** Of course a larger number of cyclone separators may be employed for this purpose. Vaporous hydrocarbons separated from catalyst particles pass into a plenum chamber **17** from which they are removed by conduit **19** for transfer to a fractionation step not shown. Catalyst separated in the cyclones is passed by diplegs **21** and **23** to a bed of catalyst **25** maintained in a lower portion of the vessel **11.** Baffle **27** positioned above the outlet of riser **3** changes the direction of the discharged suspension and this directional change in combination with a reduction in velocity promotes the separation of catalyst particles by settling into the fluid bed of catalyst **25.** The suspension passed upwardly through riser **3** may discharge directly into a plurality of cyclone separators arranged as shown in FIG. II. The separated catalyst collected as a catalyst bed **25** moves generally downwardly into and through a stripping zone therebelow and countercurrent to stripping gas introduced by conduit **29** in the lower portion of vessel **11.** The initial catalyst stripping is accomplished in an annular bed of catalyst about the upper end of riser **3.** Baffles **31** positioned in the stripping zone promotes contact of the catalyst with stripping gas therein to remove entrained vaporous hydrocarbons from the catalyst. Generally this initial stripping of the catalyst will occur at a temperature less than about 1,000° F. and more usually will be in the range of about 900° to about 975° F.

The contaminated catalyst containing carbonaceous deposits of hydrocarbon conversion and initially stripped of vaporous hydrocarbons in the stripping zone of vessel **11** is withdrawn by conduit **33** from a lower portion thereof and conveyed to a separate second stripping zone shown in FIG. I to be a riser stripping zone. In this system the catalyst is passed to the bottom portion of a riser stripping zone **35** wherein the contaminated catalyst is combined with hot freshly regenerated catalyst at a temperature in the range of 1,200° to 1,400° F. introduced by conduit **37.** Lift gas such as steam is introduced to the bottom of riser stripper **35** by conduit **39.** The catalyst mixture formed in the bottom portion of riser **35** is in such proportions as required to form a catalyst mix temperature of at least about 1,100° and preferably 1,250° F. The mixture is conveyed with lift gas upwardly through riser **35** at an elevated temperature for discharge into a fluid bed of catalyst **41** maintained in a catalyst stripping-soaking zone **43.** Hot stripping or fluidizing gas is introduced to a bottom portion of the fluid bed of catalyst **41** by conduit **45.**

In the stripping-soaking operation effected in zone **43,** at an elevated temperature of at least 1,100° F., sulfur compounds adsorbed on the catalyst carbonaceous deposits are substantially, if not completely, desorbed and removed overhead with the stripping gas. The stripping gas with desorbed sulfur materials is conveyed by conduit **47** discharging into the upper portion of vessel **11** wherein they are removed with the hydrocarbon products of catalytic conversion. The coked catalyst thus heat soaked and stripped of sulfur and hydrocarbon constituents but left with a residual carbonaceous material deposit is withdrawn from a bottom portion of vessel **43** by conduit **49** for transfer and discharge into a chamber or pot about the bottom portion of a riser regenerator **51.** Since the catalyst so removed from ves-

sel 43 is at an elevated temperature and contains a considerable amount of freshly regenerated catalyst it is contemplated recycling a portion of this heat soaked catalyst to the inlet of riser 3 thereof by-passing the regeneration sequence.

Hot freshly regenerated catalyst at a temperature in excess of about 1,200° F. may be passed if desired by conduit 53 to the bottom portion of riser regenerator 51 for admixture with the hot contaminated and regenerated catalyst. It is important to rapidly convert and remove sulfur compounds in the carbonaceous deposits on the catalyst and this may be accomplished by the initial high temperature partial burning of carbonaceous material on the contaminated catalyst upon contact with oxygen containing regeneration gas introduced by conduit 55. Catalyst flow control valves 57, 59, 61 and 63 are provided in catalyst transfer conduits 53, 49, 37 and 33 respectively.

In riser regenerator 51 maintained at an elevated temperature in excess of about 1,150° F. at least a partial burning of carbonaceous material is accomplished along with effecting the conversion and removal of sulfur compounds carried over from the catalyst soak-stripping zone 43. The suspension in riser regenerator 51 is passed through cyclone separation equipment represented by separators 65 and 67 sequentially connected wherein catalyst particles are separated from regeneration flue gases. The separated and partially regenerated catalyst separated by cyclonic means 65 and 67 is conveyed by one or more catalyst diplegs 69 and 71 into a fluid bed of catalyst 73 being further contacted under catalyst regeneration conditions with oxygen containing regeneration gases in a regeneration zone 75.

The gaseous products of combustion and containing sulfur compounds separated from the catalyst discharged from riser regenerator 51 are maintained segregated from other later obtained regeneration combustion gas products so that any sulfur compounds or conversion products thereof may be separately recovered from the bulk of the regenerator flue gas obtained as hereinafter defined. Thus the gaseous products of combustion obtained from riser regenerator 51 are separated from cyclone separator 67 by conduit 77 and passed to chamber 79 from which these combustion flue gases are removed by conduit 81. The sulfur containing flue gas recovered as by conduit 81 may then be treated for sulfur removal in equipment not shown. The catalyst particles freed of sulfur and its compounds in the above discussed combination and recovered from riser regenerator 51 is then subjected to a final phase elevated temperature catalyst regeneration in a fluid catalyst bed 73 maintained in the lower portion of regeneration vessel 75.

In the catalyst regeneration clean-up step effected in vessel 75, oxygen containing regeneration gas such as air or air supplemented with oxygen is introduced to a bottom portion of the catalyst bed 73 by conduit 83. The regeneration gas in conduit 83 may be supplemented with a combustible fuel such as a methane rich gas introduced by conduit 85. Supplemental fuel is added to the regeneration procedure when the process is operated on a coke deficient basis. However, the processing concepts of this invention are not restricted to a coke deficient operation and it is contemplated operating the process under conditions wherein there is enough coke deposited on the catalyst during hydrocarbon conversion to provide a heat balanced operation thus eliminating the need for incremental fuel addition to the regenerator.

In regenerator 75, the fluid bed of catalyst 73 is subjected to high temperature catalyst regeneration condition thereby heating the catalyst to an elevated temperature in the range of about 1,200° to 1,400° F. It is preferred that the catalyst be regenerated under conditions promoting the combustion of formed carbon monoxide to carbon dioxide and any operating parameters promoting this end are contemplated for use therein. Catalyst particles carried overhead into a dispersed phase of catalyst with regeneration flue gases pass through one or more cyclonic separation means represented by separator 87 provided with catalyst dipleg 89. Flue gases of little or no sulfur content separated from entrained catalyst particles in separator 87 are removed from the regeneration vessel by conduit 91 communicating with a separate plenum chamber 93 and conduit 95. Regenerated catalyst is removed from a bottom portion of catalyst bed 73 by conduit 5 communicating with the bottom portion of riser 3.

In the arrangement of FIG. II a more compact stacked design is proposed for carrying out the processing concepts of the present invention. In this arrangement a segregated high temperature annular stripping zone about the riser conversion zone is positioned beneath a first annular stripping zone. A first stage of segregated catalyst regeneration is coaxially positioned with respect to a secondary regeneration zone. It is contemplated modifying the arrangement of FIG. II to provide a single continuous downwardly moving bed of catalyst undergoing stripping to which hot regenerated catalyst is introduced in a lower intermediate portion thereof and in an amount sufficient to raise the temperature of the bed of catalyst up to about 1,150° F. at which temperature the catalyst is heat soaked before the catalyst is cascaded to the first stage of regeneration. In any event, no matter which arrangement is employed it is important and essential to the concept of invention to transfer all of the products of stripping into either a separate zone or system for removing sulfur material or to the hydrocarbon product recovery system. Also, the combustion flue gases of a first stage of regeneration are maintained separate from those obtained in a second regeneration stage, as discussed with respect to FIG. I.

In the arrangement of FIG. II, a light virgin gas oil (LVGO) or a low sulfur feed of broader boiling range is introduced by conduit 2 to the bottom portion of a cracking riser reactor 4 to which hot freshly regenerated catalyst is introduced by conduit 6 provided with flow control valve 8. Catalyst may also be withdrawn from the bottom of catalyst bed 28 by means not shown and conveyed to the inlet of riser 4 for the reasons discussed with respect to FIG. I. A catalyst oil suspension is formed in the bottom of riser 4 providing a mix temperature of at least about 1,000° F. but more usually at least 1,050° F. which is caused to flow upwardly through the riser at a velocity providing a hydrocarbon residence time in the more restricted portion of the riser within the range of 1 to 10 seconds. Riser 4 of restricted cross-sectional area in the lower portion thereof is expanded to a larger diameter riser reactor in the upper portion thereof. In the expanded upper portion of the riser and substantially at the transition point, means are provided for introducing a heavy vac-

uum gas oil (HVGO) or a high sulfur containing hydrocarbon charge as by conduit **10.** The heavy vacuum gas oil or high sulfur charge contacts the suspension flowing upwardly through the riser under cracking conversion conditions within the range of 900° to about 1,200° F. and lays down carbonaceous material or coke on an already precoked catalyst surface caused by contact with the light vacuum gas oil. In this operating sequence, the sulfur compounds in the heavy gas oil feed are deposited on the coked catalyst particle obtained by conversion of the light vacuum gas oil feed. The heavy or sulfur containing gas oil feed undergoes partial conversion during its traverse of the remaining portion of the enlarged riser reactor at a hydrocarbon residence time in the range of 1 to 10 seconds.

The catalyst oil suspension including products of conversion traversing riser reactor **4** are separated by cyclonic means **12** and **14** positioned at the riser discharge end. Catalyst separated from gasiform material including hydrocarbon conversion products is passed by diplegs **16** and **18** to a dense fluid bed of catalyst **20** positioned beneath the cyclonic separation means and about an upper portion of the riser. Stripping gas such as steam is introduced by conduit **22** to a lower portion of bed **20** to remove entrained vaporous material from the catalyst particles. Stripping of catalyst bed **20** will usually be effected at a temperature beneath 1,000° F. and generally in the range of from about 900° up to about 950° F. Catalyst stripped in bed **20** is withdrawn by standpipe **24** provided with flow control valve **26** and passed in this specific embodiment to a second segregated dense fluid bed of catalyst **28.** A pan **30** may be placed beneath the bottom open end of standpipe **24** to deflect catalyst into the bed of catalyst **28.** Catalyst bed **28** is separately housed in the lower portion of vessel **30** and about a lower portion of riser **4.** Some limited heat exchange between riser **4** and bed **28** may be experienced. A vent conduit **32** conveys gasiform material removed from bed **28** to an upper portion of vessel **30** from which it is removed by cyclonic means **34** provided with dipleg **36.** Vent pipe **32** may pass to separate recovery equipment, not shown, to remove sulfur components therefrom. Thus gasiform materials separated as by cyclonic means **12, 34** and **14** is removed by conduits **38, 40** and **42** communicating with plenum chamber **44** and withdrawal conduit **46.** Gasiform materials including hydrocarbon conversion products stripping gas and sulfur compounds are removed by conduit **46** and conveyed to product recovery equipment not shown.

In the segregated stripping zone housing catalyst bed **28,** the temperature of the bed is raised by the addition of hot regenerated catalyst introduced by conduit **48** and provided with catalyst flow control valve **50.** Thus sufficient hot regenerated catalyst at a temperature up to about 1,400° F. in conduit **48** is combined with contaminated catalyst in conduit **24** to form a catalyst mixture at a temperature of at least 1,150° F. The hot catalyst mixture comprising bed **28** is then heat soaked in the presence of stripping gas such as steam introduced to a lower portion of bed **28** by conduit **52.** During this heat soak-stripping operation, absorbed sulfur compounds are substantially removed from the carbonaceous material on the catalyst particles and the removed sulfur is retained with the hydrocarbon products of the process or separately treated, as discussed above. Of course all of the sulfur compounds may not be removed during the catalyst soaking step and the present invention contemplates this condition and provides for handling the situation.

In the arrangement of this invention, the transfer of some sulfur compounds not removed in the heat-soak stripping steps and retained with the coked catalyst can be removed by oxygen regeneration. Removal of sulfur compounds and some deposited coke is handled by effecting a first stage catalyst regeneration operation in an arrangement of apparatus under conditions which segregate the flue gas combustion products thereof from the flue gas products of a second stage catalyst regeneration step. In the method of this invention, it has been found convenient during transfer of catalyst to make the first stage of catalyst regeneration for removing deposited sulfur compounds a riser regeneration step with the clean-up catalyst regeneration stage accomplished in a more dense fluid catalyst regeneration operation.

In the arrangement of FIG. II, a mixture of regenerated and coke contaminated catalyst is removed from the soaking stripping step at an elevated temperature of at least 1,150° F. by conduit **54** provided with valve **56.** This hot catalyst mixture is passed to a vessel **58** housing a bed of catalyst **60** about the inlet of a riser regenerator **62.** Additional hot freshly regenerated catalyst may be added to bed **60,** if desired, to further elevate the temperature of the catalyst mixture by standpipe **64** provided with flow control valve **66.** Regeneration gas such as air or air supplemented with oxygen is introduced, for example, by hollow stem plug valve **68** aligned with the bottom open inlet of riser **62.** It is contemplated in another embodiment of connecting conduit **54** directly with the bottom portion of riser **62** in the same manner as conduit **6** connects with the bottom portion of riser **4** since the catalyst mixture in conduit **54** is normally sufficiently elevated to provide an initial regeneration temperature of at least 1,150° F. It is important to the operating combination of this invention to provide the catalyst initially subjected to contact with oxygen with an elevated temperature sufficient to promote the rapid combustion of sulfur containing carbonaceous material and the removal of sulfur compounds from the catalyst particles. In either arrangement employed, the regeneration gas such as air or an oxygen supplemented regeneration gas is brought in contact with the catalyst to form a high temperature suspension and this high temperature suspension is passed upwardly through a first riser regeneration zone maintained at an elevated regeneration temperature not to exceed about 1,400° F. before a discharge into a separation zone such as cyclonic separation means attached directly to the end of the riser regenerator. In the arrangement of FIG. II, cyclonic separators **70** and **72** are attached to the discharge end of riser **62** wherein combustion flue gases containing sulfur are separated from catalyst particles. Catalyst diplegs **74** and **76** are provided for passing the separated catalyst into a fluid bed of catalyst **78** therebelow. Combustion gases containing sulfur and separated in cyclonic means **70** and **72** are combined and removed as a separate confined stream for treatment to remove sulfurous material. The combined combustion gases of the riser regeneration stage are removed by conduit **78** communicating with a separate plenum chamber zone **80** from which they are withdrawn by conduit **82.** These separated sulfur

containing combustion flue gases are then treated to remove sulfur from the flue gases.

In fluid catalyst bed **78**, regeneration of the catalyst by burning of insufficiently removed carbonaceous deposits is completed by the introduction of regeneration gas to a lower portion of the catalyst bed **78** by conduit **84**. Regeneration temperatures are usually restricted not to exceed about 1,400° F. Gaseous products of combustion obtained from the fluid bed regeneration step with entrained catalyst fines pass through separation means such as cyclone separators **86** and **88** provided with catalyst diplegs **90** and **92** respectively. These gaseous products of combustion separated from catalyst particles in separators **86** and **88** are combined and removed as a separate confined stream by conduit **94** communicating with a separate plenum chamber **96** for withdrawal by conduit **98**.

It will be clear to those skilled in the art that the present invention relies upon a combination of operating parameters and process steps conducted in a particular sequence to accomplish the results desired. That is, the combination relies upon a particular sequence of hydrocarbon conversion and catalyst stripping steps to retain sulfur compounds particularly in the hydrocarbon product recovery system. The regeneration sequence is a segregated affair arranged to restrict the volume of any combustion flue gas containing sulfurous material in excess of 250 ppm to a confined stream separate from the remaining combustion flue gas stream so that special treatment for the removal of sulfurous material can be limited.

Having thus provided a general discussion of the method and concepts of this invention and discussed specific embodiments in support thereof, it is to be understood that no undue restrictions are to be imposed by reason thereof except as defined by the claims.

We claim:

1. In a hydrocarbon conversion operation comprising a riser conversion zone, a catalyst stripping zone and a catalyst regeneration zone, the method for improving the operation which comprises,

passing a regenerated cracking catalyst suspended in a hydrocarbon fraction substantially free of sulfur compounds through an initial portion of said conversion zone under elevated temperature hydrocarbon conversion conditions of limited duration and thereafter contacting the suspension in a downstream portion of the conversion zone with a hydrocarbon fraction containing sulfur compounds under elevated temperature hydrocarbon conversion conditions of limited duration,

separating catalyst particles with deposited contaminants of hydrocarbon conversion from hydrocarbon conversion products in a zone separate from said hydrocarbon conversion zone and stripping the separated catalyst to remove entrained vaporous hydrocarbons with stripping gas, combining stripping gas and stripped products with said hydrocarbon conversion products,

combining the stripped catalyst with a quantity of hot regenerated catalyst sufficient to form a catalyst mixture at a temperature of at least 1,050° F. during a higher temperature soaking contact with stripping gas,

passing stripping gas with desorbed gasiform material from said high temperature soaking contact step to product recovery,

passing stripped catalyst at an elevated temperature from said high temperature stripping operation through a limited duration first stage catalyst regeneration operation, recovering regeneration product gases from said first stage of catalyst regeneration as a separate stream,

passing catalyst separated from said first stage of catalyst regeneration to a second stage of catalyst regeneration, regenerating the catalyst at an elevated temperature in said second stage with oxygen containing regeneration gas,

and recovering regeneration combustion gases of said second regeneration stage separately from the gaseous products of said first regeneration stage.

2. The method of claim **1** wherein the downstream portion of the conversion zone is enlarged with respect to the initial portion thereof.

3. The method of claim **1** wherein thhe separate stages of stripping are accomplished in a contiguous stripping zone containing a downwardly moving bed of catalyst particles.

4. The method of claim **1** wherein a quantity of hot regenerated catalyst is combined with stripped catalyst passed to the first stage of catalyst regeneration.

5. A method for converting sulfur containing oil feed materials to gasoline boiling product with a cracking catalyst which comprises,

initially contacting a hot regenerated cracking catalyst with a gas oil feed substantially free of sulfur in a relatively dispersed phase condition at an elevated cracking temperature of at least 1,000° F. for a hydrocarbon residence time in the range of 1 to 10 seconds whereby the catalyst accumulates sulfur free carbonaceous deposits and thereafter contacting the catalyst with accumulated carbonaceous material with a sulfur containing gas oil feed material at a lower cracking temperature,

separating catalyst from hydrocarbon conversion products and stripping the catalyst of entrained hydrocarbon vapors, heat soaking the stripped catalyst at an elevated temperature in admixture with freshly regenerated catalyst, recovering gasiform material obtained from said stripping and elevated temperature heat soaking operation and the hydrocarbon products of catalytic cracking,

passing the heat soaked catalyst sequentially through two separate stages of oxygen regeneration arranged for the separate recovery of flue gases from each stage and recovering flue gases of low and higher sulfur content separately from the catalyst regeneration stages.

6. The method of claim **5** wherein the first stage of catalyst regeneration is accomplished in a dispersed catalyst phase regeneration zone, and the second stage of catalyst regeneration is accomplished in a fluid bed of catalyst about said dispersed catalyst phase regeneration.

7. The method of claim **5** wherein regenerated catalyst recovered from said second stage is passed to said heat soaking step for admixture with stripped catalyst in an amount to provide a mix temperature of at least 1,200° F.

8. The method of claim **5** wherein the hydrocarbon conversion operation is operated on a basis to provide insufficient coke for a heat balanced operation and supplementary fuel is burned in said catalyst regenera-

tion operation to provide the supplemental heat needed for said hydrocarbon conversion.

9. A method for cracking sulfur bearing oil feed materials to produce gasoline, lower and higher boiling products which comprises,

contacting a sulfur bearing oil feed with a cracking catalyst suspended therein at a temperature of at least 1,000° F. and a hydrocarbon residence time in the range of 0.5 to 10 seconds,

separating deactivated catalyst from hydrocarbon conversion products of said cracking operation containing carbonaceous material contaminated with sulfur compounds,

combining hot regenerated catalyst with said deactivated catalyst in an amount to provide a mixture of catalyst at an elevated soaking temperature of at least 1,050° F. and stripping gasiform material comprising sulfur from said elevated temperature catalyst mixture,

passing the heat soaked catalyst mixture from which sulfur was removed sequentially through two separate stages of catalyst oxygen regeneration and

recovering combustion flue gases separately from each stage of catalyst regeneration.

10. The method of claim **9** wherein the catalyst from the heat soaking stripping step is combined with an additional amount of hot regenerated catalyst to form a catalyst mixture at a temperature of about 1,200° F. upon initial contact with oxygen containing regeneration gas.

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