

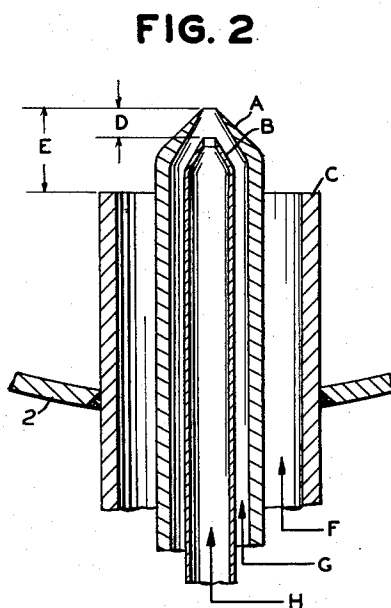
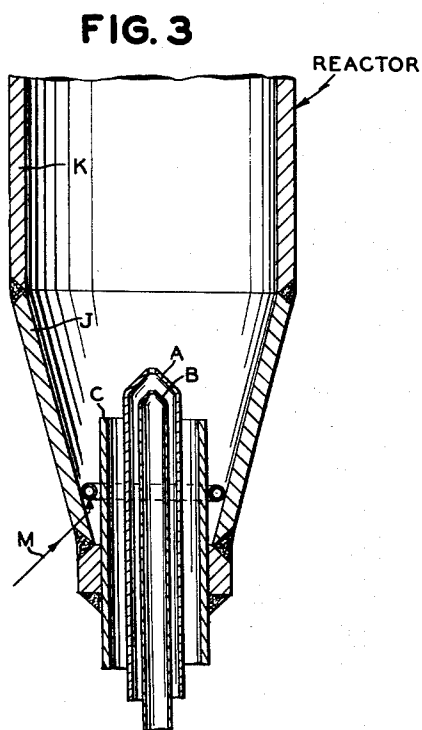
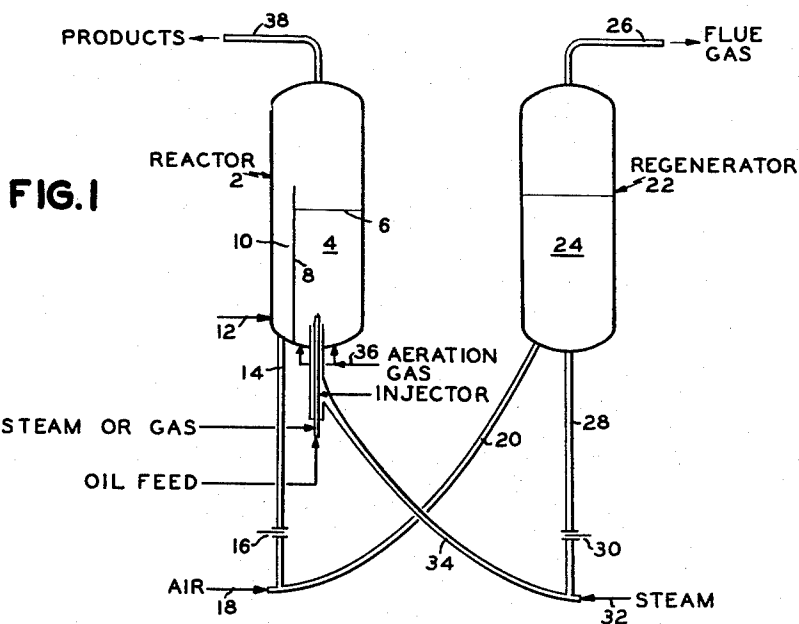
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OIL FEED SYSTEM FOR FLUID CATALYTIC CRACKING UNIT

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## OIL FEED SYSTEM FOR FLUID CATALYTIC CRACKING UNIT

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This invention relates to the method and means for contacting hydrocarbons with finely divided solid contact material. In one aspect the invention is directed to the conversion of high-boiling hydrocarbons such as gas oils, reduced crudes, heavy residual oils and other high-boiling hydrocarbons to products of lower boiling hydrocarbons, including gas oils, gasoline and gaseous hydrocarbons. More specifically, the invention is directed to the method and means for contacting high-boiling hydrocarbons with catalyst in a fluid-type of operation.

High-boiling hydrocarbons, such as residual oils obtained from atmospheric or vacuum distillation units have been treated in a variety of processes including thermal cracking, visbreaking, hydrocracking and fluid coking operations for the production of lower boiling hydrocarbons. These operations, however, have not been completely satisfactory for a variety of different reasons. One difficulty, for example, in the cracking of heavy residual oils in the present of finely divided solid contact material is the tendency of the solid particles to agglomerate into large clusters of defluidized contact material, as well as the deposition of large amounts of carbonaceous material around the feed inlet to such an extent that the unit must be shut down quite frequently for cleaning and removal of the clustered contact material.

It is an object of this invention to provide an improved method and means for cracking residual oil in the presence of finely divided solid contact material which will overcome the difficulties of the prior art.

Another object of this invention is to provide an improved method and means for introducing residual oils into contact with finely divided contact material for conversion into desired products.

Other objects and advantages of the improved method and means of this invention will become apparent from the following description.

This invention is directed to an improved method and means for introducing high-boiling hydrocarbons into contact with finely divided contact material for conversion into desired products, whereby agglomeration of contact particle material into defluidized masses of contact material and deposition of carbonaceous material at the feed inlet is substantially eliminated. In one embodiment, the improved method of this invention comprises flowing finely divided contact material as a relatively high velocity annular stream upwardly around two concentrically arranged nozzles through which the high-boiling hydrocarbon and a gaseous material are introduced.

In another embodiment, the means for effecting the method of this invention comprises in combination a substantially vertical conduit projecting into the bottom or lower portion of a reactor vessel through which finely divided solid contact material is passed at a velocity in the range of from about 10 feet per second to about 30 feet per second, preferably from about 15 to about 25 feet per second. Coaxially positioned in the conduit are two coaxially positioned nozzles arranged to provide for concurrent flow of oil through the inner nozzle and gaseous material through the outer nozzle with the gaseous material such as steam or gaseous hydrocarbons being passed through the outer nozzle at a sufficiently high velocity to shear the hydrocarbon feed into relatively fine droplets or in an atomized condition. The outer and

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inner nozzles are provided with coaxially aligned orifices to provide for intimate mixing of the gaseous material with the high-boiling hydrocarbon feed under velocity conditions to effect shearing of the hydrocarbon feed into droplets. The thus formed hydrocarbon droplets are then intimately contacted with finely divided contact material by passing the contact material as a high velocity annular stream around the nozzle arrangement described above. The inner and outer orifice openings of the atomizing nozzle may be suitably adjusted in spaced apart relationship to obtain the desired degree of break-up of the hydrocarbon feed into small droplets or substantially atomization of the hydrocarbon feed. In addition to the above, it has been found that the tip of the outer nozzle, for best results, should be from about 0 to about 5 times the outside diameter of the outer nozzle above the discharge end of the conduit through which the finely divided contact material is passed as an annular stream, and preferably the tip or orifice of the outer nozzle should be about 1.5 times the outer nozzle diameter above it.

In a preferred form of the present invention, the high-boiling hydrocarbon feed dispersed with finely divided contact material is introduced through one or more of the improved injector means or nozzle arrangements described herein into the lower portion of a reactor containing fluidized finely divided contact material therein. For example, one or more of the injector nozzles may be employed in a dense fluidized bed reactor with a single injector nozzle arrangement being employed in, for example, a transfer line or suspension reactor. In addition to the above, it is contemplated extending the finely divided contact material riser conduit upwardly into a dense fluidized bed of contact material substantially above the bottom of the reactor, the only restriction being in this arrangement that sufficient contact material should be above the nozzle means to maintain a relatively dense bed of contact material thereabove. When employing a dense fluidized bed reactor it may be desirable to assist in maintaining a uniformly fluidized bed throughout its cross-sectional area by the separate addition of additional fluidizing gas or aerating gas to the lower cross-sectional area of the bed of contact material and external to the injector means herein described.

In the practice of this invention, a residual oil having a gravity in the range of from about 5 to about 25° API, an initial boiling point in the range of from about 400° F. to about 700° F., and a 10 percent boiling point in the range of from about 600° F. to about 1000° F., may be treated in the presence of a gaseous material such as steam or gaseous hydrocarbons such that a total of from about 350 to about 2500 volumes of gaseous material per volume of oil feed is employed. That is, employing the concentric nozzle arrangement of this invention, from about 75 to about 700 volumes of gaseous material is employed to atomize each volume of liquid hydrocarbon feed with any remaining quantity of gaseous material required to fluidize the dense catalyst bed being introduced to the lower portion thereof external of the nozzle arrangement of this invention. For good atomization or shearing of the high-boiling hydrocarbon the gaseous material should leave the outer nozzle orifice at a velocity of at least about 250 feet per second, and preferably from about 300 to about 500 feet per second, with the liquid part of the heavy oil feed being passed through the inner nozzle orifice at a velocity of from about 1 to about 10 feet per second. The feed rate of the annular stream of finely divided solid contact material which is employed to wipe the tip of the nozzle and become wetted by the atomized hydrocarbon should be passed at a velocity of at least about 10 feet per second and preferably from about 15 to about 25 feet per second past the tip of the nozzle.

The oil feed being treated in accordance with this in-

vention may be preheated to an elevated temperature, however, it is important that the temperature be not sufficiently high to permit substantial vaporization of the oil feed in the nozzle proper. Accordingly, the oil feed should be in a liquid phase condition and may be heated to an elevated temperature in the range of from about 400 to about 700° F., depending upon the particular feed material being processed. By the method and means of this invention a high-boiling hydrocarbon such as a residual oil may be atomized or sheared into fine droplets and thereafter contacted with a relatively high velocity annular stream of finely divided contact material for intimately dispersing the atomized oil on the contact material. Thereafter, the mixture of contact material coated with oil droplets is passed into a relatively dense fluidized bed of contact material maintained under conversion conditions. The reactor containing fluidized contact material is generally maintained at a temperature in the range of from about 850° F. to about 1000° F., preferably from about 900° F. to about 980° F., a pressure in the range of from about 5 p.s.i.g. to about 25 p.s.i.g., preferably from about 10 to about 15 p.s.i.g., depending upon the severity of conversion desired.

For the purpose of this invention the finely divided contact material may include a variety of materials including synthetically prepared or naturally occurring cracking catalysts and/or substantially inert heat carrier materials. More specifically, the finely divided contact material may be selected from the group comprising sand, coke, silica, silica-alumina, silica-magnesia, silica-zirconium, superfiltrol, fuller's earth, bauxite or mixtures of the same. When employing a catalytic material for the conversion of residual oils and reduced crudes a partially spent cracking catalyst, such as a silica-alumina catalyst obtained from a gas oil cracking operation, may be employed. As hereinbefore indicated, the finely divided solid contact material may be used either alone or in physical admixture with a substantially inert heat carrier material such as sand or any other suitable refractory inert material. When employing an inert heat carrier, such as sand, with the catalyst, then the quantity of sand employed will be in the range of from about 25 to about 75 percent of the total weight of contact material, and preferably greater than about 50 percent of the total weight of contact material. The particle size of the finely divided contact material may be any size acceptable for a fluid or suspension type of operation which is usually less than 100 mesh size and preferably 80 percent of the material is constituted of particles ranging in size of from about 150 to about 400 mesh size.

Having thus generally described the method and means of this invention, reference will now be had by way of example to the drawings which show the preferred method and means for practicing the invention.

FIGURE 1 is a diagrammatic illustration in elevation of a relatively dense fluid bed system for cracking residual oils.

FIGURE 2 is a diagrammatic illustration in elevation of the oil contact material injector means of this invention.

FIGURE 3 is a diagrammatic illustration in elevation of the injector means of this invention as applied to a transfer line cracking reactor.

Referring now to FIGURE 1, a reactor 2 containing a relatively dense fluid bed of contact material 4 having an upper meniscus 6 is shown. A substantially vertical transverse baffle member 8 extends upwardly from the bottom of the reactor to the upper portion thereof forming a separate stripping zone 10 in open communication in the upper portion thereof with the reactor through which the finely divided contact material flows downwardly at a temperature of about 900° F., countercurrent to stripping gas introduced to the lower portion of the stripping zone by conduit 12. The stripped contact material flows downwardly from the bottom of the stripper through standpipe 14 at a preselected rate controlled by flow

control valves 16 positioned in the lower portion of the standpipe. Thereafter the contact material is picked up by regeneration gas such as air introduced by conduit 18 and conveyed by conduit 20 to regenerator 22 containing a relatively dense fluid bed of contact material 24. During the regeneration step the finely divided contact material is heated to an elevated temperature of about 1100° F. by burning with air the carbonaceous deposits contaminating the contact material. Flue gas produced during the regeneration step is removed from the upper portion of the regenerator after passage through suitable cyclone equipment, not shown, by conduit 26. The finely divided contact material at an elevated temperature of about 1050° F., is withdrawn from the regenerator 22 and passed downwardly through standpipe 28 at a preselected rate controlled by valve 30. Thereafter the hot finely divided contact material is picked up by a gaseous material such as steam introduced by conduit 32 and conveyed by conduit 34 at a velocity of about 20 feet per second to the annular portion of the injector nozzle of this invention. Provisions are made for the separate introduction of additional fluidizing gas to the lower portion of the reactor by conduit 36.

In the reactor a residual oil is converted at a temperature of about 950° F. into desired products thereby contaminating the contact material with carbonaceous deposits. The products of reaction are removed from the upper portion of the reactor after passage through suitable cyclone equipment, not shown, by conduit 38 and passed to suitable recovery equipment for separation into desired products, with the contaminated contact material passed to the stripper and regenerator, as hereinbefore described.

In order to provide a more complete understanding of the improved injector means of this invention and its method of operation as employed in the reactor of FIGURE 1, reference is now had by way of example to FIGURE 2 which shows diagrammatically the relationship of the basic components of the improved injector means. Accordingly, two concentrically arranged nozzles A and B are positioned in the discharge end of a riser conduit C forming an annular zone therewith for the transfer of finely divided contact material therethrough at a relatively high velocity, as hereinbefore indicated. The improved injector means permits the distance D between the discharge orifice of nozzle A and nozzle B to be varied over a relatively wide range for controlling the degree of atomization of the feed depending on the feed being treated with the distance E between the discharge orifice of nozzle A and conduit C being variable as desired. In the preferred method of operation of the injector, finely divided contact material is passed upwardly through the annulus indicated by arrow F at a velocity of about 20 feet per second. Steam is introduced through the annulus indicated by arrow G to maintain a velocity of about 400 feet per second at the outer orifice with a residual oil introduced through nozzle B as indicated by arrow H to maintain a velocity of about 5 feet per second at the inner orifice. One of the important aspects of this novel injector arrangement is the positioning of the concentric nozzles such that the oil nozzle is blanketed from the hot contact material by steam to prevent cracking of the oil in the oil inlet and the location of the oil-steam nozzle in the discharge end of conduit C such that the high velocity stream of contact material continuously wipes the discharge end of nozzle A from which the residual oil is discharged in an atomized condition with steam. This improved arrangement of apparatus and method of operation not only keeps the nozzle tip clean and prevents build up of carbonaceous deposits thereon, but facilitates dispersion and cracking of the atomized residual oils in the high velocity stream before the contact material becomes tacky and tends to stick together or agglomerate.

FIGURE 3 shows diagrammatically in elevation an arrangement of apparatus employing the improved injector

means of this invention as applied to the inlet of a transfer line reactor. In this embodiment, A corresponds to the outer nozzle and C to the contact material transfer line conduit, as described in connection with FIGURE 2 above. The injector is concentrically positioned within a funnel member or inverted conical frustum J forming the base of the transfer line reactor K. Provision is made for the separate introduction of fluidized gas external to and below the discharge end of conduit C through a suitable distributing device or ring designated as L and supplied by conduit M. The use of this improved injector means in the apparatus of FIGURE 3 substantially eliminates the build up of carbonaceous material on the walls of the reactor adjacent to the feed inlet, as well as agglomeration of the contact material in the reactor, which otherwise would defluidize and plug up the reactor.

#### EXAMPLE

Having thus specifically described the improved method and means for this invention, reference is now had to the following which presents the results of an investigation leading to the development of the improved injector described herein.

In the early phases of the investigation for the cracking of reduced crude in a pilot plant operation, the results were extremely unsatisfactory due to coking in the feed line and/or agglomeration of the catalyst in the reactor, particularly at the feed inlet, which limited the operation to less than about 24 hours. It was concluded from this early experience that the oil feed system was completely inadequate. Accordingly, development of an efficient heavy oil injection system was immediately initiated.

A pneumatic commercially available nozzle "A" was chosen for study and comparison with the nozzle design of this invention identified as nozzle "B." These nozzles were tested and nozzle velocities were noted where partial atomization of the feed begins and where it becomes complete. The results are presented in the table below.

Comparison of Nozzles A and B

| Nozzle Velocity, f.p.s. | Atomization |   | Jet Height at 4" Diameter, inches |     |
|-------------------------|-------------|---|-----------------------------------|-----|
|                         | A           | B | A                                 | B   |
| 58.....                 | N           | N | 5                                 | 3.5 |
| 116.....                | N           | N | 8                                 | 20  |
| 231.....                | C           | P | 10                                | 14  |
| 347.....                | C           | C | 11                                | 13  |
| 464.....                | C           | C | 12                                | 11  |

N=none, P=partial, C=complete.

These results indicated that a high nozzle velocity would be needed to produce complete atomization. It was also found that a pneumatic type of nozzle caused very high catalyst attrition rates. Similar tests employing a solid stream type of nozzle and a round spray atomizing nozzle proved also to be unsatisfactory.

Accordingly, two concentrically arranged nozzles similar to that shown in FIGURE 2 were made with the central nozzle adjustable in order that the distance at the nozzle tip could be varied for study. The nozzle was installed in suitable laboratory equipment where its operation could be observed. Preliminary tests with the new concentric nozzle arrangement were, for the purpose of observation, conducted with water. Injecting water with this nozzle design into a fluidized bed of catalyst caused agglomeration and formation of lumps of catalyst at the tip of the nozzle. Large lumps were also observed in the bottom cone of the column after several runs which appear to be broken fragments of the larger formations taking place in the bed at the nozzle level. Since the silica-alumina catalyst employed in the tests was a free flowing powder even with 50 per-

cent moisture content, it was concluded that the lump formation was due to improper nozzle performance which caused the tip of the nozzle to become wet and thus susceptible to adherence of the catalyst particles.

- 5 These particles would then hold additional particles thus forming a lump of catalyst at the tip of the nozzle. On the basis of this it was postulated that passing a high velocity stream of catalyst upwardly around the nozzle tip would provide a scouring or wiping action of the tip, 10 would give more intimate contact and dispersion of the oil droplets on the catalyst and overcome the contact material agglomeration problem. Accordingly, a sleeve was installed around the nozzle through which catalyst could be passed at different velocities around the nozzle. 15 Several tests were conducted with the new injector design which gave excellent results and completely eliminated formation of catalyst lumps which were previously observed. This improved injector system consisting of two concentrically arranged nozzles positioned within a 20 sleeve for annular flow of catalyst past the nozzle tip was then installed in the pilot plant for tests with a high-boiling hydrocarbon. Tests with this new injector design in the pilot plant feeding a residual oil provided trouble-free operation and permitted continuous operation without plugging or the formation of catalyst lumps 25 at the feed inlet. The residual oil feed used in the test was obtained from atmospheric tower bottoms which had an API gravity of about 17.8 and boiled in the range of from about 450° F. to 40 percent at about 950° F. 30 The operating conditions employed were:

Oil temperature injector nozzle..... 450° F.  
Oil rate..... 13,500 grams/hr.  
Catalyst circulation rate..... 675 lbs./hr.  
35 Injector nozzle dispersion steam..... 1,500 grams/hr.  
Aeration gas external to injector..... 145 s.c.f.h.  
Catalyst mass velocity in  
transfer line annulus..... 28.6 lbs./sec./  
ft. square.

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Having thus provided a description of the method and means of this invention along with specific illustrations thereof it should be understood that no undue limitations or restrictions are to be imposed by reason thereof.

45 We claim:

1. A method for introducing high-boiling hydrocarbons in contact with finely divided solid contact material which comprises preheating a high-boiling hydrocarbon feed to an elevated temperature but below substantial 50 vaporization of said hydrocarbon feed, passing said heated hydrocarbon through a confined passageway provided with a discharge orifice, said confined passageway being surrounded by an annular passageway having a discharge orifice aligned with the discharge orifice of said confined passageway, passing a gaseous material 55 through said annular passageway for admixture with said heated hydrocarbon discharged from the orifice of said confined passageway, passing the mixture of hydrocarbon and gaseous material through the orifice of said annular passageway under conditions whereby the hydrocarbon 60 is discharged as relatively fine droplets and passing an annular stream of finely divided contact material at a relatively high velocity along said annular passageway for contact with said hydrocarbon droplets discharged 65 from said annular passageway.

2. A method for passing heavy residual oils in contact with a dense fluidized bed of finely divided catalyst which comprises heating said residual oil to an elevated temperature, discharging said residual oil in admixture with 70 a gaseous material in a relatively atomized condition from an atomization zone into a relatively high velocity upflowing annular stream of catalyst discharged from an annular passageway around said atomization zone, the discharge of said atomization zone being at least above 75 the discharge of said annular passageway and said an-

nular passageway projecting into the lower portion of said dense fluidized bed of catalyst.

3. A method for contacting a high boiling residuum with finely divided contact material which comprises providing a first confined passageway provided with a discharge orifice, an annular passageway surrounding said first confined passageway provided with a discharge orifice spaced apart and aligned with the discharge orifice of said first confined passageway, passing said residuum heated to an elevated temperature but in liquid phase condition through said first confined passageway, passing steam at a relatively high velocity through said annular passageway, discharging residuum in an atomized condition with steam from the orifice of said annular passageway, passing an annular stream of finely divided solid contact material at an elevated temperature past the orifice of said annular passageway whereby the contact material becomes wetted by the atomized residuum, and passing the wetted contact material into a fluidized bed of contact material maintained under desired conversion conditions for conversion of the residuum to desired lower boiling products.

4. A method for cracking gas oils and higher boiling hydrocarbons in the presence of finely divided solid fluidizable contact material to lower boiling range products which comprises passing said hydrocarbon oil heated to an elevated temperature without substantial vaporization thereof through a confined passageway

within a first annular passageway, each of said passageways provided with coaxially aligned discharge orifices, passing steam at a relatively high velocity through said first annular passageway, discharging said hydrocarbon into said steam adjacent to the orifice of said first annular passageway such that the hydrocarbon is mixed with said steam and sheared into fine droplets upon discharge from said first annular passageway orifice, passing the finely divided solid contact material at an elevated temperature and a relatively high velocity through a second annular passageway surrounding said first annular passageway such that the discharge orifice of said first annular passageway is wiped by said hot contact material and the contact material becomes wetted with droplets of hydrocarbon, and passing the thus wetted contact material into a reaction zone containing fluidized contact material maintained under desired conversion conditions.

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