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CONTROL OF COKE PARTICLE SIZE IN FLUID COKING PROCESS

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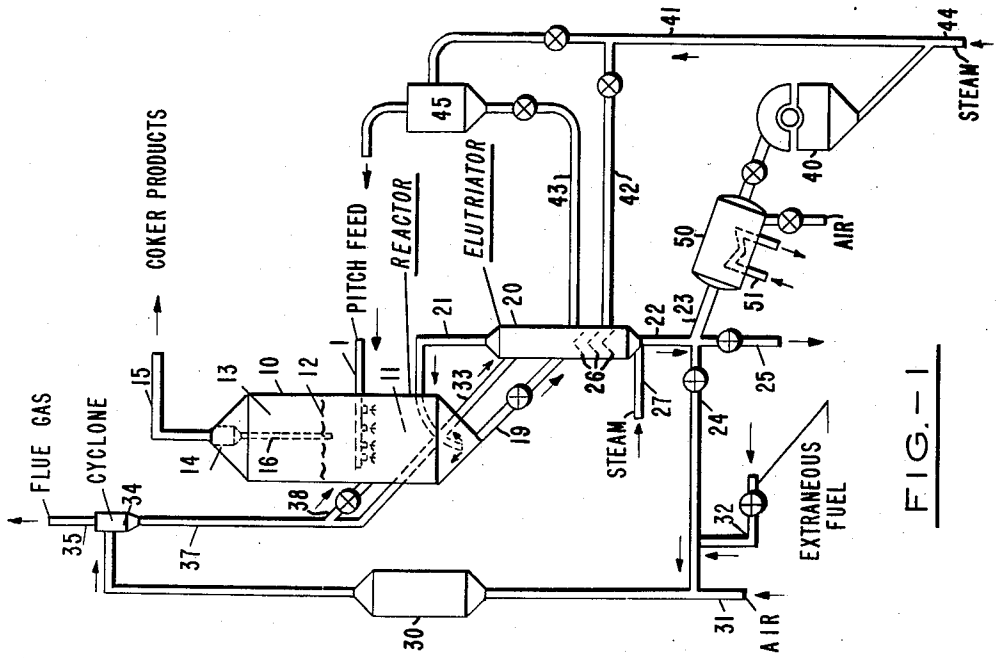


FIG. - 1

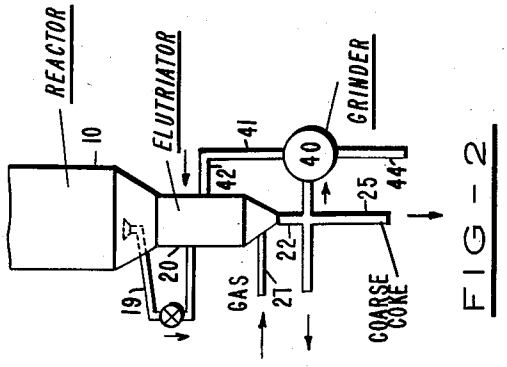


FIG - 2

CHARLES E. JAHNIG
WALTER G. MAY INVENTORS
BERNARD L. SCHULMAN
BY Catherine M. Thomas ATTORNEY

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CONTROL OF COKE PARTICLE SIZE IN FLUID COKING PROCESS

Charles E. Jahnig, Red Bank, Walter G. May, Union, and Bernard L. Schulman, Roselle, N. J., assignors to Esso Research and Engineering Company, a corporation of Delaware

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4 Claims. (Cl. 208—152)

This invention relates to the art of coking heavy hydrocarbons, and particularly to an improvement in controlling coke particle size in the coking reactor. More specifically it relates to a coking process and apparatus wherein properly sized seed coke is supplied to the coking reactor by selectively burning and grinding coarse coke and selectively returning the relatively fine portion of the ground coke to the reactor.

Processes for coking heavy hydrocarbon oils in contact with a fluidized bed of finely divided and essentially inert contact solids such as coke or sand are basically well known. However, in applying such processes on a commercial scale, numerous difficulties are encountered. For instance, as more and more feed is deposited and coked on the contact solids, the latter continuously grow in size until they become too large to be properly fluidized. Also, it is found that with larger particles the allowable feed rate relative to the total weight of coke present is reduced because of eventual sticking of the particles in the bed.

Consequently, it is desirable to maintain the average particle size in the reactor substantially constant. This can be accomplished by feeding in small seed coke particles in substantially the same numbers as large coke particles are withdrawn from the process. But here again another problem is encountered in connection with the loss of the desired fines from the system. Normally the heat requirement of fluid coking processes is supplied by withdrawing a part of the coke from the coking reactor, partially burning the withdrawn coke, and returning the reheated remainder to the coking reactor. However, combustion tends to consume a large portion of any fines present and a further amount of coke fines is usually lost in the flue gas when the latter is separated from the reheated coke. As a result the cost of preparing additional fine seed coke may add greatly to the cost of the entire process. Furthermore, the loss of fines through the flue stack may be most undesirable not only for the aforementioned operational and economic reasons, but also because of the resulting air pollution.

It is an object of the present invention to provide a coking process wherein particle size distribution in the coking reactor may be controlled within desirable limits and fluidization difficulties due to oversize particles avoided. Another object is to facilitate the selective withdrawal of large product particles from the reactor while supplying thereto the necessary amount of fine seed particles. The large particles may then be circulated through a heating system, from which the fine seeds are excluded to avoid losing them. A further object is to reduce the amount of grinding necessary for the production of the seed particles by selective partial combustion of the coarse coke particles so that they are reduced in size. Another object is to improve grinding selectivity by combining elutriation and grinding to prevent excessive size reduction in the grinder. Still another object is to accomplish the foregoing simultaneously with a minimum loss of fines in the flue gases leaving the process. These and other objects as well as the nature and advantages of the present invention will become more clearly apparent from the following description, especially when read in connection with the accompanying drawing.

Figure 1 of the drawing is a semi-diagrammatic illustration of a specific embodiment of the invention wherein a petroleum pitch is coked in contact with a dense fluidized mass of finely divided coke, and

Fig. 2 shows an alternate arrangement wherein the elutriator characteristic of the present invention is immediately beneath the main reactor. Referring to Fig. 1 of the drawing, petroleum pitch having a gravity of about —10 to 20° API, e. g., 5° API, an initial atmospheric boiling point of about 900–1200° F., e. g., 1100° F., and a Conradson carbon content of about 5–50 weight percent, e. g. 25%, is preheated by conventional means, not shown, to about 500–900° F., e. g., 700° F., and then introduced or sprayed through line **1** into coking vessel **10**. Though not essential, the feed may be mixed with say 1 to 10 weight percent steam to disperse it as it is introduced into the reactor. The coking vessel **10** contains coke particles ranging in size from about 50 to 1000 microns, e. g., 75 to 500 microns, which are maintained in the form of a dense turbulent mass **11** having an upper level **12** above which is a dilute phase **13**. Obviously, a small amount of particles or particle aggregates may form in the course of the process which are much larger than the size just indicated, and lumps as large as one inch may occasionally be encountered. The coke particles are maintained fluidized by the upflowing hydrocarbon vapors formed by the coking of the pitch and also by steam which is introduced into the lower part of vessel **10** through line **21**.

This steam addition rate is adjusted so as to provide together with the hydrocarbon vapors a total superficial upward gas velocity of about 0.5 to 5 ft./sec., e. g., 3 ft./sec. The density of the fluidized coke in bed **11** may thus be between about 30 and 60 lbs./cu. ft., e. g., 40 lbs./cu. ft., while the temperature of bed **11** is maintained at about 850 to 1100° F., e. g. at 950° F. The pressure in the upper part of coking vessel **10** is high enough to overcome the pressure drop through the recovery equipment in which the vaporized hydrocarbon products must be fractionated or otherwise treated after their withdrawal from coking reactor **10**. For instance, the pressure in the dilute phase **13** may be of the order of about 1 to 10 p. s. i. g., though considerably higher pressures such as 100 p. s. i. g., or on the other hand, subatmospheric pressure, may be preferred under special circumstances. At the bottom of reactor **10** the pressure is, of course, considerably higher than at the top of the reactor due to the hydrostatic head exerted by the dense fluidized solids. Such a hydrostatic head may amount to about 10 to 20 pounds per square inch in equipment of commercial size.

Vaporous products of coking pass overhead from fluidized bed **11**. These vapors contain some entrained solids and form the dilute phase **13**. The vapors are passed through gas-solids separating means **14** such as one or more cyclones which separate entrained solids and return them to fluidized bed **11** through dip pipe **16**. The more or less dust-free vapors then pass overhead through line **15** for further treatment in equipment which may include a fractionating tower, a catalytic cracking unit, and other conventional apparatus which need not be illustrated.

As the hydrocarbon feed is coked in vessel **10**, it is endothermally decomposed into hydrocarbon vapors as well as a solid carbonaceous residue. This solid residue deposits in filmlike layers on the finely divided fluidized

particles onto which the liquid hydrocarbon feed is sprayed, causing a continuous growth of the particles. As was explained before, this has an adverse effect on the continued operation of the coking step. It has, therefore, been found advantageous to maintain a more or less constant particle size distribution in the coking bed by continuously or at least periodically removing relatively coarse particles and replacing them by relatively fine seed coke.

At the same time, coke is normally also circulated from the fluid reactor bed to an external heater where such coke is heated to higher temperature and then returned to the reactor bed to supply the necessary heat thereto. Where such heating is accomplished by partial combustion of the withdrawn coke, this tends to reduce the average coke particle size and hence at least partially counteracts the growing tendency in the reactor. Unfortunately, combustion tends to consume the very fine particles, leaving a mixture of particles having an average particle size only somewhat smaller than the average size of the particles fed into the combution zone. Moreover, the coke production rate is sometimes much greater than that needed for fuel in the heater. For instance, at comparatively low coking temperatures and with high recycle rates to the coker, the coke formed in the process may be 50% more than the Conradson carbon content of the feed. Hence, while such combustion reduces somewhat the average particle size of the withdrawn coke, it is not very effective by itself for supplying the needed seed coke. The latter may be of any size smaller than that of the product coke, but the amount required decreases rapidly with size. Therefore, the seed normally will be in the size range of about 60–150 microns, and preferably should have a diameter not greater than ½ and preferably equal to ⅓ or ¼ or less of the diameter of the product coke withdrawn, since the amount of seed coke required decreases rapidly as the size of the seed coke particles is decreased.

In accordance with the present invention specific steps are taken to assure that only coke consisting largely of relatively coarse particles is withdrawn from the reaction zone for combustion or product recovery and that only a fraction relatively rich in fine particles is returned to the reaction zone. A portion of the withdrawn coarse coke is heated as well as reduced in size by combustion in a combustion zone while additional comminution is obtained by grinding another portion of the relatively coarse coke to obtain the required amount of finely divided seed coke. Thus, coke may be withdrawn from the fluidized coking bed and passed to an elutriator capable of separating the withdrawn coke into relatively fine particles useful as seed coke, and relatively coarse solids. A portion of the coarse solids is then passed to a heater while another portion is ground to bring the supply of seed coke to the required amount; and any surplus of the coarser coke may be recovered as product.

Referring specifically again to Fig. 1 of the drawing, the coke may be withdrawn from bed 11 through line 19 into an intermediate portion of a dilute phase elutriator 20 where it is met by an upflowing current of gas such as steam introduced through line 27. This gas is preferably introduced somewhat above the bottom of the vessel, that is, above the dense phase of coarse solids which forms at the bottom of the elutriator and whence the coarse solids are withdrawn. The elutriator preferably also contains several perforated transverse baffles 26 which serve to break up any localized streamers and thus increase the efficiency of the separation. When gas is passed upwardly through such an elutriator at a proper velocity and a mixture of solid particles of different sizes is sprayed or otherwise evenly introduced across an intermediate portion of the elutriator, relatively coarse particles fall to the bottom while fine particles are entrained overhead and pass along with the elutriating gas through line 21 back to reaction zone 11. In this way fine particles capable of serving as seed coke are retained in or continuously recycled to the coking zone.

The two principal variables affecting such separation of coarse and fine solids are the elutriant gas velocity and the rate at which the mixture of particles is fed into the column. In order to remove a major portion of the fines from the coarse, the elutriant gas velocity should be at least 1.5 to 3 times, e. g., about twice the free fall velocity of the largest particle to be taken overhead. As the gas velocity is increased less of the fines fall to the bottom with the coarse material. However, at the same time, as the gas velocity exceeds the free fall velocity of any particles of the coarse fraction, some of these coarse particles will be carried overhead and contaminate the fines. For practical purposes the elutriant gas velocity may range from about 3 ft./sec. if it is desired to recover fines of about 150 micron diameter and finer, to about 30 ft./sec. if solids to be carried overhead are to include particles of about 1000 micron diameter. Of course, the optimum elutriant velocity will vary somewhat from case to case depending on the particle sizes which one may wish to separate, the desired yield of fines recovery, the permissible contamination of fines with coarser material, and the solids feed rate. Likewise, with comparatively small, under-designed elutriators relatively higher velocities may be preferred so as to prevent an excessive amount of fines from going down with the coarser material.

The solids feed rate to the elutriator also has a pronounced effect on the degree of separation. For a given gas velocity, as the feed rate increases the amount of fines going to the bottom increases. If there is any amount of coarse material going overhead because the gas velocity exceeds the free fall velocity of the fines actually desired, an increase in the solids feed rate will decrease the amount of coarse material in the overhead. At the same time the total amount of material going overhead decreases in proportion to the amount dropping to the bottom. Consequently, there is an optimum ratio of solids feed rate to gas rate for each gas velocity, which will give only a small amount of coarse material in the overhead and only a small amount of fines in the bottom.

For instance, to separate approximately 250 micron and smaller coke particles (free fall velocity about 4 ft./sec.) from coarser coke particles, Table I represents the best range of solids feed rate to gas rate for each given gas velocity.

TABLE I

Gas velocity	Feed rate÷gas rate.
4 ft./sec	0.05–0.075 lbs./cu. ft.
5	0.075–0.125.
6	0.125–0.20.
8	0.15–0.25.
10	0.25–0.35

If the ratio of feed rate to gas rate is less than that shown above, a greater amount of coarse material is taken overhead and the capacity of the column is decreased. Conversely, when ratios greater than those shown above are used, the amount of fines lost to the bottom becomes high. This is illustrated in Table II.

TABLE II

Free Fall Velocity of Fines, Ft./Sec.	4	4	4
Gas Velocity Ft./Sec.	6	6	6
Feed Rate÷Gas Rate, Lbs./Cu. Ft.	0.076	0.20	0.267
Percent Fines in Overhead	80	82.8	73.7
Percent Fines in Bottoms	15	5.7	17.1
Percent of Total Fines Out In the Bottoms	15.7	17.5	40.0
Percent of Total Coarse Out In the Bottoms	81.0	94.5	89.7

The described combination of a dilute phase elutriator and a fluid coker is particularly effective since it permits using the gas in the elutriator both as an elutriation gas

and as a stripping gas for removing volatilizable hydrocarbons from the coke withdrawn from the reaction zone. However, instead of employing a dilute phase elutriator of the type described, the elutriator may contain very coarse packing such as large Raschig rings or the like. In addition, for taking out particles much larger than average circulating coke, e. g. aggregates of 0.5 inch diameter or larger, dense phase separation may be used.

The coarse solids which concentrate in the bottom of elutriator **20** are withdrawn through line **22**. The withdrawn coarse solids, most of which may range in size from about 200 to 800 microns, with some larger particles or agglomerates and some smaller particles or fines, may be separated into three portions. One portion constituting the net coke produced in the process may be withdrawn through line **25** and, after suitable cooling with a water spray or the like, passed to storage. This product coke may amount to about 10 to 35 weight percent, e. g., 25%, based on residual hydrocarbon feed to the reactor, and may find use as a fuel, as metallurgical coke, etc.

Another portion of the coarse coke which may equal about 5 to 15 times, e. g., about 10 times the weight of residual hydrocarbon feed, is recirculated through a heating zone to supply heat to the reactor **10**. Accordingly, coke from line **22** is passed through line **24**, suspended in an oxygen-containing gas such as air injected through line **31**, and the resulting dilute suspension then passed upwardly through a heater **30** which may be an upflow burner where the coke settles out of the suspension to form a conventional dense, fluidized bed. In burner **30** a portion of the coke is consumed while the remainder is heated to a temperature about 25 to 300° F. higher than the coking temperature, e. g. to 1250 to 1500° F. Alternatively the coke may be heated in a high velocity transfer line burner of an otherwise conventional type. In either case, hot coke from the burner may be passed through a dust separating device such as cyclone **34**, from which the separated combustion gases may be withdrawn through stack **35** while the separated reheated coke is returned to the coking zone **11** through lines **37** and **38**, to supply the heat requirements of the coking reactor. Some hot coke may also be passed from burner standpipe **37** directly to the elutriator-stripper **20** through line **33**, to permit keeping the temperature in vessel **20** at an optimum level for stripping.

Where coke commands a premium over fuels such as gaseous or liquid hydrocarbons, a suitable extraneous fuel may be injected into the burner system through line **32**. In such a case the circulating coke is reheated primarily by contact with the hot gases produced by the combustion of the extraneous fuel. Furthermore, it will of course be understood that the heat requirement of the process may be satisfied by still other means, e. g., by means of hot flue gases obtained in an independently fired auxiliary burner, or by indirectly reheating the coke in an otherwise well known manner while maintaining it as a densely fluidized bed, etc.

The third portion of coarse coke withdrawn from the elutriator is passed through line **23** to grinder **40**. This last portion is a comparatively small one, equalling normally only about 10 to 15 weight percent on residual feed, or only about 1% of the coke passing from the reactor but nonetheless it represents one of the critical features of the invention. Preferably, though not necessarily, this stream of coke is cooled to a moderate temperature, say to about 100 to 250° F., before being actually introduced into the grinder. This cooling may be done in any convenient manner, e. g., by passing the coke in an aerated condition through a heat exchanger vessel **50** which may contain a watercooled coil **51**. Grinder **40** may be of the ball or rod mill type, or other kinds of grinders suitable for the handling of coke, such as hammer mills, roller mills, or conventional gas jet grinding, may be used likewise. In grinder **40** the coarse coke is comminuted to produce a substantial fraction of particles smaller than at least about 200 microns. Grinding must be sufficient to provide the seeds needed to control particle size in the coker. This required amount of seeds may equal about 5 to 10 weight percent based on residual hydrocarbon being fed to the process.

As a typical example, the coke being fed to the grinder, which may range in size predominantly between about 200 and 500 microns, may be ground in grinder **40** until about 30 to 50 weight percent of the ground coke mixture is smaller than 100 microns in order to supply the fine particles desired as seed coke for return to the coking reactor.

However, since such seed coke is preferably a narrow cut of roughly 50 to 150 micron size, in previously contemplated coking processes this required screening of the ground material to provide the desired size fraction. In accordance with the present invention this screening step is eliminated by returning coke from the grinder **40** to elutriator **20** as shown by lines **41** and **42** or **43**. Return of the ground coke to the elutriator may be accomplished by lifting the coke as a suspension with the aid of steam injected through line **44**. If desired, the steam may be separated in cyclone **45** and eventually introduced into the bottom of the elutriator through line **27**. Lines **42** or **43** may be used in the alternative, depending on whether it is considered important to keep the desired fine particles out of the heavy tailings as much as possible, in which case the coke is fed back through the upper line **43**, or whether it is preferred to utilize the gas added through line **44** for elutriation in vessel **20**, in which case the coke is preferably fed back through lower line **42**. The choice is also affected by the diameter ratio of seed to product coke. With smaller seeds, the amount required is decreased, and the gas quantity to line **44** is less so that it is of less importance and can be added at the higher point through line **43**. Conversely, with large amounts of coke circulating around the elutriator, that is, when using relatively coarse coke as seed, it may be preferable to feed the ground coke suspension through line **42** so as to utilize the large amount of gas present.

It will be seen that in this invention the same gas stream can be used for elutriation of product coke, air classification of ground coke, stripping of spent coke, and aeration of the coker reactor. This reduces the consumption of steam or other fluidizing gas and decreases the load on the reactor and product handling equipment.

Referring to Fig. 2 of the drawing, this shows an alternate arrangement wherein the elutriator is directly beneath the reactor vessel. In this design the solids from the wide reactor vessel **10** pass through line **19** into the narrower elutriating section **20** which is directly beneath the reactor and whence the fines are blown back into the reactor. The coarser particles are again withdrawn downwardly from the elutriator through line **22**, the surplus to be recovered as product, while the remainder is burned or ground to finer size as needed similarly as in Fig. 1. The grinding section, which again may include a cooler **50** and a cyclone **45** as in Fig. 1, is shown in greatly oversimplified form in Fig. 2. The ground particles from grinder **40** are again returned to elutriator **20** and thence to the reactor as previously described. Efficient use of the coke is again assured due to the closed-cycle grinding obtainable when ground coke is passed through an elutriator for separation of coarse and fine particles and the separated coarse particles are recycled to the grinder.

Example

The advantages of the present invention of elutriating in connection with seed coke grinding in fluid coking processes are further illustrated by the following cases derived for a fluid coking unit having a petroleum pitch feed rate of 23,000 barrels per day and having a net coke make of 10 weight percent on feed, or 400 tons per

day, operating on a scheme substantially as illustrated in Fig. 1. The data are summarized in Table III.

TABLE III

COKE GRINDING REQUIREMENTS

Case No.	1	2	3	4
Seed Coke Size, microns	110	110	55	55
Average Circulating Coke Size, microns	195	195	195	195
Elutriation	Perfect	None	Perfect	None
Coke Withdrawn (To grinder and as product):				
Tons/day	434	490	403	409
Average size, microns	258	195	284	195
Seed Req'd., Tons/day	34	90	3	9
Grinding Power, H. P.	22	45	6	15
Size Distribution of Circulating Coke:				
Percent on—				
20 mesh (833 micron)		0		1
35 mesh (417 micron)		10		30
48 mesh (295 micron)	0	32	0	58
60 mesh (246 micron)	18	46	44	70
80 mesh (175 micron)	82	77	86	87
100 mesh (147 micron)	92	86	93	92
150 mesh (104 micron)	100	100	98	97
200 mesh (74 micron)			100	99
325 mesh (43 micron)				100

In the perfect elutriation cases 1 and 3 all particles larger than specified size drop down and are withdrawn from the bottom, while particles of the specified size and finer are withdrawn overhead. Practical commercial scale equipment can readily be made to operate almost as a perfect elutriator, losing comparatively little fine material through the bottom or coarse material through the top. The seed coke requirements with such a commercial elutriator may be only about 20 to 30% greater than with a perfect elutriator.

Referring to Table III it will be noted that case 1 is operated with essentially perfect elutriation so that substantially all particles of 110 micron diameter or smaller are entrained overhead in the elutriator and returned to the reactor as seed coke, and only coarser particles are passed to the grinder or withdrawn as product. In contrast, in case 2 the elutriator is completely by-passed so that coke from the reactor is passed directly to the grinder and the ground coke mixture is returned from the grinder directly to the reactor. Consequently, in case 1 the relatively coarse particles are selectively ground whereas in case 2 a considerable amount of coarse material circulates in the system. As a result of this preferential grinding of coarse particles, and preferential return of fine particles to the reactor, the weight of seeds required as well as the corresponding grinding power are very much smaller in case 1 than in case 2.

Similar conclusions can also be derived from a comparison of cases 3 and 4, where the coke was ground to a much finer size. In addition, a comparison of cases 1 and 3, or 2 and 4, shows that as the seed coke size is reduced by a factor of about 2, the amount of seed coke required is very greatly reduced, approximately by a factor of 10. This is due to the fact that the amount of seed coke required is approximately proportional to the cube of the average particle diameter. In other words, since the main purpose of the seed coke is to keep the average particle size constant by supplying a certain number of relatively small particles, it will be apparent that this number of particles in a given total weight increases rapidly as the average particle size is diminished. However, excessively small seed is not practical in view of the attendant difficulty of keeping such fine particles from blowing out of the system. Thus, while 110 micron size particles can be fairly efficiently recovered in a single separator cyclone, 55 micron particles normally will require a two-stage cyclone, and still smaller particles will be still more difficult to recover.

It can be noted from the foregoing description that the present invention permits unusually efficient use of coke since the fines suitable as seed coke are selectively retained in the reactor or immediately returned to it but are not allowed to pass to the burner, or be withdrawn with the product coke. Furthermore, selective combustion of the coarse particles in the burner reduces the amount of grinding otherwise required to maintain the proper particle size distribution.

It will be understood, of course, that the foregoing general description and specific embodiment of the invention as applied to fluid coking has been given principally for purposes of illustration rather than limitation. On the contrary, the invention can be still further modified in various ways without departing from the scope or spirit hereof. Thus, since the amount of coke circulated to burner **30** through line **24** is usually relatively large, it may require a large amount of gas to completely elutriate the entire stream. If desired, therefore, the coke stream to the burner may be withdrawn separately from above the bottom of the elutriator, and the bottom section used for more completely elutriating the coke stream in a second stage for seed grinding. Gas from the latter then is used in the upper zone which elutriates the coke to the burner, or the coke passing from the reactor to the burner may be allowed to by-pass the elutriator altogether, and only coke to and from the grinder may be elutriated to provide seed coke and, if desired, coarse product.

The invention is particularly pointed out in the appended claims.

We claim:

1. In a process for coking heavy hydrocarbonaceous material wherein the hydrocarbonaceous material is fed into a dense turbulent fluidized bed of finely divided essentially inert refractory solids maintained in a coking zone at coking temperature to produce lower boiling hydrocarbon vapors which are removed overhead and a coke-like deposit which remains on the fluidized solids, and the coke-containing solids are withdrawn from said fluidized bed, heated to a temperature of at least 1000° F. and returned to said coking zone to maintain said fluidized bed at coking temperature, the improvement which comprises passing the solids withdrawn from said coking zone to a dilute phase elutriation zone, passing an inert gas upwardly through the solids in a dilute phase in the elutriation zone at a velocity of at least 1.5 to 3 times the free fall velocity of the largest particles to be entrained, sufficient to entrain particles smaller than about 175 microns, removing the inert gas and entrained particles upwardly from the elutriation zone and passing them directly into the aforesaid fluidized bed in said coking zone, withdrawing relatively coarse particles downwardly from the elutriation zone, grinding the relatively coarse particles, and returning the ground particles to the aforesaid elutriation zone.

2. In a process for coking heavy hydrocarbonaceous material wherein the hydrocarbonaceous material is fed into a dense turbulent fluidized bed of finely divided essentially inert refractory solids maintained in a coking zone at coking temperature to produce lower boiling hydrocarbon vapors which are removed overhead and a coke-like deposit which remains on the fluidized solids, and the coke-containing solids are withdrawn from said fluidized bed, heated to a temperature of at least 1000° F. and returned to said coking zone to maintain said fluidized bed at coking temperature, the improvement which comprises passing the solids withdrawn from said coking zone to an intermediate portion of a vertical dilute phase elutriation zone, passing an inert gas upwardly through the dilute phase solids in the elutriation zone at a velocity of at least about 3 feet per second so as to entrain substantially selectively particles smaller than about 150 microns, removing the inert gas and entrained particles upwardly from the elutriation zone and passing them directly into the bottom portion of the aforesaid fluidized bed in said coking zone, withdrawing relatively coarse particles down-

wardly from the elutriation zone, passing a major portion of said withdrawn relatively coarse particles through a heating zone where the last-named particles are partially burned and heated, returning the heated particles to said coking zone, passing a minor portion of said withdrawn relatively coarse particles to a grinding zone where the said coarse particles are ground to produce a substantial fraction of particles ranging in size between about 50 and 150 microns, and returning said ground particles from said grinding zone to said elutriation zone.

3. A process according to claim 2 which comprises the additional specific steps of suspending said ground particles withdrawn from the grinding zone in an inert lift gas, passing the resulting dilute suspension to an external point elevated above an intermediate level of the elutriation zone, separating the lift gas from said ground particles, passing the separated ground particles into said elutriation zone at said intermediate level, and externally passing said separated lift gas into a bottom portion of said elutriation zone to serve as elutriation gas.

4. A process according to claim 2 wherein said solids withdrawn from the coking zone are passed to a first elutriation stage, elutriating gas is passed upwardly through said first elutriation stage to effect a rough separation of the solids into relatively large and relatively

fine particles, said separated relatively fine particles and elutriating gas are returned directly to the bottom of the aforesaid coking zone, a major portion of said separated relatively large particles is passed to the aforesaid heating zone, a minor portion of said separated relatively large particles is passed downwardly to a second elutriation stage for further separation, elutriation gas is passed upwardly through said second elutriation stage to separate the last-named relatively large particles into relatively coarse and additional relatively fine particles, said elutriation gas and entrained fine particles are passed upwardly to the bottom portion of said first elutriation stage, at least a portion of said separated relatively coarse particles is passed from said second elutriation stage to a grinding zone where said coarse particles are ground, and the resulting mixture of ground particles is returned to an intermediate portion of said second elutriation stage.

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