PROCESS AND APPARATUS FOR QUENCHING COKER PRODUCTS

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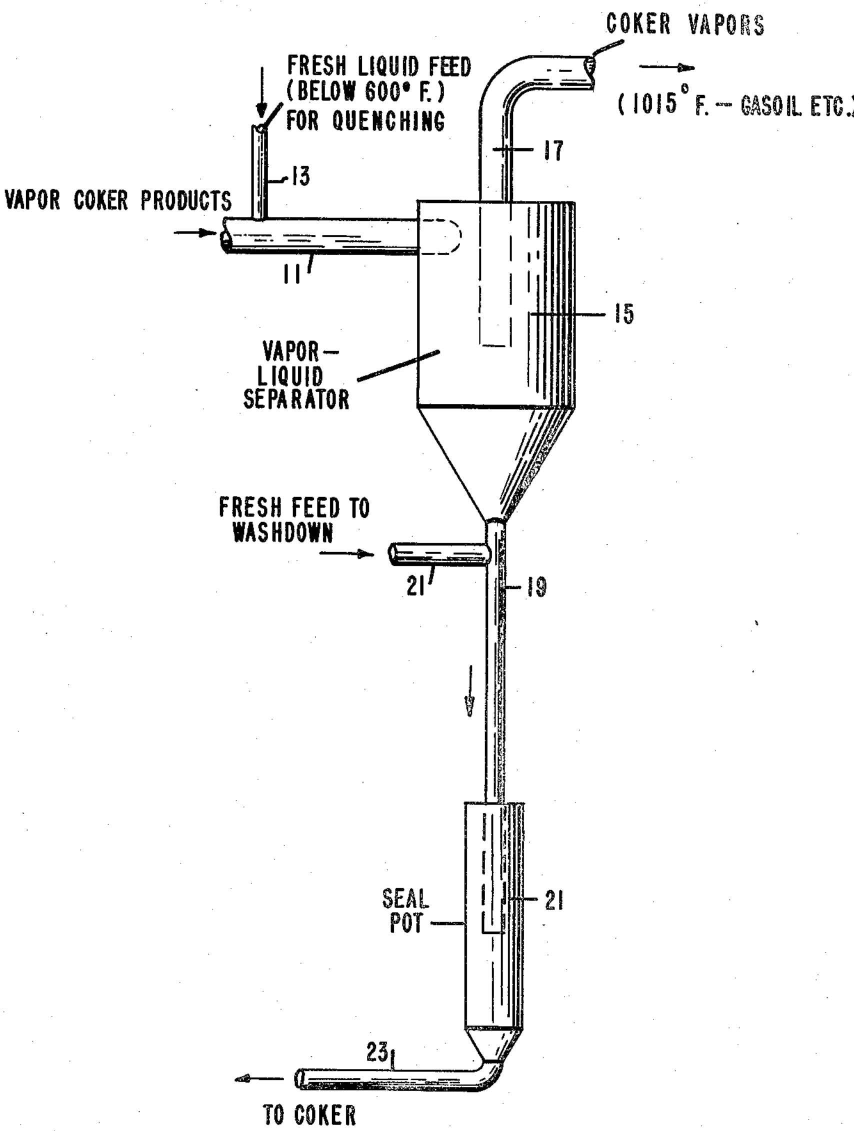

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PROCESS AND APPARATUS FOR QUENCHING COKER PRODUCTS

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The present invention relates to an improved process and apparatus for quenching coker products, i. e., the freshly converted hydrocarbon products obtained by thermally cracking heavy residual hydrocarbon oils.

It has been proposed in the prior art to convert heavy hydrocarbon oils to lower boiling hydrocarbons, with accompanying conversion of some portions to coke, by contacting the oils with preheated particulate solids for a short contact time. Various kinds of particulate solids may be used, one of the most suitable being coke particles which can be fluidized to form a mobile bed. These are preferably of a size between about 40 and about 400 microns, average particle diameter. In such a fluid bed coking process it is highly desirable to limit the time of contacting and heating to avoid overcracking or the formation of undesirable reaction products. The same is true where other types of processes are employed, such as transfer line coking, where preheated solid particles in a relatively disperse phase are used to supply the heat of reaction. In all such cases it is desirable to terminate or substantially terminate the thermal conversion at more or less an optimum point. To accomplish such control and termination of coking reactions without wasteful heat losses is one of the objects of the invention.

It is possible, of course, to quench almost any thermal reaction at any desired point by employing a large enough volume of a quenching agent at the right time. In a thermal cracking or coking operation employing preheated solid particles, however, it is desirable, for thermal efficiency, not to cool the solid particles per se any farther than necessary. It is further desirable to use the heat taken out of the products in quenching to supply heat requirements in some other part of the process. Another object of the present invention is to utilize heat absorbed in quenching coker products for supplying heat requirements elsewhere in the process. A more particular object is to use such heat to preheat or at least to assist in preheating the heavy oil feed to the system.

In converting or coking heavy residual hydrocarbons to produce fuels, one of the chief purposes, and frequently the most important purpose of all, is to convert a substantial part of the feed to a gas oil which is suitable, in turn, for feeding to a catalytic cracking process for substantial conversion to motor fuel. Heavy residual oils usually contain certain metallic compounds and other ingredients which are highly injurious to cracking catalysts. It is important to avoid, as far as possible, carrying these compounds or ingredients over into the gas oil. At the same time, it is desirable to obtain as much gas oil as practicable, by taking a wide cut of the coker conversion products.

In order to obtain a good yield of gas oil and still keep its content of metallic and other objectionable constituents or contaminants as low as possible, it is desirable to exclude from the gas oil all coker products boiling above a predetermined level, about 1000° to 1050° F., preferably about 1015° F. Above temperatures in this vicinity, some of the more common and troublesome metallic contaminants, such as those containing nickel and/or vanadium, appear to be volatile metallo-organic compounds. If a reasonably clean cut-off point in boiling range is not obtained, the gas oil will carry over substantial quantities of these undesirable materials.

By using such an apparatus as a vacuum pipe still with steam as a distilling agent to fractionate the coker products, it is possible to obtain a reasonably sharp cut-off point for the gas oil fraction. Such apparatus is commonly used, in fact, for taking a gas oil fraction from virgin crude oil. In such an operation it is quite satisfactory. The virgin materials are usually quite fully saturated and undesirable side reactions do not take place to any serious extent.

This is not true, however, of residual oil conversion products. Gas oil from reduced crudes, and especially from the more drastically reduced crudes, is highly unsaturated and contains high proportions of resinous materials, coke precursors, and the like. Its Conradson carbon content is high and it tends rapidly to form deposits of gum, coke, etc., which will clog almost any apparatus when it is allowed to remain at high temperatures (e. g. 700° F. or higher) for any appreciable length of time. The formation of adherent deposits of coke, resinous materials and the like in the coking apparatus and in the lines leading therefrom is a serious problem. An important object of the present invention is to prevent or substantially prevent formation of such deposits.

In order to obtain a gas oil fraction of a cut point of about 1015° F. it is necessary to operate with a vapor temperature of around 800° F., say 750° to 825° F. It is not feasible to pass these reactive gas oil vapors through a scrubbing liquid held at, say 800° F. for any substantial period of time because of the coking and other deposit-forming tendencies just mentioned. However, some such scrubbing or quenching is necessary to obtain the sharp cut required to keep substantial quantities of cracking catalyst contaminants out of the gas oil. The transition of the coker effluent through this general temperature range is difficult because of the deposit forming tendencies just mentioned.

According to the present invention, quenching or scrubbing at a temperature of the desired range, about 750 to 825° F., without substantial formation of deposits, may be obtained by providing a very short holding time for both vapor and liquid at such temperature. This is accomplished by rapidly quenching the effluent vapors from the coking process, having a temperature somewhere around the general range of 1000° F., down to a temperature of 750 to 825° F., using fresh feed, i. e. a liquid hydrocarbon oil, as quenching medium. The fresh residual feed, for example, is usually moderately preheated and hence is usually available at a temperature within the range of about 350 to 600° F. The coker vapors, including any solid particles entrained therein, are quenched by scrubbing or spraying them with appropriate quantities of such fresh feed. The coker products both vapor and liquid, i. e. those of boiling range below the original residuum feed, and also some higher boiling material, plus hydrocarbon vapors, are then passed immediately to a vapor-liquid separator, without allowing them time to undergo further or secondary reaction such as a deposit-forming reaction or degradation. The vapors leave the separator, which may be a more or less conventional cyclone, at the quenched temperature and they may be further quenched immediately to any desired lower temperature. Water or other hydrocarbon products may be used for this latter quenching.

The liquid thus obtained, which includes the fresh feed quenching or scrubbing material, the coker products of boiling range above the gas oil cut point, and the entrained solid particles carried over by the vapors from the coking operation, flows downwardly in the separator, e. g. in the dipleg of a cyclone. If allowed to remain even at its somewhat reduced temperature (750 to 825° F. or so) this material would soon form such heavy deposits of coke and other polymeric or resinous materials that the separator (cyclone or equivalent) and contiguous apparatus elements would be clogged.

In order to prevent coking and clogging of the separator and associated apparatus, an additional quantity of a quenching material, such as water or oil, but preferably more of the fresh feed, at its initial or preheat temperature of 350° to 600° F., is fed into the bottom of the separator to mix with and further cool the now downflowing liquid which has been separated as mentioned above. This mixture of preheated feed plus quenched liquid above the gas oil boiling range is then conveyed into the coker, the feed thereby including well preheated fresh feed plus recycled heavy ends which also include the objectionable catalyst contaminants and other degradation products.

While it is believed, that the invention so far described is clear and understandable, it may be more fully understood by detailed reference to the attached drawing which forms a part of this specification.

In the drawing, the hot vapor products are shown coming from the coking operation into a conduit **11** at coking temperature, e. g., 950° to 1050° F. or higher. A stream or spray of fresh feed at a temperature between about 350° and 600° F., preferably around 400° F., is introduced through a line **13** to quench the coker vapors to between 750° and 825° F., preferably around 800° F. just as or before they enter the vapor-liquid separating apparatus to be described. At this temperature, considering the vapor pressures of the various components, substantially all of the coker effluent products boiling above about 1015° F., i. e. above the gas oil, are condensed. The mixture of quench and quenched products passes immediately into the liquid vapor separator **15**, shown as a conventional cyclone. They enter at sufficient velocity to separate the uncondensed gas oil and lighter hydrocarbon vapors and gases from the liquid and from any entrained solids which are carried over from the coking operation by entrainment. The vapors pass overhead through a line **17** to suitable recovery apparatus, not shown, but of conventional type.

The downflowing components, with the solids, pass down into the outlet of the separator, shown as a cyclone dipleg **19**. Since these materials are still at a relatively high temperature they would still tend to form sufficient deposits of coke, polymer, etc., to clog the line **19**, if this were not prevented. Hence additional quenching material, preferably another portion of the feed, preheated like the other portions to a temperature of 350° to 600° F., preferably in the neighborhood of about 400° F., is introduced through a line **21** to wash the products down the line **19** and to cool them to a lower temperature of the general range of 500° to 700° F. This cooling extends preferably down to near 600° F. where feasible.

If desired, the fresh feed from line **21** may also be sprayed into the separator **15** itself, especially in the lower portion thereof just above the outlet **19** to prevent building up deposits inside the separator. This will depend upon the type of products being quenched and the temperatures, as well as the scouring effect or adsorbent effect of entrained solids, etc. It will be understood that other types of separators may be used instead of the cyclone illustrated, if desired. However, a cyclone as shown has been found to be quite satisfactory.

The quenched liquid flowing down the line **19** preferably pass into a surge tank **21**. This is not always necessary, but is desirable. It acts as a small reservoir to keep a continuous stream of material flowing to the outlet and thus reduce deposition within the conduits. From the surge or seal pot **21**, the effluent is withdrawn through a line **23** by a suitable pump not shown. From here the now preheated feed, including the coker bottoms and entrained solids, is taken back to the coker.

To illustrate quantitatively the quenching requirements, it has been found that with the vaporous effluent from the coker, including a small amount of entrained solids, at a temperature of 100° F., 58% of the fresh coker, at a temperature of 400° F., was required to quench the products to 760° F. Another 35% of the feed, also at 400° F., was required to bring the temperature of the liquid products flowing down the cyclone down to a temperature of 640° F. In other words, a total of 93% of the feed at 400° F. was required to quench the products to a 1015° F. end point and to further cool the heavy ends to 640° F. to prevent coking and plugging of the equipment. This clearly indicates that all or practically all of the feed may very well be preheated (from a starting point around 400° F. up to around 600° F.) by merely using it as a quenching and cooling medium for the coker products. Thus the invention contemplates heating all or substantially all of the coker feed from an initial preheat temperature of lower range, e. g. 350° to 500° F. up to a higher preheat range, e. g. 500° to 700° F., preferably about 600° F.

It will be understood that the temperature limits at each stage may be varied from those given above. Also, the point of introduction of the quenching medium, its initial temperature, and the manner of feeding it may be varied. It may be sprayed into conduits **11**, **19**, or one or more pools may be formed at appropriate places through which the coker vapors, etc. may be passed for scrubbing as well as quenching, etc.

What is claimed is:

1. A process for quenching and separating hot effluent vapors containing a small amount of entrained solids from a high temperature residual oil conversion process employing preheated particulate solids, which comprises: quenching said vapors to a temperature in the range of 750° to 825° F. by adding a liquid hydrocarbon oil having a temperature in the range 350° to 600° F. thereby liquefying the high boiling contaminant containing portion of the vapors, then separating in a cyclonic separation zone liquid and solids from the remaining quenched vapors, recovering said remaining quenched vapors, and immediately further cooling the condensed liquid and solids so separated to a temperature in the range of 500° to 700° F.

2. The process of obtaining a good yield of gas oil low in cracking catalyst contaminants from the conversion of heavy residual oils by coking in the presence of preheated particulate solids, which comprises passing the total vaporous effluent and with some entrained liquid and solids, from the coking operation to a quenching zone, introducing part of the heavy residual oil feed, at substantially lower temperature than said effluent to quench said effluent to a temperature near 800° F., corresponding to a gas oil end point of about 1015° F., thereby condensing the heavy ends of said effluent and substantially reducing their deposit-forming tendencies, passing the quenched vapors, along with condensed liquid and entrained particles into a separating zone, separating the quenched vapors in said zone, further cooling the condensed liquid and entrained solids leaving said separating zone to a temperature between 500 and 700° F., to further reduce their deposit-forming tendencies, by adding thereto a further portion of said feed at said substantially lower temperature, and thereafter passing the total liquid products, with recycle of bottoms and entrained solids to the coking operation.

3. Process according to claim 2 wherein substantially all of the feed to the coker is preheated from a mild initial preheat temperature range of about 350 to 500° F., to a higher preheat range of about 500 to 700° F.

4. In a hydrocarbon oil fluid coking system, apparatus for controlling the end boiling point of the conversion products, which comprises, in combination, a separator

of the cyclonic type adapted to separate high temperature gases from liquids and provided with an inlet conduit for conversion products from said coking system, and outlet conduits for the gas and liquid streams separated therein, and conduit means for introducing a liquid quench oil into the conversion products prior to their entry into said separator and into the separated liquid as the liquid is withdrawn from said separator.

5. Apparatus of claim 4 comprising in addition thereto means for maintaining a liquid reservoir of the liquid withdrawn from said separator.

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