

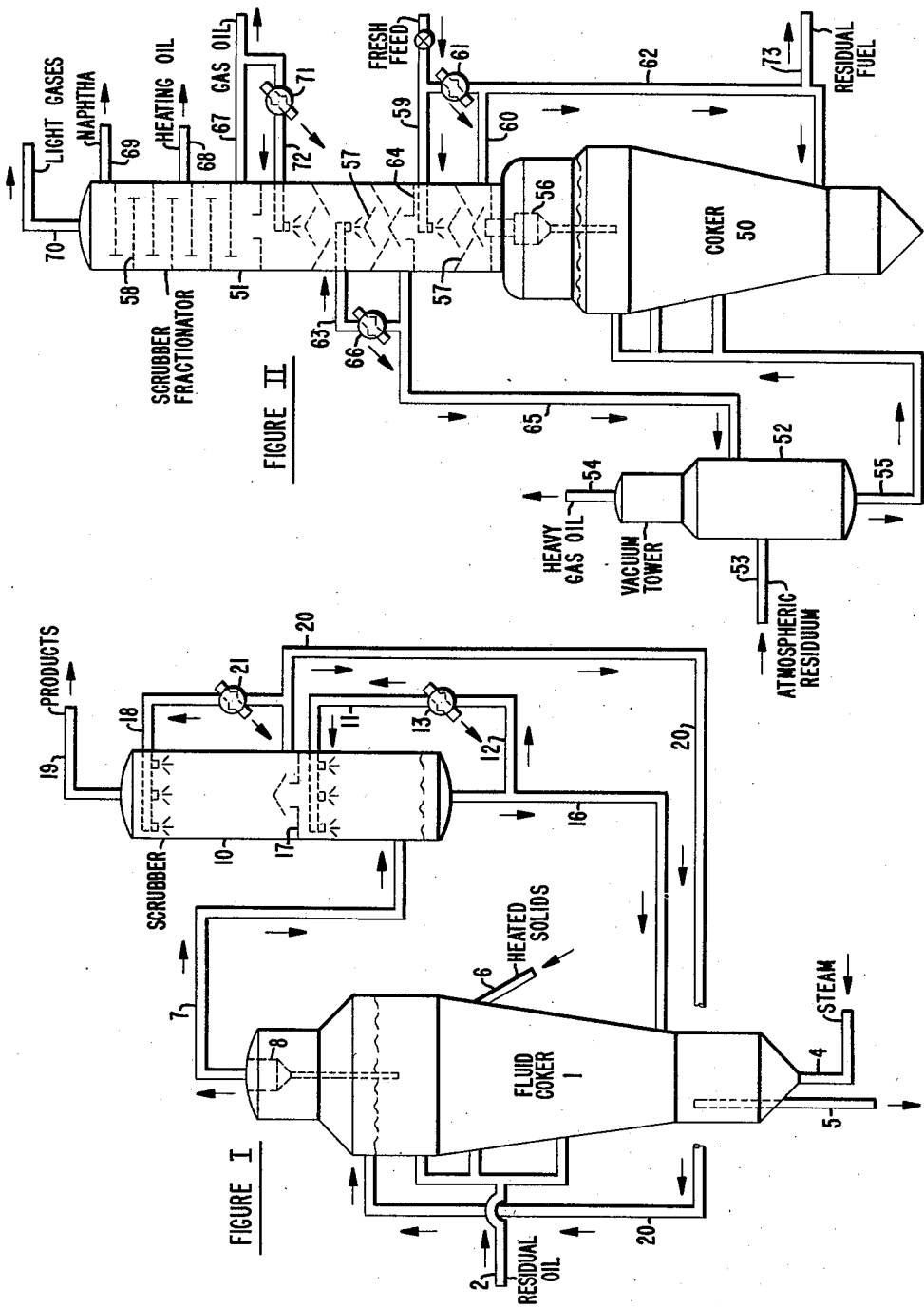
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FLUID COKING PROCESS

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FLUID COKING PROCESS

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This invention relates to the fluid coking of hydrocarbon oils, particularly heavy low value residual oils. It is more particularly concerned with an improved method of separating the vaporous conversion products therefrom whereby the quality and yield of the products is improved, and the recycle rate of the heavy ends of the conversion products is greatly reduced.

This invention is directed to an improvement of a fluid coking process wherein a heavy oil is converted in a coking zone by contact with fluidized solids maintained at a coking temperature. The improvement concerns a method of improving the yield and quality of the products which comprises scrubbing the vaporous conversion products in a scrubbing zone with a heavy oil, preferably a recycle bottoms fraction, to condense heavy ends and to remove entrained solids. The vapors are then further scrubbed with a lighter oil to condense an imperfect heavy gas oil fraction containing catalyst contaminants and coke formers. This imperfect heavy gas oil fraction is taken to circumvent the poor separation normally encountered in the scrubbing zone. The vapors so scrubbed are then separated to obtain various product fractions including a gas oil of catalytic cracking quality. The heavy ends initially separated from the vapors are returned, along with the entrained solids removed from the vapors, to the coking zone to be further converted. The heavy gas oil fraction is returned to the process in a manner such that the desirable clean gas oil components of this fraction are recovered.

In some applications it is desirable to preheat the feed to the process by having it serve as the above-mentioned heavy oil used in the scrubbing zone.

When a vacuum tower is used to prepare the fresh feed to the coking zone, it is preferred to recycle the imperfect gas oil fraction to this zone in order to recover its gas oil components free from catalyst contaminants and coke formers. When such facilities are not available, it is preferred to recycle this imperfect gas oil fraction to the uppermost part of the coking bed whereby it is vaporized with substantially no cracking or coking. The gas oil components are thereby recycled to the scrubbing zone and the coke formers in this fraction are deposited on the contact solids.

The fluid coking process normally consists of a fluid coking vessel and an external heating vessel, e.g., a fluid bed burner. A fluid bed of solids, preferably coke particles produced by the process having a size in the range of about 40–1000 microns, is maintained in the coking zone by the upward passage of a fluidizing gas, e.g., steam. The temperature of the bed is maintained at about 950° F. by circulating solids to the heating vessel and back. The heavy oil to be converted is injected into the fluid bed and upon contact with the hot solids undergoes pyrolysis evolving lighter hydrocarbon vapors and depositing residue or coke on the solids.

The turbulence of a fluid bed normally results in substantially isothermal conditions and thorough and rapid distribution of the heavy injected oil. Product vapors,

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after heavy entrained solids are removed, are withdrawn overhead from coking vessel and sent to a scrubber or fractionator for cooling and separation.

The heavy ends of the product vapors contain high boiling materials that will degrade to coke. The heavy ends also contain a substantial amount of organic salts that are extremely deleterious to cracking catalyst. The fluid coking process is used to upgrade heavy low value oils to gas oils suitable as catalytic cracking charging stocks. Therefore, the coke formers and catalyst contaminants must be removed from the product.

Because the heavy ends separated from the conversion products have a tendency to polymerize and rapidly degrade to coke, the conventional means of fractionating the vapors at these temperatures have not been used. Instead the vapors are initially contacted and cooled in a scrubbing zone relatively unobstructed with internals. The temperature of the liquid collected in the base of the scrubbing zone cannot exceed about 725° F. because it will readily coke at temperatures above this.

In the past it has been the practice to decrease the final endpoint of the gas oil product to a temperature so low as to avoid inclusion of deleterious compounds. This results, however, in the loss of a substantial amount of potential gas oil in the higher boiling bottoms that are recycled to the coking zone.

The coking characteristics of the products prevent the attainment of a sharp separation of the gas oil from the recycled bottoms fraction, i.e., perfect vapor-liquid temperature equilibrium cannot be achieved in the scrubber. Consequently the bottoms fraction contains a substantial amount, up to 30–50%, of gas oil that is of suitable catalytic cracking quality. By recycling this material, the amount of recycle is greatly increased and the repetitious pyrolysis of the gas oil in its passage through the coking zone results in relatively poor product yields and distributions. This problem is further aggravated by the light nature of the recycle bottoms fractions. As it is more volatile than the customary feed to the coking zone, the recycle fraction is customarily injected into the lower portion of the zone so that it will undergo a more severe vapor phase cracking.

In accordance with the present invention, the operation of the coking system is modified to avoid the difficulties of high recycle rates and of poor separation in the scrubbing zone. Instead of condensing only the heavy ends of the coker vapors in the scrubbing zone, two fractions are separated. The highest boiling fraction initially separated from the vapors, which also removes entrained solids, is returned to the coking zone as is customary, but the initial boiling point of this fraction is substantially higher, e.g., 1075° F., than that normally obtained in the scrubbing zone and it is substantially free from gas oil. Thus, this bottoms recycle stream returns the coke particles removed from the vapors to the coking zone as is necessary and only coke formers, and metals, e.g., asphaltenes, are present in this bottoms fraction. A second somewhat lower boiling heavy gas oil is then separated from vapors in the scrubbing zone. This fraction contains some heavier coke-forming material and all of the contaminants remaining in the vapors after the first bottoms are removed. The vapors are then further processed in a conventional manner. The second gas oil fraction is especially processed to recapture the desirable gas oil components while the undesirable components are returned to the coker and reduced to coke.

Reference to the attached drawings will make this invention clear. Figure I depicts a conventional coker with a detached scrubber tower modified in accordance with the teachings of this invention. Figure II illustrates another modification of this invention wherein a vacuum

tower is used to prepare the feed to the fluid coker and a combination fractionator-scrubber superposed on the coking vessel is used to quench and separate the product vapors.

With particular reference to Figure I, a customary feed stock, e.g., a residual oil which may be suitably pre-heated, is injected into a conventional fluid coking vessel 1 via manifold system 2. The injected oil contacts a bed of fluidized solids maintained at a coking temperature in a range of about 900° to 1200° F. and undergoes pyrolysis evolving lighter hydrocarbon vapors and depositing coke on the solids. Fluidization gas, e.g., steam is admitted to the base of the vessel by line 4. Solids, after having been stripped of adhering hydrocarbons, are withdrawn from the base of the vessel by line 5 and circulated to an external heating zone. Heated solids are returned to vessel 1 by line 6 to maintain the coking temperature. The vaporous conversion products are withdrawn overhead by line 7 after having entrained solids removed in cyclone system 8.

The vapors are introduced into a scrubber 10 to have heavy ends and catalyst contaminants removed. The vapors are initially met with a heavy recycle bottoms fraction supplied by line 11 which serves to condense materials boiling above about 1000° to 1100° F. from the vapors. The condensed material collects in the base of the scrubber. A portion of this is circulated by line 12 and cooled in heat exchanger 13 to supply the heavy scrubbing oil. The remainder is recycled by line 16 to the lower portion of the coking zone.

The vapors then pass upwardly through the scrubbing tower 10 past a drawoff plate 17 and are contacted with a lighter scrubbing oil supplied by line 18. This lighter oil serves to condense from the vapors material boiling above about 800° to 950° F. The lighter fraction contains substantially all of the catalyst contaminants in the vapors and also contains substantial amounts of catalytic cracking quality gas oils. The vapors are then removed from the top of the scrubber by line 19 and sent to further recovery equipment, e.g., a fractionator.

The lighter fraction condensed in the scrubber is withdrawn from drawoff plate 17 by line 20 and a portion of it is passed through heat exchanger 21 to supply the lighter scrubbing oil. The remainder is circulated by line 20 to the uppermost portion of the fluid bed and injected therein. In this manner the lighter constituents of this fraction are only vaporized and are not subjected to coking or cracking, while the heavy constituents are deposited on the solids to be subjected to liquid phase coking. If this fraction contains predominant proportions of gas oils then it may be injected higher up into the coker in the disperse solids phase or into the cyclone inlet which will further avoid pyrolysis of the gas oil. The solids entrained in the vapors will supply sufficient surface for any material that may condense.

In modifications of the invention it may be desired to process the imperfect gas oil in line 20 by other suitable means. For example, this fraction may be mildly vaporized in an external vaporization zone, either a fluidized bed or transfer line zone, by contacting particulate solids maintained at a temperature somewhat lower than the coking temperature, e.g., 600–800° F. The vapors produced thereby can be returned directly to the scrubbing zone while the solids in the secondary zone that contain the liquid deposit can be returned to coking zone, whereby the liquid on the solids is completely vaporized and coked.

Example.—A fluid coker operating at a temperature of 950° F. using particulate coke produced by the process having a size in the range of 40–800 microns, has injected into it a residual oil having a Conradson carbon of 24 wt. percent, API gravity of 4.2°, and an initial boiling point of 1000° F. 10 wt. percent steam based on feed is injected into the base of coker as fluidizing gas. 10

pounds of heated solids/lb. of feed are injected into the coker at a temperature of 1125° F. and an equivalent amount of solids is withdrawn from the base of the coker and circulated to a heating zone. Under these conditions about 75 wt. percent of the feed is converted to products boiling below 1000° F.

The vapors so produced are introduced into the lower portion of a scrubbing tower and contacted therein with a recycle bottoms fraction that has an initial temperature of 600° F. in amounts sufficient to condense 20 vol. percent of the vapors or all material boiling above 1030° F. The material so condensed is recycled in the coking zone at a rate of 25 vol./vol. of fresh feed. The vapors are next scrubbed with a recycled heavy gas oil having an initial temperature of 500° F. supplied in amounts sufficient to condense about 10 vol. percent of the remaining vapors or all material boiling above 950° F. The vapors are then removed as product. The second heavy gas oil fraction condensed is recycled and injected on to the surface of the coking bed at a rate of 15 vol./vol. of fresh feed.

Figure II serves to illustrate an embodiment of this invention, preferred when vacuum distillation facilities are available. Illustrated is a fluid coking vessel 50 with a superposed scrubber-fractionator 51 and a vacuum distillation tower 52. The feed to the process is introduced into the vacuum tower 52 by line 53 and may comprise, for example, atmospheric residuum obtained by the atmospheric fractionation of a whole crude. Gas oils boiling up to about 1000° F. are separated from the residuum and removed from the tower by line 54. The remaining bottoms or vacuum residuum is transferred and injected into the coking vessel by line 55.

The vapors produced by the coking reaction pass overhead through cyclone 56 wherein entrained solids are removed, and are introduced into the base of the scrubber-fractionator. The scrubber-fractionator has disc and doughnut baffles 57 in the lower portion to promote effective contacting of the liquid and vapors, and conventional fractionation trays or plates 58 in the upper portion. The vapors are initially contacted with a heavy scrubbing oil sprayed into the scrubbing section by line 59. As previously noted this heavy scrubbing oil can comprise a portion or all of the vacuum feed to the coking zone. Thus some of the vacuum residuum in line 55 may be transferred to line 59 and there introduced into the scrubbing tower. The material initially condensed from the vapors is removed by line 60. A portion of it is cooled in heat exchanger 61 to form a scrubbing oil. The remainder is recycled to the coking zone by line 62. The vapors then pass up into the upper part of the scrubbing zone and are met with a lighter scrubbing oil supplied by line 63. The material condensed in this manner collects on drawoff plate 64 and is removed by line 65. A portion of this lighter material is cooled in heat exchanger 66 and returned as the lighter scrubbing oil.

The vapors then pass to the upper part of the scrubber-fractionator and are separated by conventional means into the various product fractions desired. For example, a heavy gas oil may be separated and removed by line 67, a heating oil by line 68, a naphtha or gasoline fraction by line 69, and light gases by line 70. It is preferred to cool a portion of the gas oil product in heat exchanger 71 and introduce it into the tower via line 72 at a point just below the fractionation section in order to insure that all heavy ends and catalyst contaminants are removed from the vapors.

According to this invention the contents of line 65, i.e., the lighter fraction separated in the scrubbing zone, are transferred and introduced into the vacuum tower 52 to recover the gas oil components. The heavier components of this fraction then are removed from the vacuum tower along with the vacuum residuum in line 55. In this manner a clean gas oil of good catalytic cracking quality is

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obtained from the coker vapors in the scrubber-fractionator and yet the gas oils necessarily condensed in the scrubbing zone are not needlessly thermally degraded by repetitious passage through the coking zone. This does not appreciably reduce the capacity of unit 52 because of the relatively low volume of the lighter fractions.

While it is customary to operate a fluid coker to obtain complete elimination of the charge introduced into the coking zone, in some cases it is desirable to take a residual oil product. For the process illustrated a portion of the heavy bottoms in line 62 normally recycled to the coker, may be withdrawn by line 73 as a residual oil product.

Having described the invention, what is sought to be protected by Letters Patent is succinctly set forth in the following claims.

What is claimed is:

1. In a fluid coking process wherein a heavy hydrocarbon oil is converted in a coking zone to lower boiling hydrocarbons by contact with a fluidized bed of solids maintained at a coking temperature, a method of improving the yield and quality of the lower boiling hydrocarbons therefrom which comprises scrubbing the overhead vaporous conversion products from said coking zone in a first scrubbing zone with a relatively high boiling hydrocarbon scrubbing oil to condense heavy ends boiling above about 1030° F. and to remove entrained solids, further scrubbing the remaining vaporous conversion products in a second scrubbing zone with a hydrocarbon scrubbing oil lower boiling than said first-mentioned relatively high boiling hydrocarbon scrubbing oil to condense a heavy gas oil fraction boiling above about 950° F. and containing high boiling hydrocarbons which act as catalyst contaminants in catalytic cracking, further separating the remaining vaporous conversion products to obtain product fractions including a gas oil of catalytic cracking quality, returning a portion of said condensed heavy ends along with said entrained solids from the bottom portion of said first scrubbing zone to the bottom portion of said coking zone to further coke said heavy ends and said high boiling catalyst contaminating hydrocarbons and to deposit contaminants on the solids particles in said fluid bed, cooling and recycling the remainder of said condensed heavy ends to said first scrubbing zone as the relatively high boiling hydrocarbon scrubbing oil, returning a portion of said condensed heavy gas oil fraction from the bottom portion of said second scrubbing zone to the upper portion of said fluidized bed to vaporize and recover a clean gas oil fraction substantially free from cracking catalyst contaminants and coke formers and without any substantial amount of coking of said clean gas oil fraction and cooling and recycling the remainder of said condensed heavy gas oil fraction to said second scrubbing zone as the lower boiling hydrocarbon scrubbing oil.

2. In a fluid coking process wherein a heavy hydrocarbon oil is converted in a coking zone to lower boiling constituents and coke by contact with a fluidized bed of solids maintained at a coking temperature, a method of improving the yield and quality of the products therefrom which comprises scrubbing the overhead vaporous conversion products from said coking zone in a first scrubbing zone with a relatively high boiling hydrocarbon scrubbing oil to condense heavy ends boiling above about 1000° F. and to remove entrained solids therefrom, collecting condensed heavy ends and entrained solids in the bottom portion of said first scrubbing zone cooling and recycling at least a portion thereof to said first scrubbing zone as the relatively high boiling hydrocarbon scrubbing oil, then passing said uncondensed vaporous conversion products into a second scrubbing zone and scrubbing them there with a hydrocarbon scrubbing oil lower boiling than said first-mentioned relatively high boiling hydrocarbon scrubbing oil to condense a

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heavy gas oil fraction having an initial boiling point in the range of about 800° to 950° F. and a final boiling point in the range of about 1000° to 1100° F. and containing high boiling materials which are undesirable and act as catalyst contaminants in catalytic cracking, collecting said contaminated condensed gas oil fraction in the bottom portion of said second scrubbing zone and cooling and recycling at least a part thereof to said second scrubbing zone as the lower boiling hydrocarbon scrubbing oil, further treating said remaining vaporous conversion products to recover product fractions including a gas oil of catalytic cracking quality, returning the remainder of said condensed heavy ends collected in said first scrubbing zone to an intermediate portion of said fluidized bed in said coking zone to further coke said heavy ends, and returning the remainder of said condensed heavy gas oil fraction collected in the bottom portion of said second scrubbing zone to near the upper portion of said fluidized bed in said coking zone to vaporize and recover a vaporous gas oil from said heavy gas oil fraction without subjecting said gas oil to said coking step so as to recover a catalytic cracking gas oil feed free from said catalyst contaminants and coke formers.

3. In a fluid coking process wherein a heavy hydrocarbon oil is converted in a coking zone to lower boiling constituents and coke by contact with a fluidized solids maintained at a coking temperature, a method of improving the yield and quality of the lower boiling hydrocarbons therefrom which comprises scrubbing the overhead vaporous conversion products from said coking zone in a first scrubbing zone with a relatively high boiling hydrocarbon scrubbing oil to condense heavy ends boiling above about 1030° F. and to remove entrained solids therefrom, collecting condensed heavy ends and entrained solids in the bottom portion of said first scrubbing zone and cooling and recycling at least a portion thereof to said first scrubbing zone as the relatively high boiling hydrocarbon scrubbing oil, then passing said uncondensed vaporous conversion products into a second scrubbing zone and scrubbing them there with a scrubbing hydrocarbon oil lower boiling than said first-mentioned relatively high boiling hydrocarbon scrubbing oil to condense a heavy gas oil fraction boiling above about 950° F. and containing high boiling hydrocarbons which are undesirable as contaminants in catalytic cracking, collecting said contaminated condensed gas oil fraction in the bottom portion of said second scrubbing zone and cooling and recycling at least a portion thereof to said second scrubbing zone as the lower boiling hydrocarbon scrubbing oil, further treating said remaining vaporous conversion products to obtain product fractions including a gas oil of catalytic cracking quality substantially free of catalyst contaminants, returning the remainder of said condensed heavy ends from the bottom portion of said first scrubbing zone along with said entrained solids to an intermediate portion of said fluidized bed in said coking zone to further coke said heavy ends and high boiling hydrocarbons containing catalyst contaminants, and returning the remainder of said condensed heavy gas oil fraction from the bottom portion of said second scrubbing zone to an upper portion of said fluidized bed in said coking zone to vaporize and pass overhead a clean gas oil fraction substantially free of cracking catalyst contaminants while depositing contaminants on the fluidized solids in said coking zone without subjecting said clean gas oil fraction to any substantial amount of cracking or coking.

4. In a fluid coking process wherein a heavy hydrocarbon oil is converted in a coking zone to lower boiling constituents and coke by contact with a fluidized bed of solids maintained at a coking temperature, a method of improving the yield and quality of the products therefrom which comprises scrubbing the overhead vaporous conversion products from said coking zone in a first

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scrubbing zone with a relatively high boiling hydrocarbon scrubbing oil to condense heavy ends boiling above about 1000° F. to 1100° F. and to remove entrained solids therefrom, collecting condensed heavy ends and entrained solids in the bottom portion of said first scrubbing zone and cooling and recycling at least a portion thereof to said first scrubbing zone as the relatively high boiling hydrocarbon scrubbing oil, then passing said uncondensed vaporous conversion products into a second scrubbing zone and scrubbing them there with a hydrocarbon scrubbing oil lower boiling than said first-mentioned relatively high boiling hydrocarbon scrubbing oil to condense a heavy gas oil fraction having an initial boiling point in the range of about 800° to 950° F. and a final boiling point in the range of about 1000° to 1100° F. and containing high boiling materials which are undesirable and act as catalyst contaminants in catalytic cracking, collecting said contaminated condensed gas oil fraction in the bottom portion of said second scrubbing zone and cooling and recycling at least a portion thereof to said second scrubbing zone as the lower boiling hydrocarbon scrubbing oil, further treating said remaining vaporous conversion products to recover product fractions including a gas oil of catalytic cracking quality, returning the remainder of said condensed heavy ends collected in said first scrubbing zone to an intermediate portion of said fluidized bed in said coking zone to further coke said heavy ends, and passing the remainder of said condensed heavy gas oil fraction collected in the bottom portion of said second scrubbing zone to a vaporization zone to vaporize and separate a catalytic cracking gas oil free from catalyst contaminants and coke formers from a bottoms fraction containing catalyst contaminants and returning said bottoms fraction to an intermediate portion of said coking zone for further cracking.

5. The process according to claim 4 wherein said vaporization zone comprises the upper portion of said fluidized bed of solids in said coking zone.

6. The process according to claim 4 wherein said vaporization zone comprises a vacuum fractionation zone.

7. The process according to claim 6 wherein said vacuum fractionation zone is also used to fractionate heavy fresh hydrocarbon feed to recover bottoms as a high boiling hydrocarbon fraction which is fed to said coking zone and to recover a clean catalytic cracking gas oil overhead.

8. In a fluid coking process wherein a heavy hydro-

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carbon oil is converted in a coking zone to lower boiling constituents and coke by contact with fluidized solids maintained at a coking temperature, a method of improving the yield and quality of the lower boiling hydrocarbons therefrom which comprises scrubbing the overhead vaporous conversion products from said coking zone in a first scrubbing zone with a relatively high boiling hydrocarbon scrubbing oil to condense heavy ends boiling above about 1030° F. and to remove entrained solids, collecting condensed heavy ends and entrained solids in the bottom portion of said first scrubbing zone cooling and recycling at least a portion thereof to said first scrubbing zone as the relatively high boiling hydrocarbon scrubbing oil, then passing said uncondensed vaporous conversion products into a second scrubbing zone and scrubbing them there with a scrubbing hydrocarbon oil lower boiling than said first-mentioned relatively high boiling hydrocarbon scrubbing oil to condense a heavy gas oil fraction boiling above about 950° F. and containing high boiling hydrocarbons which are undesirable and act as catalyst contaminants in catalytic cracking, collecting said contaminated condensed gas oil fraction in the bottom portion of said second scrubbing zone cooling and recycling at least a portion thereof to said second scrubbing zone as the lower boiling hydrocarbon scrubbing oil, further treating said remaining vaporous conversion products to obtain product fractions including a gas oil of catalytic cracking quality substantially free of catalyst contaminants, returning the remainder of said condensed heavy ends from the bottom portion of said first scrubbing zone along with said entrained solids to an intermediate portion of said fluidized bed in said coking zone to further coke said heavy ends and high boiling hydrocarbons containing catalyst contaminants, and passing the remainder of said condensed heavy gas oil fraction from the bottom portion of said second scrubbing zone to a vacuum fractionation zone to vaporize and separate a catalytic cracking gas oil fraction substantially free of cracking catalyst contaminants and coke formers from a bottoms fraction containing catalyst contaminants and returning said bottoms fraction to an intermediate portion of said coking zone for further cracking.

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