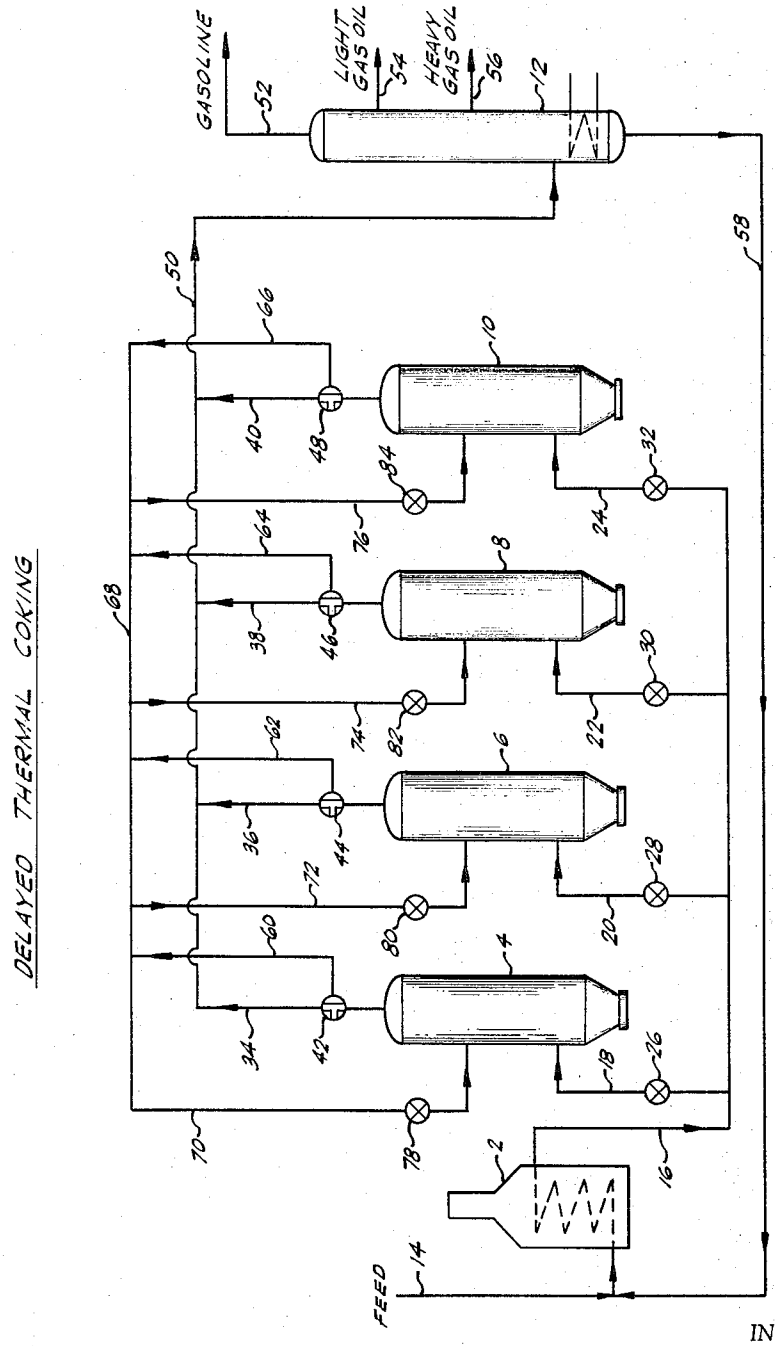
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COKING PROCESS

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COKING PROCESS

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This invention relates to the delayed thermal coking of crude oils and crude oil residua in a plurality of coking drums, and is concerned in particular with methods for increasing the throughput capacity of such plural-drum units.

It is common practice to carry out delayed thermal coking operations in a plurality of coking drums by continuously passing a stream of the feed oil through a tubular heating zone, and thence to each of the several coking drums in successive rotation. In each of the drums, the preheated oil is allowed to "soak" in its own heat, and the cracked vapors are continuously removed overhead and sent to a fractionating column, while coke builds up to successively higher levels in the drum. When a drum is filled wtih coke, the heated stream of oil is diverted to a succeeding drum and the former drum is then steamed out and cooled and the coke removed therefrom by hydraulic jets of water or other means while coking is being carried out in a succeeding drum or drums. In this manner, the unit may be kept continuously on stream with a relatively constant feed rate thereto.

A difficulty which has been encountered in this mode of operation, which places severe restrictions upon the throughput capacity of the unit, involves the carry-over of entrained heavy oil droplets and coke particles with the vapor effluent from each drum. This entrainment of coke and coke-forming liquid occurs particularly during the terminal portion of the "fill" cycle in each drum, and causes severe problems in the product fractionation column. The formation of coke in the lower portion of the fractionating column and in the reboiler causes plugging to occur, necessitating frequent shut-downs for cleaning operations. To avoid this problem, it has in the past been considered desirable to restrict the degree to which each coke drum is filled, and to terminate the fill cycle when the drum being filled is only about ½ to ¾ full. It will be appreciated that during the fill period a substantial layer of foam or froth, often 4 to 6 feet in thickness, forms on the surface of the liquid oil, and this foam and/or froth is particularly apt to become entrained as small droplets or bubbles in the vapor effluent. Heretofore, this problem could only be avoided by providing a separate knock-out drum which itself would require frequent shut-downs for cleaning, or by leaving a substantial free space, termed "outage," in the top of each drum to serve as a knock-out space. The required outage for safe operation may amount to from ¼ to about ½ of the total volume of the coke drum. Obviously, this places severe limitations on the throughput capacity of the entire unit.

In accordance with my invention the outage in each coke drum is materially reduced and its coke capacity correspondingly increased by routing the vapor product from any given coking drum which is nearing the end of a fill cycle, through the upper portion of another coke drum which is in an earlier stage of its fill cycle and hence contains a larger vapor space in the upper portion thereof. Any froth or coke entrained in the vapor from the drum nearing fill drops out in the vapor space of the emptier drum, hereinafter termed the "dephlegmator" drum. It has been found that where the *L/D* (length/diameter) ratio of the coke drums is less than about 5/1 the froth-laden vapor from a drum nearing fill may be effectively dephlegmated in another drum which is in the initial phase of a fill period, notwithstanding the fact that the linear vapor velocity in the latter drum is substantially doubled by this technique. By operating in this manner it has been found that the coke capacity of each drum can be increased by at least about 10%, and up to about 40%, with a corresponding increase in total feed throughput. Where the *L/D* ratio of the coke drums is greater than about 5, the linear vapor velocity in each drum during the fill period is normally such that a doubling of such velocity brought about by introducing the vapors from another drum reduces dephlegmation efficiency to such an extent that the effectiveness of the technique is substantially reduced.

An important aspect of the invention resides in the location of the inlet point at which the froth-laden vapors are introduced into the dephlegmator drum. It has been found that best results are obtained when the vapor inlet is positioned in the upper half, preferably the upper ⅓, of the drum, but at least about 4 feet down from the vapor outlet thereof. Positioning the inlet in the lower half of the drum is disadvantageous because such inlet is then likely to become submerged below the liquid level in said drum, resulting in increased back pressure in the drum from which vapors are being transferred, and also in increased turbulence and foaming in the dephlegmator drum. It is therefore preferred that the transferred vapor product be introduced into the dephlegmator drum at a point above the liquid level therein.

The process of this invention is normally useful only in connection with coking units involving at least three, and preferably at least four coking drums. In a two-drum unit, timing of the various cycles of coking, decoking and heat-up becomes more difficult to manage for the present purposes, and moreover the total feed rate must vary periodically. It will be understood that in the coking process, each drum is alternately filled, cooled, decoked, and heated up for the next fill cycle. The fill cycle normally requires between about 8 and 24 hours, the cooling and decoking cycle between about 6 and 16 hours, and the heat-up period about 2–4 hours. Heat-up is normally carried out by passing part of the hot product vapors from one on-stream coke drum into the empty decoked drum. In this type of operation, dephlegmation of the heat-up vapors may inherently occur in the empty drum if by chance the heat-up vapors are being transferred from a drum nearing the end of its fill cycle. However, it is impractical and uneconomical to rely for dephlegmation purposes solely upon the normal heat-up cycle in an empty drum, firstly because the total vapor output from an on-stream drum normally cannot be passed directly through an empty, cool drum without causing warpage due to overly rapid heating, and secondly because it is difficult to time the filling cycle so as to coincide with availability of an empty drum as soon as dephlegmation becomes necessary. Also, the length of time required for safe heat-up may be greater than the terminal period of a fill cycle in which dephlegmation is desired. It is therefore necessary as a practical matter where it is desired to maintain a stable, continuous operation, without damage to the drums, to utilize a drum in the initial stages of a fill cycle for dephlegmation purposes.

For a more detailed description of the invention, reference is now made to the attached drawing which is a flow diagram illustrating a four-drum coking unit. The principal items of equipment include a fired heater **2**, four coking drums **4**, **6**, **8** and **10**, and a product fractionating column **12** which may be a conventional bubble-cap tower. In the normal operation of this unit, two of the coking drums will be at different stages of the fill cycle at any given time, while the other two will be at different stages of the decoking or heat-up cycle, thereby assuring continuous operation with a constant feed rate. Reduced

crude oil and/or residuum feed is brought in via line 14, heated to coking temperatures of about 850–950° F. in heater 2, and transferred to the coking drums in sequence via distribution line 16, and lines 18, 20, 22 and 24 controlled by valves 26, 28, 30 and 32 respectively. Cracked vapor phase products are normally withdrawn from the drums via lines 34, 36, 38 and 40 controlled by three-way valves 42, 44, 46 and 48 respectively, and the combined effluent is then passed via line 50 to fractionating column 12 from which gasoline is recovered overhead via line 52, a light gas oil side-cut via line 54 and a heavy gas oil via line 56. Bottoms material boiling above about 800° F. may be withdrawn via line 58 and recycled to feed preheater 2 to undergo further cracking.

Three-way valves 42, 44, 46 and 48 also control alternate vapor transfer lines 60, 62, 64 and 66, leading from the respective drums to header line 68. From header 68, vapor injection lines 70, 72, 74 and 76 controlled by valves 78, 80, 82 and 84 respectively, lead into drums 4, 6, 8 and 10 at a point about ⅓ the distance from the top of the drum to the bottom. In normal operation, all product vapors from the two on-stream drums are withdrawn via line 50 by opening the appropriate three-way valves to two of lines 34, 36, 38 and 40, while valves 78, 80, 82 and 84 remain closed. However, during the terminal stage of the fill cycle for any given drum, usually the last 1–5 hours, one of the three-way valves 42, 44, 46 and 48 controlling the vapor outlet from that drum will be opened to the appropriate alternate transfer line 60, 62, 64 or 68, and one of valves 78, 80, 82 and 84 leading to whichever of the other drums is in the initial stages of a fill cycle (usually the first half of such cycle) will be opened, thereby diverting vapor from the drum nearing fill to that which is more nearly empty and can function effectively as a dephlegmator. The combined vapor from both drums then passes upwardly in the dephlegmator drum and is transferred via line 50 to fractionating column 12.

To illustrate operation of the process at a specific stage of the coking cycle: at a given time drum 4 is in the fill cycle about two-thirds filled with coke; drum 6 is about one-third filled; drum 8 is undergoing decoking and drum 10 has been cooled preparatory to decoking. Valves 26 and 28 are open; three-way valves 42 and 44 are open to lines 34 and 36 respectively, while valves 30, 32, 78, 80, 82 and 84 are closed. At this point, the critical coke level in drum 4 is about to be reached at which carry-over of coke and froth via line 34 will occur. To prevent this, three-way valve 42 is opened to alternate vapor transfer line 60, and valve 80 is opened so that all vapor from drum 4 flows via line 60, header 68 and line 72 into coke drum 6. The combined vapor product from drums 4 and 6 is then withdrawn via line 36 and sent to the fractionating column via line 50. This operation is continued until the desired coke level in drum 4 is reached, normally about 3–6 feet below the entrance to outlet line 34.

Before this point is reached however, it may be that coke drum 8 is decoked and ready for the preheat cycle. In this event, valve 82 may be opened or partially opened whereby a portion of the vapor from drum 4 flows via lines 60, 68 and 74 into drum 8 to effect heat-up concurrently with dephlegmation. Three-way valve 46 is opened to line 38 so that any uncondensed heat-up vapors from drum 8 will pass to fractionating column 12 via lines 38 and 50. When drum 4 has reached the desired fill level, valves 26, 80 and 82 are closed and valve 30 opened to start the fill cycle for drum 8. Shortly after this time the coke level in drum 6 may reach such a level as to cause carry-over of froth into line 36, at which time three-way valve 44 is opened to alternate vapor transfer line 36, and valve 82 is opened so as to route the vapor effluent from drum 6 through drum 8 which then functions as the dephlegmation drum. Operation is then continued in this manner with each drum in the series so as to maintain substantially constant feed throughput while at the same time achieving maximum coke fill in each drum.

In operating a unit such as that described above, it is normally desirable to adjust the feed rate to each drum so that each fill cycle will be completed in about the same length of time required for the decoking and heat-up cycle. By operating in this manner, a constant total feed rate can be maintained with no drum standing idle for any substantial length of time between cycles.

The following example is cited to illustrate the results obtainable in one specific adaptation of the invention, but is not to be construed as limiting in scope.

EXAMPLE

A commercial coking unit similar to that illustrated in the drawing utilizing four coke drums, each 16 feet in diameter by 38 feet in height (straight-side length from top head to the bottom cone seam), was being utilized prior to the invention to process about 15,500 barrels per day of mixed California crude oil residua, tars and asphalt bottoms. In order to avoid carry-over of coke-forming liquid into the fractionating column it was found necessary to maintain about a 12 to 13 foot outage in the top of each drum, with a resulting coke fill amounting to only about ⅔ of the total volume in each drum. This overall feed throughput rate was maintainable at a preheater outlet temperature of about 920° F., with the four drums operating in a staggered cycle with approximately 11-hour fill cycles and 11-hour decoking cycles, one drum being taken off stream for decoking every 6½ hours.

The foregoing coking unit was then modified by the installation of vapor transfer lines whereby product vapors could be cascaded from one drum to another in a manner similar to that illustrated in the drawing. During the terminal 2–3 hours of each fill cycle, vapor effluent from the nearly filled drum was transferred to the next drum in the series which was in the initial stages of the fill cycle, the point of entry of the transferred vapors being about 12 feet from the top of the drum. By operating in this manner, it was found that the required outage in each drum undergoing fill could be reduced to about 4–5 feet without encountering significant carry-over of coke-forming materials to the fractionating column. The coke capacity of each drum was hence increased to about 80–90% of its total volume. Moreover, it was found that this could be achieved even though the feed rate to each drum was increased by about 12% in order to accelerate the rate of fill and thus maintain the 11-hour fill cycle to balance the 11-hour decoking cycle. In this manner, it was found that the throughput capacity of the total unit could be increased to about 17,400 barrels per day, an increase of about 12%.

Although I have described the present invention in connection with specific embodiments thereof, it is not intended that the details set forth shall be regarded as limitations upon the scope of the invention, except insofar as included in the following claims.

I claim:

1. In a delayed thermal coking process wherein preheated feed comprising crude oil residuum is passed alternately to a series of soaking drums in sequence such that at least two drums are always on-stream but in staggered phases of the coke-filling cycle, the conditions within said drums being such that cracked product vapors are continuously evolved with accompanying foaming and frothing while coke deposits build up to successively higher levels therein and wherein product vapors are continuously withdrawn overhead, the improved method for avoiding carryover to product fractionation equipment of entrained coke and froth in said product vapors such as normally occurs when the coke level in said drums approaches the overhead vapor outlet thereof, which comprises diverting the product vapors from each drum entering the terminal phase of a fill cycle to the vapor space in the upper portion of another drum which is in the initial

phase of a coke-filling cycle, and withdrawing combined dephlegmated product vapors from the latter drum while allowing the former drum to fill with coke to a level substantially beyond that at which carry-over of liquid begins, whereby the coke capacity of each drum is materially increased, the *L/D* ratio in each of said drums being less than about 5/1.

2. In a delayed thermal coking process wherein a feed comprising crude oil residuum is preheated and passed to a coking unit comprising a plurality of soaking drums operated in a staggered, time sequence of on-stream coke-filling cycles and off-stream decoking cycles and wherein vapor phase products are continuously removed from the top of the on-stream drums, at least one of said drums being on stream in the initial stages of a coke-filling cycle at all such times that any other drum is on stream in the latter half of a coke-filling cycle, the improved method for increasing the permissible level to which said drums may be filled with coke during any given on-stream cycle without encountering significant carryover of coke and coke-forming liquid with the vapor phase products being withdrawn from the coking unit, which comprises passing the vapor effluent evloved from a first on-stream drum during the terminal ½ to 6 hours of its on-stream cycle into the vapor space in the upper half of a second on-stream drum which is in the initial stages of its on-stream cycle at a point at least about 4 feet below its vapor outlet line, whereby entrained coke and liquid in the transferred vapor effluent settles and is trapped in said second on-stream drum, and withdrawing overhead therefrom a combined coke- and liquid-free vapor effluent evolved in both of said on-stream drums, the *L/D* ratio in each of said drums being less than about 5/1.

3. A process as defined in claim 2 wherein the same number of drums is maintained on-stream at all times whereby a substantially constant feed rate to said coking unit may be maintained.

4. A process as defined in claim 2 wherein the feed rate to each individual drum is adjusted to give a coke-filling time cycle substantially equal to the cooling-decoking-heat-up time cycle, whereby a substantially constant feed rate to said unit may be maintained with all drums being continuously placed on stream immediately following each decoking and heat-up cycle.

5. A process as defined in claim 4 wherein the cooling-decoking-heat-up time cycle for each drum is between about 8 and 20 hours.

6. A delayed thermal coking process which comprises:

(A) preheating a feed comprising a crude oil residuum to a temperature between about 850° and 950° F.;

(B) passing the preheated feed at a substantially constant rate to a coking unit comprising four soaking drums, each having an *L/D* ratio less than about 5/1, operated in a staggered time sequence of on-stream coke-filling cycles and off-stream decoking cycles, two of said drums being on stream and receiving said preheated feed at all times in staggered sequence approximately one-half cycle apart, the other two being off-stream and undergoing decoking at all times in staggered sequence approximately one-half cycle apart;

(C) continuously removing product vapors overhead from the two on-stream drums and passing such product vapors to a fractionating column;

(D) near the terminal phase of the on-stream cycle of each drum, introducing total product vapors from such drum into the vapor space in the upper half of the second on-stream drum which is in the initial phase of a coke-filling cycle at a point at least about 4 feet below the vapor outlet thereof, and withdrawing through said vapor outlet the combined product vapors from both of said on-stream drums, whereby entrained coke and liquid oil in the product vapors from said terminal-phase drum is trapped in the vapor space of said initial-phase drum; and

(E) allowing each on-stream drum to fill with coke during step (D) to a level substantially higher than the level at which significant entrainment and carry-over of coke and coke-forming liquid begins, such as would normally require terminating the on-stream cycle, whereby the coke-capacity of each drum is substantially increased.

7. A process as defined in claim 6 wherein the feed rate to each individual drum is adjusted to give a coke-filling time cycle substantially equal to the cooling-decoking-heat-up time cycle, whereby a substantially constant feed rate to said unit may be maintained with all drums being continuously placed on stream immediately following each decoking and heat-up cycle.

8. A process as defined in claim 7 wherein the cooling-decoking-heat-up time cycle for each drum is between about 8 and 20 hours.

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