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(54) **Process and apparatus for the continuous thermal cracking of hydrocarbon oils and hydrocarbon mixtures thus prepared.**

(57) A process for the continuous thermal cracking of hydrocarbon oils by heating a hydrocarbon oil and causing it to flow through a thermal conversion zone, in which process at least part of the gaseous material produced during said heating is withdrawn from the heated oil prior to its introduction into a thermal conversion zone.

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PROCESS AND APPARATUS FOR THE CONTINUOUS THERMAL CRACKING OF HYDROCARBON OILS AND HYDROCARBON MIXTURES THUS PREPARED

The present invention relates to a process for the continuous thermal cracking of hydrocarbon oils and to hydrocarbon mixtures thus prepared.

In view of the growing demand for light hydrocarbon oil distillates and the shrinking demand for heavy fuel oils and asphalt, produced as by-products in the distillation of crude oil, thermal cracking can be suitably applied to convert residual oils into lighter products.

Two types of thermal cracking processes are well-established: furnace cracking and soaker cracking. Furnace cracking implies that the actual cracking takes place at the downstream end of a furnace and to some extent in the transfer line between the furnace and a subsequent treating unit. The residence time of the feedstock is relatively short, of the order of only one minute.

In the case of soaker cracking the feed is heated to a suitable temperature, which is considerably lower than the temperature applied in furnace cracking, and the feed is allowed to stay at that temperature for a period usually between 5 and 60 minutes in a thermal conversion vessel normally referred to as a soaker. A soaker can be defined as a vessel without supplementary heating, which vessel allows cracking to take place over a prolonged period. No heat is provided to the soaker and, since the cracking reaction is endothermic, the temperature of the feed drops by about 10-30 °C during passage through the soaker.

Soaker cracking has staged a successful come-back as a convenient and relatively inexpensive step towards reducing fuel oil residues and compares favourably with furnace cracking with respect to capital costs, fuel consumption and onstream times.

The use of an empty soaking vessel is known from U.S. patent specification 1,899,889. In order to overcome stability problems of the cracked residue obtained in soaker operation it has been proposed in European patent specification 7656 to provide the soaking vessel with internals dividing the interior of the vessel into a plurality of compartments. The internals described in said European patent specification are preferably in the form of perforated plates. This has the advantage that the swirling motion occurring in soaking vessels not provided with internals upon gas formation is in fact transformed due to the presence of such internals, into a plurality of relatively small swirls, resulting in a steep decrease of overall back-mixing and therefore in an improved product stability.

One of the factors unfavourably governing the product pattern of thermally cracked material is the degree of over-cracking which may occur when valuable products are maintained too long under cracking conditions, for instance during transport through a soaking vessel (necessary to accomplish a reasonable conversion of unconverted material), especially when substantial amounts of such products had already been formed during the heating and transporting stage of the feed, in particular when the feed had been subjected for a considerable period of time to cracking conditions.

The object of the present invention is therefore to reduce or even prevent over-cracking and thus optimizing the product yield by removing valuable materials produced or present as quickly as possible.

The present invention therefore relates to a process for the continuous thermal cracking of hydrocarbon oils by heating a hydrocarbon oil and causing it to flow through a thermal conversion zone, wherein at least part of the gaseous materials produced during said heating is withdrawn from the heated oil prior to its introduction into a thermal conversion zone.

The removal of at least part of the gaseous materials produced prior to introduction of the heated hydrocarbon oil into a thermal cracking zone has a number of advantages. Not only will the product yield pattern improve substantially, it is also possible to operate the thermal conversion zone under optimum conditions with respect to further conversion of unconverted feed since a substantial part of the material normally introduced into the soaking vessel is now directly transported for final processing or directly used in a different (hydro)conversion operation. It is also possible to allow more cracking during the early stage of the thermal cracking process since the products can now be removed prior to the conversion of unconverted feed.

The withdrawal of gaseous materials according to the process according to the present invention is suitably carried out by a phase-separator. Cyclones are examples of suitable phase-separators which can be used advantageously in the process according to the present invention. They are well-known to those skilled in the art. The capacity of the cyclone to be used will largely depend on the severity of the thermal cracking to be achieved in the early stage of the thermal cracking process. The cyclones to be used should be capable of conveniently separating amounts of gaseous materials produced corresponding with amounts of vapour up to 80 %wt calculated on hydrocarbon oil to be processed.

The thermal cracking according to the present invention is suitably performed at a temperature in the range between 350 and 550 °C, preferably at a temperature between 400 and 500 °C. Normally, the temperature at which the cyclone will be operated will be substantially the same as the outlet of the upstream heating zone (which may include a soaking vessel) and is some 20-40 °C higher than the temperature of the cracked product leaving the thermal conversion zone.

In order to facilitate further processing, it is preferred to withdraw substantially all of the gaseous material produced prior to introduction of the remaining material into the thermal conversion zone. The gaseous material removed may be subjected to further physical separation treatment(s) depending on the intended use of the products obtained.

The heated hydrocarbon oil depleted of gaseous materials according to the process according to the present invention is passed to the thermal conversion zone, preferably a soaking vessel, in order to continue the thermal conversion of yet unconverted material present therein. It is advantageous to transport the oil to be converted by means of gravity to the soaking vessel since the use of control-equipment will then be reduced or may even not be necessary at all.

Although soaking vessels not containing internals can be used in the process according to the present invention, preference is given to the use of soaking vessels containing internals as described in European patent specification 7656. Good results will be obtained when the bottom product of the phase-separator, i.e. heated hydrocarbon oil depleted of gaseous materials, is caused to flow upwardly through a soaking vessel provided with horizontal perforated plates, which effectively increase the number of mixing stages. The number of plates is preferably in the range of from 1 to 20. To achieve optimal results with the perforated plates, preferably 1-30% of the plate area is occupied by free area. Because of the fact that during the cracking process the amount of vapour products increases it is advantageous to carry out the upflow process in a vessel in which the percentage of free area per plate increases from the bottom upwards. Preferably, the ratio free area of top plate to the free area of bottom plate is in the range of from 2 to 6.

In order to reduce or even prevent the occurrence of over-cracking during residence of the heated hydrocarbon oil depleted of gaseous materials in a compartmented soaking vessel, it is advantageous to use a soaking vessel having its interior divided into a plurality of consecutive, interconnected compartments wherein heated hydrocarbon oil depleted of gaseous materials is caused to pass through the consecutive compartments prior to withdrawal of liquid material from the soaking vessel, and wherein gaseous materials present in the compartments are collected and withdrawn from the vessel. Reference is made to the use of soaking vessels as described in European patent application 84201250.

Preferred embodiments of soaking vessels provided with gas withdrawal facilities comprise vertically extending soaking vessels wherein the oil is passed downwardly through the consecutive compartments, in particular through compartments made up of inclined separating walls whilst fluid passages are positioned below the higher parts of the separating walls, which fluid passages are formed by elongated open-ended tubular elements passing through openings in the separating walls as described in said European patent application. It is furthermore beneficial to withdraw the gas present in the soaking vessel via openings in a central discharge system. Also vertically extending soaking vessels wherein the feed is processed in upward flow can be used advantageously.

The product leaving the thermal conversion zone will normally be subjected to phase-separation, e.g. by means of a cyclone. The gaseous products can be subjected to further processing and the bottom product of the phase-separator can be subjected, if desired, to a further thermal conversion in a suitable soaking vessel or can be subjected to further processing. It is also possible to subject the bottom material emanating from a cyclone, which may be material depleted of gaseous materials when specific soaking vessels as described hereinbefore have been used, to a further treatment in a furnace, followed, if desired, by further cyclonic separation and transport to a further soaking vessel. This procedure may be repeated several times depending on the product desired.

It may be useful to subject thermally converted hydrocarbon oils to quenching prior to the withdrawal of gaseous materials in order to bring the temperature of such oils on the desired level by absorbing some of the heat contained in a colder quench fluid. Suitable quench fluids comprise the usual quenching means, such as hydrocarbon oils. Steam may also be used to assist in phase-separation.

While the pressure along the reaction zone of a furnace cracker varies a great deal, soaker cracking has the advantage that a selected constant pressure can be applied. This pressure is normally chosen up to 30 bar gauge, preferably up to 15 bar gauge.

In order to facilitate the thermal conversion process it is possible to introduce steam into the soaking vessel applied. The use of steam is also advantageous when operating soaking vessels provided with a (central) gas discharge system.

The present process will now be further elucidated with reference to the Figure.

A residual oil feedstock is passed through a line 1 to a furnace 2 where it is heated to a temperature in the range of from 350-550°C. The hot feed, already partially converted, is passed through a line 3 to a phase-separator 4. Gaseous materials are withdrawn from the top of the phase-separator (cyclone) via a line 5 for further processing (not shown). The bottom product discharged from the cyclone is passed, preferably by gravity, through a line 6 to a soaking vessel 7 in which it flows upwards through horizontal perforated plates 8. The cracked product leaves the soaking vessel at the top via a line 9 through which it is transferred to a further processing stage which may include a further phase-separator (not shown) to produce valuable products (gasoline, heating oils and fuel oil). Instead of the soaking vessel 7 as described in this Figure, soaking vessels as described in European patent application 84201250 referred to hereinbefore can also be applied.

The following Example shows an embodiment of the present invention but this does not restrict the present invention at all.

EXAMPLE

When operating a conventional thermal cracking process (i.e. a process not equipped with the facility to withdraw gaseous materials between the heating zone and the thermal conversion zone) with a high sulphur Middle East 520 °C^{+} residue at a temperature of 450 °C and a pressure of 10 bar, using a soaking vessel having perforated horizontal plates, the following product yield will normally be achieved:

Product yield (%wt on feed)

gas (C_4^-)	:	2.0
gasoline (C_5-165 °C)	:	4.0
gas oil (165-350 °C)	:	11.7
heavy distillate (350-520 °C)	:	24.0
residue (520 °C^+)	:	58.3

When operating a thermal cracking process in accordance with the present invention (i.e. when the same feed is subjected to thermal cracking using a cyclone to withdraw gaseous materials produced prior to the introduction of the remaining material into the soaking vessel, which allows operating at a pressure of 2 bar) the following results can be achieved - under otherwise similar conditions - :

Product yield (%wt on feed)

gas (C_4^-)	:	2.0
gasoline (C_5-165 °C)	:	4.0
gas oil (165-350 °C)	:	12.4
heavy distillate (350-520 °C)	:	27.0
residue (520 °C^+)	:	54.6

The additional benefit in terms of "fuel reduction" is estimated to be between 0.5 and 1.0 %m on feed.

CLAIMS

1. A process for the continuous thermal cracking of hydrocarbon oils by heating a hydrocarbon oil and causing it to flow through a thermal conversion zone, characterized in that at least part of the gaseous materials produced during said heating is withdrawn from the heated oil prior to its introduction into a thermal conversion zone.

2. A process according to claim 1, characterized in that gaseous materials produced are withdrawn by means of a phase-separator from a hydrocarbon oil which has been heated to a temperature between 350 °C and 550 °C.

3. A process according to claim 2, characterized in that gaseous materials are withdrawn by means of a cyclone.

4. A process according to any one of claims 1-3, characterized in that substantially all gaseous materials produced are withdrawn.

5. A process according to any one of claims 1-4, characterized in that the heated hydrocarbon oil depleted of gaseous materials is introduced by means of gravity into the thermal conversion zone.

6. A process according to claim 5, characterized in that the heated hydrocarbon oil depleted of gaseous materials is passed in upward flow through a soaking vessel containing internals having horizontal perforated plates.

7. A process according to claim 6, characterized in that 1-30% of the plate area is occupied by free area.

8. A process according to any one of claims 1-5, characterized in that a soaking vessel is used having its interior divided into a plurality of consecutive, interconnected compartments wherein heated hydrocarbon oil depleted of gaseous materials is caused to pass through the consecutive compartments prior to withdrawal of liquid material from the soaking vessel, and wherein gaseous materials present in the compartments are collected and withdrawn from the vessel.

9. A process according to claim 8, characterized in that the soaking vessel comprises inclined separating walls whilst fluid

passages are positioned below the higher parts of the separating walls, which fluid passages are formed by elongated open-ended tubular elements passing through openings in the separating walls.

10. A process according to any one of claims 1-7, characterized in that the material emanating from the thermal conversion zone is subjected to phase-separation prior to further processing.

11. A process according to any one of claims 1-9, characterized in that steam is introduced prior to the withdrawal of gaseous materials produced.

12. A process according to any one of claims 1-11, characterized in that the heated hydrocarbon oil is subjected to quenching prior to the withdrawal of gaseous materials present therein.

13. A process according to any one of claims 1-12, characterized in that the material emanating from the thermal conversion zone is subjected to quenching prior to further processing.

14. A process for the continuous thermal cracking of residual feedstocks substantially as described hereinbefore.

15. Apparatus for the continuous thermal cracking of hydrocarbon oils, substantially as described hereinbefore with particular reference to the accompanying drawings.

16. Hydrocarbon mixtures whenever obtained using a process as claimed in any one of claims 1-14.

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