

FOULING REDUCING DUAL PRESSURE FRACTIONAL DISTILLATOR

Field of the Invention

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This invention relates to a process for fractionating cracked hydrocarbon mixtures containing foulant precursors, such as those produced by steam cracking. More particularly, the invention relates to a method of reducing fouling by use of a dual pressure, dual column fractionation configuration.

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Description of the Prior Art

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In steam cracking, the type of feedstocks and the reaction conditions determine the mix of products produced. Many steam crackers operate on light paraffin feeds consisting of ethane and propane and the like. However, a significant amount of steam cracking capacity operates on feedstocks which contain propane and heavier compounds. Steam cracking such feedstocks produces many marketable products, notably propylene, isobutylene, butadiene, amylene and pyrolytic gasoline.

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In addition to the foregoing, small quantities of undesirable contaminants, such as di- and poly-olefins, and acetylenic compounds are produced. These contaminants may cause equipment fouling, interfere with polymerization reactions, and in some cases pose safety hazards. It is, therefore, highly desirable to remove them from the distillation stream. It is in the removal from the distillation stream of these contaminants that this invention has its application.

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During steam cracking, cracked gases emerging from the reactors are rapidly quenched to arrest undesirable secondary reactions which tend to destroy light olefins. The cooled gases are subsequently compressed and separated to recover the various olefins.

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The recovery of the various olefin products is usually carried out by fractional distillation using a series of distillation steps or columns to separate out the various components. The unit which separates the methane fraction (C₁) is referred to as the "demethanizer," the unit which separates the ethane fraction (C₂) is referred to as the "deethanizer," the unit which separates the propane fraction (C₃) is referred to as the "depropanizer," and the unit which separates the butane fraction (C₄) is referred to as the "debutanizer." The residual higher carbon number fraction (C₅+) is used as gasoline.

With the development of selective furnace designs for very high conversion of liquid petroleum gas by steam cracking the amount of C₅ products has been minimized, although at a correspondingly higher concentration of lower carbon atom number foulant precursors such as di-olefinic, poly-olefinic and acetylenic compounds. This development has served to exacerbate the fouling problem which has heretofore been encountered in the fractional distillation of C₂, C₃ and C₄ fractions from each other and from heavier hydrocarbons. Fouling of the debutanizer unit by reason of the aforementioned increase in the concentration of foulant precursors has become a particular problem of increased concern.

One of the basic problems encountered in such fractional distillation processes relates to polymer fouling of the fractional distillation columns. One such problem, for example, relates to the production of foulant precursors in steam cracking which at high temperatures cause fouling in equipment. It is well known that the rate of polymer fouling increases as temperature increases. Such fouling often necessitates the shutdown of the distillation unit for cleaning. Both the shutdown and cleaning involve significant expense.

US-A 4,824,527 to Erickson teaches a method of fractionating liquid mixtures, which are subject to thermal decomposition, wherein

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two columns are used and the first column is complete with a reboiler and/or condensor. This particular energy saving configuration decreases the required vapor and liquid flow rates in the columns sufficiently that even though a larger number of stages is required, there will usually nonetheless be a lower average residence time and liquid holdup than that for a single column system (column 6, lines 26-37).

Erickson's dual pressure, dual column method does not result in operating each of the fractional distillation columns at lower operating temperatures, and hence, does not achieve the desired result of lowering the temperatures to decrease fouling while attaining effective separation.

A need still exists for a method of reducing fouling which at the same time achieves the desired separation results.

Summary of the Invention

According to the present invention, a process for fractionating a cracked hydrocarbon mixture containing foulant precursors, to separate light and heavy components with reduced polymer fouling, comprising the steps of:

- (a) at least partially vaporizing the mixture in a preheater;
- (b) separating the partially vaporized mixture in a high pressure fractional distillation column into light components enriched in foulant precursors (b1) and heavy components diminished in foulant precursors (b2) without further heating of the heavy components (b2); and
- (c) separating the heavy components (b2) in a heated low pressure fractional distillation column

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into a tops stream (c1) and a bottoms stream (c2) containing a lower proportion of foulant precursors than the starting mixture.

5 In one preferred embodiment, the starting mixture comprises C₄ and C₅+ hydrocarbons, preferably C₃, C₄ and C₅+, (b1) is C₄, preferably C₃+C₄, (b2) is C₄ and C₅+, (c1) is C₄ and (c2) is C₅+

10 Preferably, the high pressure column is operated at 2-20 bar G and the low pressure column is operated at a pressure which is lower than that of the high pressure column, preferably zero to 7 Bar G.

Brief Description of the Drawings

15 The above and other embodiments of the present invention may be more fully understood from the following detailed description, when taken together with the accompanying drawing, in which: Fig. 1 is a flow diagram of a dual pressure, dual column debutanizer.

20 Description of the Preferred Embodiments

The present invention of a method for the reduction of fouling in the treatment of cracked hydrocarbon gases involves the use of a dual pressure, dual column fractionator configuration rather than the
25 conventional single pressure, single column fractionator configurations.

While the dual pressure, dual column fractionator configuration of the present invention is suitable for a variety of
30 fractionating column systems, Fig. 1 and the subsequent discussion describes, without in any way limiting the scope of the present invention one particular embodiment of the present invention, namely a dual pressure, dual column debutanizer. The starting mixture 10 may a mixture of cracked hydrocarbons, generally starting mixture 10



will be the bottoms stream (C₄ and C₅+) fraction from a deethanizer or a depropanizer, although alternative feed compositions and sequences are possible. The mixture 10 is fed into a preheater 11 wherein the mixture is partially or totally vaporized. Preheater 11 which serves to vaporize all or part of the mixture is operated at temperatures ranging from about 10 to about 200°C, preferably from about 50 to about 90°C.

The preheated mixture 12 is fed to a high pressure fractional distillation column 13 wherein preheated mixture 12 is divided into a light fraction 14 and a heavy fraction 15. Preheated mixture 12 entering the high pressure fractional distillation column is at a pressure ranging from about 3 to about 20, preferably about 7 Bar G. Bar G represents bars at gauge or a measure of pressure where the gauge will read 0 at a pressure of 1 atmosphere. Vaporized mixture 12 is preferably introduced to the high pressure fractional distillation column at or near the bottom tray of the high pressure fractional distillation column 13. Light fraction 14 typically includes a C₄ fraction which contains from about 30 to about 100, preferably about 85 weight percent of all the foulant precursors contained in vaporized mixture 12. Light fraction 14 represents from about 10 to about 99, preferably about 80 weight percent of preheated mixture 12. Heavy fraction 15 includes the bulk of the C₅+ hydrocarbons.

Heavy fraction 15 is fed to a low pressure fractional distillation column 16, wherein the heavy fraction 15 is divided into a tops stream 17 and a bottoms stream 18. Low pressure fractional distillation column 16 includes a reboiler loop 27.

Tops stream 17 includes any remaining C₄ hydrocarbons while bottoms stream 18 includes the C₅+ hydrocarbon fraction which may be used for gasoline.

Light fraction 14 is condensed in a condenser 19 to form a



condensed stream 20. A reflux stream 21 is recirculated into high pressure column 13. Tops stream 17 is condensed in a low pressure condenser 22 to form a condensed stream 23. A reflux stream 24 is recirculated into low pressure column 16. The balance of condensed stream 20, indicated as 25, is combined with balance of condensed stream 23, indicated as 26. Bottoms stream 18 from the low pressure fractional distillation column 16 includes the C₅+ fraction which may be used as gasoline.

Fouling is reduced in the high pressure column 13 in spite of the high concentration of foulant precursors present in the starting mixture 12, due to the low temperature at which the column is operated, which temperature ranges from about -50 to about 200°C, preferably from about -10 to about 110°C. The high pressure column 13 is operated at pressures ranging from about 2 to about 20, preferably about 6 Bar G. The high pressure column is not operated in a stripping mode which obviates the need for a reboiler loop. The source of heat for operation of the column is restricted to heat generated by the preheater which vaporizes the feed.

Fouling is reduced in low pressure column 16 because it is also operated at temperatures below those required in a conventional single pressure, single column configuration. The temperatures for operation of the low pressure column 16 range from about -50 to about 200, preferably from about 10 to about 65°C. Although the low pressure column operates in a stripping mode with a reboiler loop, the fact that it operates at lower temperatures taken together with both the reduced content of C₄ contaminants in the feed 15, and the overall reduction of feed volume entering the column serve to reduce the level of fouling in this column. Low pressure column 16 is operated at pressures ranging from about 0 to about 7, preferably about 2 Bar G. Operation of the dual pressure fractional distillator of the present invention additionally results in an overall energy savings.

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Claims

1. A process for fractionating a cracked hydrocarbon mixture containing foulant precursors, to separate light and heavy components with reduced polymer fouling, comprising the steps of:
- 5
- (a) at least partially vaporizing the mixture in a preheater;
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- (b) separating the partially vaporized mixture in a high pressure fractional distillation column into light components enriched in foulant precursors (b1) and heavy components diminished in foulant precursors (b2) without further heating of the heavy components (b2); and
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- (c) separating the heavy components (b2) in a heated low pressure fractional distillation column into a tops stream (c1) and a bottoms stream (c2) containing a lower proportion of foulant precursors than the starting mixture.
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2. A process of claim 1 when performed in a debutanizer wherein the starting mixture comprises C₄ and C₅+ hydrocarbons; (b1) comprises C₄ hydrocarbons; (b2) comprises C₄ and C₅+ hydrocarbons; (c1) comprises C₄ hydrocarbons; and (c2) comprises C₅+ hydrocarbons.
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3. The process of any preceding claim, wherein the starting mixture comprises C₃, C₄ and C₅+ hydrocarbons.
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4. The process of any preceding claim, wherein (b1) contains from 30 to 100%, preferably greater than 50%, of the foulant precursors contained in the starting mixture.





5. The process of any preceding claim, wherein (b1) comprises from 10 to 99 weight percent of the starting mixture.

5 6. The process of any preceding claim, wherein step (a) is performed at a temperature of from 10 to 150°C and/or a pressure of from 3 to 20 Bar G.

10 7. The process of any preceding claim, wherein step (b) is performed at a temperature from -10 to 110°C and/or a pressure of from 2 to 20 Bar G.

15 8. The process of any preceding claim, wherein step (c) is performed at a temperature from 10 to 65°C and/or a pressure of from 0 to 7 Bar G

20 9. The process of any preceding claim which comprises the additional step, after step (c), of: combining the light components (b1) with the tops stream (c1) to produce a light fraction containing a higher proportion of foulant precursors than the starting mixture.

10. Motor gasoline comprising hydrocarbon derived from bottoms stream (C₂) produced by the process according to any preceding claim.

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