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(54) **Eljárás olefinek előállítására termikus vízgőzös krakkolással krakkoló kemencékben**

Method for producing olefins by means of thermal steam cracking in cracking furnaces

The present invention relates to a process for converting hydrocarbon inputs by thermal steamcracking to at least one olefin-containing product stream comprising at least ethylene and propylene, with at least partial conversion of a first hydrocarbon input in at least one first cracking furnace and of a second hydrocarbon input in at least one second cracking furnace.

Thermal steamcracking is a long-established petrochemical process. The standard target compound in thermal steamcracking is ethylene (also ethene), which is an important starting compound for a number of chemical syntheses.

The inputs used for the thermal steamcracking may be either gases such as ethane, propane or butane and corresponding mixtures or liquid hydrocarbons, for example naphtha, and hydrocarbon mixtures.

With regard to the specific apparatuses and reaction conditions used in thermal steamcracking, and with regard to the reactions which proceed and to details of refinery technology, reference is made to corresponding articles in reference works such as Zimmermann, H. and Walzl, R.: Ethylene, in: Ullmann's Encyclopedia of Industrial Chemistry, 6th ed. Weinheim: Wiley-VCH, 2005, and Irion, W.W. and Neuwirth, O.S.: Oil Refining, in: Ullmann's Encyclopedia of Industrial Chemistry. 6th ed. Weinheim: Wiley-VCH 2005. Processes for preparing olefins are also disclosed, for example, in US 3 714 282 A and US 6 743 961 B1, which includes a process for preparing olefins in which heavy oil is pretreated in a mild cracking process before it is conducted into a furnace for thermal cracking.

In addition, mention should be made here of US 2004/209964, which discloses that hydrocarbons which have a carbon number between 15 and 30 and have been produced by a Fischer-Tropsch synthesis and fractionated are hydrogenated and then thermally cracked under mild conditions.

For thermal steamcracking, cracking furnaces are used. The cracking furnaces, together with a quench unit and downstream devices for processing of the product mixtures formed, are integrated into corresponding larger plants for olefin production, which are referred to in the context of this application as "steamcrackers".

An important parameter in thermal steamcracking is the cracking severity, which determines the cracking conditions. The cracking conditions are influenced especially by the temperature and residence time and the partial pressures of the hydrocarbons and of the steam. The composition of the hydrocarbon mixtures used as the input and the design of the cracking furnaces used also influence the cracking conditions. Because of the mutual influences of these factors, the cracking conditions are normally defined via the ratio of propylene (also referred to as propene) to ethylene in the cracking gas.

According to the input mixture and cracking conditions, thermal steamcracking gives rise not only to ethylene, the standard target compound, but also to sometimes considerable amounts of by-products, which can be separated from a corresponding product stream. These include lower alkenes, for example propylene and butenes, and also dienes, for example butadienes, and also aromatics, for example benzene, toluene and xylenes. These are of comparatively high economic value, and so the formation thereof as "high-value products" is desirable.

US 2008/0194900 A1 discloses a process for producing olefins by steamcracking of aromatic naphtha, in which ethane formed, propane and a C5 olefin stream formed can be recycled into the cracking.

US 6 743 961 B2 discloses a process for producing olefins, in which crude oil is partly evaporated in a combined evaporation and cracking unit. The vapour formed and the remaining liquid are cracked under different cracking conditions.

US 2004/209964 A1 proposes a process in which a Fischer-Tropsch product stream is fractionated. Hydrocarbons of different chain lengths are cracked under different cracking conditions.

The problem addressed by the present invention is that of improving the means of obtaining olefin-containing product mixtures from hydrocarbons by thermal steamcracking.

Disclosure of the invention

Against this background, the invention proposes a process for converting hydrocarbon inputs by thermal steamcracking to an olefin-containing product stream comprising at least ethylene and propylene, with at least partial conversion of a first hydrocarbon input in at least one first cracking furnace and of a second hydrocarbon input in at least one second cracking furnace, having the features of the independent claims. Preferred configurations are the subject of the dependent claims and of the description which follows.

Advantages of the invention

According to the invention, a process is proposed in which the second hydrocarbon input is converted in the second cracking furnace with cracking conditions that lead to a ratio of propylene to ethylene of 0.85 to 1.6 kg/kg, and the first hydrocarbon input is converted in the first cracking furnace with cracking conditions that lead to a ratio of propylene to ethylene of 0.25 to 0.85 kg/kg at the cracking furnace exit, the value for the ratio of propylene to ethylene for the second hydrocarbon input being above the value for the ratio of propylene to ethylene for the first hydrocarbon input. These first and second hydrocarbon inputs differ in terms of composition.

In the context of the invention, the first and second hydrocarbon inputs refer to all hydrocarbons which are conducted into the first and second cracking furnaces respectively. Thus, a first hydrocarbon input is at least partly converted in a first cracking furnace and a second hydrocarbon input in a second cracking furnace, each under cracking conditions as specified in Claim 1. Cracking conditions as exist in the second cracking furnace and as specified in Claim 1 with the corresponding ratio of propylene to ethylene are referred to hereinafter as mild cracking conditions, whereas cracking conditions as exist in the first cracking furnace and which are likewise specified in Claim 1 by the ratio of propylene to ethylene are referred to hereinafter as normal cracking conditions. Normal cracking conditions are cracking conditions as typically used in thermal steamcracking.

A cracking furnace is understood in the context of this invention to mean a cracking unit in which the cracking conditions are defined. It is possible that a subdivision into two or more cracking furnaces is present in one overall furnace. In that case, reference is frequently made to furnace cells. A plurality of furnace cells forming part of an overall furnace generally have independent radiation zones and a common convection zone, and also a common smoke outlet. In these cases, each furnace cell can be operated with its own cracking conditions. Each furnace cell is thus a cracking unit and is consequently referred to here as a cracking furnace. In that case, the overall furnace has a plurality of cracking units or, in other words, it has a plurality of cracking furnaces. If only one furnace cell is present, this is the cracking unit and hence the cracking furnace. Cracking furnaces can be combined to form groups, which are supplied, for example, with the same input. The cracking conditions within a furnace group are generally adjusted to be the same or similar.

The thermal cracking of hydrocarbons of typical composition, for example naphtha, under mild cracking conditions gives rise to very large amounts of pyrolysis gasoline, which is very difficult to deal with because of the large amount. This is a result of the comparatively lower conversion of the input in the cracking furnace under mild cracking conditions. Mild cracking conditions, however, are desirable since a greater ratio of propylene to ethylene is present in the case of cracking under mild conditions than in the case of cracking under normal cracking conditions as typically used.

The process according to the invention makes it possible to operate the second cracking furnace under mild cracking conditions, since the input and cracking conditions are matched to one another. Only through the matching of input and cracking conditions is it possible to avoid the disadvantages described in the previous paragraph. These disadvantages and the solution indicated have been recognized in the context of the invention.

The process according to the invention thus makes it possible to operate a steamcracking plant in such a way that more propylene is formed in relation to the fresh input than in a conventional plant in which the process according to the invention is not used.

The higher the ratio of propylene to ethylene selected for the cracking conditions in the second cracking furnace, the more propylene is formed in relation to the fresh input. This is advantageous in the context of the invention. However, a higher ratio of propylene to ethylene is associated with a lower conversion of the input, and so the values are subject to upper technical and economic limits. Within the limits specified in the claims, it is guaranteed that, on the one hand, the inventive advantages will be achieved and, on the other hand, the steamcracker will be controllable in an industrial context and operable in an economically viable manner.

Within the limits specified for the cracking conditions in the first cracking furnace, industrially and economically advantageous steamcracking is possible, which forms ethylene and propylene as primary products of value.

Advantageously, the second hydrocarbon input is converted in the second cracking furnace with cracking conditions that lead to a ratio of propylene to ethylene to 1.4 kg/kg, more preferably of 0.85 to 1.2 kg/kg, at the cracking furnace exit.

Advantageously, the first hydrocarbon input is converted in the first cracking furnace with cracking conditions that lead to a ratio of propylene to ethylene of 0.3 to 0.75 kg/kg, more preferably of 0.4 to 0.65 kg/kg, at the cracking furnace exit.

More particularly, the values for the ratio of propylene to ethylene for the first and second hydrocarbons differ by at least 0.1 kg/kg, preferably by at least 0.15 kg/kg, more preferably by at least 0.2 kg/kg, for the advantages of the invention to be achieved to a particular degree.

According to the invention, the second hydrocarbon input comprises predominantly hydrocarbons having a maximum carbon number of 5. Such a hydrocarbon input is particularly suitable for cracking under mild conditions. This is true to a very particular degree when the second hydrocarbon input consists for the most part of hydrocarbons having a carbon number of 5 or/and 4.

The word "predominantly" is used in the context of this application to make it clear that the input or the fraction does not consist exclusively of hydrocarbons having the specified carbon number, but that hydrocarbons having other carbon numbers and other impurities may also be present alongside the hydrocarbons of the specified carbon number. The separation and processing of the fresh input, of the product stream and/or the fractions always leaves residues of the component(s) in the product stream or in the fraction. Other impurities also persist, and so a processed product stream or fraction stream always contains residues. Since the cost and inconvenience associated with separation and processing rise to an extremely high degree with the purity to be achieved, economic factors decide what proportion of residues may be present in a stream. The level of this proportion has to be weighed up according to economic considerations. A rough guide value for the proportion of unwanted hydrocarbons and other impurities will generally be that not more than 30 to 40 percent by weight may be present in the product stream and/or in the fraction. Usually, a maximum value of 15 percent by weight or less is actually attained. The hydrocarbon input therefore contains the desired hydrocarbons at at least 60 percent by weight, preferably at least 80 percent by weight and further preferably at least 90 percent by weight and more preferably at least 95 percent by weight and most preferably at least 98 percent by weight. This applies to the fresh input, to input obtained from the fresh input fractionation, and to input from recycled components.

In a particularly advantageous configuration of the invention, the second cracking furnace is supplied with one or more recycled fractions which are obtained from the product stream and which comprise predominantly hydrocarbons having a carbon number of not more than 5. The second hydrocarbon input thus comprises recycled fractions. Recycling of such fractions increases the amount of suitable input for the second cracking furnace, or such a fraction constitutes a suitable second hydrocarbon input for the second cracking furnace. A fraction comprising hydrocarbons having a carbon number of 4 and a fraction having a carbon number of 5 are also obtained in the processing of the product stream in steamcrackers, and these, after separation of the products of value, can be recycled directly or after further treatment steps.

In addition, it is advantageous to supply the first cracking furnace with at least one fraction which has been separated from the product stream and recycled, and which comprises predominantly hydrocarbons having a carbon number of at least 6. Such a fraction is suitable as the first hydrocarbon input for the first cracking furnace.

Particularly advantageously, a fresh input is used, which is fractionated into at least one first and one second fresh input fraction, and the first fresh input fraction is conducted at least partly into the first cracking furnace and the second fresh input fraction at least partly into the second cracking furnace. A fractionation of the fresh input can achieve the effect that, particularly for the second cracking furnace, an input is available which can achieve the advantages of the invention in an outstanding manner. These first and second fresh input fractions have a different composition. It is thus emphasized that the division of the fresh input is a fractionation and not a simple division into two amounts. In a fractionation, a separation is effected according to different components. After the fractionation, some components of the fresh input are thus present predominantly in the first fresh input fraction, and other components of the fresh input are present predominantly in the second fresh input fraction.

In a further advantageous configuration of the invention, the second cracking furnace is supplied with a fresh input consisting predominantly of hydrocarbons having a maximum carbon number of 5. Such a fresh input can be obtained, for example, in a refinery or in natural gas production. Because of its characteristics, it is of very good suitability as an input in the second cracking furnace under mild cracking conditions.

It should be emphasized once again here that the aforementioned inputs (recycled fractions, fresh input fraction and fresh inputs composed of hydrocarbons having a maximum carbon number of 5) are suitable as inputs for the second cracking furnace, since all of them are outstandingly suitable for mild cracking. In order to gain the advantages of the invention, the inputs proposed here can be conducted individually or as a mixture into the second cracking furnace. The second hydrocarbon input used may thus be one or more recycled fractions or a fresh input fraction or another input composed of hydrocarbons having a maximum carbon number of 5. It is also possible to use recycled fraction(s) and a fresh input fraction or recycled fraction(s) and another input composed of hydrocarbons having a maximum carbon number of 5 or a fresh input fraction and another input composed of hydrocarbons having a maximum carbon number of 5 or a mixture of all the possible inputs as the second hydrocarbon input.

As explained at the outset, the ratio of propylene to ethylene in the thermal steamcracking operation results from a number of different influencing factors, among which the cracking furnace exit temperature, i.e. the temperature of a product stream on departure from the reactor coil used (coil output temperature), plays an important role. The cracking furnace exit temperature for the conversion in the second cracking furnace is advantageously between 680°C and 820°C, preferably between 700°C and 800°C and further preferably between 710°C and 780°C and more preferably between 720°C and 760°C, while the cracking furnace exit temperature for the conversion in the first cracking furnace is advantageously between 800°C and 1000°C, preferably between 820°C and 950°C and more preferably between 840°C and 900°C. The cracking furnace exit temperature in the first cracking furnace is always higher than in the second cracking furnace.

The cracking furnace exit temperature for the conversion in the first cracking furnace is preferably at least 10°C above, more preferably at least 15°C above and most preferably at least 20°C above, the cracking furnace exit temperature for the conversion in the second cracking furnace.

In the second cracking furnace, a lower steam dilution than in the first can also be used. This reduces the amount of dilution steam needed and saves energy. However, a lower steam dilution in the second cracking furnace is unnecessary for the significant advantages of the invention to be manifested. Advantageously, in the second cracking furnace 0.15 to 0.8 kg of steam per kg of hydrocarbon is used in the input, whereas in the first cracking furnace 0.3 to 1.5 kg of steam per kg of hydrocarbon is used in the input.

It is also advantageously possible to convert especially saturated hydrocarbons having a carbon number of 2 to 3 present in the product stream by means of thermal steamcracking in a cracking furnace for gaseous input. To this end, the saturated gaseous hydrocarbons are obtained from the product stream, and recycled into and converted in the cracking furnace for gaseous input.

The fresh inputs used for the first hydrocarbon input or/and the fresh inputs used for fresh input fractionation may be either gases or gas fractions, such as ethane, propane or butane, and corresponding mixtures and condensates, or liquid hydrocarbons and hydrocarbon mixtures. These gas mixtures and condensates comprise especially what are called natural gas condensates (natural gas liquids, NGL). The liquid hydrocarbons and hydrocarbon mixtures may originate, for example, from what is called the gasoline fraction of crude oil. Such crude gasolines or naphthas (NT) and kerosene are mixtures of preferably saturated compounds having boiling points between 35 and 210°C. However, the invention is also advantageous in the case of use of middle distillates, atmospheric residues and/or mixtures derived therefrom from crude oil processing. Middle distillates comprise what are called light and heavy gas oils which can be used as starting materials for production of light heating and diesel oils and of heavy heating oil. The compounds present have boiling points of 180 to 360°C. They are preferably predominantly saturated compounds which can be converted in a thermal steamcracking operation. In addition, it is also possible to use fractions obtained by known distillative separation processes and corresponding residues, but also the use of fractions derived therefrom, for example by hydrogenation (hydrotreating) or hydrocracking. Examples are light, heavy and vacuum gas oil (atmospheric gas oil, AGO, or vacuum gas oil, VGO), and also mixtures and/or residues treated by the hydrogenation processes mentioned (hydrotreated vacuum gas oil, HVGO, hydrocracker residue, HCR, or unconverted oil, UCO).

Very particularly advantageous fresh inputs for the first hydrocarbon input are liquid hydrocarbons. More particularly, the fresh inputs used are natural gas condensates and/or crude oil fractions and/or mixtures derived therefrom.

Advantageously, the invention thus encompasses the use of hydrocarbon mixtures having a boiling range of up to 600°C as the first hydrocarbon input as fresh input for the first hydrocarbon input. Within this overall range, it is also possible to use hydrocarbon mixtures having different boiling ranges, for example having boiling ranges of up to 360°C or of up to 240°C. The reaction conditions in the cracking furnace are matched here to the hydrocarbon mixtures used in each case.

For instance, the invention can, however, also be used advantageously with any desired fresh inputs having comparable properties, for example biogenic or/and synthetic hydrocarbons.

Brief description of the drawing

The process according to the invention in a particularly advantageous configuration is to be elucidated in detail with reference to the process flow diagrams which show the essential process steps in schematic form. For better understanding, the known process is first illustrated with reference to figure 1.

Figure 1 shows to this end a schematic view of a known method for olefin production. Figure 2 shows a schematic view of the essential steps of the process according to the invention in a particularly advantageous configuration, and figures 3 and 4 show, likewise in schematic form, the essential steps of a particularly advantageous configuration of the invention. In the figures, corresponding elements bear identical reference numerals.

The schematic process flow diagram 100 of figure 1 for the known process includes a cracking furnace 1 into which the fresh input A (for example naphtha) and the recycled fractions S and P as hydrocarbon inputs are conducted. In the cracking furnace 1, the hydrocarbon input is heated and converted in convection and radiation zones. Steam is added to the cracking furnace, usually 0.5 to 1 kg of process steam per kg of hydrocarbon. A product stream C emerges from the cracking furnace 1, and this is also referred to as the cracking product stream directly at the exit from the cracking furnace. On exit from the cracking furnace, this cracking product stream has a temperature normally between 840°C and 900°C. The ratio of propylene to ethylene is generally 0.35 to 0.6 kg/kg. After a first quench (not shown), the product stream is processed in a processing unit 4. From the processing unit, the following fractions are obtained as essential product fractions E to N: hydrogen E, waste liquor F, methane G, ethylene H, propylene I, gaseous hydrocarbons L having a carbon number of 4, pyrolysis gasoline M and pyrolysis oil N. The gaseous hydrocarbons L having a carbon number of 4 are treated further in a C4 processing unit 5, which is utilized for the processing of hydrocarbons having a carbon number of 4. Such a C4 processing unit 5 treats the fraction having a carbon number of 4 further in such a way that butadiene O can be removed. The other hydrocarbons having a carbon number of 4 constitute a fraction P which is recycled into the cracking furnace 1. The pyrolysis gasoline M comprising hydrocarbons having a carbon number of 5 or more is processed further in a pyrolysis gasoline processing unit 6, and aromatics Q and hydrocarbons R having a carbon number of, for example, more than 9 are removed. The other hydrocarbons having a carbon number of 5 or more are recycled as fraction S into the cracking furnace 1. The processing unit 4, and also the C4 processing unit 5 and the pyrolysis gasoline processing unit 6, comprise customary units for further processing of the product stream or of the product fractions, which serve to execute various process steps, for example compression, condensation and cooling, drying, distillation and fractionation, extraction and hydrogenation. The process steps are customary in olefin plants are are known to those skilled in the art.

The schematic process flow diagram 10 of figure 2 then shows the process according to the invention in a particularly advantageous configuration, and the essential process steps thereof. In addition to the cracking furnace 1, a second cracking furnace 2 is present here, as is a fresh input fractionation unit 7. A fresh input B (for example naphtha) is then fractionated in the fresh input fractionation unit 7 and the first fresh input fraction B1 is conducted into the first cracking furnace 1, while the second fresh input fraction B2 is conducted into the second cracking furnace 2. For the processes for fractionation of the fresh input, the customary methods for separation and treatment of hydrocarbon streams are used, as known from olefin plants from refineries. The person skilled in the art knows of these, and how to use them. A fraction U is additionally recycled into the first cracking furnace 1, and the fractions T and P are additionally recycled into the second cracking furnace 2 (for further details see below). In addition, the second cracking furnace is supplied with a further input BL composed of hydrocarbons having a maximum carbon number of 5 as a fresh input. In turn, the cracking product stream C having the abovementioned properties emerges from the first cracking furnace 1. The cracking product stream X emerges from the second cracking furnace 2. The cracking product stream X is at a temperature advantageously between 700°C and 800°C. The ratio of propylene to ethylene therein is advantageously between 0.85 and 1.5 kg/kg. The product streams C and X are processed further in the processing unit 4 and combined at a suitable point to give a common product stream. The processes for further treatment and processing in the processing unit 4 are known and have just been described. Thus, the processing unit 4 also leads, as just described, to the product fractions E to N. The product fractions L and M too, as just described, are treated further in the specific processing units 5 and 6. In contrast to the process described in figure 1, the fraction P comprising hydrocarbons having a carbon number of 4 is then advantageously also recycled not into the cracking furnace 1 but into the second cracking furnace 2. In the pyrolysis gasoline processing unit 6, as well as the abovementioned fractions Q and R, the fractions T and U are obtained. The fraction T comprising hydrocarbons having a carbon number of 5 is advantageously recycled into the second cracking furnace 2, while the fraction U comprising hydrocarbons having a carbon number of 6 or more, especially between 6 and 9, is advantageously recycled into the first cracking furnace 1. In figure 2, various inputs for the second cracking furnace are conducted. These then form the second hydrocarbon input. It should be mentioned that the enumeration of the various inputs is not conclusive and, more particularly, that the inputs shown in figure 2 for the second cracking furnace (B2, BL, T and P) need not always all be conducted into the second cracking furnace 2; instead, it is sufficient in many cases to conduct some of the possible inputs into the second cracking furnace 2, for example a recycled fraction T composed of hydrocarbons having a carbon number of 5 and a fresh input BL composed of hydrocarbons having a maximum carbon number of 5 or, for example, recycled fractions T and P comprising hydrocarbons having carbon numbers of 5 and 4 and LPG BL. In short, the following inputs into the second cracking furnace are possible: B2, BL, T, P, B2+BL, B2+T, B2+P, BL+T, BL+P, T+P, B2+BL+T, B2+BL+P, B2+P+T, BL+P+T or B2+BL+P+T.

A particularly advantageous configuration of the invention is likewise present in figure 3. Figure 3 has the same schematic process flow diagram as also shown in figure 2. This is supplemented by a cracking furnace 3 for gaseous input, into which a fraction V is conducted as input. The fraction V comprises saturated gaseous hydrocarbons having a carbon number of 2 or 3, which are likewise obtained in the processing unit 4.

Figure 4 too shows an advantageous configuration of the invention. Figure 4 includes the same schematic process flow diagram as figure 2, except that the fresh input fractionation is absent here. Fresh input is added here as fresh input B to the first cracking furnace 1, and a fresh input BL composed of hydrocarbons having a maximum carbon number of 5 is added to the second cracking furnace 2. The further process steps have already been elucidated in the figure description for figure 2.

List of reference numerals

1	cracking furnace (normal cracking conditions)
2	cracking furnace (mild cracking conditions)
3	cracking furnace for gaseous input
4	processing unit
5	C4 processing unit
6	pyrolysis gasoline processing unit
7	fresh input fractionation unit
10	schematic process flow diagrams for a known process
100	schematic process flow diagrams for the process according to the invention in a particularly advantageous configuration
A, B, BL	fresh input
B1, B2	fresh input fractions
C, D, X	product streams
E–V	product fractions

Szabadalmi igénypontok

1. Eljárás szénhidrogén betáplált anyag átalakítására termikus vízgőzös krakkolással egy olefint tartalmazó termékárammá, amely legalább etilént és propilént tartalmaz, egy első szénhidrogén betáplált anyag legalább részleges átalakításával legalább egy (1) első krakkoló kemencében és egy második szénhidrogén betáplált anyag legalább részleges átalakításával legalább egy (2) második krakkoló kemencében, **azzal jellemezve, hogy** a második szénhidrogén betáplált anyagot átalakítjuk a (2) második krakkoló kemencében, olyan krakkolási feltételek mellett, amelyek 0,85-1,6 kg/kg propilén/etilén arányhoz vezetnek a kemence kimeneténél, és **azzal, hogy** az első szénhidrogén betáplált anyagot átalakítjuk az (1) első krakkoló kemencében, olyan krakkolási feltételek mellett, amelyek 0,25-0,85 kg/kg propilén/etilén arányhoz vezetnek a kemence kimeneténél, és a propilén/etilén arány értéke a második szénhidrogén betáplált anyagnál magasabb mint az első szénhidrogén betáplált anyagnál kapott értékek, és a második szénhidrogén betáplált anyag elsősorban legfeljebb 5 szénatomos szénhidrogéneket tartalmaz.

2. Az 1. igénypont szerinti eljárás, **azzal jellemezve, hogy** a második szénhidrogén betáplált anyagot átalakítjuk a (2) második krakkoló kemencében, olyan krakkolási feltételek mellett, amelyek 1,2 kg/kg propilén/etilén arányhoz vezetnek a kemence kimeneténél.

3. Az 1. vagy 2. igénypont szerinti eljárás, **azzal jellemezve, hogy** az első szénhidrogén betáplált anyagot átalakítjuk az (1) első krakkoló kemencében, olyan krakkolási feltételek mellett, amelyek 0,3-0,75 kg/kg, előnyösen 0,4-0,65 kg/kg propilén/etilén arányhoz vezetnek a kemence kimeneténél.

4. Az 1-3. igénypontok bármelyike szerinti eljárás, ahol az első és a második szénhidrogén betáplált anyagra vonatkozó propilén-etilén arány értékek különbsége legalább 0,1 kg/kg, előnyösen legalább 0,15 kg/kg, és előnyösebben legalább 0,2 kg/kg.

5. Az 1-4. igénypontok bármelyike szerinti eljárás, **azzal jellemezve, hogy** a második szénhidrogén betáplált anyag nagyrész 5- és/vagy 4-tagú szénhidrogéneket tartalmaz.

6. Az 1-5. igénypontok bármelyike szerinti eljárás, **azzal jellemezve, hogy** a második krakkoló kemencébe egy vagy több visszavezetett (P, T) frakciót táplálunk be, amelyeket a termékáramból nyerünk, és amelyek elsősorban legfeljebb 5 szénatomos szénhidrogéneket tartalmaznak.

7. Az 1-6. igénypontok bármelyike szerinti eljárás, **azzal jellemezve, hogy** az első krakkoló kemencébe legalább egy (U) frakciót táplálunk be, amelyet a termékáramból különítünk el és újra felhasználjuk, és amely elsősorban legalább 6 szénatomos szénhidrogéneket tartalmaz.

8. Az 1-7. igénypontok bármelyike szerinti eljárás, **azzal jellemezve, hogy** friss betáplált anyagot alkalmazunk, amelyet legalább egy első és legalább egy második friss betáplált anyag frakcióvá

frakcionálunk, és az első friss betáplált anyag frakciót legalább részben az első krakkoló kemencébe vezetjük, és a második friss betáplált anyag frakciót legalább részben a második krakkoló kemencébe vezetjük

9. Az 1-8. igénypontok bármelyike szerinti eljárás, **azzal jellemezve, hogy** a (2) második krakkoló kemencébe nemcsak a (B2) második friss betáplált anyag frakciót, hanem további (BL) friss betáplált anyagot is betáplálunk, amely elsősorban legfeljebb 5 szénatomos szénhidrogéneket tartalmaz.

10. Az 1-9. igénypontok bármelyike szerinti eljárás, ahol a krakkoló kemence kilépési hőmérséklet a (2) második krakkoló kemencében történő átalakításhoz 680°C és 820°C közötti, előnyösen 700°C és 800°C közötti, előnyösebben 710°C és 780°C közötti, és még előnyösebben 720°C és 760°C közötti, és a krakkoló kemence kilépési hőmérséklet a (1) első krakkoló kemencében történő átalakításhoz 800°C és 1000°C közötti, előnyösen 820°C és 950°C közötti, és előnyösebben 840°C és 900°C közötti; az (1) első krakkoló kemence kilépési hőmérséklete magasabb a (2) második krakkoló kemence kilépési hőmérsékleténél.

11. A 10. igénypont szerinti eljárás, ahol a krakkoló kemence kilépési hőmérséklet az (1) első krakkoló kemencében történő átalakításhoz legalább 10°C-kal, előnyösen legalább 15°C-kal, előnyösebben legalább 20°C-kal haladja meg a (2) második krakkoló kemencében történő átalakításhoz szükséges krakkoló kemence kilépési hőmérsékletet.

12. Az 1-11. igénypontok bármelyike szerinti eljárás, ahol 1 kg szénhidrogén betáplált anyagra számítva az (1) első krakkoló kemencében 0,3-1,5 kg áramot, és a (2) második krakkoló kemencében 0,15-0,8 kg áramot alkalmazunk.

13. Az 1-12. igénypontok bármelyike szerinti eljárás, ahol legalább egy, főleg 2 vagy 3 szénatomos szénhidrogéneket tartalmazó (V) frakciót nyerünk a termékáramból, és egy (3) krakkoló kemencében legalább részlegesen gázállapotú betáplált anyaggá alakítjuk.

14. Az 1-13. igénypontok bármelyike szerinti eljárás, **azzal jellemezve, hogy** az alkalmazott (B) friss betáplált anyag, amelyet az (1) első krakkoló kemencéhez és/vagy a (7) friss betáplált anyag frakcionáláshoz használt friss betáplált anyaghoz használunk, természetes gáz kondenzátumokat és/vagy nyers olajfrakciókat tartalmaz, különösen naftát, és/vagy szintetikus és/vagy biogén szénhidrogéneket és/vagy ezek keverékeit.

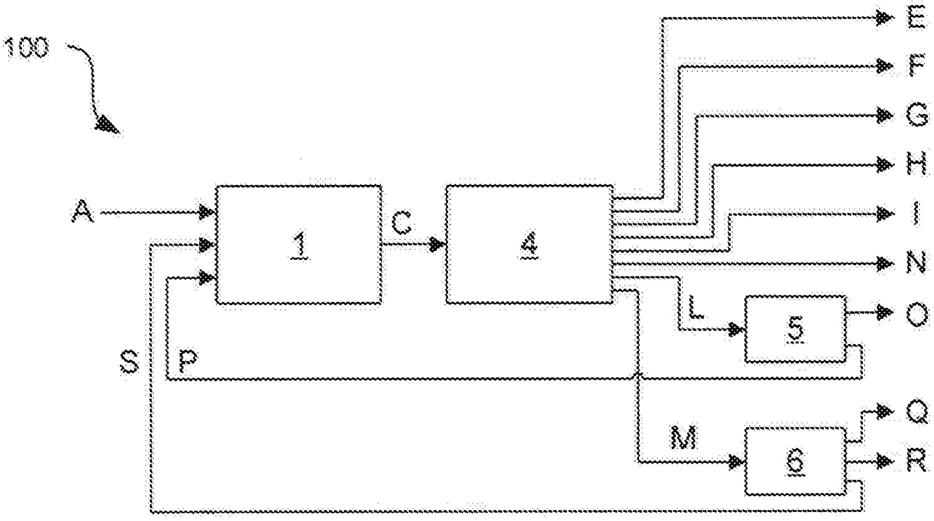
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Fig. 1

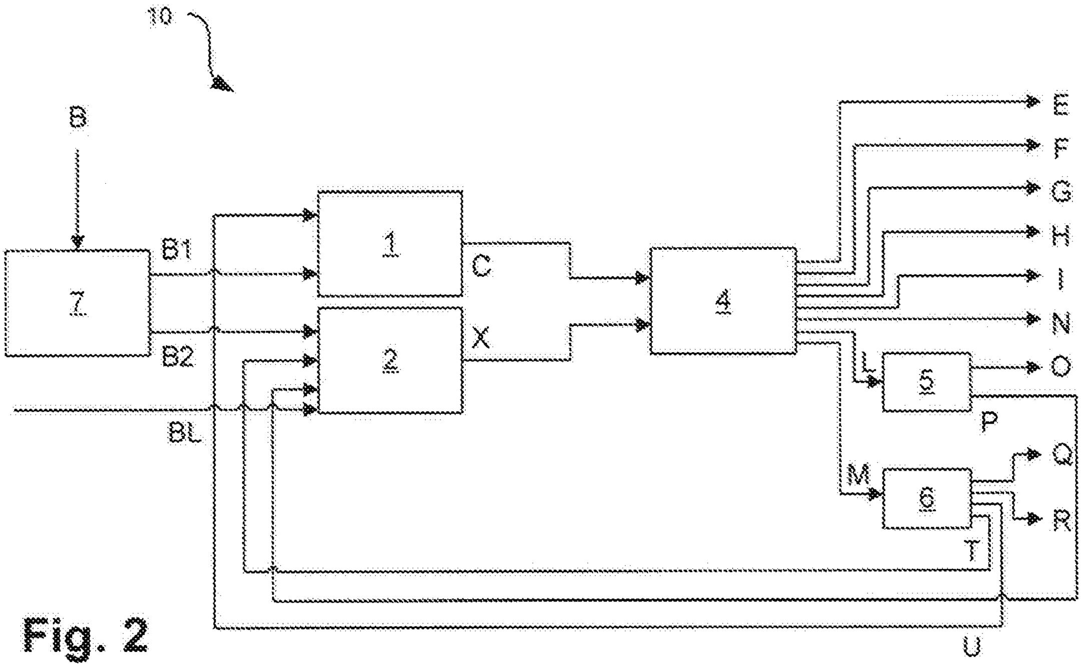
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Fig. 2

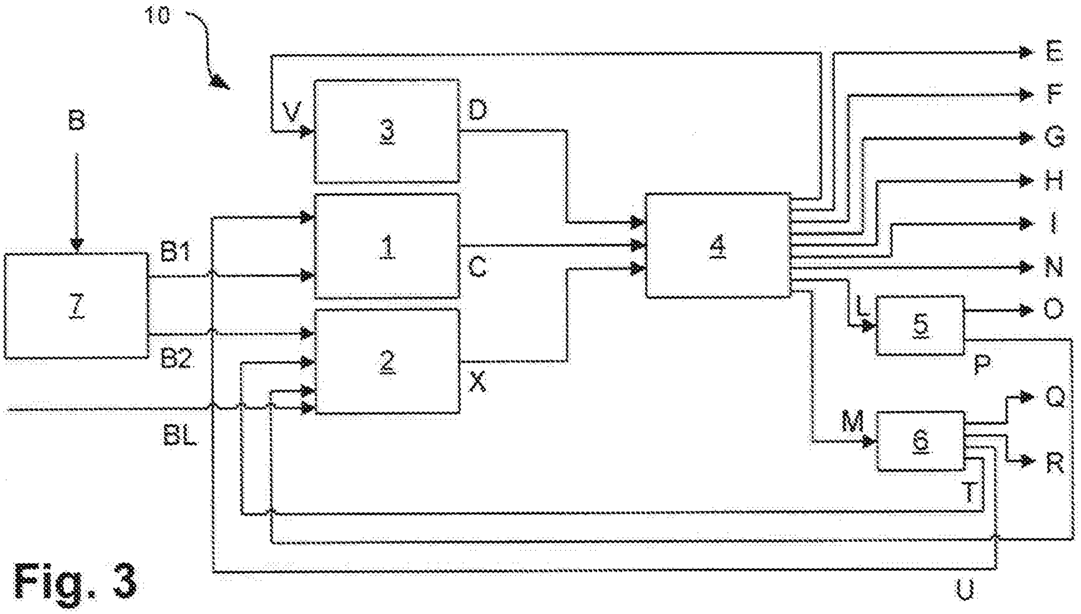
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Fig. 3

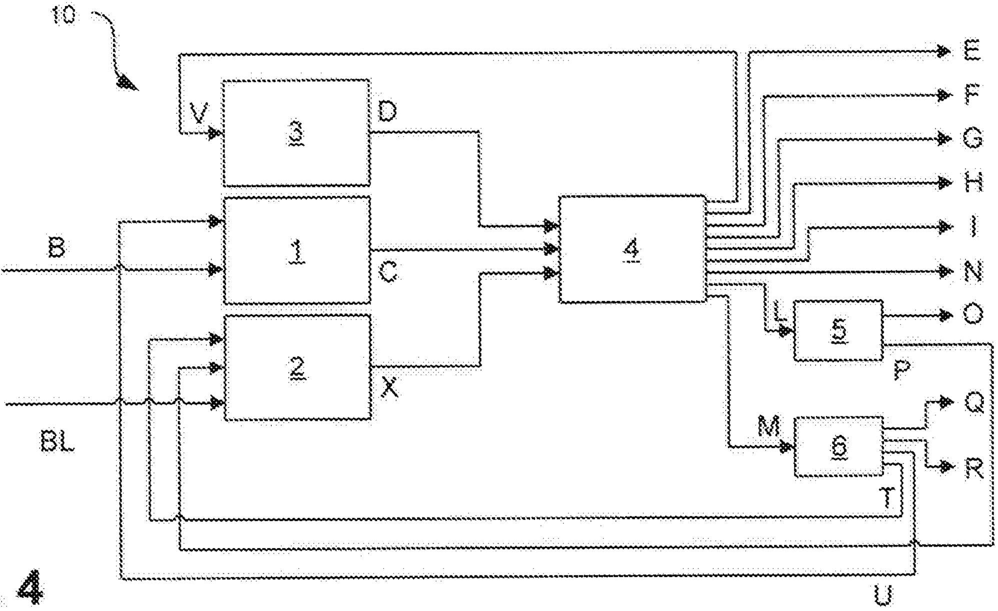
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Fig. 4