

Description

The present invention relates to a movable catalyst bed reactor suitable for the catalytic treatment of hydrocarbons, in particular catalytic desulphurization and demetallization of petroleum residues.

Movable catalyst bed reactors generally comprise a normally vertically extending cylindrical vessel having separate inlets for reactant and catalyst at the upper part of the vessel and containing catalyst bed supporting means in the shape of a downwardly converging conical surface, the lower end thereof being connected to a vertical outlet channel with a circumferential wall for the combined passage of catalyst and separation of reactor effluent, said circumferential wall being provided with a circular screen section for withdrawing reactor effluent from catalyst, said vessel further having separate outlets for reactor effluent and catalyst downstream of said screen section. See, for instance USA patent specification 3,883,312. According to this publication both, the used catalyst particles and the reactor effluent, are removed from a movable catalyst bed reactor through the same withdrawal conduit. The reactor effluent exits the conduit through openings of a circumferential screen section in its wall.

In the last years there is a tendency to carry out processes of the kind concerned on an ever increasing scale, which consequently is associated with growing problems in the design of reactors when scaled up to large capacities. One such problem is the circumstance that the catalyst bed area is inevitably growing therewith and that the cross-sectional area of the catalyst/reactor effluent outlet channel is to be increased to allow the growing mass of catalyst to pass through the outlet channel at an acceptable rate. Increase of the cross-sectional area of the catalyst/reactor outlet channel however means impairment of the catalyst/reactor effluent separation efficiency in that separation of reactor effluent from central parts of the bed becomes more and more difficult. Such scaling-up problems could be solved by e.g. a parallel arrangement as described in US patent specification 3,186,935. However, such arrangement has other disadvantages, e.g. the fact that unavoidably part of the cross-sectional reactor area will not be utilized in such arrangement, which is rather expensive for equipment of this size.

European patent specification 45.108 relates to an improved movable catalyst bed reactor of a design in which the above scaling-up difficulty inherent in the increase of the outlet channel has been overcome. According to said specification the catalyst/reactor effluent outlet channel is provided with further screen sections within its wall for with-

drawal of reactor effluent from catalyst.

Such a reactor is also known from European patent specification 70.591, in which reactor a separating section is arranged at an angle with respect to the horizontal and further comprises a means for inducing a pressure gradient with the pressure decreasing in downward direction along the separating section during operation. In this way fluid will pass obliquely through the separating section instead of perpendicularly, thereby reducing the risk of formation of a stagnant zone adjacent to a separating section.

A further problem associated with upscaling of catalytic treatment processes resides in the constructional design of large capacity reactors. Increase of the diameter of the catalyst/reactor effluent outlet channel, and thus increase of the circumferential screen section in the wall of the channel complicates manufacture and installation of the screen section. Another consequence of process upscaling is the fact that the screen sections in the outlet channels should be able to withstand ever increasing loads both in horizontal and in vertical direction.

In European patent specification 68.558, a movable catalyst bed reactor is described, in which reactor the circumferential screen section of a catalyst/reactor effluent outlet channel is composed of a plurality of separate screen segments which are preferably supported in lateral outward direction and in vertical direction by special supporting elements. The separate screen segments enable a simple fabrication and installation of the complete screen section in a reactor. According to the above-mentioned specification, the catalyst/reactor effluent outlet channels, of especially large reactor vessels may be provided with further screen sections within the outlet channels for promoting reactor effluent separation from the catalyst particles passing through said channels.

Especially in very large reactors, supporting of the screen sections in the catalyst/reactor effluent outlet channels may form a severe constructional problem, in particular if the channels are to be provided with extra internal screen sections within the outlet channels to meet the required separation efficiency.

If a reactor is provided with several superimposed catalyst beds, for example required for allowing intermediate cooling of reactor effluent, requirements are set as to the redistribution of fluid from a catalyst bed over a next lower catalyst bed. In particular when large diameter reactors are to be applied it is very important to have a proper redistribution of fluid over as much of the catalyst bed(s) as possible to keep the catalyst bed height(s) within acceptable limits. Increase of the bed height means increase of the length of the reactor vessel

and thus a considerable rise in manufacturing costs, particularly when the vessel is a so-called pressure vessel, as is normal in catalytic treatment processes.

As already mentioned hereinbefore, high capacity operation requires in general the application of further screen sections for reactor effluent withdrawal in the known movable catalyst bed reactors. For supporting such further internal screen sections special supporting constructions will be necessary for transferring the load on these screen sections to the wall of the outlet channel in which these sections are arranged.

Object of the present invention is therefore to further improve a movable bed reactor of the type specified above in order to optimize the possibilities for fluid redistribution in the reactor and to enable the application of simpler and less heavy supporting equipment of the screen sections.

The present invention therefore relates to a movable catalyst bed reactor which comprises a normally vertically extending cylindrical vessel having separate inlets for reactant and catalyst at the upper part of the vessel and separate outlets for reactor effluent and catalyst, intermediate catalyst bed supporting means and bottom catalyst bed supporting means inside the vessel, wherein at least the intermediate catalyst bed supporting means consists of a plurality of interconnected downwardly converging frusto-conical surfaces, each having its lower end connected to a spaced apart vertical outlet channel having a circumferential screen section for withdrawing reactor effluent from catalyst, the vertical outlet channels having their axes arranged substantially uniformly distributed in a circular pattern.

By the above arrangement of downwardly converging conical surfaces with accompanying vertical outlet channels, catalyst from said outlet channels can be more regularly distributed over the next lower catalyst bed supporting means than in the situation that a single annular outlet channel is applied. A more regular distribution of catalyst particles over the cross-section of the vessel means that the height of the catalyst bed(s) and therefore the total height of the vessel can be kept smaller than with the known configurations of outlet channels. The total number of outlet channels which should be chosen depends in first instance on the total screen area required for a desired throughput of reactor effluent.

Since there is a tendency to design larger reactors, the number of outlet channels is likely to increase even further. The number of outlet channels present in a certain reactor may range from 3 to several hundred, depending on the size of the individual outlet channels chosen. A suitable number of outlet channels is chosen in the range of 3

through 8, inclusive; multiples of suitable numbers, governed by geometrical design considerations, can be advantageously applied.

By the above arrangement of vertical outlet channels according to the invention, the outlet channels may be fully supported by external supporting means without the necessity of internal supporting means passing through the outlet channels.

The proposed design further enables redistribution of reactor effluent passed through the screen openings in the outlet channels over the total cross-section of the vessel prior to introducing the fluid into a next lower catalyst bed. This redistribution of the reactor effluent enables a further optimization of the minimum required catalyst bed height.

In a preferred embodiment of the reactor according to the invention, the parts of the frusto-conical surfaces facing one another are at their upper ends detachably connected to an upwardly converging conical surface substantially coaxially arranged with respect to the vessel. By this arrangement, the space between the vertical outlet channels is easily accessible for maintenance and inspection of the inner parts of the screen segments in said channels. The top angle of the upwardly converging conical surfaces and the top angle of the adjacent frusto conical surfaces are preferably substantially equal to one another and are suitably from about 30° through 90° inclusive to allow a smooth entry of catalyst particles into the vertical outlet channels.

For absorbing the load on the upwardly converging conical surface this conical surface is preferably supported by separate supporting means, for example formed by a tubular element which is in its turn supported by the supporting means of the vertical outlet channels.

The invention will now further be illustrated with reference to the accompanying drawings, wherein

Figure 1 is a schematic sectional view showing a reactor vessel provided with catalyst/reactor effluent outlet channels according to the invention;

Figure 2 schematically shows cross section II-II of Figure 1; and

Figure 3 schematically shows cross section III-III of Figure 1.

Figure 1 shows a vertical section of a normally vertically extending substantially cylindrical reactor vessel 1 having a side wall 2. The reactor vessel 1 is provided with separate inlets 3 and 4 for reactant and catalyst, respectively, in the top part 5 of the vessel and separate outlets 6 and 7 for reactor effluent and catalyst, respectively, in the bottom part 8 of the vessel. The reactor vessel 1 is internally provided with a plurality of superposed cata-

lyst bed supporting means, dividing the interior of the vessel into a plurality of reactor zones 8. The catalyst bed supporting means may be subdivided into intermediate supporting means and bottom supporting means.

The intermediate catalyst bed supporting means, generally indicated with reference numeral 9, consists of a plurality of downwardly converging frusto-conical surfaces 10 having their axes arranged in a circular pattern substantially coaxially with the main axis 11 of the reactor vessel 1. The converging conical surfaces 10 each terminate at their lower ends in a vertical outlet channel 12 for the passage of catalyst and reactor effluent. In this case the angle with the vertical axis of the conical surfaces 10 is about 20°. The conical surfaces are connected to an upwardly extending cylindrical structure 13, which in its turn is supported by cone supports 14 at the inner surface of the reactor side wall 2.

Each vertical outlet channel 12 is provided with a ring-shaped screen 15 in the channel wall for separating reactor effluent, which passes through the screen-openings, from the catalyst. The vertical outlet channels 12 each comprise a substantially cylindrical upper part 16 in which the screens are positioned, a downwardly converging intermediate part 17 and a substantially cylindrical lower part 18. The downwardly converging intermediate parts 17 are intended to increase the back pressure in the channels 12 during operation and thereby promoting the separation of reactor effluent from the catalyst via the screens 15. The half top angle of the intermediate parts 17 should preferably be chosen in the range from 15-45 degrees to promote mass-flow of catalyst through the outlet channels 11. For absorbing the vertical load on the screens 15 in the vertical outlet channels the screens are preferably supported via baffles 19 by cylindrical skirts 20 secured to the main support structure 13.

The parts of the conical surfaces 10, which face one another are at their upper end connected to a substantially centrally arranged upwardly converging cone 21. The top angle of this cone 21 is preferably chosen substantially equal to the top angle of the conical surfaces 10 to provide a smooth passage for catalyst from an upper part of the catalyst bed into the vertical outlet channels 12. The cone 21 is detachably mounted on the conical surfaces 10 via a pin/slot arrangement 22 passing through a tubular element 23. The cone 21 is supported by the main support structure 13 via a tubular element 24 and a further skirt 25.

The vessel 1 is further provided with a quench fluid supply pipe 26 extending from the top of the vessel to a quench fluid injection pipe 27 connected therewith, and with liquid distributor trays 28 above the catalyst beds supported on the conical

surfaces 10.

Although only one intermediate catalyst bed supporting means, formed by the conical surfaces 10, is shown in the drawings, it should be understood that a plurality of such intermediate superposed catalyst bed supporting means may be applied.

In the embodiment of the vessel shown in the Figures, the bottom catalyst bed supporting means, generally indicated with reference numeral 30, are formed in the same manner as the intermediate catalyst bed supporting means 9. The various components of the supporting means 30 have therefore been indicated with the same reference numerals as the parts of the supporting means 9. The vertical outlet channels 12 of the bottom catalyst bed supporting means 30 terminate at their lower ends in a single catalyst withdrawal pipe 31 passing through an opening in the bottom of the vessel thereby forming the catalyst outlet 7.

As discussed hereinbefore, it is also possible to operate a reactor having a multiple of a number of outlet channels having their axes arranged substantially uniformly distributed in a circular pattern. For instance, the number of six outlet channels as depicted in Figures 2 and 3 can be suitably arranged in the form of six arrays, or even larger multiples, e.g. in a reactor having a larger cross-section or by designing smaller outlet channels, or both. Normally, it will be the desired total circumference of the screens which will govern the number of outlet channels, whether or not in the form of multiples.

It will be understood that instead of using a single catalyst withdrawal pipe, it is also possible to have the lower vertical outlet channels extended through openings in the bottom of the vessel. In this case the catalyst outlet is formed by the lower ends of the vertical outlet channels together.

In the shown reactor design, the intermediate catalyst bed supporting means and the bottom catalyst bed supporting means have been constructed according to the invention. As already mentioned in the above, important advantages of the configuration of supporting means according to the invention are amongst others the possibility of reactor effluent redistribution over the cross-section of the vessel and the possibility of substantially uniform distribution of catalyst over a next lower catalyst bed. Since these advantages do not play a role in the bottom part of the vessel, the bottom catalyst bed supporting means may be formed differently from the intermediate catalyst bed supporting means, without departing from the invention.

The screens 15 in the vertical outlet channels 12 may be of any suitable configuration, such as for example described in European patent speci-

fication 68.558.

The movable catalytic bed reactors can be suitably applied in the catalytic treatment of hydrocarbons. They are eminently suitable in the catalytic desulphurization and demetallization of heavy hydrocarbons, in particular petroleum residues. The process conditions to be applied are well-known to those skilled in the art.

It should be noted that the present invention is not restricted to the embodiments described above by way of example. In practice the selection of the number of vertical outlet channels is dependent on the process requirements and in particular on the capacities wanted and the constructional consequences thereof.

Claims

1. Movable catalyst bed reactor comprising a normally vertically extending cylindrical vessel having separate inlets for reactant and catalyst at the upper part of the vessel and separate outlets for reactor effluent and catalyst, intermediate catalyst bed supporting means and bottom catalyst bed supporting means inside the vessel, wherein at least the intermediate catalyst bed supporting means consists of a plurality of interconnected downwardly converging frusto-conical surfaces, each having its lower end connected to a spaced apart vertical outlet channel having a circumferential screen section for withdrawing reactor effluent from catalyst, the vertical outlet channels having their axes arranged substantially uniformly distributed in a circular pattern.
2. Movable catalyst bed reactor as claimed in claim 1, wherein the number of vertical outlet channels of each intermediate catalyst bed supporting means is chosen in the range of 3 through 8, inclusive, or multiples thereof.
3. Movable catalyst bed reactor as claimed in claim 1 or 2, wherein the vertical outlet channels are supported by external supporting means fully arranged outside said channels.
4. Movable catalyst bed reactor as claimed in any one of the claims 1-3, wherein the parts of the frusto-conical surfaces facing one another are at their upper ends detachably connected to an upwardly converging conical surface substantially coaxially arranged with respect to the vessel.
5. Movable catalyst bed reactor as claimed in claim 4, wherein the top angle of the upwardly converging conical surface and the top angle

of the adjacent frusto-conical surfaces are substantially equal to one another.

6. Movable catalyst bed reactor as claimed in claim 4 or 5, wherein the top angle of the upwardly converging conical surface and the top angle of the adjacent frusto-conical surfaces are each in the range from about 30° through 90°, inclusive.
7. Movable catalyst bed reactor as claimed in any one of the claims 4-6, wherein the vessel is further provided with separate means for supporting the upwardly converging conical surface.
8. Movable catalyst bed reactor as claimed in claim 7, wherein the separate supporting means is in its turn supported by the external supporting means of the vertical outlet channels.
9. Use of a reactor as claimed in any one of claims 1-8 for the catalytic treatment of hydrocarbons.
10. Use of a reactor as claimed in claim 9, wherein petroleum residues are catalytically desulphurized and demetallized.

Revendications

1. Réacteur à lit catalytique amovible comprenant un récipient cylindrique s'étendant normalement verticalement ayant des entrées séparées pour le réactif et le catalyseur à la partie supérieure du récipient et des parties séparées pour l'effluent du réacteur et de catalyseur, un organe de support de lit de catalyseur intermédiaire et un organe de support de lit de catalyseur de fond à l'intérieur du récipient, où au moins l'organe de support de lit de catalyseur intermédiaire se compose de plusieurs surfaces tronconiques convergeant vers le bas et interconnectées, chacune ayant son extrémité inférieure reliée à un canal de sortie vertical espacé ayant une section de tamis circonferentielle pour retirer l'effluent du réacteur du catalyseur, les canaux de sortie verticaux ayant leurs axes disposés de manière répartie de façon sensiblement uniforme dans un dessin circulaire.
2. Réacteur à lit catalytique amovible selon la revendication 1, dans lequel le nombre de canaux de sortie verticaux de chaque organe de support de lit de catalyseur intermédiaire est choisi dans un intervalle de 3 à 8 compris, ou



fication 68.558.

The movable catalytic bed reactors can be suitably applied in the catalytic treatment of hydrocarbons. They are eminently suitable in the catalytic desulphurization and demetallization of heavy hydrocarbons, in particular petroleum residues. The process conditions to be applied are well-known to those skilled in the art.

It should be noted that the present invention is not restricted to the embodiments described above by way of example. In practice the selection of the number of vertical outlet channels is dependent on the process requirements and in particular on the capacities wanted and the constructional consequences thereof.

Claims

1. Movable catalyst bed reactor comprising a normally vertically extending cylindrical vessel having separate inlets for reactant and catalyst at the upper part of the vessel and separate outlets for reactor effluent and catalyst, intermediate catalyst bed supporting means and bottom catalyst bed supporting means inside the vessel, wherein at least the intermediate catalyst bed supporting means consists of a plurality of interconnected downwardly converging frusto-conical surfaces, each having its lower end connected to a spaced apart vertical outlet channel having a circumferential screen section for withdrawing reactor effluent from catalyst, the vertical outlet channels having their axes arranged substantially uniformly distributed in a circular pattern.
2. Movable catalyst bed reactor as claimed in claim 1, wherein the number of vertical outlet channels of each intermediate catalyst bed supporting means is chosen in the range of 3 through 8, inclusive, or multiples thereof.
3. Movable catalyst bed reactor as claimed in claim 1 or 2, wherein the vertical outlet channels are supported by external supporting means fully arranged outside said channels.
4. Movable catalyst bed reactor as claimed in any one of the claims 1-3, wherein the parts of the frusto-conical surfaces facing one another are at their upper ends detachably connected to an upwardly converging conical surface substantially coaxially arranged with respect to the vessel.
5. Movable catalyst bed reactor as claimed in claim 4, wherein the top angle of the upwardly converging conical surface and the top angle

of the adjacent frusto-conical surfaces are substantially equal to one another.

6. Movable catalyst bed reactor as claimed in claim 4 or 5, wherein the top angle of the upwardly converging conical surface and the top angle of the adjacent frusto-conical surfaces are each in the range from about 30° through 90°, inclusive.
7. Movable catalyst bed reactor as claimed in any one of the claims 4-6, wherein the vessel is further provided with separate means for supporting the upwardly converging conical surface.
8. Movable catalyst bed reactor as claimed in claim 7, wherein the separate supporting means is in its turn supported by the external supporting means of the vertical outlet channels.
9. Use of a reactor as claimed in any one of claims 1-8 for the catalytic treatment of hydrocarbons.
10. Use of a reactor as claimed in claim 9, wherein petroleum residues are catalytically desulphurized and demetallized.

Revendications

1. Réacteur à lit catalytique amovible comprenant un récipient cylindrique s'étendant normalement verticalement ayant des entrées séparées pour le réactif et le catalyseur à la partie supérieure du récipient et des parties séparées pour l'effluent du réacteur et de catalyseur, un organe de support de lit de catalyseur intermédiaire et un organe de support de lit de catalyseur de fond à l'intérieur du récipient, où au moins l'organe de support de lit de catalyseur intermédiaire se compose de plusieurs surfaces tronconiques convergeant vers le bas et interconnectées, chacune ayant son extrémité inférieure reliée à un canal de sortie vertical espacé ayant une section de tamis circonferentielle pour retirer l'effluent du réacteur du catalyseur, les canaux de sortie verticaux ayant leurs axes disposés de manière répartie de façon sensiblement uniforme dans un dessin circulaire.
2. Réacteur à lit catalytique amovible selon la revendication 1, dans lequel le nombre de canaux de sortie verticaux de chaque organe de support de lit de catalyseur intermédiaire est choisi dans un intervalle de 3 à 8 compris, ou



leurs multiples.

3. Réacteur à lit catalytique amovible selon la revendication 1 ou 2, dans lequel les canaux de sortie verticaux sont supportés par des organes de support externes entièrement disposés à l'intérieur desdits canaux. 5
4. Réacteur à lit catalytique amovible selon l'une quelconque des revendications 1-3, dans lequel les pièces des surfaces tronconiques qui se font face sont à leurs extrémités supérieures reliées de façon détachable à une surface conique convergeant vers le haut disposée de manière sensiblement coaxiale par rapport au récipient. 10 15
5. Réacteur à lit catalytique amovible selon la revendication 4, dans lequel l'angle supérieur de la surface conique convergeant vers le haut et l'angle supérieur des surfaces tronconiques adjacentes sont sensiblement égaux entre eux. 20
6. Réacteur à lit catalytique amovible selon la revendication 4 ou 5, dans lequel l'angle supérieur de la surface conique convergeant vers le haut et l'angle supérieur des surfaces tronconiques adjacentes sont l'un et l'autre dans un intervalle de 30° à 90° compris. 25
7. Réacteur à lit catalytique amovible selon l'une quelconque des revendications 4-6, dans lequel le récipient est encore muni d'organes séparés pour supporter la surface conique convergeant vers le haut. 30 35
8. Réacteur à lit catalytique amovible selon la revendication 7, dans lequel l'organe de support séparé est à son tour supporté par l'organe de support externe des canaux de sortie verticaux. 40
9. Application d'un réacteur selon l'une quelconque des revendications 1-8 au traitement catalytique des hydrocarbures. 45
10. Application d'un réacteur selon la revendication 9 dans lequel on effectue une désulfuration et une déméthallisation catalytiques de résidus pétroliers. 50

Patentansprüche

1. Ein Reaktor mit einem in Bewegung befindlichen Katalysatorbett, umfassend ein normalerweise sich in vertikaler Richtung erstreckendes zylindrisches Gefäß mit getrennten Einlaßöffnungen für Reaktionsteilnehmer und Katalysa- 55

tor am oberen Ende des Gefäßes und getrennten Auslaßöffnungen für den Reaktorabfluß und den Katalysator, eine in einer Zwischenzone angeordnete Stützvorrichtung für das Katalysatorbett und eine am Boden angeordnete Stützvorrichtung für das Katalysatorbett innerhalb des Gefäßes, wobei mindestens die in einer Zwischenzone angeordnete Stützvorrichtung für das Katalysatorbett aus einer Mehrzahl von miteinander verbundenen, nach unten konvergierend verlaufenden kegelstumpfförmigen Oberflächen besteht, deren untere Enden jeweils mit einem in einem Abstand vorgesehenen vertikalen Auslaßkanal verbunden sind, welcher einen am Umfang befindlichen Siebabschnitt zum Abtrennen von Reaktorabfluß vom Katalysator umfaßt, wobei die Achsen der vertikalen Auslaßkanäle in einer kreisförmigen Anordnung im wesentlichen gleichförmig verteilt sind.

2. Der Reaktor mit einem in Bewegung befindlichen Katalysatorbett nach Anspruch 1, in welchem die Anzahl vertikaler Auslaßkanäle jeder in einer Zwischenzone angeordneten Stützvorrichtung für das Katalysatorbett im Bereich von 3 bis einschließlich 8 oder ein Mehrfaches davon ausgewählt wird.

3. Der Reaktor mit einem in Bewegung befindlichen Katalysatorbett nach Anspruch 1 oder 2, in welchem die vertikalen Auslaßkanäle durch externe Stützvorrichtungen, welche völlig außerhalb der genannten Kanäle angebracht sind, abgestützt werden. 35

4. Der Reaktor mit einem in Bewegung befindlichen Katalysatorbett nach einem der Ansprüche 1 bis 3, in welchem die Teile der einander zugewandten kegelstumpfförmigen Oberflächen an ihren oberen Enden mit einer nach oben konvergierend verlaufenden konischen Oberfläche, welche in bezug auf das Gefäß im wesentlichen koaxial angeordnet ist, lösbar verbunden sind. 40 45

5. Der Reaktor mit einem in Bewegung befindlichen Katalysatorbett nach Anspruch 4, in welchem der obere Winkel der nach oben konvergierend verlaufenden konischen Oberfläche und der obere Winkel der anliegenden kegelstumpfförmigen Oberflächen im wesentlichen gleich sind. 50

6. Der Reaktor mit einem in Bewegung befindlichen Katalysatorbett nach Anspruch 4 oder 5, in welchem der obere Winkel der nach oben konvergierend verlaufenden konischen Oberflä- 55



che und der obere Winkel der anliegenden kegelstumpfförmigen Oberflächen jeweils in Bereich von ca. 30° bis einschließlich 90° liegen.

7. Der Reaktor mit einem in Bewegung befindlichen Katalysatorbett nach einem der Ansprüche 4 bis 6, in welchem das Gefäß ferner mit getrennten Vorrichtungen zum Abstützen der nach oben konvergierend verlaufenden konischen Oberfläche ausgestattet ist. 5
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8. Der Reaktor mit einem in Bewegung befindlichen Katalysatorbett nach Anspruch 7, in welchem die getrennte Stützvorrichtung ihrerseits durch die externe Stützvorrichtung der vertikalen Auslaßkanäle abgestützt wird. 15
9. Verwendung eines Reaktors nach einem der Ansprüche 1 bis 8 zur katalytischen Behandlung von Kohlenwasserstoffen. 20
10. Verwendung eines Reaktors nach Anspruch 9, in welchem Erdölrückstände katalytisch entschwefelt und entmetallisiert werden. 25

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