

Moving catalyst bed reactor for treating hydrocarbons

The present invention relates to a moving bed reactor for the catalytic treatment of hydrocarbons, in particular catalytic desulphurization and demetallization of petroleum residues, of the type which contains at least one tray as well as supporting means for one or more catalyst beds, means which are permeable to liquid and gas and impermeable to catalyst particles and in which the supporting means are at least partly in the shape of a conical surface of a truncated cone and which supporting means are attached to the wall of the reactor.

More particularly, the invention relates to a moving catalyst bed reactor comprising a vertical cylindrical vessel having separate inlets for reactant and catalyst at the upper part of the vessel and catalyst bed supporting means in the shape of one or more downwardly converging conical surfaces the lower end thereof being connected to one or more vertical outlet channels having circumferential walls for the combined passage of catalyst and separation of reactor effluent, said circumferential walls being provided with a screen section for withdrawing reactor effluent from catalyst, and separate outlet conduits for reactor effluent and catalyst downstream of said screen section.

Moving bed reactors of a design as identified above are known. Examples thereof have been described e.g. in USA Patent Specification No. 3,883,312 and in British Patent Specification No. 1,500,213. According to the US specification both the used solid catalyst and the reactor effluent are removed from a moving bed reactor through the same withdrawal conduit. The reactor effluent exits the conduit through perforations in its wall. The catalyst descends past the perforations and is washed by an upward moving wash oil which leaves through the same perforations. An alternative solution for the separation of reactor effluent and catalyst and optionally wash fluid has been described in British Patent Specification 1,500,213, the screen section being situated in the conical part of the supporting means and being of specific design consisting of bars of particular configuration and slit type sieve openings.

Both solutions have their advantages and disadvantages. Vertical screen surfaces have a rather small risk that catalyst fines may penetrate into the sieve openings, but usually have, due to constructional conditions, a smaller sieve area than a screen provided in conical supporting means.

In the last years, however, 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 constructional design of the reactors when scaled up to such large capacities. One such problem is the circumstance that the catalyst bed area is growing therewith and that

separation of reactor effluent from parts of the bed at distance from a screen area becomes more and more difficult.

Object of the present invention is to overcome such scaling-up difficulties and according to a main feature thereof, according to the invention, a moving bed reactor of the type specified above, is characterized in that the vertical outlet channels (7,26) are provided with further wall portions (5,23) within said channels each bearing a screen section (5,24) for withdrawal of reactor effluent from catalyst.

Movable catalyst bed reactors in which concentric tubular catalyst-retaining screens are present, are known from USA Patent Specification No. 3,854,887. No reference is made, however, to the presence of downwardly converging conical catalyst bed supporting means or vertical outlet channels for the combined passage of catalyst and reactant.

The invention further resides in measures for the adequate design of the supporting surface with its associated screen section adapted to the requirements in scaling-up reactors of the type concerned in which the following process and design conditions have to be taken into account.

As far as the flow of fluids and solids are concerned, the mass flow behaviour of the solids should be maintained, whilst the spread in residence time should be kept as small as possible. Further the pressure drop over the catalyst bed supporting and passage internals is to be kept as low as possible and the liquid redistribution has to be possible over an optimal percentage of the reactor cross-sectional area. Screen loads have to be in the same order of magnitude throughout the reactor for reasons of preventing as much as possible fouling of the screens and pinning of the catalyst particles against the screens. And finally, forces and stresses on the reactor internals supporting and guiding the catalyst should be carefully calculated and checked.

To this end, meeting the above requirements, according to the invention, in a moving bed reactor of the kind concerned the conical surfaces and their associated outlet channels (7) are preferably ring shaped in cross-section, the inner walls (5) of the channels bearing the further screen section (5). Further, and in particular in very large-sized reactors, a plurality of concentric ring shaped conical surfaces with associated channels may be provided, the inner (5) and outer (6) wall of each channel bearing a screen section (5, 6).

As an alternative, either as a separate provision or in combination with the above solution at least one double walled hollow partition (23) may be provided within the vertical outlet channel(s) (26) each wall thereof bearing a screen section (24). Such a partition (23) for each such

partition (23) may be circular and concentric with the outer wall of the outlet channel(s) (26). Alternatively, the or each partition (23) may be straight and extend vertically from the outer wall of the outlet channel(s) (26) to an opposite wall. In case more and at least two straight partitions (23) are present, the partitions preferably are parallel and at equal distance from each other.

Further, according to the invention, a cooling fluid inlet conduit (22) may be provided communicating with the each combined catalyst and reactor effluent outlet channel (26) below the perforated screen section (23).

In a preferred embodiment, the acute angle (4a, 4b, 21b) formed by a line (or lines) lying in the conical surface(s) (23) and the axis of the reactor preferably is from 15°—45°. Finally the vertical outlet channels may include at least one inverted conical section connected at its top and at its bottom with a cylindrical or annular screen section. Alternatively, for constructional reasons, the cylindrical or annular section may also be of polygonal configuration.

It should be noted that there are different solutions in reactor designs suitable for solving scaling-up problems. An example thereof may be a parallel arrangement, as described in USA Patent Specification No. 3,186,935. It will be clear, however, that such an arrangement unavoidably will leave part of the cross sectional reactor area non-utilized, which is rather expensive for equipment of this size.

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

Figure 1 is a schematic sectional view showing part of a reactor according to the invention;

Figure 2A is a schematic sectional view of the bottom part of an embodiment of a reactor according to the invention;

Figure 2B is a view inside the bottom part of the reactor of figure 2A from above;

Figure 3 is a schematic sectional view of the bottom part of another embodiment of a reactor according to the invention and

Figure 3A and 3B are sections of a partition wall as shown in figure 3 on an enlarged scale.

Similar parts in the embodiments shown in the figures have been identified by the same reference numerals as used herein before, whilst no reference numerals have been used for those parts not requiring further elucidation for a good understanding of the invention.

Referring now to the embodiment of figure 1 showing part of a reactor the reactor wall has been designated by 1. The reactor is cylindrical as usual and has been provided internally with supporting means consisting of an outer conical surface 2 and an inner conical surface 3, terminating at their lower end in a ring shaped channel 7 for the passage of catalyst and reactor effluent. In this example the angle 4a with the vertical axis of the conical inner surface

is about 30° and the angle 4b with the outer surface is about 20°.

The channel 7 is provided with an inner screen 5 and an outer screen 6 for separating the reactor effluent, which passes through the screens, from the catalyst. A quench fluid supply pipe 8 leads from the top of the reactor to a quench fluid injection pipe 9 connected therewith. The reactor effluent is received by a liquid distributor tray 10 and similar internals as described above may be present more downstream of the reactor section shown. A thermobar 11 is present for the usual temperature measurement. The internal supporting means 3 and the inner screens 5 and further associated parts are carried and supported by insert supports 12 and 14 and the outer internal supporting means by cone supports 13.

In figure 2A and 2B a bottom part of a reactor is shown, which may e.g. be the terminal downstream section of a reactor as shown in figure 1.

Similar parts as described in connection with figure 1 have been identified by the same reference numerals. The bottom part shown is provided with a lower cone segment 15 which is surrounded by an insulating layer 16. The bottom reactor head 17 comprises a reactor effluent outlet nozzle 18 and a central catalyst withdrawal pipe 19 including a catalyst unloading nozzle 20. It should be noted that the various parts have been shown only schematically merely for mentioning their presence and that not has been entered into a detailed mechanical construction thereof, this being no part of the present invention and not requiring a detailed description for a good understanding thereof.

By way of example a few cone angles have been indicated by 21^a and 21^b respectively, the angles in question in this embodiment being about 30°.

Figure 3 represents an alternative embodiment of a reactor according to the invention, and shows, by way of example, the bottom part thereof comprising the lower part of the shell 1 and the bottom reactor head 17. The bottom head is provided with effluent outlet nozzle 18, catalyst withdrawal pipe 19 and further with a cooling fluid inlet 22.

The catalyst/reactor effluent separation section comprises a cylindrical part which is provided with a number of double walled vertical partitions 23 arranged at equal distances from each other. In this example the partitions are straight running from wall to wall in the cylindrical part. However, the partitions may also be cylindrical in concentric arrangement. These partitions serve during operation as units for separating reactor effluent from the catalyst. Between the partitions a number of vertical channel sections 26 is left, which channel sections can be compared with the vertical channels 7 comprising the screen sections, as shown in the embodiments of

figures 1 and 2.

A partition 23 is shown on a larger scale in figures 3A and 3B. In figure 3A such a partition in a similar vertical section as in figure 3 is represented, and comprises a cone shaped top portion, a number of vertical parallel bars leaving vertical slits between them, an inner space provided with distant pieces for receiving reactor effluent passing through the slits and an effluent withdrawal pipe 25 at the bottom. Figure 3B is a section along the line A—A of figure 3A showing the screen sections 24 constituting the walls of the partition. The bars may be of a configuration as described in British Patent Specification 1,500,213 with particular reference to figure 3 thereof.

It will be understood that the invention is not restricted to the embodiments described above by way of example. In practice the selection of which arrangement has to be used is dependent on the process requirements and in particular to the capacities wanted and the constructional consequences thereof. In this connection it should be noted that also combinations of the design features of the embodiments of on the one hand figures 1 and 2 and on the other hand figure 3 may be used either at choice in a particular sieve section or simultaneously, e.g. by providing extra intermediate partitions 23 of figure 3 in the sieve section of channels 7 in an embodiment of a set-up as shown in figures 1 and/or 2.

Reference numerals in drawings

1	reactor wall or shell
2	outer conical surface
3	inner conical surface
4a,b	angle with vertical axis of conical surface
5	inner screen
6	outer screen
7	vertical channel
8	quench fluid supply pipe
9	quench fluid injection pipe
10	liquid distributor tray
11	thermo bar
12	insert support
13	internal support
14	cone support
15	lower cone segment
16	insulation of cone segment
17	reactor head
18	effluent outlet nozzle
19	catalyst withdrawal pipe
20	catalyst unloading nozzle
21a,b	cone angles
22	cooling fluid inlet
23	partition
24	walls of partition/screens
25	effluent withdrawal pipe
26	vertical channel sections

Claims

1. Moving catalyst bed reactor comprising a vertical cylindrical vessel having separate inlets for reactant and catalyst at the upper part of the vessel and catalyst bed supporting means in the shape of one or more downwardly converging conical surfaces the lower end thereof being connected to one or more vertical outlet channels having circumferential walls for the combined passage of catalyst and separation of reactor effluent, said circumferential walls being provided with a screen section for withdrawing reactor effluent from catalyst, and separate outlet conduits for reactor effluent and catalyst downstream of said screen section, characterized in that the vertical outlet channels (7, 26) are provided with further wall portions (5, 23) within said channels each bearing a screen section (5, 24) for withdrawal of reactor effluent from catalyst.

2. Moving bed reactor according to claim 1, characterized in that the conical surfaces and their associated outlet channels (7) are ring shaped in cross-section, the inner walls (5) of the channels bearing the further screen section (5).

3. Moving bed reactor according to claim 2, characterized by a plurality of concentric ring shaped conical surfaces with associated channels, the inner (5) and outer (6) wall of each channel bearing a screen section (5, 6).

4. Moving bed reactor according to claim 1, characterized by at least one double walled hollow partition (23) within the vertical outlet channel(s) (26) each wall thereof bearing a screen section (24).

5. Moving bed reactor according to claim 4, characterized in that the/each partition (23) is circular and concentric with the outer wall of the outlet channel(s) (26).

6. Moving bed reactor according to claim 4, characterized in that the/each partition (23) is straight and extends vertically from the outer wall of the outlet channel(s) (26) to an opposite wall.

7. Moving bed reactor according to claim 6, characterized in that at least two straight partitions (23) are present, the partitions being parallel and at equal distance from each other.

8. Moving bed reactor according to any one of the preceding claims, characterized by a cooling fluid inlet conduit (22) communicating with the/each combined catalyst and reactor effluent outlet channel (26) below the perforated screen section (23).

9. Moving bed reactor according to any one of the preceding claims, characterized in that the acute angle (4a, 4b, 21b) formed by a line (or lines) lying in the conical surface(s) (2, 3) and the axis of the reactor is from 15° — 45°.

10. Moving bed reactor as claimed in any one

figures 1 and 2.

A partition 23 is shown on a larger scale in figures 3A and 3B. In figure 3A such a partition in a similar vertical section as in figure 3 is represented, and comprises a cone shaped top portion, a number of vertical parallel bars leaving vertical slits between them, an inner space provided with distant pieces for receiving reactor effluent passing through the slits and an effluent withdrawal pipe 25 at the bottom. Figure 3B is a section along the line A—A of figure 3A showing the screen sections 24 constituting the walls of the partition. The bars may be of a configuration as described in British Patent Specification 1,500,213 with particular reference to figure 3 thereof.

It will be understood that the invention is not restricted to the embodiments described above by way of example. In practice the selection of which arrangement has to be used is dependent on the process requirements and in particular to the capacities wanted and the constructional consequences thereof. In this connection it should be noted that also combinations of the design features of the embodiments of on the one hand figures 1 and 2 and on the other hand figure 3 may be used either at choice in a particular sieve section or simultaneously, e.g. by providing extra intermediate partitions 23 of figure 3 in the sieve section of channels 7 in an embodiment of a set-up as shown in figures 1 and/or 2.

Reference numerals in drawings

1	reactor wall or shell
2	outer conical surface
3	inner conical surface
4a,b	angle with vertical axis of conical surface
5	inner screen
6	outer screen
7	vertical channel
8	quench fluid supply pipe
9	quench fluid injection pipe
10	liquid distributor tray
11	thermo bar
12	insert support
13	internal support
14	cone support
15	lower cone segment
16	insulation of cone segment
17	reactor head
18	effluent outlet nozzle
19	catalyst withdrawal pipe
20	catalyst unloading nozzle
21a,b	cone angles
22	cooling fluid inlet
23	partition
24	walls of partition/screens
25	effluent withdrawal pipe
26	vertical channel sections

Claims

1. Moving catalyst bed reactor comprising a vertical cylindrical vessel having separate inlets for reactant and catalyst at the upper part of the vessel and catalyst bed supporting means in the shape of one or more downwardly converging conical surfaces the lower end thereof being connected to one or more vertical outlet channels having circumferential walls for the combined passage of catalyst and separation of reactor effluent, said circumferential walls being provided with a screen section for withdrawing reactor effluent from catalyst, and separate outlet conduits for reactor effluent and catalyst downstream of said screen section, characterized in that the vertical outlet channels (7, 26) are provided with further wall portions (5, 23) within said channels each bearing a screen section (5, 24) for withdrawal of reactor effluent from catalyst.

2. Moving bed reactor according to claim 1, characterized in that the conical surfaces and their associated outlet channels (7) are ring shaped in cross-section, the inner walls (5) of the channels bearing the further screen section (5).

3. Moving bed reactor according to claim 2, characterized by a plurality of concentric ring shaped conical surfaces with associated channels, the inner (5) and outer (6) wall of each channel bearing a screen section (5, 6).

4. Moving bed reactor according to claim 1, characterized by at least one double walled hollow partition (23) within the vertical outlet channel(s) (26) each wall thereof bearing a screen section (24).

5. Moving bed reactor according to claim 4, characterized in that the/each partition (23) is circular and concentric with the outer wall of the outlet channel(s) (26).

6. Moving bed reactor according to claim 4, characterized in that the/each partition (23) is straight and extends vertically from the outer wall of the outlet channel(s) (26) to an opposite wall.

7. Moving bed reactor according to claim 6, characterized in that at least two straight partitions (23) are present, the partitions being parallel and at equal distance from each other.

8. Moving bed reactor according to any one of the preceding claims, characterized by a cooling fluid inlet conduit (22) communicating with the/each combined catalyst and reactor effluent outlet channel (26) below the perforated screen section (23).

9. Moving bed reactor according to any one of the preceding claims, characterized in that the acute angle (4a, 4b, 21b) formed by a line (or lines lying in the conical surface(s) (2, 3) and the axis of the reactor is from 15° — 45°.

10. Moving bed reactor as claimed in any one



of the preceding claims, characterized in that the vertical outlet channels include at least one inverted conical section connected at its top and at its bottom with an annular screen section of cylindrical, polygonal or annular configuration.

Revendications

1. Un réacteur à lit mobile de catalyseur comprenant un récipient cylindrique vertical ayant des entrées séparées pour le corps en réaction et le catalyseur à la partie supérieure du récipient et des moyens de support de lit de catalyseur sous la forme d'une ou plusieurs surfaces coniques convergeant vers le bas dont l'extrémité inférieure est reliée à un ou plusieurs canaux verticaux de sortie ayant des parois circonférentielles pour le passage combiné du catalyseur et la séparation de l'effluent du réacteur, les parois circonférentielles comportant une portion en tamis pour séparer l'effluent du réacteur du catalyseur, et des conduits de sortie séparés pour l'effluent du réacteur et le catalyseur en aval de la portion en tamis, caractérisé en ce que les canaux verticaux de sortie (7, 26) sont pourvus d'autres portions de paroi (5, 23) dans ces canaux portant chacune une portion en tamis (5, 24) pour séparer l'effluent du réacteur du catalyseur.

2. Un réacteur à lit mobile selon la revendication 1, caractérisé en ce que les surfaces coniques et leurs canaux de sortie associés (7) sont de forme annulaire en section transversale, les parois intérieures (5) des canaux comportant en outre la portion en tamis supplémentaire (5).

3. Un réacteur à lit mobile selon la revendication 2, caractérisé par une multiplicité de surfaces coniques de forme annulaire coaxiales avec des canaux associés, les parois intérieure (5) et extérieure (6) de chaque canal comportant une portion en tamis (5, 6).

4. Un réacteur à lit mobile selon la revendication 1, caractérisé par au moins une cloison creuse à double paroi (23) à l'intérieur du canal ou des canaux verticaux de sortie (26), dont chacune des parois comporte une portion en tamis (24).

5. Un réacteur à lit mobile selon la revendication 4, caractérisé en ce que la ou chaque cloison (23) est circulaire et concentrique à la paroi extérieure du ou des canaux de sortie (26).

6. Un réacteur à lit mobile selon la revendication 4, caractérisé en ce que la ou chaque cloison (23) est droite et s'étend verticalement de la paroi extérieure du ou des canaux de sortie (26) à une paroi opposée.

7. Un réacteur à lit mobile selon la revendication 6, caractérisé en ce qu'au moins deux cloisons droites (23) sont présentes, les cloisons étant parallèles et à égale distance les unes des autres.

8. Un réacteur à lit mobile selon l'une quelconque des revendications précédentes,

caractérisé par un conduit d'entrée pour fluide de refroidissement (22) communiquant avec le ou chaque canal de sortie combiné (26) pour le catalyseur et l'effluent du réacteur au-dessous de la portion en tamis perforée (23).

9. Un réacteur à lit mobile selon l'une quelconque des revendications précédentes, caractérisé en ce que l'angle aigu (4a, 4b, 21b) formé par une ligne (ou des lignes) se trouvant dans la surface ou les surfaces coniques et l'axe du réacteur est compris entre 25° et 45°.

10. Un réacteur à lit mobile selon l'une quelconque des revendications précédentes, caractérisé en ce que les canaux de sortie verticaux comprennent au moins une portion en forme de cône renversé reliée à son sommet et à son fond à une portion en tamis annulaire de configuration cylindrique, polygonale ou annulaire.

Patentansprüche

1. Bewegter Katalysatorbettreaktor, der einen vertikalen zylindrischen Behälter, der separate Einlässe für Reaktionsmittel und Katalysator an dem oberen Teil des Behälters besitzt, und eine Katalysatorbett-Trägereinrichtung in der Form einer oder mehrerer nach unten konvergierenden konischer Oberflächen umfaßt, deren unteres Ende mit einem oder mehreren vertikalen Auslaßkanälen verbunden ist, die Umfangswände für die kombinierte Passage von Katalysator und Trennung von Reaktorausfluß besitzen, wobei die Umfangswände mit einem Siebabschnitt für die Entnahme von Reaktorausfluß von dem Katalysator und separaten Auslaßleitungen für Reaktorausfluß und Katalysator stromabwärts des Siebabschnittes versehen sind, dadurch gekennzeichnet, daß die vertikalen Auslaßkanäle (7, 26) mit weiteren Wandabschnitten (5, 23) innerhalb der Kanäle versehen sind, die jeweils einen Siebabschnitt (5, 24) für die Entnahme von Reaktorausfluß vom Katalysator tragen.

2. Bewegter Bettreaktor nach Anspruch 1, dadurch gekennzeichnet, daß die konischen Flächen und ihre zugeordneten Auslaßkanäle (7) im Querschnitt ringförmig sind, wobei die inneren Wände (5) der Kanäle den weiteren Siebabschnitt (5) tragen.

3. Bewegter Bettreaktor nach Anspruch 2, gekennzeichnet durch eine Anzahl von konzentrischen, ringförmigen, konischen Oberflächen mit zugeordneten Kanälen, wobei die innere (5) und die äußere (6) Wand eines jeden Kanals einen Siebabschnitt (5, 6) trägt.

4. Bewegter Bettreaktor nach Anspruch 1, gekennzeichnet durch zumindest eine doppelwandige, hohle Scheidewand (23) innerhalb des (der) vertikalen Auslaßkanals (-kanäle (26), von dem (denen) jede Wand einen Siebabschnitt (24) trägt.

5. Bewegter Bettreaktor nach Anspruch 4, dadurch gekennzeichnet daß die/jede Scheidewand (23) kreisförmig und mit der äußeren Wand des Auslaßkanals (der Auslaßkanäle (26)



konzentrisch ist.

6. Bewegter Bettreaktor nach Anspruch 4, dadurch gekennzeichnet, daß die/jede Scheidewand (23) gerade ist und sich vertikal von der äußeren Wand des Auslaßkanals (der Auslaßkanäle (26) zu einer gegenüberliegenden Wand erstreckt.

7. Bewegter Bettreaktor nach Anspruch 6, dadurch gekennzeichnet, daß zumindest zwei gerade Scheidewände (23) vorhanden sind, wobei die Scheidewände parallel und in gleichem Abstand voneinander sind.

8. Bewegter Bettreaktor nach einem der vorhergehenden Ansprüche, gekennzeichnet durch eine Kühlflüssigkeitseinlaßleitung (22), die mit dem/jedem kombinierten Ausflußkanal (26) für Katalysator und Reaktorausfluß unterhalb des

perforierten Siebabschnittes (23) kommuniziert.

9. Bewegter Bettreaktor nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der spitze Winkel (4a, 4b, 21b), der durch eine Linie (oder Linien), die in der (den) konischen Oberfläche(n) (2, 3) liegt (liegen), und die Achse des Reaktors gebildet ist, 15° 45° ist.

10. Bewegter Bettreaktor nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die vertikalen Auslaßkanäle zumindest einen umgekehrten konischen Abschnitt umfassen, der an seinem oberen Ende und seinem Boden mit einem ringförmigen Siebabschnitt von zylindrischer, polygonaler oder ringförmiger Gestalt verbunden ist.

20

25

30

35

40

45

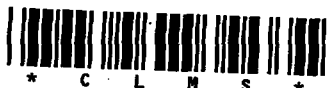
50

55

60

65

6



* C L H S *