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Bezeichnung der Erfindung: Movable catalyst bed reactor
Title of invention:
Titre de l'invention :

Klassifikation / Classification / Classement : B01J 8/12

ENTSCHEIDUNG / DECISION

vom / of / du 23 August 1990

Anmelder / Applicant / Demandeur : Shell Internationale Research Maatschappij B.V.

Patentinhaber / Proprietor of the patent / Titulaire du brevet :

Einsprechender / Opponent / Opposant :

Stichwort / Headword / Référence :

EPÜ / EPC / CBE Article 56

Schlagwort / Keyword / Mot clé : "Inventive step (yes) - non-obvious improvement"

Leitsatz / Headnote / Sommaire

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Case Number : T 385/88 - 3.3.2

D E C I S I O N
of the Technical Board of Appeal 3.3.2.
of 23 August 1990

Appellant : Shell Internationale Research
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Decision under appeal : Decision of Examining Division 033 of the European Patent Office dated 18 March 1988 refusing European patent application No. 84 201 395.5 pursuant to Article 97(1) EPC

Composition of the Board :

Chairman : P. Lançon
Members : M. Eberhard
M. Lewenton

Summary of Facts and Submissions

I. European patent application No. 84 201 395.5 with publication No. 137 561 was refused by a decision of the Examining Division. The decision was based on Claim 1 filed on 10 December 1987 and Claims 2-11 as originally filed. Independent Claim 1 reads as follows:

> 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 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.

II. The ground for refusal was that the subject-matter of Claim 1 did not involve an inventive step in the light of the disclosure in EP-A-70 591 (D1) and US-A-3 186 935 (D2). D1 was considered as closest prior art. It was held that the frusto-conical shape of the downwardly converging surfaces was a direct consequence of the use of separate outlet channels and therefore this feature could not support any inventive activity. According to the decision, the second distinguishing feature, i.e. the provision of a plurality of outlet channels uniformly distributed in a circular pattern, was obvious to the person skilled in the

art in view of D2, especially column 5, lines 21-28 and Figure 4. Although D2 did not relate to a movable catalyst bed, the skilled worker would have combined the teachings of D1 and D2 since the relevant statement in D2 dealt with the transport of catalyst from one catalyst bed to another, as well as D1.

III. The Appellant filed a notice of appeal against this decision together with payment of the prescribed fee. A Statement of Grounds of Appeal was filed later on.

IV. In reply to a Board's communication, the Appellant submitted a new set of ten claims as main request on 25 July 1990. Claims 1-8 are identical to those rejected by the Examining Division except for the incorporation of the word "bed" between "bottom catalyst" and "supporting means" in the sixth line of Claim 1 and the correction of the word "angle" in Claim 5. Independent Claim 9 relates to the use of a reactor as claimed in any one of Claims 1-8 for the catalytic treatment of hydrocarbons, and Claim 10 concerns a preferred embodiment thereof.

V. During the appeal procedure, the Appellant pointed out that D1 was a further development of a moving bed reactor as described in EP-A-45 108 (D3) and indicated the disadvantages of the box-like structures proposed in D1 to solve the problem of "pinning" associated with operations at ever increasing fluid flow velocities. The Appellant contended that a person skilled in the art faced with scaling-up problems would not have come to the claimed solution either on the basis of the knowledge of both D1 and D3 or by combining the teaching of D2 with D1, the catalyst tubes of D2 being of a different nature and being constructed for another purpose. He further argued that the concept of the problem discussed in D2 was fundamentally different from the problem to be solved in the application and that upscaling did not come into account at all.

Furthermore, the size ratio recommended in D2 would have led to a reactor of considerable height. In the Appellant's view, a streaming profile as required for movable bed technology would have been completely unattainable with the various catalyst tubes present in the equipment of D2. The Appellant also contested that the frusto-conical shape of the multi-cone solution was the direct and unavoidable consequence of the separate outlet channels known from D2. In this context he stressed that the catalyst tubes rather represented a bundle of unverted (upside-down) stacked segments having separate and unconnected outlets compared with the multi-cones claimed in the rejected application, which have their outlets in the same catalyst bed.

Furthermore, the Appellant gave comparative data concerning the relative force of fluids on the screen in order to show that less heavy supporting equipment can be applied in the case of the claimed reactor.

VI. The Appellant requests that the decision under appeal be set aside and that a patent be granted on the basis of Claims 1-10 filed on 25 July 1990.

Reasons for the Decision

1. The appeal is admissible.

2. There are no objections under Article 123(2) to the amended Claim 1 since it is supported by original Claim 1 and the description as originally filed, page 6, lines 14-17. In particular, the feature that each frusto-conical surface is connected at its lower end to a spaced apart outlet channel finds its counterpart in the cited passage of page 6 in connection with Figures 1-3. In the amended Claim 1 it is not mentioned any longer that the outlet channels have circumferential walls, but as this feature is implicit, its

omission does not contravene Article 123(2). The expression "bottom catalyst bed supporting means" in Claim 1 and the word "angle" in Claim 5 have a support respectively in Claims 1 and 5 as originally filed. The use Claims 9 and 10 are based on original Claims 10 and 11 and the original text at page 1, lines 1-4.

3. The refused patent application relates to a movable catalyst bed reactor comprising a vertically extending cylindrical vessel having separate inlets for reactant and catalyst at its upper part, intermediate and bottom catalyst bed supporting means inside the vessel and separate outlets for reactor effluent and catalyst. D1 and D3 (cited in the search report) both concern this kind of reactor. The Board considers D3 as closest prior art since it discloses a moving catalyst bed reactor which is structurally as close to the claimed reactor as that of D1 and additionally deals with the problem of fluid redistribution over an optimal percentage of the reactor cross-section, arising in up-scaling.

3.1 The intermediate catalyst bed supporting means of the reactor known from D3 consists of an outer downwardly converging 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. The inner and outer walls of this channel are provided with inner and outer screens (5) and (6) for separating the reactor effluent from the catalyst. Similar equipment may be present more downstream of the reactor section shown in Figure 1. Very large-sized reactors are equipped with a plurality of concentric ring shaped conical surfaces with associated channels, the inner and outer wall of each channel bearing a screen section (cf. Figure 1; page 5, line 26 to page 6, line 19; page 4, lines 2-6; Claims 1 to 3). This moving bed reactor enables to overcome the scaling-up difficulties inherent in the increase of the

outlet channel, in particular the more difficult separation of reaction effluent from parts of the bed at distance from a screen. Moreover, further requirements in connection with up-scaling are also met, such as, amongst other, the liquid redistribution over an optimal percentage of the reactor cross-section (see page 2, line 17 to page 4, line 6). However, in the case of large diameter reactors of this type, it is desirable to further optimise the proper distribution of fluid over as much of the catalyst bed(s) as possible in order to keep the catalyst bed height(s) and thus the reactor height within acceptable limits.

3.2 In the light of this prior art, the problem underlying the application can be seen in providing a movable catalyst bed reactor which enables a better fluid redistribution over its cross-section and a more regular distribution of the catalyst over the next lower catalyst bed supporting means. Furthermore, it should render possible the use of less heavy supporting equipment for the screen sections.

According to Claim 1, it is proposed to solve this problem by an intermediate catalyst bed supporting means which consists of a plurality of interconnected downwardly converging frusto-conical surfaces, each having its lower end connected to a spaced apart vertical outlet channel provided with a circumferential screen section, the outlet channels having their axes arranged substantially uniformly distributed in a circular pattern. For the sake of simplicity, this arrangement will be termed in this decision as multi-cone arrangement with associated spaced apart outlet channels.

In view of the statements in the description, in particular on page 4, lines 11-19; page 5, lines 1-6, and page 8, lines 14-22, and taking into account the comparative datas about the relative force of fluids on the screen filed

during the appeal procedure, the Board is satisfied that the above defined technical problem has been plausibly solved.

4. After examination of the cited documents, the Board has come to the conclusion that none of them discloses a movable bed reactor comprising an intermediate catalyst bed supporting means which consists of the combination of features indicated in point 3.2 above and that the subject-matter of Claim 1 is therefore novel. Since the issue of novelty has not been raised by the Examining Division, it is not necessary to consider this matter in further detail.

5. It still remains to be examined whether the claimed subject-matter involves an inventive step with regard to the teaching of the cited documents.

5.1 Document D3 itself teaches the provision of additional screen sections in the ring-shaped channel (7) in order to solve the problem of efficient separation of the reactor effluent from catalyst, encountered in up-scaling of reactors. According to D3, very large-sized reactors are equipped with a plurality of concentric conical surfaces and associated channels, each channel bearing a screen in its outer and inner wall, thus making possible the liquid redistribution over an optimal percentage of the reactor cross-section (see page 3, lines 15-17, 23-25 and page 4, lines 1-6). From the whole context of D3 it is unambiguous that the reactor is provided with several superimposed catalyst bed supporting means disposed at different heights or levels thereof (see in particular Figures 1 and 2 and page 6, lines 13-14) and that, at each level, one single ring-shaped channel is connected to the two ring-shaped conical surfaces (2) and (3). D3 contains no indication from which the skilled person could find an incentive to replace this intermediate catalyst bed supporting means by

the multi-cone arrangement and its associated spaced apart channels as defined in Claim 1 in order to further improve the fluid redistribution over the reactor cross-section and the catalyst distribution over the next catalyst bed supporting means.

5.2 Document D1 discloses a movable bed reactor of the same kind as that of D3, comprising an intermediate particles bed supporting means which consists of an inner and an outer conical surface (6) and (4) connected at their lower end to a ring-shaped channel (9). This channel also bears an outer and an inner screen (18 and 16). The purpose followed in D1 is to reduce the growing risk of "pinning" (i.e. formation of a stagnant zone) associated with operations at ever increasing fluid flow velocities which are desirable to obtain higher throughputs. In order to reduce this risk D1 teaches the use of means for inducing a pressure gradient along the screen, which are preferably arranged in a box-like structure positioned behind the screen (see Figure 1; page 1, lines 1-23; page 2, line 17 to page 3, line 6; page 4, lines 1-33; page 5, line 25 to page 6, line 27). This document is wholly silent with respect to the problem of redistribution of fluid or distribution of catalyst over the reactor cross-section and gives no information which could be of some assistance to the skilled person seeking to solve this problem.

5.3 Document D2 is referred to in D3 as a solution in reactor designs, which might be suitable for solving scaling-up problems (cf. page 5, second paragraph). Therefore, although the parallel arrangement of D2 is said to be rather expensive, the Board is convinced that the skilled person faced with the problems of fluid redistribution and catalyst distribution arising in up-scaling of reactors would consider this document, hoping that he could find some suggestions or at least get more information about what should be avoided.

D2 relates to a process and a reactor for effecting cross-flow hydrogenation and/or hydrocracking of liquid hydrocarbons which gravitate downwardly through an elongated fixed-bed of catalyst. The principal objective of D2 is to avoid overcracking and to minimise the deleterious effects of volatile catalyst poisons upon the catalyst (cf. column 1, lines 9-21 and 41-42; column 2, line 71 to column 3, line 6). The reactor used for this purpose comprises an upper catalyst chamber with a perforated plate (8) for supporting catalyst bed (44), an interspace (6) into which the preheated feed is admixed and, thereunder, an elongated annular catalyst bed (14), the outer and inner periphery of which are defined by two series of frusto-conical baffles (16) and (18), the inner baffles (18) being affixed to a central perforated pipe (20) for upward removal of the vapor phase product. In the bottom part of the reactor the supporting means of the annular catalyst bed define an included annulus which communicates with a plurality of refractory-filled perforated standpipes (28). The liquid phase of the feed is delivered to the annular catalyst bed through a plurality of open-ended sealing legs (12) which appear to be substantially uniformly distributed in a circular pattern and are filled with refractory material (cf. Figures 1, 3, 4 and 5; Claims 14 and 17; column 3, lines 39-54 and 68-75; column 4, lines 1-12). A plurality of optional downcomers or drain tubes (45), depending from the perforated plate (8), terminates concentrically each in a sealing leg. They are provided as a means for draining the upper catalyst bed (44) downwardly when the annular bed (14) is drained through the standpipes (28), thereby permitting either the entire catalyst charge to be drained and replaced, or if desired, bed (14) to be drained and replaced with catalyst from bed (44) (cf. column 5, lines 21-28).

D2 does not deal with upscaling of reactors, in particular with the problems of fluid redistribution, catalyst distribution and weight of the screens supporting equipment arising in up-scaling. Furthermore, it clearly derives from the function of the drain tubes indicated in D2 that they neither contribute to the separation of catalyst from reactor effluent nor to the redistribution of fluid over the reactor cross-section. Means are indeed foreseen for ensuring a better redistribution of the liquid feed in its downward path through the reactor, however, they consist of the perforated upright frusto-conical baffles (40) (see column 1, lines 52-54; column 4, lines 43-48; Claim 15 and Figure 1) which anyway cannot point to the claimed solution.

Although, according to D2, the drain tubes permit drainage of the catalyst from the upper bed to the lower annular bed, it can be neither deduced therefrom that the use of such tubes might improve the regularity of catalyst distribution over the lower catalyst bed in large-sized reactors nor that they would enable to maintain the streaming profile of catalyst which is required for movable bed technology. Under these circumstances, in particular in the absence of any indication in D2 from which the skilled person could reasonably expect an improvement in fluid redistribution or in catalyst distribution, the Board considers that this document would not provide the skilled person with any motivation or incentive to replace the annular channel of the moving bed reactor of D3 (or D1) by the plurality of drain tubes used in the fixed bed reactor of D2 in order to solve the problem defined above. The combination of the teachings of D1 and D2 as envisaged by the Examining Division seems, under these circumstances, to amount to a hindsight analysis.

5.4 Not only the replacement as discussed above is necessary to arrive at the claimed solution but also a further modification of the intermediate catalyst bed supporting means used in the reactor of D3 (or D1). The claimed modification, namely the provision of a multi-cone arrangement as defined in 3.2 instead of the inner and outer conical surfaces (3) and (2), is not described in the cited documents.

Since the provision of a plurality of separate outlet channels as claimed in Claim 1 is itself considered to involve an inventive step, it is not necessary to further examine whether the claimed modification of the supporting means is obvious or not. However it should be noted in this respect that, on the one hand, the skilled person would obviously realise that the catalyst bed supporting means of D3 (or D1) have to be modified when using separate outlet channels, but that, on the other hand, there exists several possible modifications. Two examples of catalyst bed supporting means connected to spaced apart outlet channels are indeed already described in D2 (see on Figures 1, 3 and 5 the supporting means (8), (22), (24), (25) for the upper and the lower catalyst beds, which both communicate with a plurality of tubes (45) and (28)). Therefore, in the Board's view the multi-cone arrangement cannot be regarded as the direct consequence of the use of a plurality of separate outlet channels but results from the choice of one particular arrangement which, in combination with the separate outlet channels, enables to achieve the desired improvement.

5.5 In conclusion, for the reasons given above, the Board considers that the subject-matter of Claim 1 implies an inventive step.

6. Dependent Claims 2 to 8, which relate to preferred embodiments of Claim 1, as well as Claims 9 and 10, which concern the use of the claimed reactor, derive their patentability from Claim 1.

Order

For these reasons, it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the Examining Division with the order to grant a patent on the basis of Claims 1 to 10 filed on 25 July 1990 with a description and drawings which are in agreement with the amended claims.

The Registrar: The Chairman:

M. Beer P. Lançon