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D E C I S I O N
of 22 February 2000

Case Number: T 0282/95 - 3.3.1

Application Number: 88311188.2

Publication Number: 0319208

IPC: C07C 29/14

Language of the proceedings: EN

Title of invention:
Process for hydrogenating

Patentee:
DAVY McKEE (LONDON) LIMITED

Opponent:
(01) Degussa-Hüls Aktiengesellschaft Patente und Marken
Standort Marl
(02) Exxon Chemical Patents Inc.
(03) BASF Aktiengesellschaft, Ludwigshafen

Headword:
Hydrogenation/DAVY McKEE

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"Novelty (yes)"
"Inventive step (no) - obvious alternative process"

Decisions cited:
-

Catchword:
-



Case Number: T 0282/95 - 3.3.1

D E C I S I O N
of the Technical Board of Appeal 3.3.1
of 22 February 2000

Appellant: DAVY McKEE (LONDON) LIMITED
(Proprietor of the patent) Davy House
68 Hammersmith Road
London W14 8YW (GB)

Representative: Eyles, Christopher Thomas
W. P. THOMPSON & CO.
Celcon House
289-293 High Holborn
London WC1V 7HU (GB)

Respondent: Degussa-Hüls Aktiengesellschaft
(Opponent 01) Patente und Marken
Standort Marl
Bau 1042/PB 15
D-45764 Marl (DE)

Representative: -

Respondent: Exxon Chemical Patents Inc.
(Opponent 02) 1900 East Linden Avenue
Linden, New Jersey 07036 (US)

Representative: Franck, Peter
Beselerstrasse 4
D-22607 Hamburg (DE)

Respondent: BASF Aktiengesellschaft, Ludwigshafen
(Opponent 03) - Patentabteilung - C6 -
Carl-Bosch-Strasse 38
D-67056 Ludwigshafen (DE)

Representative: -

Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 30 January 1995
revoking European patent No. 0 319 208 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: A. J. Nuss

Members: J. M. Jonk
S. C. Perryman

Summary of Facts and Submissions

I. The Appellant (Patentee) lodged an appeal against the decision of the Opposition Division by which the European patent No. 0 319 208 (European patent application No. 88 311 188.2) was revoked.

II. The opposition was supported by several documents including:

- (1) DE-A-1 941 633,
- (2) DE-A-2 040 501,
- (4) "Trickle-Bed Reactors", AIChE Journal (Vol. 21, No. 2), March 1975, 209 to 228, and
- (6) Weekman et al., AIChE Journal (Vol. 10, No. 6), November 1964, 951 to 957.

III. The decision was based on the Claims 1 to 9 as granted, independent Claim 1 reading as follows:

"A liquid phase catalytic hydrogenation process in which an organic feedstock is contacted with hydrogen in the presence of a solid hydrogenation catalyst under hydrogenation conditions to produce a hydrogenation product, which process comprises passing a feed solution of the organic feedstock in an inert diluent therefor downwardly in co-current with a hydrogen-containing gas through a hydrogenation zone containing a bed of a particulate hydrogenation catalyst whose particles substantially all lie in the range of from about 0.5 mm to about 5 mm, maintaining the bed of catalyst particles under temperature and pressure conditions conducive to hydrogenation, recovering from a bottom part of the bed a liquid phase containing the hydrogenation product, controlling the rate of supply

of the feed solution to the bed so as to maintain a superficial liquid velocity of the liquid down the bed in the range of from about 1.5 cm/sec to about 5 cm/sec, and controlling the rate of supply of the hydrogen-containing gas to the bed at the chosen rate of supply of feed solution so as to set up a pressure drop across the bed of at least about 0.1 kg/cm² per metre of bed depth, so as to maintain at the top surface of the bed of catalyst particles a flow of hydrogen-containing gas containing from 1.00 to about 1.15 times the stoichiometric quantity of hydrogen theoretically necessary to convert the organic feedstock completely to the hydrogenation product and so as to ensure that all parts of the bed are subjected to forced irrigation with liquid containing entrained bubbles of hydrogen-containing gas."

- IV. The Opposition Division held that the subject-matter of the claims met the requirements of "sufficiency" and "novelty" within the meaning of Articles 83 and 54 EPC, respectively, but that it did not involve an inventive step in the light of documents (1) and (2).

- V. Oral proceedings were held before the Board on 22 February 2000. After having informed the Board accordingly, the Respondent (1) (Opponent (1)) did not attend this hearing.

- VI. The Appellant firstly observed with respect to the issue of novelty that the process of Example 2 of document (1) essentially differed from the process of Claim 1 of the patent in suit in that according to said example, due to the recycling of unreacted hydrogen, 2.76 times the stoichiometric amount of hydrogen required to hydrogenate the nitrobenzene was supplied

to the reactor.

Furthermore, he disputed that the claimed subject-matter would be obvious to the skilled person in the light of the cited documents. In this context, and accepting that document (2) represented the closest state of the art, he argued essentially that by using the hydrogenation conditions specified in Claim 1 of the patent in suit high yields of hydrogenation products could be obtained at a reduced hydrogen supply and without the need for recycling of hydrogen-containing gasses. Regarding said hydrogenation conditions, he emphasised by relying on document (4) (i) that the flow regime applied according to Claim 1 of the patent in suit differed from the transition or rippling flow as described in document (6) and used in accordance with documents (1) and (2), (ii) that the flow regime as claimed in the patent in suit actually corresponded to the range of flow conditions indicated in Fig. 1 of document (4) by way of the diagonal arrow and the vertical flags on it, and (iii) that a prejudice existed in that in hydrogenation processes high stoichiometric amounts of hydrogen had to be applied.

He also submitted on 24 January 2000 a set of Claims 1 to 9 as auxiliary request. These claims corresponded to those of the main request, except that in Claim 1 of the auxiliary request it was indicated that the process was conducted without recycling of hydrogen-containing gas.

VII. The Respondents (Opponents (2) and (3)) maintained their point of view that the subject-matter of Claim 1 as granted lacked novelty in the light of Example 2 of

document (1). In this context, they contended that, if the stoichiometric amount of hydrogen indicated in Claim 1 of the patent in suit related to the overall stoichiometric amount, the constantly recycled amount of hydrogen to the reactor could not be taken into consideration and that therefore according to said example 1.08 times instead of 2.76 times the stoichiometric amount of hydrogen required to hydrogenate the nitrobenzene, i.e. an amount falling under the scope of Claim 1 of the patent in suit, was supplied to the reactor.

They also argued that the claimed process was obvious to the skilled person, since the flow conditions defined in Claim 1 of the patent in suit using particular parameters actually corresponded to the transition flow conditions described in document (6), which transition flow conditions were to be used in accordance with documents (1) and (2). In this context, Respondent (2) (Opponent (2)) submitted during the oral proceedings before the Board, as a straight answer to the Appellant's contention that the flow regime as claimed in the patent in suit actually corresponded to the range of flow conditions indicated in Fig. 1 of document (4) by way of the diagonal arrow and the vertical flags on it, a Fig. 1 of document (4) modified so that the range corresponding to the liquid and gas flow conditions defined in Claim 1 of the patent in suit was indicated thereupon by a shaded area. This range showing the extent of the scope of Claim 1 of the patent in suit did not only cover the range of flow conditions defined by the diagonal arrow and the vertical flags on it referred to by the Appellant, but also the points marking the prior art liquid and gas flow conditions as indicated in Examples 2 and 3 of

document (2) and Examples 2 and 3 of document (1). He concluded that the liquid and gas flow conditions used in accordance with said prior art examples therefore corresponded to the flow regime as defined in Claim 1 of the patent in suit.

VIII. The Appellant requested that the decision under appeal be set aside, and that the patent be maintained as main request as granted or as auxiliary request on the basis of Claims 1 to 9 filed on 24 January 2000.

The Respondents requested that the appeal be dismissed.

IX. At the conclusion of the oral proceedings the Board's decision was pronounced.

Reasons for the decision

1. The appeal is admissible.

Main request

2. *Novelty*

2.1 After examination of the cited prior art, the Board has reached the conclusion that the subject-matter of the claims is novel.

2.2 It is true, that the Respondents submitted that the process as defined in Claim 1 lacked novelty in view of Example 2 of document (1), but this novelty objection was based on the assumption that in calculating the stoichiometric ratio of hydrogen to the nitrobenzene the amount of recycled unreacted hydrogen should not be

considered.

- 2.3 However, the Board cannot accept this point of view, because according to Claim 1 of the patent in suit the rate of supply of the hydrogen-containing gas must be controlled in such a way that **at the top surface of the bed of catalyst particles** a flow of hydrogen-containing gas containing from **1.00 to about 1.15 times** the stoichiometric quantity of hydrogen theoretically necessary to convert the organic feedstock completely to the hydrogenation product is maintained. This means, that in calculating whether the supply of hydrogen as disclosed in said Example 2 meets this claimed condition, the **total amount** of hydrogen at the top surface of the catalyst bed, i.e. including the recycled amount of hydrogen, has to be taken into account. Furthermore, the parties to the proceedings agreed that, taking the recycled amount of hydrogen into account, said Example 2 disclosed the supply of an amount of hydrogen of **2.76 times** the stoichiometric amount of hydrogen required to hydrogenate the organic feedstock (nitrobenzene), i.e. the supply of an amount of hydrogen falling outside the range as claimed in accordance with the patent in suit.

3. *Inventive step*

- 3.1 The remaining issue to be dealt with is whether the subject-matter of the present claims involves an inventive step.
- 3.2 Article 56 EPC sets forth that an invention involves an inventive step if, having regard to the state of the art (in the sense of Article 54(2) EPC), it is not obvious to a person skilled in the art.

3.3 For deciding whether or not a claimed invention meets this criterion, the Boards of Appeal consistently apply the problem and solution approach, which consists essentially in (a) identifying the closest prior art, (b) assessing the technical results (or effects) achieved by the claimed invention when compared with the closest state of the art established, (c) defining the technical problem to be solved as the object of the invention to achieve these results, and (d) examining whether or not a skilled person starting from the closest prior art **would** arrive at something falling within Claim 1 by following the suggestions made in the prior art in the sense of Article 54(2) EPC.

If the technical results of the invention provide some improvement over the closest prior art, the problem can be seen as providing such improvement, provided this improvement necessarily results from the claimed features for all that is claimed. If, however, there is no improvement, but the means of implementation are different, the technical problem can be defined as the provision of an alternative to the closest prior art.

3.4 In the present case, the Board considers - in agreement with the parties - that the closest state of the art is document (2).

This document (2) discloses a process for carrying out an exothermic reaction between a gas and a liquid, such as a catalytic hydrogenation, in the presence of a catalytic fixed bed packed in an elongated reactor by passing the gas and the liquid concurrently downwardly through the reactor so that (i) the passage of gas and liquid through the bed of catalyst particles is in the form of a **transition flow** regime as defined in document

(6) and (ii) the ratio of gas feed to off-gas is **from 4:1 to 100:1 by volume** (see page 2, first paragraph; page 9, last paragraph to page 10, first paragraph; and Examples 2 and 3).

Said **transition flow** regime represents, as indicated in document (6), a turbulent flow regime which is observed between a **continuous flow** regime and a **pulsing flow** regime depending on the rates at which gas and liquid are passed through the bed of catalyst particles (see document (6), page 952, right column, under "FLUID-FLOW MEASUREMENTS", to page 953, left column, third paragraph; and document (2), page 1, second paragraph).

Document (2) also discloses that by using the transition flow regime, the gas and liquid are intimately mixed and the rate of flow of the so obtained mixture of gas and liquid through the bed is substantially higher than in the process carried out in the region of continuous flow, so that the occurrence of **hot spots** causing the forming of by-products can be avoided and the reaction products can be obtained in a higher purity and in **higher space-time yields** (see page 2, second paragraph).

Moreover, it discloses that by adjusting the gas feed and the reaction rate so as to maintain said ratio of gas feed to off-gas from 4:1 to 100:1, the occurrence of the pulsing flow regime, which causes damaging pressure pulses in the apparatus and reduces the reaction rate, can be prevented, and that this process feature provides the further advantage that **the amount of gas leaving the reactor is so small that it is usually not worth recycling and consequently a considerable saving of apparatus is achieved** (see

page 2, third paragraph).

3.5 Having regard to the fact that the Appellant did not provide any evidence that the claimed process of the patent in suit compared to the process of document (2) showed an improvement, but instead only referred to the beneficial effects already achieved by the process of document (2), the technical problem underlying the patent in suit in the light of the closest state of the art can only be seen in the provision of an alternative liquid phase catalytic hydrogenation process.

3.6 This technical problem is solved by the process as defined in present Claim 1 of the patent in suit, which - according to the Appellant's submissions - is essentially characterised by the use of a **particular flow regime** achieved by:

- (a) using **catalyst particles** substantially all lying in the range of from about 0.5 mm to about 5 mm,
- (b) controlling the **rate of supply of the feed solution** to the bed so as to maintain a superficial liquid velocity of the liquid down the bed in the range of from about 1.5 cm/sec to about 5 cm/sec,
- (c) controlling the **rate of supply of the hydrogen-containing gas** to the bed at the chosen rate of supply of feed solution so as to set up a **pressure drop** across the bed of at least about 0.1 kg/cm² per metre of bed depth, so as to maintain **at the top surface** of the bed of catalyst particles a **flow of hydrogen-containing gas** containing from 1.00 to about 1.15 times the stoichiometric

quantity of hydrogen theoretically necessary to convert the organic feedstock completely to the hydrogenation product, and

- (d) **so as to ensure** that all parts of the bed are subjected to forced irrigation with a liquid containing **entrained bubbles** of hydrogen-containing gas.

3.7 Having regard to the specification of the patent in suit (in particular, page 12, first paragraph) and the Appellant's submissions concerning the effectiveness of the process of the patent in suit, the Board considers it plausible that the technical problem as defined above has been solved. Actually, the Respondents did not contest the Appellant's submissions in this respect.

3.8 In assessing inventive step, the next question thus is whether a skilled person starting from document (2) and by following the suggestions made in the cited prior art when trying to solve the technical problem indicated above, would arrive at something falling within Claim 1 of the patent in suit.

3.9 Document (2) discloses, as indicated above, a process for carrying out an exothermic reaction between a gas and a liquid, such as a catalytic hydrogenation, in the presence of a catalytic fixed bed packed in an elongated reactor by passing the gas and the liquid concurrently downwardly through the reactor. Suitable catalyst particles have, e.g. the form of spheres or cylinders, whereby the spheres generally have diameters of between 2 and 8 mm and the cylindrical bodies generally have a diameter of between 2 and 6 mm and a

length of from 2 to 15 mm (see page 3, third paragraph).

Thus, in view of the fact that according to the patent in suit in case of cylindrical catalyst particles or particles of more complex shape the size range refers to the shortest particle dimension (see page 7, lines 40 to 43), document (2) actually teaches the use of catalyst particles which substantially correspond to the size range indicated in Claim 1 of the patent in suit (see feature (a) indicated under point 3.6 above).

3.10 Furthermore, the Examples 2 and 3 of this document relating to catalytic hydrogenation processes under transition flow conditions disclose, as calculated and agreed upon by the parties to these proceedings, the use of superficial liquid velocities of the liquid down the catalyst bed of 2.0 cm/sec and 2.2 cm/sec, respectively. Therefore, the skilled person wishing to set up a transition flow corresponding to a **suitable high liquid flow rate** so as to keep the desired high yield per reactor volume and time and an effective removal of heat of reaction in order to reduce the forming of by-products (see also point 3.4 above, fourth paragraph), would have a **clear incentive to apply liquid flow rates falling within the range of about 1.5 cm/sec to about 5 cm/sec** as claimed according to the patent in suit (see feature (b) indicated under point 3.6 above).

3.11 As indicated above (see point 3.4, fifth paragraph), document (2) also discloses as an essential feature that the transition flow regime must be adjusted so as to achieve a ratio of gas feed to off-gas in the range of from 4:1 to 100:1 by volume in order to avoid the

occurrence of a pulsing stream and **to make it possible to perform the process without the need of recycling the reaction gas**. Therefore, in case of using an undiluted reaction gas, which represents apparently the preferred embodiment of the process of document (2) (see the paragraph bridging pages 2 and 3; and the examples), this ratio implies, as calculated and agreed upon by the parties to these proceedings, the use of an amount of reaction gas of from **1.01 to 1.25** times the stoichiometric quantity of the reaction gas theoretically necessary to convert the liquid organic feedstock completely.

In this context, the Board observes that the upper limit of the amount of reaction gas of 1.25, which could be applied according to document (2), lies above the upper limit of 1.15 indicated in Claim 1 of the patent in suit (see feature (c) indicated above under point 3.6). However, in reading document (2) the skilled person would immediately understand that, in order to obtain a high yield and at the same time **to avoid the recycling or loss of valuable reaction gas (hydrogen) as off-gas**, optimum results can be expected to be achieved by selecting **the lowest amount of reaction gas** within said range of from 1.01 to 1.25 still providing a substantially complete conversion of the feedstock.

Therefore, in the Board's judgment, the teaching of document (2) as a whole also gives a clear incentive to the skilled person to apply a rather low amount of hydrogen containing reaction gas corresponding to a near stoichiometric quantity of hydrogen which leads to the range of 1.00 to 1.15 as claimed in the patent in suit (see feature (c) indicated under point 3.6 above).

3.12 Furthermore, document (2) discloses that the transition flow to be applied can be adjusted by measurement of the pressure difference (ΔP) or, in other words, by measurement of the **pressure drop (ΔP)** (see page 4, last paragraph, first sentence).

In this context, it discloses in particular (see page 4, penultimate line, to page 5, line 25):

- (i) that an increase of the liquid flow rate at a certain gas flow rate firstly provides a **linear rise** of the ΔP corresponding to the **continuous flow** regime,
- (ii) that a further increase of the liquid flow rate gives a **sudden strong rise** of the ΔP indicating the **change** from the **continuous flow** regime to the **transition flow** regime,
- (iii) that at a further increase of the liquid flow again a **linear rise** of the ΔP is obtained, which is however **steeper** than the linear rise of the ΔP corresponding to the continuous flow regime, and
- (iv) that at a still further increase of the liquid flow rate **the range of transition flow is passed through** and finally the pulsing flow regime is reached, which is characterised by fluctuations of the ΔP , which approximately occur with the frequency of the pulsation.

Thus, document (2) clearly teaches that the transition flow regime to be maintained **starts** at the sudden

strong rise of the ΔP , **proceeds** at increasing liquid flow rates in the range of the linear rise of the ΔP which is **steeper** than the linear rise of the ΔP corresponding to the continuous flow, and **terminates** at the high liquid flow rate where a pulsing flow commences.

Furthermore, it can be derived from **Fig. 1** of document (2), which shows a number of suitable transition state regimes in relation to **pressure drops (ΔP)** and **liquid flow rates at different gas flow rates**, that the transition flow regimes represented by the respective designated **steeper linear rises** of the ΔP at increasing liquid flow rates **all start at a minimum value of the ΔP of about 80 mm Hg to about 90 mm Hg, i.e. around 0.1 kg/cm² (88.3 mm Hg) per metre of bed depth.**

Thus, in the Board's judgment, the skilled person would conclude from the technical teaching of document (2) as set out above that the set up of a transition flow at a suitable **high liquid flow rate falling within the range of about 1.5 cm/sec to about 5 cm/sec** so as to achieve high yields per reactor volume and time and at a suitable **low flow rate of hydrogen in an amount of from 1.00 to about 1.15 times the stoichiometric quantity of hydrogen** theoretically necessary to convert the organic feedstock completely to the hydrogenation product so as to avoid recycling of the hydrogen gas, actually, **implies** the adjustment of a relative high **pressure drop (ΔP) of more than 0.1 kg/cm² per metre of bed depth** as claimed in accordance with the patent in suit (see also feature (c) as indicated under point 3.6 above).

3.13 Concerning said Fig. 1 of document (2) the Board

observes, that the experiments were carried out by using water as the liquid phase instead of an organic feedstock and a bed of glass spheres of 3 mm instead of a bed of particulate hydrogenation catalyst (see document (2), page 12, last paragraph to page 13, line 3).

However, the skilled person in reading document (2) would have understood that these different experimental conditions were apparently considered to be comparable to the conditions used for the catalytic hydrogenation such as disclosed in Examples 2 and 3.

Moreover, a similar simulation was applied by the Appellant in the experiment of Example 37 of the patent in suit, in which water as the liquid phase, ceramic spheres of about 3 mm instead of catalyst particles and air as the gas phase were used.

Therefore, the Board sees no reason to doubt the validity of the above conclusions on the basis of said Fig. 1.

3.14 Furthermore, document (2) also discloses that the transition flow regime to be applied can be set up by visual inspection as indicated in document (6) (see document (2), page 5, line 25 to 27).

In this context, it discloses in particular (see page 5, line 27 to page 6, line 3) that, in doing so, the flow conditions are adjusted such that:

- (i) the initial portion of the reactor downstream of the gas and liquid inlets is seen to contain an intimate mixture of gas and liquid in the form of a **turbulent stream**,
- (ii) the number of **gas bubbles** in the reaction mixture decreases as the mixture flows through the reactor, and
- (iii) that it is seen that at the gas outlet of the reactor the amount of off-gas **in the form of bubbles** in the liquid is only a fraction of the gas feed, or **may even be zero**, depending on the percentage conversion of the gas or the proportion of inert gas mixed therewith.

Therefore, the transition flow to be adjusted in accordance with document (2) corresponds to the flow regime to be used according to Claim 1 of the patent in suit in that it **ensures** that all parts of the bed are subjected to forced irrigation with a liquid containing **entrained bubbles** of hydrogen-containing gas (see feature (d) indicated under point 3.6 above).

3.15 The Appellant argued by relying on document (4) that the flow regime applied according to Claim 1 of the

patent in suit differed from the transition flow regime as described in document (2) and actually consisted of a flow regime sometimes termed **dispersed bubble flow**, which was characterised by a continuous liquid phase, gas in the form of bubbles, high liquid flow rates, sufficiently low gas flow rates, and substantially corresponded to the range of liquid and gas flow conditions indicated in Fig. 1 of document (4) by way of the diagonal arrow and the vertical flags on it (see document (4), page 212, first paragraph under point 2.2, lines 11 to 14, and Fig. 1).

However, like said dispersed bubble flow, which would correspond to the flow regime to be applied according to the patent in suit, the transition flow regime as applied according to document (2) is also characterised by a flow of a liquid phase containing gas in the form of bubbles and by essentially corresponding high liquid and low gas flow rates (see the above considerations under points 3.10, 3.11 and 3.14 above).

Furthermore, it can be derived from the Fig. 1 of document (4) in the form submitted during the oral proceedings before the Board by the Respondent, that the range defined by the liquid flow rate of about 1.5 cm/sec to about 5 cm/sec and the maximum gas flow rate as claimed in the patent in suit does not only comprise the dispersed bubble flow range referred to by the Appellant, but also the two flow regimes corresponding to the Examples 2 and 3 of document (2). This has not been disputed by the Appellant.

Thus, in view of these considerations, the Board concludes that said dispersed bubble flow regime cannot be differentiated from the transition flow regime to be

applied according to document (2), and that therefore the Appellant's contention in this respect cannot be accepted.

- 3.16 The Appellant also argued that the dispersed bubble flow as applied in accordance with the patent in suit was in particular characterised by the **combined selection** of the **liquid flow rate** in the range of from about 1.5 cm/sec to about 5 cm/sec, the **pressure drop** across the bed of at least about 0.1 kg/cm² per metre of bed depth, and the **flow of hydrogen-containing gas** containing from 1.00 to about 1.15 times the stoichiometric quantity of hydrogen theoretically necessary to convert the organic feedstock completely to the hydrogenation product, and that this mandatory combined selection of said parameters could not be derived from document (2).

However, the Board cannot accept this argument either, because, as follows from the considerations under above points 3.9, 3.10 and 3.11, document (2) gives a clear incentive to the skilled person to apply catalyst particles, as well as liquid and gas flow conditions falling under the scope of present Claim 1 of the patent in suit, and suitable pressure drops directly result from the other flow conditions to be applied according to document (2), which do not differ from those of the patent in suit.

- 3.17 Furthermore, the Appellant argued by referring to document (4), which deals with trickle-bed reactors in which a liquid phase and a gas phase flow concurrently downward through a fixed bed of catalyst particles while the reaction takes place, that a prejudice existed in that in hydrogenation processes high

stoichiometric amounts of hydrogen had to be applied.

In said document (4) it is stated in relation to the item "Industrial Petroleum Refining" (point 1.3) that:

"The quantity of H₂ furnished usually far exceeds that needed for stoichiometric reaction and is usually determined primarily by the requirements for temperature control, and perhaps in some cases to help achieve better liquid distribution or to prolong the life of the catalyst" (see page 211, left column, in the middle of the second paragraph),

and in relation to the item "External Mass Transfer - Overall" (point 3.1) that:

"The gaseous reactant is usually present in substantial stoichiometric excess and in relatively high fractional concentration in the vapour phase as well as being relatively insoluble in the liquid, as in the case of hydrogen." (see page 215, the sentence bridging the left column and the right column).

However, this point of view of the Appellant on the basis of these statements cannot be accepted by the Board, because:

- (a) having regard to the expression "usually" in said statements, the skilled person would understand that a substantial stoichiometric excess would not always be necessary,
- (b) it cannot be derived from these statements, or even document (4) as a whole, that a substantial stoichiometric excess would be necessary under

transition flow or dispersed bubble flow conditions, which - as indicated above - are both characterised by high liquid flow rates and low gas flow rates, and

- (c) the skilled person would have understood in view of the teaching of the closest prior art document (2) that - as indicated above (point 3.4, fourth paragraph) - by using the transition flow regime the occurrence of hot spots can be avoided and that therefore the use of a stoichiometric excess of hydrogen for temperature control probably would be redundant.

3.18 Thus, in view of the above considerations the Board concludes that the solution of the technical problem underlying the patent in suit in accordance with Claim 1 of the present main request was obvious to the skilled person in the light of document (2), and that therefore the subject-matter of this Claim does not involve an inventive step in the sense of article 56 EPC.

Claims 2 to 9 fall with Claim 1, since the Board can only decide on the request as a whole.

Auxiliary request

- 4. Claims 1 to 9 of the auxiliary request correspond to those of the main request, except that Claim 1 of the auxiliary request is restricted by indicating that the process is conducted without recycling of hydrogen-containing gas.

However, in view of the above considerations and the

fact that the process of document (2) is preferably carried out such that the amount of gas leaving the reactor is so small that it is usually not worth recycling and consequently a considerable saving of apparatus is achieved (see page 2, third paragraph, and also point 3.4 above, last paragraph), it follows that said limitation in accordance with the Appellant's auxiliary request does not lead to patentable subject-matter either (Article 56 EPC).

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

E. Görgmaier

A. Nuss