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D E C I S I O N
of 23 April 1998

Case Number: T 0551/95 - 3.3.5

Application Number: 88121134.6

Publication Number: 0320979

IPC: C01B 3/38

Language of the proceedings: EN

Title of invention:
A process for steam reforming of hydrocarbons

Patentee:
Osaka Gas Co., Ltd.

Opponent:
Linde Aktiengesellschaft
Imperial Chemical Industries PLC

Headword:
Steam reforming/OSAKA GAS

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no), predictable improvement, new explanation no additional technical problem - commercial considerations"

Decisions cited:
T 0229/85

Catchword:
-

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Case Number: T 0551/95 - 3.3.5

D E C I S I O N
of the Technical Board of Appeal 3.3.5
of 23 April 1998

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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office posted 9 May 1995 concerning maintenance of European patent No. 0 320 979 in amended form.**

Composition of the Board:

Chairman: R. K. Spangenberg
Members: G. J. Wassenaar
M. B. Günzel

Summary of Facts and Submissions

I. The appeal is from the decision of the Opposition Division maintaining European patent No. 0 320 979 in amended form with claims 1 to 12 as submitted during oral proceedings on 21 February 1995. Claim 1 thereof reads as follows:

"A process for desulfurizing and steam reforming of hydrocarbons including organic sulfur compounds comprising the steps of:

(a) desulfurizing the hydrocarbons to a sulfur content of 1 ppb by volume or less by use of a desulfurizing agent, and

(b) steam reforming the resultant desulfurized hydrocarbons using 0.7-3.5 moles of steam per mole of carbon in the hydrocarbons."

II. In the decision, inter alia, the following documents were considered:

D1: Catalyst Handbook, 1st ed. 1970, pages 46 to 63, 66, 69, 73, 83 to 86.

D4: JP-A-62 017 003

D10: JP-A-60 238 389

The Opposition Division held that the basic problem addressed by the invention was to prolong the lifetime of a steam reforming catalyst and in particular to prevent carbon deposition on it. The solution as given in claim 1 was considered to involve an inventive step.

III. In the statement of the grounds of appeal and during oral proceedings, which took place on 23 April 1998, the Appellant (Opponent I) maintained that the process of claim 1 lacked an inventive step. The arguments put forward by the Appellant and the "party as of right" (Opponent II) during the written and oral proceedings can be summarized as follows:

The closest prior art, represented by D10, already solved the problem of increasing the lifetime of the catalyst. Anyhow the Respondent had not provided convincing evidence that by reducing the sulphur content slightly below 1 ppb the lifetime of the catalyst was substantially increased. D4 disclosed a catalyst lifetime of at least 3000 hours in a steam reforming process with desulphurized naphtha having a sulphur content of 20 ppb at a steam to carbon ratio of 1.1. This lifetime was longer than the catalyst lifetimes mentioned in the examples of the patent in suit. Since it was known from D10 to desulphurise hydrocarbons to 1 ppb and that thereby the lifetime of steam reforming catalyst could be greatly extended, it was obvious to a skilled person, to desulphurise hydrocarbons for use in a steam reforming process as described in D4 to a sulphur content of 1 ppb or less.

IV. The Respondent argued essentially that the basic problem tackled by the present invention was to prolong the life of a steam reforming catalyst by preventing it from clogging due to deposition of carbon during use and that the patentee had surprisingly found that by reducing the sulphur content below 1 ppb, carbon deposition on the steam reforming catalyst was substantially prevented even if the steam/carbon ratio was below 3.5. In this way it was possible to extend the lifetime of the steam reforming catalyst to several years before regeneration was necessary. With the teaching of D10 it was possible to prevent the sulphur

poisoning of the catalyst but not the carbon deposition. The graph of "Figure C", filed with the letter dated 10 January 1996, and based on comparative examples made by the patentee, showed that by reducing the sulphur content, carbon deposition was reduced, whereby a sudden and unexpected reduction below 7 ppb and an almost complete prevention of carbon deposition below 1 ppb could be observed. Also Figure 6 of the patent in suit clearly showed that removal of sulphur strongly reduced carbon deposition. Deposited carbon, although not a poison for the catalyst, reduced the lifetime of the catalyst because it decreased the activity of the catalyst and might clog the reactor. Since the relationship between sulphur content and carbon deposition was not known before the priority date of the patent in suit, it was not obvious that the lifetime of the catalyst could be increased by further reducing the sulphur content. Keeping in mind that the effort and costs for further reduction would exponentially grow, the skilled person would not take into consideration any further reduction of the sulphur content below the level indicated in D10. Reference was made to the book "Catalysis-Science and Technology, Vol. 5 (1984), pages 79 and 80", disclosing the deterioration of a steam reforming catalyst due to charring and the prevention thereof by using a high steam/carbon ratio, the presence of hydrogen in the feed and high inlet temperatures. Further reference was made to patents purportedly granted on the basis of substantially the same claims in countries with substantive examination such as US and DK and documents rewarding the invention, published after the priority date of the patent in suit, to illustrate the surprising character of the claimed process.

V. The Appellant requested that the decision under appeal be set aside and that the patent be revoked.

The Respondent requested that the appeal be dismissed.

At the end of the oral proceedings the decision was announced.

Reasons for the Decision

1. The appeal is admissible.

2. Novelty was not contested in the appeal proceedings. The only issue that remains to be decided is therefore that of inventive step.

3. *Inventive step*

3.1 In the Board's judgment D4 represents the closest state of the art, since it contains in the form of examples 1 and 2 an explicit disclosure of a steam reforming process using a steam/carbon ratio within the range required by claim 1. The Respondent has stressed that said ratio is an essential feature of the invention. By contrast, D10 is silent about this feature. In addition, D4 represents the closest prior art acknowledged in the patent in suit (page 2, line 43 to 47).

D4 discloses a process for desulphurizing naphtha to a sulphur content below 0.05 ppm (50 ppb) followed by steam reforming with a ruthenium catalyst. According to example 1 the desulphurized naphtha has a sulphur content of 0.02 ppm (20 ppb) and is steam reformed with a steam/carbon ratio which can be calculated to be 1.1 as acknowledged by the Respondent (Respondent's letter

of 23 March 1998, page 2). Although not explicitly mentioned in D4, the fact that naphtha contains organic sulphur was not in dispute and is consistent with the use of naphtha as a feedstock according to the patent in suit (see Example 1).

3.2 The patent in suit does not contain an explicit statement concerning the problem underlying the invention. In the examples of the patent in suit the activity of the steam reforming catalyst after a certain lapse of time in operation with a desulphurized naphtha according to the invention (0.1 ppb)is compared with the activity of the same catalyst operated with a naphtha which was only primarily desulphurized (2 ppm). From this it can be inferred that the real problem was to maintain a high catalyst activity for an extended period of time.

Starting from D4, the technical problem underlying the invention can therefore be seen in providing a steam reforming process which allows longer operation with the same catalyst. This formulation of the problem is essentially in agreement with the first part of the Opposition Division's and the Respondent's formulation of the problem underlying the invention. They both added in their formulation, however, the prevention of carbon deposition on the catalyst. In the Board's opinion, prevention of carbon deposition is the explanation given by the Respondent for the increased lifetime of the catalyst occurring as a consequence of a reduction of the sulphur content in the hydrocarbons to be steam reformed and not a separate or additional technical problem. The relationship between sulphur content of the hydrocarbons and carbon deposition on the catalyst has been explored by the Respondent. To have recognised that, by reducing sulphur below a certain limit, carbon deposition is substantially prevented and that this is the technical reason why the

operation time of the catalyst is increased, already forms a pointer to the solution of the above mentioned problem. The formulation of the technical problem underlying the invention may, however, not contain pointers to the solution; cf. T 229/85, OJ EPO, 1987, 237.

Although no direct comparison with the process according to D4 has been made, there is convincing evidence that the said problem has actually been solved. As indicated above, carbon deposition reduces the lifetime of the catalyst. From said "Figure C" it follows that when the sulphur content of the naphtha feedstock is reduced below 20 ppb the carbon deposition is further reduced and consequently the lifetime of the catalyst is increased. The Board is therefore satisfied that the process according to present claim 1 actually solves the above mentioned technical problem.

3.3 The process of present claim 1 differs from the process disclosed in D4 only in that the sulphur content of the feedstock is 1 ppb by volume or less. It is therefore to be decided whether the reduction of the sulphur content of the hydrocarbon feedstock to that extent was obvious to a person skilled in the art.

3.4 D4 discloses that by working with a sulphur content below 0.05 ppm, it will be possible to continuously carry out the steam reformation for 8000 hours without changing the catalyst (page 4 of the English translation). D4 contains therefore already a clear hint that the lifetime of the catalyst may be extended by reducing the sulphur content of the feedstock. At the priority date of the patent in suit, the skilled person was also aware of D10, a recent patent relating to a highly efficient desulphurizing method for gases and its application to steam reforming. D10 discloses that after conventional desulphurization by a ZnO

catalyst the sulphur compound concentration can be reduced to 1 ppb by a copper containing catalyst. In the examples it is indicated that the sulphur compound concentration of the finally obtained purified gas was always lower than 0.01 mg S/Nm^3, which value corresponds to 7 ppb. According to D10 the sulphur compound concentration can be easily reduced to about 1 ppb and thereby protect the catalyst from being poisoned in the subsequent steam reforming and therefore greatly extend the lifetime of the catalyst (page 4 of the English translation, the chapter "Effects of the Invention"). The skilled person, knowing from D4 that the lifetime of the steam reforming catalyst can be increased by reducing the sulphur content below 20 ppb and from D10 that the lifetime can be further extended by reducing the sulphur content to 1 ppb, would thus have expected that by still further reducing the sulphur content, the lifetime of the catalyst could be further extended.

The skilled person was also aware of the fact that further reducing the sulphur content implies additional costs and would have seriously considered further reduction of the sulphur content only if this could have been done without excessive costs. The decision to further reduce of the sulphur content is therefore not so much a technical question but merely depends on economical considerations. The claimed process does, however, not relate to an economic way of further reducing the sulfur content, because it follows from the functionally defined, general wording of claim 1 that it includes all known disadvantageous methods for such a reduction of the sulfur content. Therefore, the process of claim 1 makes use of the known advantages, but also of the known disadvantages of the state of the art.

Apparently, at the priority date of the patent in suit an economical process for reducing the sulphur content below 1 ppb was not available to the skilled person. It was the invention of an improved desulphurization catalyst by the Respondent as laid down in Respondent's Japanese laid open patent applications JP-A-01 123 627 and JP-A-01 123 628, which formed the basis of EP-A-324 071, which made it economically feasible to further reduce the sulphur content. The examples of the patent in suit were in fact all performed with a desulphurizing catalyst according to EP-A-324 071. The patentability of the process described in the examples, which according to the Respondent's submission had been highly appreciated by those skilled in the art and may well involve an inventive step, is, however, not at issue here. In view of the above, the process of present claim 1, making use of any conceivable desulphurization method, cannot derive its patentability from the desulphurization method used in the examples. The economical obstacles which would have led the skilled person, according to the Respondent's submission, to refrain from actually performing the claimed process before the priority date of the patent in suit are, under these circumstances, no indication that the process of present claim 1 involves an inventive step. The Board holds that the invention of one economical way to execute a process having a predictable desirable effect does not justify the monopolisation of all conceivable possibilities for obtaining this desirable effect, including those having predictable disadvantages.

3.5 The Respondent further argued that, in spite of the economical drawbacks, the skilled person would have considered a further reduction of the sulfur content of the feedstock had he foreseen the surprising decline of carbon deposition if the sulphur content was reduced to 1 ppb or less, resulting in an extremely great

improvement of the lifetime of the reforming catalyst. Although the Board can agree with the Respondent in that the skilled person was unaware that the carbon deposition is reduced to the extent as indicated in the said "Figure C" by reducing the sulphur content from 50 to 0.1 ppb in the feedstock, the Board cannot accept that the recognition of this unpredictable extent of improvement is in the present circumstances relevant to the assessment of the inventive step. D10 unambiguously teaches to reduce the sulphur content to 1 ppb in order to extend the lifetime of the catalyst. There is no evidence that a dramatic increase in catalyst lifetime is caused by a further slight reduction of the sulfur content, so that the Respondent has insofar merely given a plausible explanation for the known relationship between the sulphur content of the steam reforming feedstock and the lifetime of the catalyst.

The disclosure in the examples of D10 of a sulphur concentration less than 7 ppb does not support the Respondent's further submission that 7 ppb is the lowest practical value obtainable with the desulphurizing catalyst disclosed therein, because this value can also be considered to be the detection limit, as submitted by the Appellant. No other evidence to the effect that the teaching of a sulfur content of 1 ppb would have been disregarded by a skilled person has been submitted by the Respondent, so that the Board considers that the lower limit of 1 ppb mentioned in D10 is realistic. There is no indication in D10 or any other document on file that below 1 ppb sulphur in the feedstock no further extension of the lifetime of the reforming catalyst could be expected. There was thus no technical reason for the skilled person to stop trying to further reduce the sulphur content below 1 ppb.

3.6 The Respondent's argument, that reduction of carbon deposition by reducing the sulphur content is not a "one way street", so that it was not obvious to select the option of sulphur reduction as a method for increasing the lifetime of the reforming catalyst, is in the Board's judgment not relevant to the assessment of inventive step in the present case. The Board accepts that the skilled person indeed had other technical options for reducing carbon deposition and thereby increasing the catalyst lifetime, such as the addition of hydrogen, an increase of the steam/carbon ratio or the inlet temperature, as mentioned in the Catalyst Handbook, referred to by the Respondent, but these were not the options the skilled person was guided to by D10 for increasing the lifetime of the catalyst beyond the level reached by D4. As indicated above and stressed by the Respondent, the skilled person need not have been aware of the relationship between sulphur content and carbon deposition, because his choice for reducing the sulphur content to 1 ppb or less as a method for increasing the catalyst lifetime was independent from such knowledge and made only use of the relationship between sulphur content and catalyst lifetime explicitly disclosed in D10.

3.7 For these reasons the Board holds that the process of claim 1 lacks an inventive step. The mere fact that granted patents exist in other countries for the same or similar subject matter does not suffice to justify a different decision.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The patent is revoked.

The Registrar: The Chairman:

S. Hue R. Spangenberg