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D E C I S I O N
of 9 February 2006

Case Number: T 0704/03 - 3.3.05

Application Number: 99117339.4

Publication Number: 0983790

IPC: B01J 3/00

Language of the proceedings: EN

Title of invention:

Hot gas reactor and process for using same

Applicant:

PRAXAIR TECHNOLOGY, INC.

Opponent:

-

Headword:

Hot gas reactor/PRAXAIR

Relevant legal provisions:

EPC Art. 123(2), 83, 56

Keyword:

"Sufficiency of disclosure (yes)"

"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 0704/03 - 3.3.05

D E C I S I O N
of the Technical Board of Appeal 3.3.05
of 9 February 2006

Appellant: PRAXAIR TECHNOLOGY, INC.
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 18 February 2003
refusing European application No. 99117339.4
pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: M. Eberhard
Members: J.-M. Schwaller
H. Preglau

Summary of Facts and Submissions

- I. The appeal was lodged against the decision of the examining division to reject European patent application No. 99117339.4.

The decision was based on the amended claims 1-11 and 13-15 submitted with letter of 15 February 2002 and on amended claim 12 filed on 27 December 2002.

- II. In the decision, the examining division put forward *inter alia* the following arguments:

Claim 1 did not meet the requirements of Article 83 EPC because it was not possible to carry out the method set forth in claim 1 over the entire range claimed, i.e. it was not possible to prevent substantial reaction taking place within the mixing chamber for all embodiments encompassed by the scope of the claim. Figure 3, for example the data for 800 °C and 900 °C, revealed that substantial conversion of the reactants occurred in the mixing chamber at contact times of about 0.5 and 1 milliseconds. Serious doubts also arose that reaction in the mixing chamber could be prevented to any "substantial" degree at 2800 °C.

Claim 1 lacked an inventive step over D1 (GB-A-911421) for the following reasons: the first distinguishing feature, namely the temperature and velocity ranges of the first reactant gas, was trivial since it represented an arbitrary choice of specific ranges for the general terms "*elevated temperatures*" and "*supersonic velocity*" given in claim 6 of D1. Furthermore, the presently selected ranges were those

which would be expected for hydrocarbon oxidation. The second differentiating feature, namely that the reactant gases were mixed under reactive conditions, was regarded as the key difference to D1 which disclosed that they were mixed under non-reactive conditions. The technical problem underlying the invention was to achieve high selectivity and conversion in a vapour phase reactor, as well as providing safety and incurring low costs. Because reaction between the reactant gases did occur in the mixing chamber under some of the claimed conditions, these advantages could not be achieved over the entire scope of claim 1, and therefore no inventive step could be acknowledged for the subject-matter of claim 1. Furthermore, claim 12 did not meet the requirements of Article 123(2) EPC.

III. With the grounds of appeal, the appellant filed amended claims 1, 9 and 10 along with amended pages of description and an amended Figure 1.

IV. In a communication, the board raised *inter alia* the following objections:

Claims 1 and 12 then on file appeared to violate the requirements of Article 123(2) EPC; as regards specifically claim 1, steps (a) and (b) defined in the application as originally filed were omitted.

The terms "*thermal nozzle*" (claim 12) and "*about*" (claims 1 and 12) were objected to under lack of clarity.

The subject-matter of claim 1 was considered as lacking an inventive step. Starting from D4 (EP-A-001946), the problem to be solved was seen in the provision of an alternative chemical vapour reaction process. It was common general knowledge that an increased gas velocity would increase the Reynolds number and turbulence thereof and thus the mixing dynamics and efficiency when said gas was brought into contact with a second gas. Thus, it would lie within the competence of a skilled person to determine by routine experimentation the velocity of the first reactant gas which would lead to an appropriate mixing of the reactant gases. The determination of the optimal temperature relationship between two reactants would be within the competence of a skilled person faced with the above problem and could have been achieved by routine experimentation. The use of gas preheating temperatures greater than 500 °C would have been contemplated by a skilled reader of D4.

- V. In reply to the above communication, with a letter dated 26 January 2006 the appellant filed an amended set of claims 1-11 as a main request as well as a set of claims 1-9 as an auxiliary request.

Claim 1 of the main request reads:

"1. A method for producing chemical products by a vapor phase reaction, comprising:

- a) feeding a first reactant gas at a first pressure to a first chamber (1);*
- b) heating said first reactant gas;*
- c) expanding said first reactant gas having a temperature of from 500 °C to 2800 °C and a velocity greater than 300 m/s through one or more nozzles (4) in a mixing chamber (2);*

d) *injecting a second reactant gas having a lower temperature than the first reactant gas in the mixing chamber (2) so that the second reactant gas is entrained with the first reactant gas and rapidly mixed together to produce, under reactive conditions, a substantially uniform mixture, wherein the contact time of the first and second reactant gases in the mixing chamber (2) is short enough to prevent any substantial reaction from taking place in the mixing chamber; and*
e) *reacting the mixture in a reaction zone (6)."*

VI. During the oral proceedings, which took place on 9 February 2006, the appellant filed an additional document and calculations in support of its arguments as well as an amended description with drawings.

VII. During the appeal proceedings, the appellant presented in particular the following arguments:

The inclusion into claim 1 of the feature that the contact time of the first and second reactant gases in the mixing chamber has to be short enough to prevent any substantial reaction from taking place in the mixing chamber enabled the skilled man to obtain all the claimed embodiments.

In D4, a subsonic, preheated stream of oxygen was injected into a mixing head through a multitude of slots or channels, thus providing a plurality of laminar film-like oxygen streams. These oxygen films were then sandwiched between two layers of process gas introduced tangentially and mixing occurred by the swirling movement of the process gas. In the present invention, a heated high velocity first gas was

expanded through nozzles thus providing a low pressure, low density zone into which the second gas having a higher density was entrained, thus providing a very rapid mixing of the gases. The apparatus of D4, which required a multitude of tubes, was more complicated than the device necessary for carrying out the present process. The present invention thus provided for a different mixing principle to that of D4 and allowed the use of a simpler and therefore less expensive device than D4.

VIII. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of claims 1 to 11 as filed with letter dated 26 January 2006 (main request) or in the alternative on the basis of claims 1 to 9 as filed as an auxiliary request with letter dated 26 January 2006.

Reasons for the Decision

Main request

1. *Allowability of the amended claims under Article 123(2) EPC*

The process claims 1-11 have a basis as follows in the application documents as originally filed:

- claim 1: claim 9; page 6, 1st paragraph of "Detailed description of the invention"; page 7, lines 4-11; page 8, lines 8-19; page 9, line 3 - page 10, line 4; page 11, lines 10-14; Figure 1
- claim 2: page 9, lines 9-13; page 16, lines 16-21

- claim 3: page 16, lines 17-21
- claim 4: page 16, line 17 and lines 28-32
- claim 5: page 16, line 29 - page 17, line 3
- claim 6: page 17, lines 16-18
- claims 7, 8: page 7, lines 12-16
- claims 9, 10: page 8, lines 19-23
- claim 11: page 6, first paragraph of "Detailed description of the invention"

2. *Clarity*

The terms "*thermal nozzle*" and "*about*", objected to under clarity in the communication from the board, having been deleted, these objections are therewith overcome.

3. *Sufficiency of disclosure*

The examining division argued that it was not possible to carry out the method set out in claim 1 filed with letter of 15 February 2002 over the entire range claimed, since it was not possible to prevent substantial reaction taking place within the mixing chamber for all embodiments encompassed by the scope of said claim 1.

In order to overcome the above objection, the appellant included the features "*the contact time of the first and second reactant gases in the mixing chamber is short enough to prevent any substantial reaction from taking place*" into claim 1.

The board observes that the so prescribed time requirement limits the scope of claim 1 to embodiments involving a contact time for which any substantial reaction is prevented and contact times which do not prevent any substantial reaction from taking place are thereby excluded. Furthermore, the contact time necessary for preventing any substantial reaction within the mixing chamber between a first and a second reactant gas (for example oxygen and propane) can be determined by the skilled person for different temperatures in view of the information given in the description, and the board has no reason to believe that such a determination would be beyond the skills of the ordinary practitioner for reactant gas mixtures other than those exemplified in the description. As regards the serious doubt expressed by the examining division that at 2800 °C a reaction could not be prevented to any substantial degree in the mixing chamber, this situation being outside the scope of protection of the claims, it would thus not be detrimental to the requirement of sufficiency of disclosure. Accordingly, the board is of the opinion that the skilled person would be able to carry out the invention over the entire ambit of claim 1 and the requirements of Article 83 EPC are therefore fulfilled.

4. *Novelty*

Novelty was not contested in the impugned decision. Present claim 1 includes the additional feature that *"the contact time of the first and second reactant gases in the mixing chamber (2) is short enough to prevent any substantial reaction from taking place in*

the mixing chamber". Its subject-matter is novel over the documents cited in the European search report.

5. *Inventive step*

- 5.1 The examining division considered D1 as the closest prior art. D1 discloses (see claim 6) a method of mixing at least two chemically reactive gas streams, which comprises supplying separate streams of each of said gases at subsonic velocity and at elevated temperatures so that their average temperature is above reaction temperature, subdividing each of said streams into a group of smaller narrow streams, accelerating the gas of each said narrow stream at supersonic velocity sufficient thereby to cool the gases to below reaction temperature, discharging the resultant cooled supersonic streams in a substantially common direction in closely interspersed relation into one end of an elongated mixing zone, and passing said streams through said mixing zone continuously at said supersonic velocity and without chemical reaction between the gases thereof for a distance at least twenty times the maximum width of the widest of said narrow streams at the upstream end thereof, thereby effecting lateral mixing between said streams of different groups during said flow. D1 further discloses that the temperature of the heated reactant gases may be the same or different before being cooled below the reaction temperature (page 3, lines 107-117). D1 however does not give any detail as to the specific temperatures in the mixing zone, let alone that the temperature of the second reactant is lower than that of the first one, as required in claim 1 of this request.

- 5.2 The subject-matter of claim 1 differs from the disclosure of D1 at least in that the gases are mixed in the mixing chamber under reactive conditions, the first reactant gas has a temperature of from 500 °C to 2800 °C and the temperature of the second reactant gas is lower than that of the first reactant gas.
- 5.3 Thus, unlike the principle of the process defined in claim 1 of this request wherein the mixing operation is performed under reactive conditions, in D1 the gases are deliberately kept under non-reactive conditions in the mixing zone. This requirement implies additional measures in the process of D1 in order to bring the mixed gases under reactive conditions; for instance the mixed gases are decelerated (D1, claim 16) or they flow past a wedge 13 wherein standing shock waves are formed (D1, page 3, lines 121-125). As pointed out in the appealed decision, the fact that in D1 the two reactant gases are mixed under non-reactive conditions, whereas in the claimed process the gases are rapidly mixed under reactive conditions, constitutes a key difference between D1 and the claimed process. In these circumstances, it is questionable whether D1 represents the closest prior art and the board considers that D4 is a more appropriate starting point for the assessment of inventive step for the following reasons.
- 5.4 D4 discloses a process and an apparatus for rapidly mixing preheated reactant gases, e.g. an oxidizing gas and a process gas containing hydrocarbons, in order to have a quasi-homogeneous mixture without substantial reaction taking place in the mixing chamber, said mixture being then introduced in a catalytic reforming reactor for producing chemical products in the vapour

phase (D4, page 1, lines 3-36; page 3, lines 22-26). The apparatus comprises a refractory casing and a distributor and the process gas is injected tangentially so as to impart a helical gas motion to said gas inside the casing. The distributor introduces the oxidizing gas through a multitude of parallel channels having exit orifices with at least one dimension being less than 20 mm (see claim 1 and Figures). The exit orifices are preferably slot-shaped (claim 2). The oxidizing gas must be injected into the mixing zone in the form of thin films or thin streams, in order for the oxidizing gas to travel a very short distance before being dispersed into the process gas (D4, page 5, lines 12-18). The kinetic of dispersion is further improved by imparting the process gas with a strong helical motion around said channels (D4, page 5, lines 29-34).

Thus, contrary to the disclosure of D1 and like the claimed process, D4 contemplates on the one hand, having the reactant gases under reactive conditions in the mixing chamber and on the other hand, mixing the reactant gases very rapidly to prevent any substantial reaction from taking place.

- 5.5 Starting from D4, the technical problem to be solved by the subject-matter of claim 1 can be seen in the provision of another process for producing chemical products by a vapor phase reaction, which process can be performed in a less complicated device (see in this respect page 15, lines 4-6 of the application).

It is proposed to solve the above problem by the process as defined in claim 1, which differs from the process in D4 by:

- expanding the first reactant gas having a temperature of from 500 °C to 2800 °C and a velocity greater than 300 m/s through one or more nozzles in the mixing chamber;
- injecting the second reactant gas having a lower temperature than the first reactant gas in the mixing chamber, so that the second reactant gas is entrained with the first reactant gas and rapidly mixed together.

In view of the information in the description and drawings, it is credible that the above problem has been effectively solved. The claimed process can be performed in an apparatus having a very simple construction, such as the one described at page 10, line 30 to page 11, line 1 of the application, which is less complicated than the apparatus of D4 where a bundle of channels or pipes is required. As pointed out by the appellant, a multiplicity of nozzles may be used according to claim 1; this is nevertheless not mandatory and a high reactant gas flow rate may be achieved in the claimed process with only one nozzle, namely just by increasing its diameter, while in the process of D4 the presence of a multiplicity of pipes or channels is an absolute necessity.

- 5.6 It is observed that the combination of features c) and d) according to claim 1 of the present request implies a different mixing principle to that in D4. As explained by the appellant, in the process presently claimed, the rapid mixing of the two reactant gases is

due to the expansion through one or more nozzles of the first reactant gas at a high velocity and a high temperature to create a low pressure and low density zone and to the injection of the second reactant gas at a lower temperature than that of the first reactant gas, the consequence of these operating conditions being that the second gas is entrained with the first gas which has a lower density than the second one. On the other hand, in D4 the rapid mixing results from the injection of the oxidizing gas in the form of a plurality of thin films or streams into the process gas which has a helical motion around the channels, thus rapidly dispersing the oxidizing gas. This different mixing principle furthermore allows the process according to present claim 1 to be performed using a simpler and less expensive apparatus than in D4.

Neither D1 nor D4 nor the other documents cited in the European search report suggest the combination of operating conditions recited in features c) and d) to achieve, under reactive conditions, the mixing effect as explained above and thus to solve the problem defined in point 5.5.

- 5.7 In the impugned decision, the lack of inventive step objection with respect to D1 was *inter alia* based on the fact that because reaction between the reactant gases did occur in the mixing chamber under some of the claimed conditions, the advantages provided by the invention could not be achieved over the entire scope of claim 1 then on file. These arguments no longer apply to present claim 1, because as already mentioned in item 3. *supra*, its scope is now restricted to embodiments involving a contact time for which any

substantial reaction is prevented; consequently, contact times which do not prevent any substantial reaction from taking place are thereby excluded. D1 furthermore explicitly requires that the gases be maintained under non-reactive conditions in the mixing chamber. Thus, as acknowledged in the decision appealed, the teaching of D1 is opposite to the claimed subject-matter which requires mixing the reactant gases under reactive conditions. D1 also neither contains any information which would prompt the skilled person to perform the mixing step under reactive conditions, nor does it suggest how a rapid mixing could be obtained under such conditions without any substantial reaction taking place in the mixing chamber. Apart from the information at page 3, lines 110-117, that "*the temperatures (of the reactant gases) may be the same or different*" and that "*when flowing through the supersonic nozzle they undergo a significant drop in temperature, so that when the gases are brought into contact at the downstream ends of the nozzle they are below reaction temperature*", D1 does not give any further details as to the reactant gases temperatures in the mixing chamber. The skilled person can thus neither infer therefrom that the first reactant gas temperature has to be within the range from 500 °C to 2800 °C nor that the second reactant gas must have a lower temperature than the first reactant gas in the mixing chamber in order to obtain the mixing effect as explained in point 5.6 above, under reactive conditions. D1 finally teaches at page 3, lines 85-87 that "*mixing between supersonic streams is inherently slow*" and in the board's view, this teaching would not prompt the skilled person faced with the above problem to try high velocities to achieve rapid mixing. Under these

circumstances, the board considers that any lack of inventive step argumentation based on D1 in order to arrive at the subject-matter of present claim 1 would only be based on hindsight.

- 5.8 Accordingly, for the reasons indicated above, the subject-matter of claim 1 cannot be considered as being obvious to a person skilled in the art in view of cited prior art. The claims 2-11 being dependent on claim 1, these claims therefore also meet the requirements of Article 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to grant a patent on the basis of claims 1 to 11 according to the main request as filed with letter dated 26 January 2006, the amended description as filed during the oral proceedings and drawings - Figures 1 to 3 - as filed during the oral proceedings.

The Registrar:

The Chairman:

A. Wallrodt

M. Eberhard