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D E C I S I O N
of 17 February 2005

Case Number: T 0451/03 - 3.2.3
Application Number: 95109042.2
Publication Number: 0687853
IPC: F23C 6/04, F23C 1/00
Language of the proceedings: EN

Title of invention:
Staged combustion for reducing nitrogen oxides

Patentee:
PRAXAIR TECHNOLOGY, INC.

Opponent:
L'AIR LIQUIDE S.A.

Headword:

-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (main request: no)"
"Admissibility of the auxiliary requests: no"

Decisions cited:

Catchword:

-



Case Number: T 0451/03 - 3.2.3

D E C I S I O N
of the Technical Board of Appeal 3.2.3
of 17 February 2005

Appellant: L'AIR LIQUIDE S.A.
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Representative: -

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Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 19 February 2003
rejecting the opposition filed against European
patent No. 0687853 pursuant to Article 102(2)
EPC.

Composition of the Board:

Chairman: U. Krause
Members: Y. G. A. Jest
J. P. B. Seitz

Summary of Facts and Submissions

- I. The appeal was lodged by the Opponent and contests the decision of the Opposition Division dated 19 February 2003 to reject the opposition against European patent No. 0 687 853.

The opposition was based on the grounds of lack of novelty and inventive step (Article 100(a) EPC), of insufficient disclosure (Article 100(b) EPC) and of added subject-matter (Article 100(c) EPC). Before the decision under appeal was issued, the Opponent withdrew the grounds of Article 100(b) and 100(c) EPC and no longer contested novelty of the subject-matter of the patent. As regards the ground of lack of inventive step (Article 56 EPC) the Opposition Division came to the conclusion that no combination of cited documents would actually lead the person skilled in the art to arrive at the claimed subject-matter of the patent.

- II. The single independent claim of the patent as granted reads as follows:

"1. A process for combusting liquid fuel with reduced nitrogen oxides generation, said process comprising:
(a) providing in a combustion zone at least one liquid fuel stream;
(b) injecting a substoichiometric amount of a primary oxidant stream in the form of an annular stream to surround or envelop at least a portion of a length of said at least one liquid fuel stream;
(c) entraining at least a portion of said primary oxidant stream within said liquid fuel stream and

partially combusting said liquid fuel with the entrained oxidant to form partially combusted products; (d) injecting at least one secondary oxidant stream to establish an ambient gas circulation pattern wherein a large volume of ambient gas is entrained within said at least one secondary oxidant stream to form a diluted stream having an oxygen concentration of about 1 to about 30 percent by volume before being mixed with said partially combusted products; and

(e) mixing said diluted stream with said partially combusted products and thereafter combusting said partially combusted products with the oxidant in said diluted stream;

characterized in that

in step (a) said at least one liquid fuel stream is provided in the form of a spreading spray having an outer periphery angle of less than 15°, measured from the axis of said at least one liquid fuel stream; and in step (b) said primary oxidant stream is injected at a velocity of less than about 61 m/s (200 feet per second)."

III. With respect to the issue of inventive step inter alia the following prior art was taken into consideration:

D4: US-A-5 076 779

D7: US-A-5 267 850

IV. The notice of appeal was filed by the Opponent (hereinafter: Appellant) on 16 April 2003 and the appeal fee was paid on the same day. The statement of the grounds of appeal was submitted on 19 June 2003.

With communication pursuant to Article 11(1) RPBA dated 18 May 2004 the Board summoned the parties to oral proceedings arranged for 17 February 2005 and informed them of its provisional opinion.

Thereafter the Respondent submitted with letter dated 9 February 2005 three amended set of claims as "auxiliary requests". The independent claim of each of these sets (hereinafter AR1, AR2, AR3) is based on claim 1 as granted and on the following additional features:

- in AR1: the added feature at the end of the claim reads: "and the amount of oxygen in the primary oxidant is 10 to 30% of the stoichiometric amount of oxygen for reacting with the liquid fuel stream";
- in AR2: the added feature "having a velocity greater than 76,2 m/s (250 fps)" being inserted between "injecting at least one secondary oxidant stream" and "to establish an ambient gas circulation pattern" in feature (d) of the preamble portion;;
- in AR3: claim 1 of AR3 comprises both additional features mentioned above and corresponds thus to the combination of both AR1 and AR2.

In oral proceedings held on 17 February 2005 the issue of inventive step was discussed essentially by reference to a combination of D4 and D7.

V. The Appellant requests that the decision under appeal be set aside and that the patent be revoked. Its arguments in support of this request can be summarized as follows:

Prior art document D4 shows a staged combustion process having all the steps (a) to (e) according to the preamble of claim 1. The claimed method differs from D4 by the characterising features of claim 1, i.e. the upper limits of the values of both the velocity of the primary oxidant and the angle of the fuel spray. From these features two technical problems may be derived:

- adapt the method so as to allow the use of a non-water cooled burner,
- reduce the NO_x formation by increasing the flame stability.

To solve these problems, which actually corresponds to the objectives of the invention (see patent page 4, lines 8-10 and 19-21) the person skilled in the art would contemplate the relevant state of the art in all the related fields: staged combustion of liquid fuels, soot formation and corrosion of burners using liquid fuels, non-water cooled burners.

During his investigation the person skilled in the art would consider document D7, which, though not relating to a staged combustion, indicates some technical arrangements of a burner to allow it to operate without water-cooling. The main teaching of D7 resides in the location of the burner nozzle in a cavity provided in the wall of the combustion chamber and in means for

obtaining the stability of the flame at the burner nozzle, which means consists of the selection of a low velocity for the flow of oxidant encircling the fuel spray (actually a velocity smaller than 100 feet per second). Accordingly the second technical problem is solved by the teaching of D7 which recommends a low velocity of the flow of oxidant around the fuel spray so as to "attach" said flame at the burner nozzle.

The first problem would be solved by the person skilled in the art on the basis of the teaching of the same document D7, which teaches that the ratio L/D , D being the diameter of the recess in which the nozzle of the burner is located and L the distance of its distal end to the wall of the combustion chamber, should be in the range 1 to 4 in order to avoid damage to the burner or soot deposition in the recess. From this range the person skilled in the art may derive the range for the fuel spray angle (smaller than 9°) simply by applying trigonometric tables.

The Appellant thus concluded that the method of claim 1 as granted was obviously derivable from the combination of the teaching of D4 and D7 and therefore lacked inventive step in the meaning of Art.56 EPC.

VI. The Proprietor of the Patent (hereinafter: Respondent) requests that the appeal be dismissed or, auxiliarily, that the decision under appeal be set aside and the patent be maintained as amended on the basis of one of the amended set of claims filed on 9 February 2005.

Its arguments can be summarised as follows:

The method according to the invention relates to a staged combustion process of the type known from D4, in which oxidant is supplied in two distinguished flows, the so-called primary and secondary oxidant. The characterising feature defining a narrow spray angle for the liquid fuel spray actually promotes the use of a non-water cooled liquid fuel burner and also enhances the effective combustion with reduced NO_x generation. According to the Respondent the person skilled in the art would not have considered prior art documents which do not relate to a staged combustion, for instance prior art D7, mainly because some technical arrangements in a single stage combustion are specific to this technology and cannot be simply transferred to a staged combustion process, at least not with the aim of achieving the expected advantages directly linked to a single staged combustion. But even if the person skilled in the art had considered D7 and applied its technical teaching to prior art method of D4, the result would be a change from the staged combustion process of D4 into a single combustion process, and thus different from the claimed invention.

Reasons for the Decision

1. The appeal meets the requirements of Rule 65(1) EPC and is therefore admissible.

2. *Main request*

2.1 The Board concurs with the parties and the decision under appeal in that the subject-matter of claim 1 is new and that document D4 is to be considered as closest prior art for the assessment of inventive step. It has not been disputed by the parties that this document discloses a method for combusting liquid fuel according to the preamble of claim 1 as granted by providing:

- a liquid (see column 3, line 52) fuel stream 3 (feature a) of claim 1),
- a small amount of stabilising oxidant (see column 4, lines 13 to 18) forming a primary oxidant stream of substoichiometric amount in the form of an annular stream to surround at least a portion of the length of the liquid fuel stream (feature b) of claim 1),
- a secondary oxidant stream 2 injected at a velocity sufficient to establish an ambient gas circulation pattern (see column 3, lines 10 to 26) so as to entrain a large volume of ambient gas within said at least one secondary oxidant stream to form a diluted stream (as defined by feature d) of claim 1).

2.2 The claimed method thus differs from prior art D4 by the characterising features:

- in step (a) said at least one liquid fuel stream is provided in the form of a spreading spray having an outer periphery angle of less than 15° , measured

from the axis of said at least one liquid fuel stream; and

- in step (b) said primary oxidant stream is injected at a velocity of less than about 61 m/s (200 feet per second).

These two distinguishing features actually provide two different technical effects and thus define two separate objective technical problems.

2.2.1 The low value of the spray angle enables the application of the combustion method to a non-water cooled burner. In non-water cooled burners the burner nozzle is generally located in a refractory port provided in a furnace wall and its tip is recessed from the opening of said port in the surface of the wall so as to reduce the burner tip temperature without having to utilise water-cooling. Due to the narrow fuel spray in combination with such a non-water cooled arrangement one can avoid soot deposition in the port and prevent other damage to the burner and especially to the wall of the recess (see patent page 2, lines 26-28 and page 6, lines 9-11).

The Respondent referred to a second technical effect obtainable by the narrow fuel spray, as mentioned in the patent, page 4, lines 8-10, in the sense that the narrow spray is said to enhance the effective and efficient combustion of the liquid fuel with reduced generation of nitrogen oxides. In the Board's view there is no general knowledge or shared understanding in the field that a reduction of NO_x generation can be achieved purely by narrowing the fuel spray, neither does the

patent contain any explanation of this alleged effect. No additional information related to that effect was delivered by the Respondent during the procedure. The Board therefore does not consider this second effect as being directly linked to or achieved by the feature defining a narrow fuel spray.

The objective technical problem derivable from the first distinguishing feature (narrow fuel spray) would thus consist of adapting the method of D4 so as to enable the use of a non-water cooled burner.

2.2.2 The second distinguishing feature concerns the relatively low velocity of the primary flow of oxidant. As set forth in the patent (page 4, lines 19 to 22) the technical effect linked to this feature consists in promoting a stable flame at the tip of the burner and additionally, as a consequence, a reduction of NO_x generation.

2.3 The Board arrives at the conclusion that the two distinguishing method-steps of claim 1 actually solve two separate technical problems without having a synergetic effect. The person skilled in the art will thus have to solve two different problems starting from the method known by D4.

First, the method should allow utilising non-water cooled burners and, second, the stability of the flame should be guaranteed.

2.4 In the Board's view the person skilled in the art will be prompted by D7 to adapt the method of D4 in order to solve both of these technical problems so as to arrive at the claimed method.

2.4.1 Prior art D7 specifically deals with the problem of designing a burner combustion method using for instance a spray of liquid fuel (see column 2, line 68) and without need for water cooling (see column 1, lines 31 to 34). From the document as a whole and in particular from claim 1, the person skilled in the art is taught to apply two main principles. First the burner nozzle should be located in a cavity and recessed from the opening by a distance L being comprised between D and $4D$, D being the diameter of the recess (see features (A) and (B) of claim 1 of D7). Second an annular stream of oxidant should be injected coaxially with the fuel stream at a low velocity, i.e. not more than 100 feet per second (see feature (C) of claim 1). The technical effects of these method steps are explained in detail in column 2, lines 47-58 and column 3, lines 32-64. The burner system and especially its nozzle are protected from damage even without water-cooling. This is due to the recessed location of the nozzle and to the low velocity of the oxidant injected in the recess. By these measures the flame remains stable and attached at the tip of the burner nozzle despite the high velocity of the fuel spray. The flame expands slowly and extends into the combustion zone wherein combustion continues while furnace gases are prevented from entering the cavity (column 3, lines 39 to 41 and 48 to 54 of D7). The ratio L/D determines the maximum allowed angle of the fuel spray within the cavity, bearing in mind that the cavity wall should not be damaged by the fuel or

the flame. From the range 1 to 4 of the ratio L/D it can be derived by simple trigonometric considerations that the angle from the axis of the cavity to the edge of its inlet in the combustion zone is between 7° and 26°, which means that the angle of the fuel spray measured at the circular outlet of the injecting tube must be substantially smaller due to the dimension of the injection tube. Values below 15° for the fuel spray angle are, therefore, derivable from D7.

In conclusion the characterising features of claim 1 of the main request are known from D7.

The remaining issue to be dealt with concerns the obvious application of the principles disclosed in D7 to a method known by D4.

- 2.4.2 The Respondent argued that the person skilled in the art would not have considered D7 when looking for a suitable solution to the aforementioned problems. The suggested reason is mainly based on the apparent different combustion processes: in the invention and in D4 the combustion proceeded in two stages because of the separate first and second oxidant streams, while D7 taught a single staged combustion because the whole amount of oxidant was injected at the same time around the injected fuel in the area of the cavity. These two types of combustion methods were in several aspects quite different and the person skilled in the art would not consider a single staged combustion process such as in D7 when attempting to improve the two-staged combustion of D4.

2.4.3 The Board cannot share the Respondent's views regarding the teaching of D7 for the following reasons.

From the whole disclosure of D7 (see especially lines 51-58 of column 2 and lines 32-64 of column 3) the person skilled in the art is taught that D7 concerns the problems encountered in combustion utilising a non-water cooled burner, and how to solve these problems. The first aspect of the solution, the location of the burner tip in a recess of the furnace and the resulting small spray angle of the fuel, is described in D7 without making reference to the oxidant stream, and clearly applies to any type of combustion, whether staged or not. This also applies to the second aspect, i.e. the low velocity of the encircling oxidant stream. Although D7 refers generally to the stream of oxidant, it neither emphasizes that part of the technical solution consists in providing the whole amount of oxidant right from the beginning of the combustion process nor does it appear to be of any relevance in this respect; the person skilled in the art is simply taught to inject the oxidant flow encircling the fuel stream with reduced velocity to stabilize the flame. The same effect on flame stabilisation can be expected for any annular oxidant stream and it does not, therefore, matter whether this oxidant stream comprises a substoichiometric portion, as in D4, or the entire amount required for full combustion. Even if, as pointed out by the Respondent, the whole amount of oxidant needed for the combustion was actually injected in a single stage, the combustion would not be wholly performed in the cavity but would continue in the subsequent combustion zone.

In other words, D7 does not require a single stage combustion process to solve the technical problem and leaves the choice of condition under which the full combustion can be arranged. Prior art D7 teaches clearly that the solution to the problem is to be found in the location of the burner tip and in the velocity of the oxidant in the vicinity around the fuel stream.

- 2.4.4 For these reasons the Board considers that the person skilled in the art would not only have noticed that D7 provides a solution to the technical problems addressed but also would have contemplated the inclusion of the specific method steps suggested by D7 in the method known from D4.

The method of claim 1 as granted (main request) therefore lacks inventive step in the meaning of Article 56 EPC.

3. *Auxiliary requests - Admissibility*

The amended sets of claims of the three auxiliary requests AR1, AR2, AR3 for the maintenance of the patent in an amended form were filed with letter dated 9 February 2005 and received by fax the same day, thus only a few days before the date of the oral proceedings of 17 February 2005.

The Board exercises its discretion not to admit these late filed requests for the following reasons.

- 3.1 Claim 1 of both auxiliary requests AR1 and AR3 is based on granted claim 1 and incorporates an additional feature ("the amount of oxygen in the primary oxidant

is 10 to 30% of the stoichiometric amount") derived from the description, so that the subject-matter of this claim was not previously the subject-matter of any of the claims as granted. Furthermore the addition of this feature would appear to give rise to fresh issues not yet addressed and which would lead to undue procedural delay. Indeed the state of the art disclosed in D4 could obviously no longer act as closest prior art and it is not apparent from the content of the case which currently cited reference or document should replace D4 in this respect. As a result, the whole assessment of the inventive step based on the problem-solution approach would have to be revised.

- 3.2 The sole feature added to claim 1 as granted to form claim 1 of auxiliary request AR2 is considered by the Respondent to be already known from closest prior art D4 since it has been placed in the preamble portion of amended claim 1.
- Accordingly this additional feature would prima facie not appear to further distinguish the invention over the combination D4 and D7 so that the method of claim 1 of AR2 would prima facie still lack inventive step for the same reasons as set out above for the main request and therefore not meet the outstanding objections under the EPC.

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:

A. Vottner

U. Krause