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D E C I S I O N
of 22 May 2003

Case Number: T 1029/01 - 3.2.3

Application Number: 94118073.9

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Language of the proceedings: EN

Title of invention:
Method for deeply staged combustion

Patentee:
PRAXAIR TECHNOLOGY, INC.

Opponent:
L'AIR LIQIDE, SOCIETE ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCEDES GEORGES CLAUDE

Headword:
-

Relevant legal provisions:
EPC Art. 83, 56

Keyword:
"Sufficiency of disclosure - yes (main request)"
"Inventive step - yes (main request)"

Decisions cited:
-

Catchword:
-

Case Number: T 1029/01 - 3.2.3

D E C I S I O N
of the Technical Board of Appeal 3.2.3
of 22 May 2003

Appellant: (Opponent)
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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office posted 30 August 2001 concerning maintenance of European patent No. 0 653 590 in amended form.**

Composition of the Board:

Chairman: C. T. Wilson
Members: U. Krause
J. P. B. Seitz

Summary of Facts and Submissions

I. The appeal contests the decision of the Opposition Division dated 6 July 2001 and posted on 30 August 2001 to maintain European patent No. 0 653 590 in amended form with the following independent claim 1:

"1. A method for carrying out combustion while achieving reduced generation of nitrogen oxides comprising:

(A) injecting primary fuel and primary oxidant together or separately into a combustion zone in a ratio within the range of from 5 to 50 percent of stoichiometric, said primary oxidant being a fluid having an oxygen concentration of at least 90 volume percent, wherein when injecting primary fuel and primary oxidant together in a premixed condition, the mixture is injected into the combustion zone at a velocity of at least 15 m/s 50 feet per second), and wherein, when injecting primary fuel and primary oxidant separately, the primary fuel is injected into the combustion zone at a velocity of at least 15 m/s (50 feet per second) and the primary oxidant is injected into the combustion zone at a velocity less than that of the primary fuel;

(B) injecting secondary oxidant into the combustion zone at a point spaced from where said primary fuel and primary oxidant are injected into the combustion zone;

(C) combusting primary fuel and primary oxidant within the combustion zone separate from the secondary oxidant to produce combustion reaction products; and

(D) mixing secondary oxidant with combustion reaction products within the combustion zone and thereafter combusting secondary oxidant with combustion reaction products."

II. 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). Since no substantiation was provided for the grounds of Article 100(c) this objection was not dealt with in the decision under appeal. As regards the other grounds the Opposition Division came to the conclusion that the upper limit for the injection velocity of the mixture could be easily found by a skilled person and that the injection of the primary fuel and oxidant having an oxygen concentration of at least 90% with a velocity of at least 15 m/s in the first stage of a staged combustion process for reducing nitrogen oxides was not derivable from the available prior art. The admissibility of the opposition with respect to the grounds of Article 100(a), which was disputed by the Proprietor of the patent, was acknowledged as some of the essential features of claim 1 were discussed in view of a prior art document.

III. The Opponent (hereinafter denoted Appellant) filed the notice of appeal on 17 September 2001 and paid the appeal fee on the same day. The statement of the grounds of appeal was filed on 28 December 2001.

In response to the statement of the grounds of appeal the proprietor of the patent (hereinafter denoted Respondent) filed amended sets of claims according to a first and second auxiliary request.

In oral proceedings held on 22 May 2003 the Appellant declared that novelty was no longer disputed. Further, no arguments concerning the grounds of Article 100(c) EPC were brought forward.

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

D1: A.I.Dalton and D.W.Tyndall, "Oxygen Enriched Air/Natural Gas Burner System Development", Final Report, November 1989, Gas Research Institute, Chicago, Ill.

D3: EP-A-0 507 995

D4: DE-A-41 42 401

D7: C.E.Baukal and A.I.Dalton, "No_x Measurements in Oxygen-Enriched, Air-Natural Gas Combustion Systems", Gas Research Institute 1990, pages 1,5,6

D9: S.K.Panahi et al., "Low-NO_x Technologies for Natural Gas-Fired Regenerative Glass Melters", Institute of Gas Technology, paper presented at The Scandinavian Society of Glass Technology Annual Meeting 1992, page 10

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:

The patent lacked a sufficiently clear and complete disclosure because a skilled person would not know how he should, in step (D) of claim 1, carry out the step of mixing the secondary oxidant with combustion reaction products before combusting it therewith, since combustion would start when mixing the oxidant with the combustion reaction products and no measures were disclosed which would allow separation of the mixing zone from the combustion zone and prevent the fuel from spreading all over the combustion chamber. Further, it was unclear whether an injection velocity of 15 m/s was the "high" velocity required according to column 4, lines 13 to 20, of the patent to lower the No_x emissions. It appeared from Figure 4 and column 5, lines 33 to 46, of the patent that the velocity should be considerably higher, at least 58 m/s.

Since both staged combustion with a low level of oxygen enrichment in the primary oxidant as well as a combustion with a highly oxygen enriched oxidant were suggested in D1 and D7 as suitable measures to reduce the formation of nitrogen oxides, it was obvious to combine both measures, in particular as the reduction by oxy-fuel combustion, ie with pure oxygen as oxidant, works irrespective of the different flame temperature in both processes. Further, it was known from D4 to include, in a staged combustion process, a substoichiometric combustion with oxygen as primary oxidant in order to reduce No_x emissions by avoiding high temperature zones to form. A skilled person faced with the problem of further reducing the emissions will turn to D3 disclosing the concept of reducing the flame temperature by diluting the fuel and the oxidant with furnace gases before combustion by injecting both streams with a high velocity into the combustion chamber. Applying this concept to the process of D4 and carrying out routine tests in order to find the appropriate injection velocity would lead the skilled person directly to the method of claim 1, especially as the principle of dilution by high injection velocity was applicable to single and multiple stages of combustion. The injection of stabilizing oxidant into the combustion zone proximate the fuel stream, as disclosed in column 5, lines 3 to 12 of D3, could be seen as a further pointer towards a staged combustion.

V. The Respondent requests that the appeal be dismissed or, auxiliarily, that the patent be maintained on the basis of one of the two auxiliary requests filed on 6 May 2002.

It submits essentially the following arguments in support of this request:

A description of how to carry out step (D) of claim 1 was to be found in column 4, lines 33 to 44 of the patent, wherefrom it could be derived that, due to the concentration gradient for the combustion products within the combustion chamber, the secondary oxidant would first mix with products of complete combustion before arriving at a zone with unburned fuel for combustion. The term "combustion reaction products" was used in step (D) to include products of complete combustion as well as unburned fuel or products of incomplete combustion. As to the injection velocity, no ambiguity was seen because claim 1, rather than referring to a "high velocity", specified a defined lower value. An inconsistency with the description, if any, or doubts as to whether the problem of reducing No_x emissions was solved with velocities within the specified range would have to be treated as objections under Article 84 and 56, respectively. However, such objections were unfounded because there was no evidence that the desired results were not achieved with the specified velocities.

As to inventive step, both D1 and D7 disclosed either a staged combustion with low oxygen enrichment of the primary oxidant or a single-stage combustion with high oxygen enrichment of the oxidant as alternatives for reducing No_x emissions. Thus, both documents taught away from using staged combustion with high levels of oxygen enrichment.

When starting from D4 as closest prior art, document D3 specifying a value for the injection velocity of the oxidant could not suggest the injection velocity as defined in step (A) of claim 1 because D3 related to the separate injection of fuel and oxidant in a one-stage combustion process in a furnace with a uniform furnace atmosphere and neither could nor would be combined with D4 relating to a reduction of emissions by staging the combustion in a furnace. Moreover, D3 taught to dilute the oxidant by injection thereof and could not, therefore, provide a pointer to select an injection velocity for the fuel, as defined in step (A) of claim 1, for mixing with combustion reaction products. The injection of additional oxidant described in column 5 of D3 concerned the stabilisation of the flame and could not, therefore, serve as an indication for a staged combustion for reducing No_x emissions.

Reasons for the Decision

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

2. The admissibility of the opposition was no longer challenged by the Respondent in the appeal procedure. The Board has examined this issue ex officio and came to the conclusion that the grounds of Article 100(a) and (b) were sufficiently substantiated so as to render the opposition admissible. It is noted, however, that an insufficient substantiation with regard to one ground, as brought forward by the Respondent in the proceedings before the first instance, could cause neither an inadmissibility of the opposition as a whole nor an inadmissibility of that ground of opposition if there is a sufficient substantiation with regard to at least one other ground, in this case the grounds of Article 100(b), because the opposition cannot be partly inadmissible. Rather, the unsubstantiated ground would have to be considered in this case if it was decided that, exercising the discretion provided by Article 114(2) EPC, any relevant facts or evidence concerning this ground and submitted by the Appellant/Opponent after expiry of the opposition period should be admitted into the proceedings.

   In the present case the opposition ground of added subject-matter (Article 100(c) EPC) was marked on the opposition form 2300 but no facts, evidence or arguments in support of this ground were filed by the Appellant. Thus, this ground will not have to be considered.

3. The sufficiency of disclosure was disputed by the Appellant for two reasons, namely the inability of the skilled person to carry out step (D) of claim 1 and the uncertainty with regard to the injection velocity to be selected in step (A) of claim 1.

Regarding the first reason there would indeed be a problem of mixing the secondary oxidant with combustion reaction products before initiating the combustion of this secondary oxidant with the combustion reaction products, if the term "combustion reaction products" defined, in both occurrences in step (D), the same products of incomplete combustion as in step (C) of claim 1. In this case the combustion would, due to the unburned fuel in the combustion reaction products, inevitably start when mixing both components. There is, however, no need to interpret claim 1 in this manner. In fact, the term "combustion reaction products" is not accompanied by a definite article, which would provide a link to the corresponding products of step (C), and is a general term including products of complete combustion and unburned fuel or products of incomplete combustion, as defined in column 2, lines 39 to 48, of the patent in suit. Thus, step (D) could also be understood in the sense that the secondary oxidant is first mixed with products of complete combustion in one zone of the combustion chamber and thereafter brought to a different zone where this mixture is combusted with unburned fuel or products of incomplete combustion. A skilled person would adopt this interpretation because he is aware that the interpretation followed by the Appellant is problematic from a technical point of view and that a gradient is present in the combustion chamber from a zone closer to the injected fuel stream where the concentration of unburned fuel and of products of incomplete combustion is higher to a zone closer to the injected secondary oxidant where the concentration of completely combusted products is higher. Any further doubts as to how step (D) should be carried out could be removed by reference to the description of the patent in column 4, lines 38 to 42, which confirms the above interpretation by stating that the products of complete combustion are entrained into the secondary oxidant stream prior to the combustion of the secondary oxidant stream with unburned fuel.

As to the second reason for insufficient disclosure, the Appellant argued that it was unclear whether an injection velocity of 15 m/s was the "high" velocity required according to column 4, lines 13 to 20, of the patent to lower the No_x emissions and that it appeared from Figure 4 and column 5, line 36 of the patent that the velocity should be considerably higher, at least 58 m/s. This argument must fail for the reason alone that the requirement of Article 100(b) relates to the invention, which is the subject-matter as defined in the claims, and claim 1 does not refer to a "high" velocity but specifies, in step (A), a clear lower threshold for the injection velocity. It was not, and cannot seriously be, disputed that a skilled person is able to realise an injection velocity above this threshold. Whether or not it was derivable from the description that it was impossible to solve the problem of reducing No_x emissions with such an injection velocity, as argued by the Appellant, does not affect the possibility of carrying out the method as defined in claim 1 but may raise a clarity problem which would also have to be taken into account when assessing inventive step. However, such objections were unfounded because there was no evidence that the desired results were not achieved with the specified velocities. The Appellant made reference to Figure 4 of the patent in suit to demonstrate that higher velocities than just 15 m/s are required for reducing No_x emissions. This argument is based on the assumption that a desirable reduction of the emission should be below that obtained with injection velocities of 44 or 58 m/s. There is, however, no basis for this assumption. In fact, the emission level of 0.045 obtained with "low" injection velocities of 39 and 50 m/s may already be a desired low level, and a further reduction by selecting a "high" injection velocity of 175 or 199 m/s may be preferred but not mandatory, as set out in column 5, lines 43 to 46, of the patent under appeal.

It is therefore concluded that the invention as defined in claim 1 is disclosed in the patent in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art. The grounds of Article 100(b), therefore, do not prejudice the maintenance of the patent according to the main request.

4. The Appellant has dropped the objection of lack of novelty and the Board is satisfied that none of the available documents discloses a method as defined in claim 1. Thus, no further consideration of this issue is required.

5. In the decision under appeal document D1 was considered as closest prior art for the assessment of inventive step. This document discusses possibilities of reducing emissions of nitrogen oxides for high or low levels of oxygen enrichment of the oxidant and comes to the

conclusion, on page 189, that at low levels of enrichment the flame temperature should be minimized by a staged combustion, whereas at high levels of enrichment the nitrogen content was the controlling parameter which must be minimized. This means that the staged combustion is suggested for a low level of oxygen enrichment only and that, consequently, D1 does not teach combining a high level of enrichment, such as the oxygen concentration of at least 90 volume percent specified in claim 1 for the primary oxidant, with a staged combustion wherein products of incomplete combustion of the fuel with primary oxidant are further combusted with a separately injected secondary oxidant.

Such a combination is, however, derivable from document D4 disclosing a primary combustion of fuel with a highly oxygen-enriched primary oxidant or even pure oxygen ("Sauerstoffbrenner 4") within combustion zone 5 and a secondary combustion downstream of that combustion zone with oxygen injected through a separate oxygen lance 8. According to column 1, lines 51 to 57, of D4 the combustion of the fuel is delayed by the staged addition of the oxidant, thereby reducing the combustion temperature and the formation of nitrogen oxides. Thus, the staged combustion described in D4 also serves the purpose of reducing the No_x emissions. It is, therefore, evident that this document is a more suitable starting point than D1 for assessment of inventive step.

6. In the combustion process disclosed in D4 the reduction of No_x emissions should be obtained solely by the delayed combustion resulting from the staged supply of the oxygen required for combustion (column 1, lines 51 to 57), whereby the fuel is incompletely combusted in a

first stage with oxygen gas at a substoichiometric oxygen to fuel ratio of 10 to 70% and thereafter completely combusted with a secondary oxygen stream which is injected into the furnace so as to meet the combustion products of the first stage at a considerable distance downstream of the burner for the first stage (column 1, lines 37 to 50, and column 2, lines 9 to 14).

In addition to these known measures, claim 1 according to the main request specifies, in step (A), a minimum injection velocity of 15 m/s for the primary fuel and oxidant, if injected together, or of the primary fuel if injected separately from the primary oxidant. As stated in column 4, lines 13 to 20, this injection velocity of the fuel shall promote mixing of products of complete combustion with the primary fuel jet to enable the combustion of primary fuel and oxidant to proceed at a lower temperature, thus reducing the tendency of No_x to form. A corresponding mixture is specified in step (D) of claim 1 for the secondary oxidant for diluting the secondary oxidant stream prior to its combustion with the unburned fuel (column 4, lines 38 to 42).

It is, therefore, evident that the claimed method incorporates, in both stages, the concept of diluting the reactants, ie the fuel, or fuel and primary oxidant, in the first stage and the secondary oxidant in the second stage, by mixture with combustion products prior to the combustion reaction as an additional measure, as compared with the process of D4, to obtain a further reduction of the nitrogen oxide emissions. It will have to be determined whether this modification of the staged combustion process described in D4 was obvious in view of the other available prior art.

7. The Appellant argues that a skilled person faced with the problem of further reducing the emissions of nitrogen oxides in the process of D4 will turn to D3 disclosing the concept of reducing the flame temperature by diluting the fuel and the oxidant with furnace gases before combustion by injecting both streams with a high velocity into the combustion chamber.

As set out under the heading "Detailed Description" in the last paragraph of column 2 and in the first paragraph of column 3 of D3, conditions favouring No_x formation shall be avoided by combusting fuel with oxidant which has been diluted by mixture with furnace gases in an oxidant mixing zone which is maintained separate from the fuel reaction zone in a combustion chamber having a substantially uniform combustion zone atmosphere outside of the oxidant mixing and fuel reaction zones. The fuel is reacted, within the fuel reaction zone, with the combustion zone atmosphere containing the diluted oxidant.

Thus, the teaching of D3 cannot be reduced to the general concept of "dilution by injection", as argued by the Appellant, but includes, as essential elements, the creation of a uniform furnace atmosphere by mixing oxidant and combustion reaction products and the combustion of the fuel with the uniform furnace atmosphere in a fuel reaction zone separated from the oxidant mixing zone. This may easily be achieved in a one-stage combustion process, as in D3, wherein the fuel undergoes substantially complete combustion with the furnace gases within the fuel reaction zone so that there is no significant amount of uncombusted fuel outside of the fuel reaction zone (see column 5, lines 26 to 31, of D3). It is, however, not obvious how to incorporate this process in the staged combustion process disclosed in D4.

In fact, the successive combustion of the fuel in the staged combustion process of D4, with an incomplete combustion at a substoichiometric oxidant to fuel ratio in the first stage within one section of the furnace and a complete combustion at the second stage within another section of the furnace, implies the control of the oxidant concentration within the furnace of D4 by injecting defined amounts of the oxidant through the burner 4 and the lance 8 into different regions of the furnace to achieve a separation of the first stage and the second stage, which is at variance with a uniform furnace atmosphere as defined in D3. Moreover, the substantially complete combustion of the fuel within the fuel reaction zone of D3 would exclude any final combustion of unburned fuel in a second combustion stage. Thus, the skilled person would not expect a combustion of the fuel with diluted oxidant in a uniform furnace atmosphere, as disclosed in D3, to be suitable for the staged combustion process described in D4 which requires a different atmosphere in two distinct regions of the furnace for the first and second combustion stages, respectively. Consequently, he would not have a reason to carry out routine tests in order to select an injection velocity for the oxidant and fuel which could, as in D3, provide sufficient mixing of the oxidant with combustion reaction products within the furnace to obtain a uniform atmosphere therein (see column 4, lines 16 to 31 of D3).

8. It may be true that, as argued by the Appellant, the principle of dilution by injection is applicable to single and multiple stages of combustion in general. This argument must, however, fail because, as set out above, D3 does not teach this general principle and the actual process described in D3 cannot be applied to the process disclosed in D4 without jeopardising the staged combustion.

Further, the Appellant argued that the injection of stabilizing oxidant into the combustion zone proximate the fuel stream, as disclosed in column 5, lines 3 to 12 of D3, could be seen as indicating a staged combustion. This argument is likewise not convincing because D3 expressly states that this oxidant is a small amount for the purpose of curing flame instabilities, rather than of staging the combustion for reducing the emissions of nitrogen oxides.

9. A pointer towards a dilution of the oxidant and fuel with combustion reaction products prior to combustion in both stages of a staged combustion process cannot be derived from the other available documents either. Document D7 corresponds to D1 in that it suggests, in the first two paragraphs of page 6, either staged combustion with a first fuel-rich stage or a stoichiometric combustion with highly oxygen enriched oxidant as alternative measures for reducing No_x formation. There is no mention of a dilution of the oxidant or fuel by furnace gases prior to combustion. This also applies to document D9 disclosing, under the heading "Oxygen-Enriched Combustion Air Staging", a

staged combustion with air as oxidant in the first stage and an oxygen-enriched second stage for the specific purpose of increasing the combustible burnout.

10. Since the subject-matter of claim 1 of the main request is not rendered obvious by the available prior art it is considered as involving an inventive step (Article 56 EPC). The dependent claims define preferred embodiments of the combustion method of claim 1 and, therefore, likewise meet the requirement of inventive step.

11. In summary, the grounds of opposition according to Articles 100(b) and 100(c) EPC do not prejudice the maintenance of the patent in amended form in accordance with the main request. There is, therefore, no need to consider the auxiliary requests.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

A. Counillon C. T. Wilson