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**D E C I S I O N**  
**of 10 July 2001**

**Case Number:** T 0627/98 - 3.2.3  
**Application Number:** 93112436.6  
**Publication Number:** 0601274  
**IPC:** F23C 6/04, F23C 9/00, F23L 7/00,  
C03B 5/235

**Language of the proceedings:** EN

**Title of invention:**  
Hybrid oxidant combustion method

**Patentee:**  
Praxair Technology, Inc.

**Opponent:**  
L'Air Liquide, S.A. pour l'étude et l'exploitation des  
procédés Georges Claude

**Headword:**  
-

**Relevant legal provisions:**  
EPC Art. 54, 56

**Keyword:**  
"Novelty (yes) - no implicit disclosure"  
"Inventive step - non-obvious combination of known features"

**Decisions cited:**  
-

**Catchword:**  
-



Case Number: T 0627/98 - 3.2.3

**D E C I S I O N**  
**of the Technical Board of Appeal 3.2.3**  
**of 10 July 2001**

**Appellant:**  
(Opponent)

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**Representative:**

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**Respondent:**  
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**Decision under appeal:**

**Decision of the Opposition Division of the  
European Patent Office posted 3 June 1998  
rejecting the opposition filed against European  
patent No. 0 601 274 pursuant to Article 102(2)  
EPC.**

**Composition of the Board:**

**Chairman:** C. T. Wilson  
**Members:** U. Krause  
M. K. S. Aúz Castro

## Summary of Facts and Submissions

I. The appeal contests the decision of the Opposition Division, dated 24 April 1998 and issued in writing on 3 June 1998, to reject the opposition against European Patent No. 0 601 274. The patent relates to a hybrid oxidant combustion method and includes a single independent claim which reads as follows:

"1. A method for carrying out combustion comprising:

- (A) injecting fuel and first oxidant into a combustion chamber which contains furnace gases, and incompletely combusting the fuel with first oxidant within the combustion chamber in a flame stream to produce products of incomplete combustion;
- (B) injecting into the combustion chamber a stream of second oxidant, having an oxygen concentration which exceeds that of the first oxidant, spaced from the flame stream and at a velocity of at least 200 feet per second;
- (C) entraining furnace gases into the high velocity second oxidant to produce a diluted second oxidant stream;
- (D) passing the diluted second oxidant stream into the flame stream such that the axis of the diluted second oxidant stream does not intersect the flame stream until the flame stream has passed through the combustion chamber a distance such that at least 90

percent of the oxygen in the first oxidant has reacted with fuel; and

(E) mixing the diluted second oxidant stream with the flame stream and combusting products of incomplete combustion with the diluted second oxidant."

II. The opposition was filed against the patent in its entirety on the grounds of Article 100(a) (novelty and inventive activity), 100(b) and 100(c) EPC. The following document cited in support of the grounds of Article 100(a) EPC were considered in the decision under appeal and in the appeal procedure:

D1: L'Air Liquide, "Les combustions suroxygénées dans l'industrie", collection of leaflets published in June 1975 (public availability not in dispute)

D7: US-A-5 076 779

D29: EP-B-0 038 257 (corresponding to US-A-4 541 796)

III. The Appellant (Opponent) filed the notice of appeal on 18 June 1998 and paid the appeal fee on the same day. The statement of the grounds of appeal was filed on 7 October 1998.

In Oral proceedings held on 10 July 2001 the Appellant dropped the objections relating to the grounds of Articles 100(b) and (c).

The Appellant requested that the decision under appeal be set aside and the European patent No. 0 601 271 be revoked.

The Respondent (Proprietor) requested that the appeal be dismissed.

IV. The essential arguments of the parties can be summarized as follows:

(a) the Appellant

A method as defined in claim 1 was known either from D1 or from D29. Figure 18 of D1 showed a combustion in a furnace whereby fuel and a first oxidant were incompletely combusted in a flame stream and oxygen was injected into the flame stream as a second oxidant for final combustion at a point past the midpoint of the furnace which indicated, according to column 3, lines 46 to 52, of the patent, a condition where at least 90 percent of the oxygen in the first oxidant has reacted with fuel. A velocity of at least 200 fps was a typical value for the injection of oxygen and therefore implicit. This velocity in combination with the spacing of the injection lance from the flame shown in the Figure entrained furnace gases to thereby dilute the injected oxygen before its mixture with the flame stream. Document D29 not only disclosed injecting fuel and a first oxidant into a combustion chamber which contains furnace gases, and injecting into the combustion chamber a stream of second oxidant at a velocity of at least 200 fps, as acknowledged in the decision under appeal, but also the remaining features of claim 1. In particular, the higher oxygen concentration of the second oxidant injected from nozzles (4) was derivable from the possibility of using either air or oxygen as

described in column 10, lines 42 to 46, and a calculation would demonstrate that more than 90 percent of the oxygen in the first oxidant injected from the annulus around the fuel nozzle must have reacted at the intersection point of the diluted second oxidant stream with the flame stream.

As to inventive step, D1 disclosing a combustion using first and second oxidants was a suitable starting point in the case that the second oxidant was considered to be mixed with the flame stream without any previous dilution by furnace gases. This resulted in a high combustion temperature, increasing the formation of nitrogen oxides. An increase of the injection velocity alone would have no effect but a solution could be found in D29 disclosing the dilution of an oxygen-enriched oxidant by furnace gases, using the aspirating effect of a high speed injection of the oxidant spaced from the flame stream, as a measure for reducing NO<sub>x</sub> formation. Further, taking D29 as a starting point, the incomplete combustion of fuel in a flame stream using a first oxidant having a lower oxygen concentration before completing the combustion by mixture of the flame stream with a high oxygen concentration oxidant was suggested by D1.

(b) the Respondent:

The combustion process derivable from D1 was distinguished from that of claim 1 of the patent in that the oxygen was injected directly into the flame stream to generate a hot spot, whereas the

process of claim 1 considered a dilution of this stream with furnace gases prior to mixing with the flame stream by injecting the oxidant with a high velocity and spaced from the flame stream. Since, in D29, the outlet for the first oxidant communicated with the outlet for the second oxidant, both oxidants should have the same oxygen concentration. Further, the first oxidant was a minor portion serving the purpose of flame stabilisation rather than that of combusting the fuel in a flame stream. Taking D29 as a suitable starting point for the assessment of inventive step because it was also concerned with reducing nitrogen oxides, a skilled person would not take D1 into consideration because the deliberate generation of hot spots was incompatible with the aim of reducing nitrogen oxides. D7 taught combustion using several diluted oxidant jets all having the same oxygen concentration. There was no indication in the prior art for achieving low NO<sub>x</sub> at lower cost by the claimed two-step combustion process including a first incomplete combustion with a first oxidant having a lower oxygen concentration and a final combustion with a diluted second oxidant having a higher oxygen concentration.

### **Reasons for the Decision**

1. The appeal meets the requirements of Articles 106 to 108 and Rules 1(1) and 64 EPC and is, therefore, admissible.
2. *Novelty*

2.1 D1 describes a variety of applications of oxygen in combustion processes. The relevant parts referred to by the Appellant are Figure 18 and the explanatory remarks on page 14 preceding this Figure. The Figure shows a combustion chamber wherein a bent flame stream extends from a burner on one end of the chamber to the opposite heating end and partly back to the one end, and oxygen is injected into the flame stream through a lance located close to the heating end and in the immediate neighbourhood of the flame stream. As set out on page 14, this oxygen injection serves the purpose of locally increasing, at the heating end of the combustion chamber, the flame temperature to generate a hot spot, without altering the flame stream at other positions. There is no disclosure of an injection of the oxygen at a certain velocity and of an entrainment of furnace gases into the oxygen jet. Of course, a negligible entrainment of gases at the periphery of the oxygen jet cannot be avoided if, as in Figure 18, oxygen is injected directly into the flame stream even at a low speed. However, the entrainment specified in claim 1 of the patent must be substantial to achieve the claimed dilution of the second oxidant stream, which requires both a high velocity of the oxygen jet as a driving force for the entrainment and substantial distance between the flame stream and the point of injection of the oxygen for the aspiration of the furnace gases (see patent column 3, lines 22 to 27, and column 4, lines 28 to 37). Neither of these conditions is met in Figure 18 of D1. In fact, a substantial entrainment of furnace gases would be incompatible with the aim of producing a hot zone because it would lower the flame temperature at the hot zone, and a skilled person will therefore assume that conditions favouring such entrainment, i.e. a high velocity of the oxygen



jet and a spacing between the injection point and the flame stream, should be avoided. Thus, the injection of the second oxidant spaced from the flame stream and at a high velocity of at least 200 fps for entraining furnace gases cannot be considered as implicit to the disclosure of D1.

As to the point of injection of the second oxidant, the Appellant argues that the injection beyond the midpoint of the combustion chamber, as shown in D1, would correspond to a point where more than 90 percent of the oxygen in the first oxidant has reacted with fuel. This relationship was used in the patent in column 3, lines 34 to 52, to express that the diluted second oxidant stream should combine with the flame stream at a point where the flame temperature has decreased from the maximum. Apparently, this correlation between the extension of the flame and of the combustion chamber makes sense only if applied to a straight flame. In D1 the bent flame is longer than the combustion chamber and the oxygen is injected about halfway down the flame length. Having no further information in this respect, the skilled person will be aware that, in order to achieve the desired effect of increasing the flame temperature to create a hot spot, the temperature of the flame at this injection point should be close to its maximum. Thus, the intersection of the diluted second oxidant stream with the flame stream at a point where at least 90 percent of the oxygen in the first oxidant has reacted with fuel is likewise not derivable from D1.

2.2 D29 relates to an "oxygen aspirator burner" which is disclosed in Figures 3a and 3b. Oxidant is injected through nozzles (4) separately and spaced from the fuel

(nozzle 6) with a high velocity of 135 to 305 m/s into a furnace so that furnace gases are aspirated and entrained into the oxidant stream in order to supply the mass necessary for gas mixing and recirculation, and to act as a diluent for decreasing the flame temperature and the NO<sub>x</sub> formation in an oxygen or oxygen-enriched air system (see in particular column 6, lines 39 to 51, column 7, lines 31 to 50, and column 8, lines 53 to 65). A small quantity of the oxidant is fed from the main oxidant feed to an annulus (10) around the fuel nozzle (6) to create an oxidant envelope around the fuel jet thereby creating a continuous flame front and stabilising the flame (column 9, lines 32 to 45). Hence, there is a single common oxidant source, with the consequence that the small quantity of the "first" oxidant injected through the annulus (10) around the fuel nozzle has the same oxygen concentration as the "second" oxidant injected through the nozzles (4). It is evident from the text in column 6, line 41, that D29 is primarily concerned with oxygen or oxygen-enriched air as common oxidant, but the general reference to air or oxygen in column 10, lines 42 to 47, suggests that an oxidant having an oxygen concentration between that of air and of oxygen may be suitable, without however making any distinction between the oxidant injected through the annulus (10) and the oxidant injected through nozzles (4). Thus, the use of two oxidants having different oxygen concentrations cannot be derived from this document. Furthermore, the oxidant envelope creates a flame front for stabilisation of the flame on the surface of the fuel jet, rather than a flame stream as in claim 1, which is understood to define an extensive combustion zone as shown e.g. in D1.

2.3 Document D7 discloses a combustion process whereby one or several oxidant mixing zones and fuel reaction zones are established. In an oxidant mixing zone an oxygen-enriched stream injected at a high velocity is diluted by entrained furnace gases. The oxidant mixing zones are spaced from the fuel reaction zones to provide sufficient dilution of the oxygen-enriched streams before being mixed with the fuel in the fuel reaction zones for combustion. There is no mention of different oxygen concentration of the oxygen-enriched streams. As in D29, a small amount of oxidant may be used for flame stabilisation (see column 4, lines 10 to 18), and this oxidant is not distinguished from the oxygen-enriched streams as regards oxygen concentration.

2.4 In summary, none of the relevant documents in the proceedings discloses a method for carrying out a combustion as defined in claim 1. The subject-matter of claim 1 is, therefore, considered to be new.

3. *Inventive step*

3.1 The Board shares the opinion expressed in the appealed decision that D29, which corresponds to document US-A-4 541 796 referred to as D3 in that decision, is the proper starting point for assessing inventive step, mainly because this document is also concerned with the reduction of NO<sub>x</sub> formation in a combustion process by diluting an oxygen-rich oxidant with furnace gases before mixing it with the fuel for combustion. In the combustion process described in D29, the low NO<sub>x</sub> formation is achieved by combusting the fuel with a diluted oxygen-enriched oxidant, whereby the dilution with furnace gases reduces the combustion temperature without introducing nitrogen into the

combustion zone.

As set out in above section 2.2, the method of claim 1 differs from this known combustion process essentially in that the fuel is incompletely combusted with a first oxidant, having a lower oxygen concentration than the second oxidant, in a flame stream before mixing with the diluted second oxidant stream for final combustion. Thus, the combustion is made in two steps by first combusting part of the fuel with the first oxidant and thereafter combusting the rest of the fuel with the diluted second oxidant. Since the first oxidant has a lower oxygen concentration, the necessary amount of the more expensive high oxygen concentration oxidant is reduced. The incomplete combustion in the first step keeps  $\text{NO}_x$  formation low even if nitrogen is present in the first oxidant, for example in the case of air as oxidant, because there is hardly any oxygen available for reaction with the nitrogen. Thus, the two-step combustion method of claim 1 reduces the costs of a low  $\text{NO}_x$  combustion process.

- 3.2 It will therefore have to be determined whether the prior art provides a pointer towards the solution of the problem of reducing the costs of a low  $\text{NO}_x$  combustion process by incompletely combusting the fuel using lower oxygen concentration oxidant in a first step preceding the combustion with diluted higher oxygen concentration oxidant.
- 3.3 The Appellant is of the opinion that such a pointer was provided by D1 showing an incomplete combustion of fuel in a flame stream using a first oxidant having a lower oxygen concentration before injecting oxygen into the flame stream for further combustion. It is not disputed

that such a combustion process is shown in Figure 18 of D1. However, D1 is concerned neither with a low NO<sub>x</sub> combustion process nor with reducing costs of such a combustion process. Rather, as set out above in section 2.1, the oxygen is directly injected into the flame stream to locally increase the flame temperature to create a hot spot, for example for selectively heating parts of the furnace. This temperature increase favours the formation of nitrogen oxides, which is contrary to the aim of keeping NO<sub>x</sub> formation low at low costs. The Board is therefore convinced that a skilled person faced with the problem of reducing the costs of a low NO<sub>x</sub> combustion process would have no reason whatsoever to take D1 into consideration because it is evident that the combustion process derivable from D1 does not solve this problem and would even worsen the situation with regard to the nitrogen oxides.

- 3.4 According to a further argument of the Appellant it was obvious to solve, in the combustion process shown in Figure 18 of D1, the problem of NO<sub>x</sub> formation by diluting the oxygen with entrained furnace gases, as disclosed in D29, before mixing it with the flame stream. The Board cannot follow this argument for two reasons. Firstly, D1 is not a proper starting point for considerations of inventive step because, as outlined above, it is concerned with the different problem of increasing the heat output from a furnace. Secondly, the dilution of the injected oxygen will, as described in D29, column 4, lines 31 to 43, make the temperature distribution in the furnace more uniform and lower the flame temperature, both effects being counterproductive and conflicting with the desired effect in D1 of obtaining a locally increased flame temperature. It would just make no sense to dilute the oxygen jet of D1

as this dilution would render the oxygen jet ineffective for the purpose intended for in D1. As far as this dilution is described in column 2 of D29 as a solution to the problems of high flame temperatures and corresponding high NO<sub>x</sub> emissions as well as of low gas momentum in the furnace, this solution applies to furnaces using oxygen as a replacement for air as an oxidant (see column 1, lines 36 to 41), rather than to a furnace which, as in D1, uses air as the main oxidant and injects oxygen for the particular purpose of achieving a locally raised flame temperature.

3.5 In the combustion process disclosed in D7 the one or several oxygen-enriched streams all have the same oxygen concentration and are all arranged so that they do not intersect a fuel reaction zone formed by injecting a fuel stream into the furnace. The oxygen-enriched streams are diluted by entrained furnace gases and form part of the atmosphere within the furnace, and the fuel is combusted in the fuel reaction zone within this atmosphere. It follows that the fuel is mixed and combusted by a single oxidant, which in this case is a diluted oxygen-enriched oxidant. Thus, this process corresponds to D29 in that it uses a single costly oxygen-enriched oxidant for combustion, and cannot provide a suggestion towards the claimed two-step combustion process using a lower oxygen concentration oxidant for a first incomplete combustion step.

3.6 In summary, the combustion method of claim 1 is not obvious, having regard to the available prior art, to a person skilled in the art and is, therefore, considered to involve an inventive step.

4. The Appellant has dropped the objections concerning the

grounds of Articles 100(b) and (c) EPC and since the Board also sees no objection under these grounds, it is not necessary to discuss them.

**Order**

**For these reasons it is decided that:**

The appeal is dismissed.

The Registrar:

The Chairman:

A. Counillon

C. T. Wilson