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Datasheet for the decision of 11 January 2008

Case Number: T 0916/04 - 3.3.06

Application Number: 96108696.4

Publication Number: 0747108

IPC: B01D 53/22

Language of the proceedings: EN

Title of invention:
Oxygen production by ion transport membranes with work recovery

Patentee:
AIR PRODUCTS AND CHEMICALS, INC.

Opponent:
Praxair, Inc.

Headword:
Work recovery/AIR PRODUCTS

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no): all requests"

Decisions cited:
-

Catchword:
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Case Number: T 0916/04 **-** 3.3.06

D E C I S I O N
of the Technical Board of Appeal 3.3.06
of 11 January 2008

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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office posted 12 May 2004 concerning maintenance of European patent No. 0747108 in amended form.**

Composition of the Board:

Chairman: P.-P. Bracke
Members: G. Dischinger-Höppler
U. Tronser

Summary of Facts and Submissions

I. This appeal is from the interlocutory decision of the Opposition Division concerning maintenance of the European patent No. 0 747 108 in amended form on the basis of the then pending first auxiliary request, the independent Claim 1 reading:

"1. A process for the recovery of oxygen from an oxygen-containing gas which comprises:

(a) compressing and heating a stream of oxygen-containing feed gas to yield a hot pressurized feed; and

(b) passing said hot pressurized feed into a membrane separation zone comprising one or more oxygen-selective ion transport membranes which divide said zone into a feed side and a permeate side, and withdrawing from said zone a hot, pressurized, oxygen-depleted non-permeate gas from the feed side and a hot oxygen permeate product from the permeate side, wherein said membrane separation zone operates at a first temperature, at which or above which first temperature a hot gas expansion turbine operates;

characterized by

(c) cooling at least a portion of said hot, pressurized, oxygen-depleted non-permeate gas to a second temperature; and

(d) recovering useful work from at least a portion of the resulting cooled, pressurized oxygen-depleted non-permeate gas by expanding the gas to a lower pressure in a device from a class of work recovery devices different from a hot gas expansion turbine,

and operating at temperatures lower than those of hot gas expansion turbines."

II. A notice of opposition had been filed against the granted patent, wherein the Opponent sought revocation of the patent on the grounds of Article 100(a) EPC for lack of novelty and lack of inventive step (Articles 52(1), 54 and 56 EPC). The opposition was based, amongst others, on the following documents

D2 Topical Report "Advanced Oxygen Separation Membranes" by J.D. Wright et al., Gas Research Institute, September 1990, pages 33 to 63;

D3 US-A-5 035 727; and

D6 US-A-4 041 210.

III. In its decision, the Opposition Division held that the subject-matter claimed in accordance with the first auxiliary request fulfilled the requirements of the EPC. The main request which was based on the claims as granted was held to be not allowable due to lack of novelty under Article 54(3) EPC.

IV. This decision was appealed by the Opponent, now Appellant.

The Patent Proprietor, now Respondent, maintained the claims held allowable by the Opposition Division as its main request and filed document

D8 H. Miller, "Chapter 57, Gas Turbines" in Mechanical Engineers' Handbook, 2nd ed., 1998, John Wiley & Sons, Inc., pages 1723 to 1764.

under cover of a letter dated 20 January 2007 as well as amended sets of claims in three auxiliary requests under cover of a letter dated 10 December 2007.

Claim 1 of the first auxiliary request differs from that of the main request by deleting the term ", at which or above which first temperature a hot gas expansion turbine operates" and replacing the term "in a device from a class of work recovery devices different from a hot gas expansion turbine, and operating at temperatures lower than those of hot gas expansion turbines" by the following ", wherein the useful work is used in a number of applications selected from:
a) operation of pneumatic tools and equipment
b) atomization of single or multi-phase fluids in gas-driven nozzles;
c) pneumatic conveying of solids
d) separation of the cooled, pressurized, oxygen-depleted gas into higher purity nitrogen products by pressure swing adsorption or polymeric membrane permeation processes without the need for further feed compression;
e) mechanical deformation of materials by stamping or gas blowing and
f) acceleration of particulate matter for cleaning or finishing of material surfaces; or
g) in combination with use of the oxygen permeate product as an oxidant in combustion systems."

Claim 1 of the second auxiliary request differs from that of the main request by the deletion of the terms ", at which or above which first temperature a hot gas expansion turbine operates" and "in a device from a class of work recovery devices different from a hot gas expansion turbine, and operating at temperatures lower than those of hot gas expansion turbines" and introducing in feature (c) prior to the term "; and" the term "being below 316°C".

Claim 1 of the third auxiliary request differs from that of the first auxiliary request by introducing in feature (c) prior to the term "; and" the term "being below 316°C".

V. Oral proceedings were held before the Board on 11 January 2008.

VI. The Appellant submitted, orally and in writing, in essence the following arguments:

- The amendments made to the claims of all requests were not allowable under the provisions of Articles 84 and/or 123(2) EPC.

- The subject-matter claimed in the main request and first auxiliary request was not novel over the cited prior art.

- According to the patent in suit, it was accepted that the features distinguishing the claimed subject-matter from the prior art disclosed in document D3 implied a loss of efficiency in energy recovery and no evidence was on file showing that

any other effect was obtained by these distinguishing features than providing a further process for the same purpose of work recovery from the hot, pressurised non-permeate gas exciting from an oxygen-selective ion transport membrane. It was, however, obvious for a skilled person to use other known expansion devices than gas turbines and adjust the inlet temperature accordingly as was apparent from documents D2 and D6. The subject-matter claimed in any request was, therefore, not based on an inventive step.

VII. The Respondent, orally and in writing, refuted the Appellant's objections and submitted in essence

- that the amendments made to the claims were allowable under Article 84 and 123(2) EPC and that the claimed subject-matter was novel in view of the cited prior art.

- Concerning inventive step, it was submitted that in contrast to the prior art taught in document D3, the present invention allowed for the integration of work recovered from a hot, pressurized non-permeate stream of an oxygen recovery system in a number of other processes than mere hot gas work recovery for producing electricity or shaft power. Therefore, the technical problem solved by the distinguishing features in view of document D3 consisted in the provision of another process for recovering useful work from a pressurized, oxygen-depleted non-permeate gas exciting from a membrane separation zone comprising one or more oxygen selective ion membranes. However, there had been

no motivation in the prior art to make the specific steps of cooling down the non-permeate gas to a lower temperature and recover useful work from the lower temperature gas. On the contrary, according to the general technical knowledge in the art of work recovery as set out in document D8, the efficiency of work recovery improved as the temperature of the gas for expansion increased. Since this technical knowledge would have prevented those skilled in the art from intentionally cooling down hot gas prior to expansion, the claimed subject-matter was not rendered obvious by the cited prior art.

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

The Respondent requested that the appeal be dismissed or in the alternative that the decision under appeal be set aside and that the patent be maintained on the basis of the claims according to one of the auxiliary requests 1 to 3 submitted under cover of the letter dated 10 December 2007.

Reasons for the Decision

1. *Amendments and novelty*

The question of whether the amendments made to the claims of all requests are admissible under Articles 123(2) and 84 EPC or whether the claimed subject-matter is novel in view of the cited prior art (Article 54 EPC)

need not be gone into since, eventually, the appeal succeeds for the reason of lack of inventive step.

2. *Inventive Step - Main Request*

2.1 The patent in suit and Claim 1 relate to the separation of oxygen from an oxygen-containing gas by ion transport membranes, and in particular to the recovery of useful work from pressurized, oxygen-depleted non-permeate gas (paragraph [0001]).

The relevant prior art mentioned in the patent in suit relates to processes of oxygen recovery from air at high temperatures using ion transport membranes wherein a significant amount of heat energy is available in the membrane permeate and non-permeate streams. It is indicated that energy recovery and effective utilization thereof is possible by the integration with the membrane module of compressors, combustors, hot gas turbines, steam turbines and heat exchangers (page 2, paragraph [0003]).

One such process is disclosed in document D3 (see also patent in suit, page 2, paragraph [0004]) which relates to the separation of oxygen from an oxygen-containing gas by ion transport membranes and recovering useful work in the form of shaft power and electric power by expanding the hot, compressed and oxygen-lean gas through a gas turbine (column 2, lines 29 to 54, column 3, lines 29 to 53, figure 2 and column 4, lines 45 to 60).

The Board agrees with the parties that document D3 is a suitable starting point for the assessment of inventive step.

The Board further agrees with the parties that document D3 does not disclose the characterising portion of Claim 1, namely features (c) and (d). Accordingly, the subject-matter of Claim 1 differs from the process disclosed in document D3 in that

- hot pressurized non-permeate gas withdrawn from the membrane is cooled and

- useful work is recovered from such cooled non-permeate gas by expanding the gas in a work recovery device operating at temperatures lower than those of hot gas expansion turbines.

It is explained in the description of the patent in suit that in the cited prior art the energy contained in the hot pressurized non-permeate gas is recovered in high temperature expansion turbines operating at or above the membrane operating temperature of 427 to 1092°C to generate electric power (page 3, paragraph [0009] in combination with page 5, paragraph [0026]).

The Board concludes therefrom that the term "work recovery device operating at temperatures lower than those of hot gas expansion turbines" implies that work recovery is achieved in devices run at temperatures below the membrane operating temperature.

It is further explained that, compared with the prior art, the patent in suit allowed the selection of a

wider range of methods to utilize the energy or useful work contained in the hot, pressurised non-permeate gas by recovering the energy or useful work at temperatures below the membrane temperature. (page 3, paragraph [0010], page 4, paragraph [0019]).

The Board agrees, therefore, with the Respondent that the technical problem credibly solved by the claimed subject-matter over the disclosure of document D3 can be seen as providing another process for recovering useful work from a pressurized, oxygen-depleted non-permeate gas exciting from a membrane separation zone comprising one or more oxygen selective ion membranes.

2.2 It remains to be decided whether, in view of the available prior art documents, it was obvious for someone skilled in the art to solve the above stated technical problem by the features distinguishing the claimed subject-matter from the process disclosed in document D3, namely by cooling hot, pressurized non-permeate gas and recovering therefrom useful work by expansion in a device operating at such lower temperature as defined in Claim 1.

2.3 The Respondent argued that it was apparent from document D8 that the higher the inlet temperature of the gas to be fed into an expansion turbine was, the more effective was the work recovery. In contrast, the patent in suit completely broke with that concept and taught to intentionally cool the hot pressurized non-permeate gas and use other work recovery devices than hot gas expansion turbines. This radical change had nowhere been suggested in the art but allowed for work recovery not exclusively in the form of electric energy.

In writing, the Respondent also produced the argument that such a change in concept would not necessarily reduce the efficiency of work recovery as might be suggested by the reduced temperature. This was due to the fact that the claimed process avoided work losses associated with multiple stages of work conversion since it could dispense of the necessity to first recover work in the form of electricity and later convert this electric energy into other forms of work. Since there was simply no motivation in the prior art to break with the known concept of work recovery, the claimed subject-matter was based on an inventive step.

2.4 The Respondent's arguments are not convincing for the following reasons:

2.4.1 As pointed out above (point 2.1), document D3 does not contain a hint towards a cooling of the hot pressurized non-permeate prior to expansion.

However, there exist processes in the art wherein a hot, pressurised gas is cooled down before recovering work by expansion. Thus, document D2 implies the case where the membrane operating temperature is 1000°C (page 48, last paragraph, and page 51, second full paragraph) whereas the inlet temperature of the turbine may be only 627°C (900 K) (page 55, lines 1 to 17 and Figure 5.12). Likewise, document D6 discloses in Figure 3 an embodiment where a stream 156 of hot, pressurised gas exciting from a fuel cell is cooled in heat exchanger 166 before work is recovered in turbine 171 by expansion (column 6, lines 12 to 42). It is true that document D6 does not relate to the recovery of useful work from a process for producing oxygen from an

oxygen-containing gas using a solid electrolyte membrane as the patent in suit and document D3 but to the generation of power by means of a high temperature fuel cell. This is, however, irrelevant as far as the recovery of work from cooled pressurised gas by expansion is concerned.

2.4.2 The Board concurs with the Respondent concerning the teaching of document D8 that high turbine inlet temperatures increase the cycle efficiency and the power produced by a gas turbine of a given physical size and mass flow (page 1724, last paragraph to page 1726, second full paragraph in combination with Figures 57.2 (a) and (b)).

The Respondent's argument that, nevertheless, the efficiency of work recovery would not necessarily be reduced by the cooling step is not relevant to the subject-matter claimed since the efficiency of work recovery depends on the particular process conditions applied, such as the temperature difference resulting from the cooling step or the efficiency of the particular work recovery device used. Neither the temperature difference nor the work recovery device is specified in Claim 1.

Above all, however, the Respondent has not shown by evidence or even argued that and under what circumstances the efficiency of the claimed process was as high as or comparable with that of the process disclosed in document D3 or that, in contrast to the teaching of document D8, a cooling down of the non-permeate gas before expansion as claimed would not

reduce the efficiency in work recovery if applied in the process of document D3.

The Board, therefore, shares the Appellant's opinion, that in conformity with the disclosure of document D8 and depending on the particular process conditions, a loss in efficiency of work recovery results if in the process of document D3 the non-permeate stream is cooled down before expansion.

2.4.3 The Board, further, observes that gas turbines may be run at temperatures below the membrane operating temperature (see e.g. document D8, figure 57.2 (a) or document D2, page 48, last paragraph, in combination with page 55, first paragraph). In addition, devices for work recovery by expansion different from gas turbines are known in the art. Such devices include, for example, pneumatic tools which are mentioned in the patent in suit amongst a variety of other suitable devices (page 4, paragraph [0020] and page 5, paragraph [0029]).

2.4.4 The Respondent has also not contested that gases exciting directly from the membrane module may be too hot to be immediately fed to expansion devices like pneumatic tools. The Board finds, however, that using such devices for expansion at adapted temperatures is within the ordinary skill of those experienced in the technical field of work recovery from hot, pressurised gases. This is also evident from documents D2 and D6 (see 2.4.1 above).

2.5 Since the efficiency of work recovery is not an issue in the present case (point 2.4.2), the Board is, thus,

of the opinion that cooling down the gas before expansion as suggested in documents D2 and D6 (point 2.4.1) and using either gas turbines or other suitable expansion devices at the resulting temperatures below the membrane operating temperature are all options which a skilled person would consider in the expectation to provide another process than that disclosed in document D3 for recovering useful work from a pressurized, oxygen-depleted non-permeate gas exciting from a membrane separation zone comprising one or more oxygen selective ion membranes.

2.6 For these reasons, the Board concludes that the subject-matter of Claim 1 of the main request is not based on an inventive step and does not comply with the requirements of Articles 52 (1) and 56 EPC.

3. *Auxiliary requests*

3.1 Claim 1 of the first auxiliary request relates to subject-matter which differs from that of the main request only in that a selection of applications of work a) to g) has been specified which may include work recovery devices different to hot gas expansion turbines (point IV above).

Since such work recovery devices, e.g. pneumatic tools, are known in the art, the reasoning set out above applies also to the subject-matter of Claim 1 of the first auxiliary request.

3.2 Claim 1 of the second auxiliary request covers subject-matter differing from that of the main request only in

that it is specified that the gas is cooled to a temperature below 316°C (point IV above).

However, the Respondent did not provide arguments or show that and why a particular effect could be based on that specific temperature. The temperature of below 316°C does not, therefore, constitute anything else than an arbitrary selection of a temperature to which the gas may be cooled before expansion.

3.3 Claim 1 of the third auxiliary request is a combination of Claim 1 of the first auxiliary request with that of the second auxiliary request (point IV above). Again, no specific effect has been shown or is apparent for this combination.

Therefore, the reasoning set out above in point 2. applies mutatis mutandis to the subject-matter of Claim 1 of the third auxiliary request.

4. Since all of the Respondent's requests fail, the patent has to be revoked.

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:

G. Rauh P.-P Bracke