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DECISION
of 30 March 1999

Case Number:	T 0212/96 - 3.3.5
Application Number:	88113011.6
Publication Number:	0354259
IPC:	B01D 53/04
Language of the proceedings:	EN

Title of invention:
Improved pressure swing adsorption process

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. 56

Keyword:
"Inventive step (no) obvious combination, known effect"

Decisions cited:
-

Catchword:
-

Case Number: T 0212/96 - 3.3.5

DECISION
of the Technical Board of Appeal 3.3.5
of 30 March 1999

Appellant: (Proprietor of the patent)	Praxair Technology, Inc. 39 Old Ridgebury Road Danbury, CT 06810-5113 (US)
Representative:	Schwan, Gerhard, Dipl.-Ing. Elfenstrasse 32 81739 München (DE)
Respondent: (Opponent)	L'air Liquide, S.A. pour l'étude et l'exploitation des procédés Georges Claude 75 quai d'Orsay 75321 Paris (FR)
Representative:	Le Moenner, Gabriel L'air Liquide, Société Anonyme pour l'étude et l'exploitation des procédés Georges Claude 75 quai d'Orsay 75321 Paris (FR)

Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 20 December 1995 revoking European patent No. 0 354 259 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: R. K. Spangenberg
Members: A.-T Liu

J. H. van Moer

Summary of Facts and Submissions

I. The appeal is against the decision of the opposition division revoking the European patent No. 0 354 259.

II. The decision under appeal was based on claims 1 to 13 as granted. The opposition division held that the processes as defined in claims 1 to 3 and 8 to 10 of the patent-in-suit lacked novelty and that the subject-matter of the remaining dependent claims 4 to 7 and 11 to 13 lacked an inventive step.

III. With the statement of grounds of appeal, the appellant (patentee) filed amended texts, which were later superseded by seven new sets of amended claims and adapted pages of description submitted with a letter dated 1 March 1999.

IV. Oral proceedings were held on 30 March 1999 during which the appellant cancelled the texts submitted on 1 March 1999 as second and fourth to sixth auxiliary requests.

V. Claim 1 of the set of 8 claims submitted as main request on 1 March 1999 reads as follows:

"A pressure swing adsorption process for the separation of a feed gas mixture containing a less readily adsorbable component and a more readily adsorbable component in an adsorption system having at least two adsorbent beds capable of selectively adsorbing said more readily adsorbable component, each bed, on a cyclic basis, undergoing a processing sequence comprising:

(a) introducing gas into the product end of the bed following desorption thereof to increase the pressure of the bed from its lower subatmospheric desorption pressure to a lower intermediate pressure level, said gas having been released from another bed in the system initially at a higher pressure;

(b) passing feed gas to the feed end of the bed without the discharge of less readily adsorbable component from the product end of the bed to increase the pressure of the bed from said lower intermediate pressure level to an upper intermediate pressure level;

(c) passing additional feed gas to the feed end of the bed while simultaneously discharging less readily adsorbable component from the product end of the bed as product gas, the rate of addition, discharge and adsorption in the bed being such as to repressurize the bed from said upper intermediate pressure level to its higher adsorption pressure;

(d) passing additional feed gas to the feed end of the bed at the higher adsorption pressure, while simultaneously discharging additional less readily adsorbable component from the product end of the bed as additional product gas;

(e) cocurrently depressurizing the bed from said higher adsorption pressure to an intermediate pressure by the release of void space gas from the product end thereof, said released gas being passed to the product end of another bed in the system initially at the lower subatmospheric desorption pressure, the purity of the void space gas degrading in the less readily adsorbable component upon completion of said cocurrent depressurization step; thereafter

(f) countercurrently depressurizing the bed with release of the more readily adsorbable component from the feed end of the bed, the pressure of the bed being reduced from the intermediate pressure level to said lower subatmospheric desorption pressure; and

(g) repeating steps (a) - (f) on a cyclic basis with additional feed gas being passed to the bed during steps (b), (c) and (d),

wherein in steps (a) and (e) said passage of gas is continued for a period of time such as to partially, but not fully, equalize the pressure between said beds, the difference in pressure between said beds upon the completion of said partial pressure equalization in steps (a) and (e) being from about 6.0 to 69 kPa (about 1 to about 10 psi)".

VI. The first auxiliary request contains 6 claims. The subject-matter of claim 1 differs from that of the main request in that the process is restricted to the use of an adsorption system having two adsorbents beds. The wording of claim 1 corresponds to the wording of claim 1 of the main request, with the only difference that the preamble now reads as follows:

"A pressure swing adsorption process for the separation of a feed gas mixture containing a less readily adsorbable component and a more readily adsorbable component in an adsorption system having two adsorbent beds capable of selectively adsorbing said more readily adsorbable component, each bed, on a cyclic basis, undergoing a processing sequence comprising:".

VII. Claim 1 of the set of 8 claims submitted on 1 March 1999 as third auxiliary request differs from claim 1 of the main request in the additional specification that the intermediate pressure achieved through cocurrently depressurizing the bed by the release of void space gas in step (e) is subatmospheric. The wording of claim 1 thus corresponds to that of claim 1 of the main request, with the only difference that step (e) now reads as follows:

"(e) cocurrently depressurizing the bed from said higher adsorption pressure to an intermediate subatmospheric pressure by the release of void space gas from the product end thereof, said released gas being passed to the product end of another bed in the system initially at the lower subatmospheric desorption pressure, the purity of the void space gas degrading in the less readily adsorbable component upon completion of said cocurrent depressurization step; thereafter"

VIII. The following citations were retained as relevant for the present decision:

D1: EP-A-0 248 922

D2: US-A-3 738 087

IX. Concerning the main request, the appellant argued that the combination of features of claim 1 could not be derived from a combination of document D2 with D1. In particular, it was contended that the partial pressure equalisation as taught in D1 was tied to the essential requirement that the cocurrent depressurisation and countercurrent depressurisation steps were to be carried out simultaneously. For this reason, the skilled person would not have combined D2 with D1 in order to arrive at the present process which specified a cocurrent depressurisation step separate from a subsequent depressurisation step.

The appellant added that there was even less incentive for the skilled person to restrict the process to one using an adsorbent system having only two adsorbent beds or to a process comprising cocurrently depressurising the adsorbent bed from the high adsorption pressure to an intermediate subatmospheric pressure. The arguments advanced by the appellant in this context were that D2 only disclosed the two-step adsorption in combination with a four-bed adsorption system so that even a combination of D2 with D1 would not lead to the subject-matter of claim 1 of the first auxiliary request. Furthermore, the process of D2 was carried out entirely at superatmospheric pressures. Thus, it would have required a non-obvious selection and combination of technical features from D2 and D1 to arrive at the subject-matter of claim 1 of the third auxiliary request.

X. The respondent's main objection was that the invention as claimed lacked an inventive step with regard to D2 in combination with D1. In his view, the subject-matter of claim 1 of the main request was only distinguished from D2 in the specification of the pressure difference upon completion of the partial pressure equalisation. As was also recognised by the appellant, the selection of the range of pressure difference was already known from D1. In the respondent's opinion, the skilled person would have combined the teaching of D1 with that of D2 if a reduction in product recovery had been tolerated.

Furthermore, the respondent contested that the disclosure of the two-step adsorption in D2 was restricted to a four-bed adsorbent system. It was also contended that the example in D1 demonstrated that the choice of subatmospheric or superatmospheric intermediate pressures merely depended on the circumstances, with the resulting effect being known. The process modifications according to claim 1 of the first and third auxiliary requests were thus also obvious in view of D2 and D1.

XI. At the end of the oral proceedings, the requests were as follows:

- The appellant (patentee) requested the decision under appeal to be set aside, the maintenance of the patent on the basis of the text submitted as main Request with the letter of 1 March 1999 or with the text submitted as first auxiliary request or as third auxiliary request with the letter of 1 March 1999.

- The respondent (opponent) requested that the appeal be dismissed.

Reasons for the Decision

Main request

1. *Novelty*

The Board is satisfied that the subject-matter of claim 1 is novel. This has never been queried; no reason needs therefore be given for this finding.

2. *Inventive step*

2.1 Among the citations which concern the same technical area of pressure swing adsorption (PSA) for separation of gases (air), D2 is considered by all the parties as comprising the closest prior art teaching. In this known process, gas mixtures such as air are separated in selective adsorbent beds to produce product such as oxygen by introducing compressed air to a partially repressurised bed, selectively adsorbing nitrogen and discharging oxygen, all at rates such that the bed pressure increases (see abstract, column 5, line 13 to column 6, line 68 and claim 4). The fact that D2 discloses a separate step of adsorption at increasing pressure followed by adsorption at constant pressure was no longer disputed by the appellant at the oral proceedings.

2.2 According to the appellant, the problem to be solved by the invention with respect to D2 is to decrease the adsorbent requirement without significant loss in recovery of the less readily adsorbable component product gas.

The solution proposed by the patent-in-suit consists essentially in that the flow of gas from one adsorption bed at higher adsorption pressure to another adsorption bed at the desorption pressure is carried out only for a period of time such as to partially, but not fully, equalize the pressure between said beds. This is in contrast to the process in D2 where the pressure equalization is continued until the two beds are essentially at the same equalisation pressure (see D2, column 6, lines 27 to 32).

2.3 In the Board's judgement, it is immediately apparent, without need for verification by experiments, that the problem as stated by the patentee is indeed solved by the claimed process. This is not in dispute.

2.4 The Board, however, considers the modification proposed by the invention obvious with regard to D2 in the knowledge of D1 for the following reasons.

2.4.1 The Board does not agree with the appellant that the skilled person would ignore the disclosure of D1 when seeking a solution to the present problem. Contrary to the appellant's assertions, the teaching of partial pressure equalisation is not restricted to a process wherein the cocurrent depressurisation step is necessarily carried out simultaneously with the countercurrent depressurisation. As explained in D1, the simultaneous countercurrent depressurisation is to prevent the nitrogen gas desorbed from the adsorbent from breaking through to the outlet, together with the oxygen-enriched gas (D1, column 3, lines 32 to 41). Thus, if a reduction in product purity can be tolerated, then there is no need to carry out these steps simultaneously. Although a direct comparison between the experimental results given in D1 and the patent-in-suit is not possible due to the differing process parameters, the data on the oxygen products given in the patent-in-suit and in D1 appear to support this view (compare 90.1% oxygen purity in patent-in-suit, page 8, line 56 with 93% oxygen purity in D1, column 6, line 41). The appellant has admitted that the patent-in-suit did not aim at improving or optimising the product purity.

2.4.2 It is moreover irrefutable that D1 specifically refers to D2 as representative of conventional processes it seeks to improve (see D1, column 1, lines 17 to 39, in particular line 29). As is clearly stated in the introductory part of D1, it is known that the full pressure equalisation in such conventional PSA processes entails certain technical problems. Furthermore, it is disclosed that these problems are overcome by keeping as short as possible the time for transferring the oxygen-enriched gas from a column which has completed adsorption to another column which has completed desorption (see column 1, line 52 to column 2, line 7). The solution disclosed in D1 for that purpose essentially involves discontinuing the gas transfer from the adsorption bed at higher adsorption pressure to the adsorption bed at the desorption pressure before the pressure in both beds is fully equalised (D1, column 2, lines 52 to 55). The examples demonstrate that, with given adsorbents and product purity, an appropriate partial pressure equalisation allows a higher oxygen recovery rate at a higher feed inflow rate than full pressure equalisation (see D1, column 5, line 46 to column 6, line 42). In the Board's judgement, a skilled person would immediately recognise the implication of these results which is that, for obtaining the same oxygen recovery rate at the same feed rate, less adsorbent is required in a process with partial pressure equalisation than in a process including full pressure equalisation.

2.4.3 Thus, although D1 does not explicitly address the problem of reducing the adsorbent requirements, it can be inferred from the experimental data that a reduction in duration of the gas transfer will automatically decrease the adsorbent requirement. With the present goal in mind, the skilled person would therefore consider replacing the full pressure equalisation step in D2 by the partial pressure equalisation according to D1. Furthermore, the range of pressure difference proposed in D1 is entirely overlapped by the range specified for the pressure difference in steps (a) and (e) of present claim 1 (see D1, column 3, line 46 to column 4, line 11). In the Board's judgement, a skilled person seeking to improve the process according to D2 would include the solution offered in D1 and thus arrive at the invention by a straightforward combination of D2 with D1. Furthermore, the patentee has not argued, let alone proved, that the partial pressure equalisation synergistically interacts with the remaining technical features specified in claim 1. The subject-matter of claim 1 therefore lacks an inventive step.

3. *First auxiliary request*

3.1 The subject-matter of claim 1 differs from that of claim 1 of the main request only in that it is now restricted to a PSA process for gas separation in an adsorption system having two adsorbent beds.

3.2 It is true that a specific PSA process comprising a constant pressure adsorption step following the increasing pressure adsorption step is described in D2 in connection with an adsorption system having four adsorbent beds (column 14, line 59 to column 15, line 7). However, the increasing pressure adsorption step is not disclosed in D2 as being solely applicable to this particular embodiment but is also described in general terms in the summary of the invention, irrespective of the number of adsorbent beds (column 3, lines 8 to 19). This is also reflected in the wording of claim 4 which specifies that "said increasing pressure adsorption step is continued until the pressure of said adsorption zone is raised to said highest pressure and thereafter the feed gas introduction, one component adsorption and one component-depleted gas discharge are continued at relative rates such that said one component-depleted gas is discharged from the adsorption zone at substantially said highest pressure so as to comprise a constant adsorption step". The fact that claim 4 refers back to claim 1 which is directed to a process for gas separation "by selectively adsorbing at least one component in each of at least two adsorption zones" unmistakably implies that the teaching of D2 encompasses a gas separation process comprising a two-step adsorption in a system with only two adsorbent beds. This view was also accepted by the appellant at the oral proceedings.

3.3 As a consequence, the Board considers that the factual situation in respect of this request is substantially the same as the one concerning the main request. The arguments leading to the finding of lack of inventive step for claim 1 of the main request thus apply mutatis mutandis to the subject-matter of present claim 1. The subject-matter of claim 1 of the first auxiliary request is therefore not considered to involve an inventive step.

4. *Second auxiliary request*
(Text submitted as third auxiliary request on 1 March 1999)

4.1 Claim 1 differs from claim 1 of the main request only in that the intermediate pressure to be reached in the step of cocurrent depressurisation (e) is now defined as subatmospheric. The pressure condition is declared to be advantageous in that the subsequent evacuation step is less energy intensive since the adsorbent bed in question is already reduced to vacuum conditions (see description as filed, page 16, last paragraph).

4.2 The Board, however, considers the additional feature trivial.

In the process according to D1, the initial pressure after adsorption is between atmospheric and 5000 mm H_2O (see column 2, lines 3 to 4 and claim 1, column 6, lines 53 to 54). Thus, the subsequent step of depressurisation will necessarily be under subatmospheric conditions, as is confirmed by the requirement in D1 that desorption is carried out "under a vacuum pressure down to the final pressure of 150 mm Hg abs." (see column 3, lines 26 to 28 and claim 1, column 6, lines 55 to 56). Since present claim 1 does not specify the initial pressure to start from, it also covers processes wherein, similar to D1, the adsorption pressure is substantially atmospheric or subatmospheric. In such cases, the intermediate pressure reached in step (e) would also be automatically subatmospheric. Therefore, the skilled person would arrive at the present process by replacing the full equalisation step of D2 with the partial pressure equalisation step as taught in D1 in the straightforward manner as discussed above. Any advantage associated with this feature would be the same as obtained in D1.

The other findings in the case of the main request apply to the present auxiliary request as well, which request must therefore also be refused.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Hue R. Spangenberg