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Datasheet for the decision of 13 January 2017

Case Number: T 0044/14 - 3.3.06

Application Number: 07112589.2

Publication Number: 1880753

IPC: B01D53/047

Language of the proceedings: EN

Title of invention:
Pressure swing adsorption method with multiple parallel vessel beds

Patent Proprietor:
Air Products and Chemicals, Inc.

Opponent:
L'Air Liquide Société Anonyme pour l'Etude et l'Exploitation des Procédés Georges Claude

Headword:
Composite beds PSA / AIR PRODUCTS

Relevant legal provisions:
EPC Art. 52(1), 56

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:

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Case Number: T 0044/14 - 3.3.06

D E C I S I O N
of Technical Board of Appeal 3.3.06
of 13 January 2017

Appellant: (Opponent)	L'Air Liquide Société Anonyme pour l'Etude et l'Exploitation des Procédés Georges Claude Direction de la Propriété Intellectuelle 75, Quai d'Orsay 75007 Paris (FR)
Representative:	Beroud, Amandine L'air Liquide Direction Propriété Intellectuelle 75, quai d'Orsay F-75321 Paris Cedex 07 (FR)
Respondent: (Patent Proprietor)	Air Products and Chemicals, Inc. 7201 Hamilton Boulevard Allentown, PA 18195-1501 (US)
Representative:	Schwabe - Sandmair - Marx Patentanwälte Rechtsanwalt Partnerschaft mbB Joseph-Wild-Straße 20 81829 München (DE)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 8 November 2013 concerning maintenance of the European Patent No. 1880753 in amended form.**

Composition of the Board:

Chairman	B. Czech
Members:	G. Santavicca
	S. Fernández de Córdoba

Summary of Facts and Submissions

I. The appeal by the Opponent lies from the interlocutory decision of the Opposition Division concerning maintenance of European patent n° EP 1 880 753 in amended form.

II. The patent in suit concerns a **p**ressure **s**wing **a**dsorption (PSA hereinafter) process for the separation of a gas mixture.

It had been opposed on the grounds of Article 100(a) EPC (lack of novelty and lack of inventive step). The evidence relied upon by the parties includes the following prior art documents:

D1: WO 2005/009577 A2,

D2: US 6,699,307 B1, and

D5: EP 1 114 666 A2.

III. Amended Claim 1 according to the Main Request held allowable by the Opposition Division reads as follows:

"*1. A pressure swing adsorption process for the separation of a feed gas mixture containing two or more components, the process comprising:*
a) providing a pressure swing adsorption system comprising one or more composite beds, each composite bed comprising adsorbent material disposed in two or more vessels in parallel flow configuration, each vessel having a feed end and a product end;
b) performing cyclic sequential steps comprising
b1) introducing the feed gas mixture into the feed

ends of two or more vessels of the composite bed and withdrawing product gas from the product ends of the two or more vessels of the composite bed,

b2) withdrawing gas at decreasing pressure from the feed ends of the two or more vessels of the composite bed,

b3) purging the composite bed by introducing purge gas into the product ends of the two or more vessels of the composite bed and withdrawing purge effluent gas from the feed ends of the two or more vessels of the composite bed, and

b4) introducing gas into the product ends and/or feed ends of the two or more vessels of the composite bed at increasing pressure; and

c) for any of the sequential steps, setting a flow rate or flow rates of one or more gases selected from the group consisting of

c1) gas introduced into the feed end or ends of any of the two or more vessels,

c2) gas introduced into the product end or ends of any of the two or more vessels,

c3) gas withdrawn from the feed end or ends of any of the two or more vessels, and

c4) gas withdrawn from the product end or ends of any of the two or more vessels;

wherein the flow rate to and/or from each vessel is set selectively for one or more of the process steps to maintain the values of selected control parameters for the two or more vessels such that

the absolute difference between the selected control parameters for any two of the two or more vessels is less than a predetermined value, or

the absolute difference between the selected control parameter from each of the two or more vessels of the composite bed and the average of the control parameters from each of the two or more

vessels of the composite bed is less than a predetermined value,

wherein the control parameter for each vessel is selected from the group consisting of

1) the time-average concentration of a selected component in the product gas from the vessel;

2) the minimum or maximum concentration of a selected component in the product gas from the vessel;

3) the time-average of the concentration of a selected component in the purge effluent gas from the vessel;

4) the minimum or maximum concentration of a selected component in the purge effluent gas from the vessel;

5) the minimum or maximum concentration of a selected component in the void space of the adsorbent at a selected point in the vessel;

6) the differential pressure between two points in the vessel at a selected time during the sequential steps;

7) the minimum or maximum temperature at a selected point in the vessels during the sequential steps; and

8) the minimum or maximum pressure at a selected point in the during the sequential steps."

IV. In the decision under appeal the opposition division found, in particular, that the amended patent with the claims according to then pending Main Request complied with the requirements of Article 123(2) and (3) EPC. The claimed subject-matter was novel even over D1 read in conjunction with D2, which did not disclose the features of Claim 1 appended after feature c4) during the opposition procedure, beginning with "*wherein the flow rate to and/or from each vessel is set*

selectively ..." (in **bold** under point III, *supra*). Taking D1 as the closest prior art disclosing "a PSA system with multiple beds operated ... as a composite bed", the claimed subject-matter also involved an inventive step, even taking into account (*inter alia*) D2 and D5.

V. In its statement setting out the grounds of appeal, the Appellant (Opponent) maintained that the subject-matter of the amended claims held allowable by the Opposition Division lacked an inventive step in the light of a combination of D1/D2 (to be taken together as the closest prior art) with D5.

VI. In its reply dated 20 June 2014, the Respondent (Proprietor) defended the patent in the amended form held allowable by the Opposition Division (Main Request) and rebutted the objection based on the combination of D1/D2 with D5.

VII. The parties were summoned to oral proceedings.

VIII. In a further letter dated 8 December 2016, the Appellant maintained its objection concerning inventive step, but announced that it would not attend the oral proceedings.

IX. Oral proceedings were held on 13 January 2017 in the absence of the Appellant.

The debate focused on the issue of inventive step over the combination of D1/D2 (closest prior art) with D5.

X. Requests

The Appellant (Opponent) requested in writing that the

decision under appeal be set aside and the patent be revoked.

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

XI. The arguments of the Appellant of relevance for the present decision can be summarised as follows:

The closest prior art was represented by D1 (paragraphs [0023] to [0026]; Figure 1) describing a PSA system with eight modules comprising seven vessels each, the modules being operated in parallel, more particularly (see D1, paragraph [0025]) according to the "seven beds" process with "three-stage pressure equalisation" described in D2. Concerning the latter, the following parts of D2 were of relevance: the PSA cycle diagram of Figure 7, the valve diagram of Figure 8, and the corresponding description in columns 14 to 18.

The subject-matter of claim 1 differed from the teaching of D1 by the features (in **bold** under III, *supra*) "*wherein the flow rate to and/or from each vessel is set selectively for one or more of the process steps to ...*"

The technical problem was thus to provide a better synchronisation of the parallel adsorbers.

D5 also addressed the technical problem of how to prevent variations in the functioning of different adsorbers. The person skilled in the art seeking to solve the technical problem would thus take the teaching of D5 into account.

D5 taught to monitor the oxygen concentration in the

effluent gas of each adsorber in the regeneration phase, by means of an analyser, then to compare these values to see whether there was a disequilibrium, and, if there was one, to adjust the different fluxes. The person skilled in the art applying the teaching of D5 to the system of D1/D2 would thus not encounter any technical difficulties and would inevitably arrive at a PSA system falling within the ambit of Claim 1 at issue.

The claimed subject-matter was thus not inventive.

XII. The counter-arguments of the Respondent presented in writing and at the oral proceedings can be summarised as follows:

The seven adsorbent-chambers module of D1 (Figures 1 and 6), the operating cycle of which was disclosed in D2, referred to in D1, was the closest prior art. The pressure swing adsorption apparatus of Figure 6 of D1 comprised modules 10 to 80, each designed as shown on Figures 3a and 4, which were connected in parallel via product, gas feed and raffinate manifolds. According to D1, the apparatus described could be operated according to four strategies (paragraphs [0025] and [0026]), each giving the technical effects in terms of overall output ("raffinate flow") depicted in Figure 2 of D1.

A "*composite bed*", made up of two or more vessels as defined in Claim 1, was different from a "module" as disclosed in D1. The former comprised (with reference to Figure 6 of D1) at least two adsorber vessels, each belonging to a different one of the at least two modules working in parallel, the at least two vessels running synchronously on phase, i.e. in a same step of the PSA process cycle, whereas the seven vessels

forming a "module" according to D1 were not running in phase.

The claimed invention addressed the issue of performance differences between vessels of a PSA system working as "*composite bed*".

Also in the light of D1/D2, the technical problem was to maximize the performance of multiple beds operating in parallel as "*composite bed*", as also acknowledged in the decision under appeal.

D1 and D2 did not address or suggest measures for controlling and compensating differences in the performance of the vessels forming a "*composite bed*".

D5 disclosed a conventional PSA system with two single beds A and B, operating out of phase, and did not disclose a "*composite bed*" within the meaning of the paten in suit. The conventional unit of D5 thus corresponded to one "module" of D1, not to the arrangement of the eight modules disclosed by D1. In particular, D5 disclosed to monitor oxygen concentration and/or pressure in beds A and B and to thereby control the equalization times and step times.

Since D5 did not relate to a process involving operating parallel adsorbent chambers (vessels) as "*composite bed*", the skilled person seeking to solve the technical problem posed in the light of D1/D2 would not consider D5 at all.

Even if D5 were (*arguendo*) combined with D1 and D2, the skilled person would at most come up with a process comprising adjusting the flows between out-of-phase "modules" according to D1, and/or with balancing the

flows between the several adsorbent chambers (vessels) of an individual single "module" according to D1.

Starting from the apparatus of Figure 6 of D1, the person skilled in the art would definitely not be led to a control a vessel of a "module" working synchronously on phase with a vessel of another "module" of D1, in order to compensate for performance differences between these vessels being part of a "*composite bed*". Thus, not even the hypothetical combination of D1 and D2 with D5 would lead the skilled person to the claimed subject-matter.

Consequently, the claimed subject-matter was inventive.

Reasons for the Decision

Main Request

1. The Main Request in appeal proceedings is identical with the Main Request dealt with in the decision under appeal.

2. The only objection maintained by the Appellant as regards the claims held allowable by the Opposition Division is an inventive step objection based on the combination of D1/D2 with D5.

The Board sees no reason for calling into question the findings of the Opposition Division regarding compliance of the claims at issue with Article 123(2) EPC and novelty.

3. Inventive step

3.1 The invention

3.1.1 The invention concerns a PSA method for the separation of a feed gas mixture using a plurality of parallel adsorbent beds, each operated in cyclic sequence of steps in order to maintain a constant product flow rate (paragraph [0001] of the patent).

3.1.2 In particular (paragraph [0026], last two sentences) the invention concerns a process for operating a PSA system comprising one or more "*composite beds*", wherein each "*composite bed*" comprises adsorbent material disposed in two or more vessels in parallel flow configuration (paragraph [0026] of the patent). The "*total amount of adsorbent material contained in the two or more parallel vessels ... is subjected collectively to the total gas inflow and outflow of the composite bed during the steps of the PSA cycle such that the adsorbent material in each vessel is subjected to the same process cycle step of the same duration in a given time period. The parallel vessels of the composite beds therefore operate synchronously throughout the steps in the PSA cycle*".

3.2 The closest prior art

3.2.1 It is common ground between the opposing parties that D1 read in conjunction with D2 represents the closest prior art for assessing inventive step, D2 being explicitly incorporated by reference into D1 (paragraph [0007]).

Considering the similarities in terms of the technical problem addressed and the relevant technical features

of the PSA apparatus and its operation according to the patent in suit and D1/D2, respectively, the Board has no reason to take a different stance.

3.2.2 More particularly, Figure 6 of D1 discloses a PSA apparatus comprising eight "modules" (10 to 80), each comprising seven adsorbent chambers 101 (see Figures 3a and 3b), i.e. "*vessels*" in the terminology of the patent in suit, which are operated according to a "first embodiment" of D1 (paragraphs [0021] and [0026], third sentence). According to this embodiment, two groups of four modules are operated 180 degrees out of phase with one another. The four modules of a same group are synchronized to run their individual PSA cycles in phase. An adsorbent chamber of the first module synchronously undergoes a particular step of the cycle with an adsorbent chamber of each one of the other three modules belonging to the same group of four modules. The adsorbent chambers of the four modules synchronously running the same step of the cycle make up a "*composite bed*" according to the patent in suit.

3.2.3 As regards the operation of the preferred apparatus depicted in Figures 1, 3a and 6 of D1 in terms of the PSA cycle steps sequence, the latter refers expressly (paragraphs [0025] and [0032]) to the "three equalization", "seven bed" PSA process described in D2, preferably to be carried out in the apparatus of D1.

3.2.4 It is not in dispute that D1/D2 discloses a process with all the features up to and including feature c4) of Claim 1 at issue, but not the subsequent (bolded in the wording under Point III, *supra*) features of the latter relating to the control of the operation of the vessels belonging to a given "*composite bed*" within the meaning of Claim 1.

3.3 The technical problem

3.3.1 The rather vague formulation of the technical problem proposed by the Appellant, i.e. providing a better synchronisation of the parallel adsorbers, finds no *verbatim* basis in the relevant paragraphs of the patent in suit dealing with the technical problem (paragraphs [0037] and [0038]).

3.3.2 The latter deal more specifically with the compensation of performance differences among the individual parallel vessels of a "*composite bed*", to be achieved according to the invention (see also paragraph [0034] in this respect), in order to maximize the performance of the PSA system.

3.3.3 Therefore, the Board sees no reason for departing from the formulation of the technical problem implicit to these passages of the patent in suit (also invoked by the Opposition Division and the Respondent), namely the provision of a process for carrying out PSA in a system comprising one or more "*composite beds*" with maximised performance.

3.4 The solution

The patent proposes to solve the technical problem by providing the "*pressure swing adsorption process for the separation of a feed gas mixture containing two or more components*" according to Claim 1 at issue, which is characterized in particular in that the PSA system used comprises "*one or more composite beds*" and is operated in the manner specifically defined in those features of Claim 1 appearing in **bold** under III, *supra*.

3.5 The success of the solution

It is technically plausible, and not disputed by the Appellant, that the method of Claim 1 at issue permits to control the performance of each vessel of the one or more "*composite bed(s)*", thereby maximising the performance of the PSA system comprising the "*composite bed(s)*".

The Board thus accepts that the technical problem posed is effectively solved by the claimed process.

3.6 (Non)Obviousness

3.6.1 It remains to be decided whether the claimed solution was obvious to the skilled person having regard to the state of the art. More, particularly, it is to be decided
- whether the person skilled in the art would, starting from D1/D2 and seeking to solve the technical problem posed, consider D5 at all, and
- if yes, whether he would envisage applying elements of the control method of D5 to the system of D1/D2, and
-if yes, whether he would, thereby, arrive at a process falling within the ambit Claim 1 in an obvious manner.

3.6.2 Documents D1/D2

D1 (paragraphs [0008] to [0012] and [0050]) addresses the process-related issues of flow pulsations, ease of maintenance/repair and reliability. D2 (Summary of the invention, Column 2, lines 53-65) addresses the problem of optimising product recovery and adsorbent productivity while reducing mechanical complexity (number of valves).

However, neither D1 nor D2 addresses the problem of compensating performance differences between parallel adsorbers synchronously running a same step of the PSA cycle as "*composite bed*". Taken alone or in combination, D1 and D2 thus contain nothing that could orient the person skilled in the art towards a process with all the features of Claim 1 at issue.

This is not in dispute either.

3.6.3 Document D5

D5 (paragraph [0001]) "relates to control of a PSA process and, more particularly, to a method for adjusting adsorption/desorption step times and vessel reflux step times and flows, based on observed pressures and purities, to maintain vessel pressures slightly below or at predetermined values in order to optimize and achieve maximum production".

This control of the length of the single steps of the cycle is applied to a conventional PSA apparatus comprising two vessels containing, respectively, adsorbent "Bed A" and "Bed B" (Figure 1c), which are operated 180° out of phase. This conventional apparatus of D5 is thus equivalent to one "module" of parallel adsorber vessels according to D1 or D2. The key feature of the control process of D5 (see paragraph [0017]) is "that it systematically adjusts individual cycle step times (feed time, purge time, equalization time) to keep the overall system at its optimum pressure levels".

The method of D5 (paragraph [0016]) balances the vessel operation, i.e "equalizes flows into and out of the vessels by monitoring the individual vessel effluents

(waste stream) during each evacuation half cycle and logging the minimum oxygen concentration found during the period of time. Then, the equalization flows (vessel effluent that is transferred from the bed currently in the adsorption phase of the cycle to the bed that is currently desorbing) are adjusted accordingly so as to achieve similar O_2 concentration in the vessel waste streams."

It is immediately apparent from *inter alia* these indications that D5 does not relate to the operation of "*composite beds*", i.e. beds arranged in vessels operated synchronously in parallel (i.e. synchronously running the same step of the PSA cycle), let alone the control of the operation of the vessels belonging to a "*composite bed*" in order to compensate differences in their performance.

Already for this reason, there is no particular motivation for the skilled person seeking to solve the technical problem posed to even consider D5.

3.6.4 However, even if it the person skilled in the art would consider adopting some particular features of the process disclosed in D5 in the process of the closest prior art D1/D2, this would not lead him to a process falling within the ambit of Claim 1 at issue for the following reason.

D5 does not address any control of the flow rates in beds synchronously running the same cycle step as "*composite bed*" in order to balance them, i.e. to compensate for variations in their performance. The step times of the vessels operated as "*composite bed*" (all running in the same step) are conceptually different from the step times of the vessels within a

module according to D1/D2 (not all vessels running in the same step of the PSA cycle), or the two vessels of the conventional unit of D5, i.e. those to which the control according to D5 is directed.

Conclusion

4. The inventive step objection maintained by the Appellant does not prejudice maintenance of the patent in the amended form held allowable by the Opposition Division.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

D. Magliano B. Czech

Decision electronically authenticated