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Datasheet for the decision of 12 December 2007

Case Number: T 1557/06 - 3.3.05

Application Number: 98913061.2

Publication Number: 1019321

IPC: B01D 53/56

Language of the proceedings: EN

Title of invention:
Methods for the production of ammonia from urea and uses thereof

Patentee:
EC & C Technologies, Inc.

Opponent:
SIIRTEC NIGI SPA

Headword:
Removing NO_x/EC & C

Relevant legal provisions (EPC 1973):
EPC Art. 56

Keyword:
"Inventive step (main request): yes"

Decisions cited:
-

Catchword:
-

Case Number: T 1557/06 - 3.3.05

DECISION
of the Technical Board of Appeal 3.3.05
of 12 December 2007

Appellant: (Opponent)	SIIRTEC NIGI SPA VIA ALGARDI, 2 I-20148 MILANO (IT)
Representative:	Austin, Hedley William Chapman Molony Technium Digital Swansea University Singleton Park Swansea West Glamorgan SA2 8PP (GB)
Respondent: (Patent Proprietor)	EC & C Technologies, Inc. 23629 Mill Valley Valencia, CA 91355 (US)
Representative:	Keen, Celia Mary J.A. Kemp & Co. 14 South Square Gray's Inn London WC1R 5JJ (GB)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted 16 August 2006 rejecting the opposition filed against European patent No. 1019321 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: G. Raths
Members: B. Czech
H. Preglau

Summary of Facts and Submissions

I. This appeal is from the decision of the opposition division concerning the rejection of the opposition against European patent No. 1 019 321.

II. Independent claim 1 of the patent as granted reads:

"*1. A process for removing nitrogen oxides from a combustion gas stream by SNCR (Selective Non-Catalytic Reduction) or SCR (Selective Catalytic Reduction), which process comprises:*
(a) heating an aqueous solution of urea, or a mixture of urea, containing biuret or ammonium carbamate on site,. [sic] in a hydrolysis reactor operated at a temperature of from 110°C to 300° C and a gas pressure from 138 to 3450 kPa gauge (20 to 500 psig) such that a gaseous ammonia-containing product is obtained which is essentially free of urea, biuret, or ammonium carbamate, the temperature and pressure being maintained by the input of heat to the reactor;
(b) separating the gaseous ammonia-containing product from the liquid phase aqueous reaction media at the operating pressure;
(c) retaining the liquid phase reaction medium in the reactor for further conversion to gaseous ammonia and carbon dioxide, and/or recycling at least a portion of the said reaction medium back into the reactor, a urea dissolver, or the feed solution to the reactor for further conversion;
(d) withdrawing the aqueous [sic] ammonia and carbon dioxide-containing product separated in step (b) at a controlled rate; and
(e) contacting the gaseous ammonia-containing product with the combustion gas stream at a rate which essentially matches the needs of nitrogen oxides removal in said combustion gas stream."

III. The opposition was based on the ground that the claimed subject-matter lacked an inventive step. The prior art documents cited in the course of the opposition proceedings include the following:

D2: JP 8-71372 A
D2T: translation of D2 into English filed as D5
D3: US 4 341 640 A
D6: US 5 281 403 A
D7: US 5 240 688 A
D8: JP 8-281074 A
D8T: translation of D8 into English
D9: US 5 252 308 A (cited by third party)

In the contested decision, the opposition division held that starting from either D2 or D8 as closest prior art, the process according to claim 1 as granted was inventive.

IV. In its original statement of grounds of appeal and the subsequently filed version thereof comprising clerical corrections, the appellant (opponent) referred to documents D1 to D8 already on file and generally mentioned "Kempe's Engineers Year Book".

The appellant argued that claim 1 as granted lacked an inventive step

- over D8 in the light of common general knowledge, as well as over combinations of D8 with any of D3, D6, D7 or D9;
- over D2 combined with any of D3, D6, D7 or D9; and
- over D9 combined with common general knowledge.

With a further letter, the appellant filed document

D10: Kempe's Engineers Year Book 1991, 96th edition, Volume 2; front page and page F10/5 (a steam table).

V. With its reply of 4 May 2007, the respondent (proprietor of the patent) filed three sets of amended claims as first to third auxiliary requests. It maintained that the claimed process was not obvious in view of the prior art relied upon by the appellant.

VI. Oral proceedings were held on 12 December 2007. At the oral proceedings, the appellant confirmed that it had no objections having regard to novelty and essentially argued that starting from D8 as closest prior art the claimed process was not based on an inventive step. Concerning the other lines of attack on inventive step both the appellant and the respondent relied on their written submissions.

VII. The arguments of the parties can be summarised as follows:

A) The appellant acknowledged that D8 represented the closest prior art. The reactor of D8 also contained a certain amount of ammonia gas stored under pressure which was immediately available for injection. This pressure was kept constant upon increased NH_3 demand by a controlled increase of the current to the heater. The pressures disclosed in D8 were only slightly below the lower limit of the claimed pressure range. The only distinguishing feature of the claimed invention over D8 was the requirement that the hydrolysis had to be operated in the pressure range of from 138 to 3450 kPa gauge. D8 also disclosed a system which avoided the problems associated with the use of stored ammonia, had good responsiveness to NO_x fluctuations in the exhaust gas, and provided NH_3 at a rate essentially matching the demand.

However, fluctuations in NO_x concentrations were not mentioned in the patent in suit and all the examples related to steady state operating conditions. An alleged improved responsiveness of the claimed system to a variation in NH_3 demand was not mentioned in the application as filed and was not related to the technical problem initially suggested, i.e. the avoidance of risks associated with handling and storing ammonia. Moreover, no evidence had been presented to support the alleged shorter response time of the claimed method.

The technical problem was therefore to provide a larger molar amount of ammonia gas available for dosing into the exhaust gas stream than the amount provided within the hydrolysis reactor of D8. However, even if it were accepted that the problem consisted in improving the response time of the system of D8, the solution consisting in providing a larger amount of available ammonia was obvious. In particular, it belonged to the common general knowledge of the skilled chemist that reaction rates increase with increasing temperature, and that, in the context of D8, an increase in temperature could be achieved by increasing the pressure in the reactor. D8 taught that the pressure used could be increased beyond the specific values disclosed (Figure 5 and paragraph [0025] of D8T). Modifying the teaching of D8 by increasing the overpressure prevailing in the reactor to a value in the range of claim 1 was thus obvious to the skilled person in the light of common general knowledge.

D3 disclosed the performance of urea hydrolysis at temperatures and pressures falling within the ranges claimed in the patent in suit. It would therefore be an obvious step to increase the overpressure of the process of D8 to values disclosed in D3 to thereby provide a higher pressure store of ammonia gas, i.e. a larger amount of available NH_3.

D6 and D7 both taught carrying out the hydrolysis of urea at temperatures and pressures within the range of claim 1 of the patent in suit, and both disclosed introducing ammonia into an exhaust gas stream for reducing NO_x. It would therefore be obvious to the skilled person to modify the system of D8 to operate at the temperatures and pressures disclosed in D6 or D7. More particularly, the skilled person would consider it obvious to increase the overpressure in the process of D8 to thereby provide a (more) pressurised store of ammonia gas within the vaporiser, in order to provide a larger molar amount of available ammonia for dosing into the exhaust gas.

D9 related to a process having, at least implicitly, all the features of claim 1, except for the pressure range of present claim 1. D9 disclosed that ammonia gas may be removed from the hydrolysis reactor under pressure since the reaction is done at high temperatures. The temperatures of 150 to 210 °C disclosed in D9 could only be reached when operating the reactor at elevated pressures. It was also common general knowledge that the required pressures could be found in standard steam tables such as D10, which disclosed that the pressure must be raised by 18 bar (265 psi) to raise the boiling point to 210°C. Identifying the pressures required to operate the hydrolysis reactor over the entire temperature range of from 145 to 210 °C was a matter of routine trial and error. Near the higher end of this range the pressure required to attain the boiling point would self-evidently fall within the range of present claim 1. Claim 1 therefore lacked an inventive step over D9 combined with common general knowledge. Claim 1 also lacked an inventive step over a combination of D8 with D9 and common general knowledge. In particular, it was obvious in view of D9 to operate the process of D8 at a pressure within the claimed range in order to provide a larger amount of available ammonia.

The claimed subject-matter also lacked an inventive step over D2/D2T taken as the closest prior art in view of common general knowledge, and in view of combinations of D2/D2T with any of D3, D6, D7 or D9, the reasons given being analogous to those considered when taking D8 as the closest prior art.

B) The respondent essentially argued that starting from D8 as the closest prior art, the claimed process provided a non-obvious alternative process. By the present invention, a process was provided which allowed ammonia to be supplied from urea with good responsiveness to the denitration needs in a NO_x containing exhaust gas. None of the cited references, whether taken individually or in combination, taught or suggested the use of heat input to the hydrolyser to maintain a pressure in the range of from 138 to 3450 kPa gauge, such that a head of ammonia gas at that pressure is immediately available for quantitative NO_x scrubbing over a range of demand conditions. In addition, the high pressure head of ammonia allowed a rapid response to any fluctuations in the NO_x concentration of the combustion gas stream. The high pressure in the hydrolyser allowed the reaction to occur at higher temperature and hence with a higher ammonia generation rate than in a low pressure system as disclosed in D8. The pressurised ammonia permanently available for instant release permitted a more rapid response to such fluctuations than the process of D8, since there was no time lag due to adjustments of pump and heating rates as in D8.

D3 related to the purification of aqueous urea containing waste streams by hydrolysis. D3 failed to teach anything about the use to be made of the ammonia containing gas stream withdrawn from the process and was thus not relevant to the present invention. D3 would not be read in combination with D8 in the first place. In any case, although it taught hydrolysis temperatures and pressures in the claimed range, D3 failed to remedy the deficiencies in the teaching of D8.

According to D6 a partially converted aqueous urea solution was injected into the exhaust gas stream. This resulted in fouling the flue gas with various salts and by-products. The other embodiment shown in Figure 4 of D6 comprised releasing gaseous ammonia from the solution reacted at high pressures and containing dissolved ammonia by flashing to a lower pressure through a pressure relief valve. There was no disclosure of suitable means for controlling the gaseous ammonia flow to the combustion gas stream to essentially match the demand for effective NO_x scrubbing. D6 did not suggest maintaining a hydrolyser pressure of at least 138 kPa in the low pressure method of D8.

According to D7, both the liquid and gas phases produced by urea hydrolysis and subsequent pressure release in a decompression vessel were injected into the combustion gases. However, such an injection of liquid was not desirable for several reasons including build-up of salts, scale and other by-products in the flue. No high pressure liquid-gas containing reactor was disclosed. While the on-line hydrolysis was carried out at elevated pressure, the pressure was not used to provide a potential for driving the ammonia gas into contact with the combustion gases. D7 taught away from the present invention since it only related to pressurised solutions. It was not obvious to drastically increase the pressures used in D8 to the levels involved in the process according to D7.

D9 was not primarily concerned with NO_x scrubbing and did not disclose any system for the controlled quantitative removal of NO_x. D9 disclosed specific urea hydrolysis methods making use of specific acids and reaction mechanisms. D9 did not disclose how to control the apparatus to produce an ammonia gas stream at a variable rate suitable for quantitative removal of nitrogen oxides from combustion gas streams. Although D9 disclosed operating the reaction vessel at temperatures of from 150 to 210 °C, this document did not teach that the heat supplied to the vessel was controlled responsive to a variable demand. The pressure during ammonia evolution was not controlled in any way.

Moreover, the appellant held that the respondent only speculated, with reference to common general knowledge allegedly to be found in steam tables, that based on the temperatures disclosed in D9, the pressure had to be elevated substantially above atmospheric pressure. The claimed process was thus not suggested by or obvious from D9. Combining the differing teachings of D8 and D9 made no sense. In view of the differences, it was not obvious to attempt to convert the process of D8 to a high pressure process.

Concerning the combinations of the low pressure (atmospheric) process disclosed in D2/D2T with common general knowledge or with the teaching of any of D3, D6, D7 or D9, the arguments of the respondent were essentially analogous to those submitted with respect to the combinations of D8 with the other documents. None of D3, D6, D7 or D9 suggested changing the process of D2/D2T to a process wherein the hydrolysis reactor was maintained at a pressure within the claimed range.

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

The respondent requested that the appeal be dismissed (main request) 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 first to third auxiliary requests filed with letter of 4th May 2007.

Reasons for the Decision

1. *Wording of claim 1 as granted (main request)*

The expression "*aqueous ammonia*" in feature (d) of claim 1 is obviously wrong and the board concurs with the parties in that it is immediately apparent that it should read "gaseous ammonia".

2. *Novelty (main request)*

The board is satisfied that none of the cited prior art documents discloses the claimed subject-matter. Since novelty was not at dispute in the appeal proceedings, detailed reasons need not be given in this respect.

3. *Inventive step (main request)*

3.1 The patent in suit relates to a process for removing nitrogen oxides from a combustion gas stream by contacting the stream with gaseous ammonia generated on site in a hydrolysis reactor operated under elevated temperature and pressure.

3.2 Closest prior art

3.2.1 D8/D8T discloses a system for removing NO_x from exhaust gas streams by SCR using NH_3 gas as a reducing agent. The gaseous NH_3 is generated by hydrolysis of an aqueous urea solution 27 fed to a heated vaporiser 29 containing a catalyst solution 31, preferably an aqueous solution of a basic compound or an ammonium salt of a mineral acid. The vaporiser is operated at or close to the boiling point of the liquid mix. D8 mentions reaction temperatures and slight overpressures of up to 125°C and 1000 mm H_2O (i.e. about 9,8 kPa or 1,4 psig), respectively. The NH_3 gas produced is separated from the liquid mix remaining in the vaporiser, withdrawn from the vaporiser via a line comprising a controlled valve 35, and carried to nozzles 25 through which it is injected into the exhaust gas stream. The amount of NH_3 injected into the exhaust gas stream is controlled by a controller 38, acting on the valve 35 and the urea solution feed pump 28 in response to an increased or decreased concentration of nitrogen oxides in the exhaust gas, which is detected by a NO_x monitor 37. When the feed pump rate is increased or decreased in response to changes in the ammonia demand, the current supplied to the heater is also increased or decreased to keep the pressure inside the vaporiser constant. The system is stated to have a good responsiveness to fluctuations of the NO_x concentration in the exhaust gas as occurring e.g. upon start-up or shutdown of the combustion gas generating source. The system also overcomes the safety problems associated with exhaust gas denitration systems making use of ammonia or aqueous ammonia in areas having a high population density. In the embodiment shown in Figure 1, the NH_3 generated is discharged from the vaporiser by heated air blown into the vaporiser via gas feed line 34. Reference is made in particular to D8T, claims 1 to 4; figures 1, 4 and 5(c), and to sections [0001], [0004], [0005], [0011] to [0012] and [0021] to [0034].

3.2.2 In view of the similarities between the process according to claim 1 of the patent in suit (see point II. herein above) and the process disclosed in D8, the board shares the view of both parties that the disclosure of D8 constitutes the closest prior art.

3.2.3 The process disclosed in D8 differs from the one according to claim 1 in that it does not disclose operating the hydrolysis reactor at pressures as high as those required by present claim 1. This was not disputed.

3.3 Technical problem

3.3.1 In the patent in suit there is no explicit statement of a technical problem to be solved. However, it is clear from the description, that one purpose of the invention is to provide a process for removing NO_x by an SNCR or SCR method by which the environmental hazards of transporting and storing anhydrous or aqueous ammonia may be avoided (see sections [0006] and [0012] of the description). As is readily apparent from e.g. claim 1, a further purpose of the invention is to provide a process wherein the gaseous ammonia is contacted with the combustion gas stream at a rate essentially matching the needs of nitrogen oxides removal.

3.3.2 It was undisputed that by virtue of the higher pressure maintained in the reactor, a larger amount of pressurised gaseous ammonia is immediately available for dosing into the exhaust gas, i.e. without having to be generated first, than under the operating conditions of D8. In this connection it is noted that the lower pressure limit of present claim 1 of 138 kPa gauge (about 14100 mm H_2O) is not only slightly higher but about fourteen times higher than the highest pressure value (1000 mm H_2O) actually investigated in D8. The board can accept that, compared to the process of D8, maintaining the reactor pressure at the more elevated values within the range of present claim 1 may inherently make the claimed process better suited to respond to certain kinds of rapid and/or important fluctuations of the NO_x concentration in the exhaust gas to be treated. In case such fluctuations occur, the larger amount of pressurised ammonia gas acting as a "buffer" makes the system less dependent on the responsiveness of the ammonia generating equipment used. However, such fluctuations and the required responsiveness thereto are not addressed at all in the patent in suit, and present claim 1 also covers processes wherein the NO_x concentration does not fluctuate. Hence, in view of the breadth of claim 1, the alleged advantage of improved responsiveness as invoked by the respondent cannot be taken into account in the formulation of the technical problem.

3.3.3 However, it was not disputed that the process disclosed in D8 accomplishes the two purposes of the present invention mentioned under point 3.3.1 herein above. The board thus accepts that starting from D8 the technical problem underlying the present invention can in any case be seen in the provision of a further process for removing nitrogen oxides from a combustion gas stream. As pointed out by the appellant, an increase in the reaction temperature leads to an increase of the ammonia generation rate (see e.g. Figure 7 of the patent). Other things being equal, this rate will thus be higher at the temperatures corresponding to the more elevated pressures according to present claim 1 than at the slight overpressures disclosed in D8.

3.3.4 It is plausible and it was not contested that the stated technical problem is solved by the process according to present claim 1.

3.3.5 According to the appellant, the technical problem consisted in providing a larger molar amount of ammonia gas available for dosing into the exhaust gas stream than the amount provided within the hydrolysis reactor of D8. Operating a hydrolysis reactor of a given size at an elevated pressure within the range indicated in present claim 1 would be one way to provide a larger amount of NH3 available for dosing than when the same reagents were reacted in the same reactor at the slight overpressures disclosed in D8. Considering that the claimed process is not defined in terms of the amount of available ammonia gas or in terms of the reactor's size but in terms of the operating pressure prevailing within the reactor, the board takes the view that the technical problem as formulated by the appellant is based on an ex post facto view and partially anticipates the claimed solution. This formulation of the technical problem is thus not accepted in accordance with established case law of the boards of appeal, see "Case Law of the Boards of Appeal of the EPO", 5th edition, 2006, page 128, section I.D.4.3.1, first paragraph.

3.4 Non-obviousness

3.4.1 The appellant has not convinced the board that the claimed solution to the stated technical problem was obvious in view of the prior art relied upon and common general knowledge.

3.4.2 D8 taken alone does not suggest operating the hydrolysis reactor in the pressure range of present claim 1. D8 reports results of experiments investigating operating pressure values (gauge) of 22, 100, 300 and 1000 mm H_2O (9.8 kPa); see D8T, paragraphs [0023] to [0025] and the diagrams shown in Figures 4 (a) and (b) and 5 (b) and (c). The X-axis (pressure gauge) of the diagrams in Figure 5 (b) and (c) stops at 1200mm H_2O (11.8 kPa), and the highest value actually measured lies close to 1000 mm H_2O. Although it can be gathered from the latter two diagrams and paragraph [0025] that higher pressures within the vaporiser correspond to higher temperatures and higher NH_3 generation rates, nothing in D8 suggests increasing the pressure prevailing in the vaporiser by a factor of greater than 14. According to D8, variations in the NH_3 demand are met only by varying the urea feed pump rate and the heating power, such as to keep the ammonia pressure in the reactor constant.

3.4.3 The appellant argued that increasing the pressure in the system of D8 was obvious since it was well known to use ammonia gas stored at high pressure for use in NO_x reduction processes. However, the board cannot accept this argument because the inventors of D8 were fully aware of this technology and actually designed their process in a manner to circumvent the use of the conventional high pressure ammonia storage containers (see D8T, paragraphs [0004] and [0005]). They did simply not envisage the use of significantly higher pressures in order to achieve higher NH_3 generation rates or to provide a "buffer" of pressurised ammonia gas. The fact that a reaction rate and in particular the NH_3 generation rate can be increased by an increase in temperature does not as such make it obvious to increase the operating pressure in the process of D8 to a level according to present claim 1, since such a higher NH_3 generation rate, or a "higher amount of available ammonia", can be obtained in a more straightforward manner by increasing the capacity of the hydrolyser without modifying the operating conditions. Hence, the process of claim 1 is not obvious in view of D8 and common general knowledge. This conclusion would remain the same even if the technical problem as formulated by the appellant (see point 3.3.5 herein above) were to be adopted.

3.4.4 As will appear from the following, none of the other documents cited in combination with D8, i.e. D3, D6, D7 or D9, suggests increasing the pressure used according to D8 to values in the range according to present claim 1 either.

3.4.5 D3 relates to the purification of urea containing waste streams by hydrolysing the urea contained in the waste stream in a column preferably operated at temperatures and pressures of from 120 to 250°C and from 30 to 300 psig, respectively, whereby the hydrolysis products are stripped from the waste stream by steam. Reference is made in particular to claims 1, 4 and 8 and column 3, lines 14 to 20. The main purpose of the process of D3 is the efficient destruction of the urea present in the waste stream, so that the stream can be released in the environment; see column 1, lines 16 to 30; column 3, lines 51 to 53; column 4, lines 19 to 22. D3 mentions no other use of the hydrolysis products NH_3 and CO_2 than their recirculation into the production of urea.

Since D3 does not even mention NO_x removal by NH_3, it is questionable whether the skilled person starting from the process of D8 and confronted with the stated technical problem would have considered D3 at all. In any case, excluding hindsight considerations, there is nothing in D3 inducing him to increase the relatively low temperatures and pressures used in the process according to D8 to those higher values disclosed in D3.

3.4.6 D6 discloses the conversion of an aqueous solution of urea to ammonia by hydrolysis in the presence of a metal-based catalyst at elevated temperatures and pressures, one of the main objectives being an efficient conversion. Preferably, the temperatures are in the range of from about 177 to 343 °C (350 to 650 °F) and the pressures exceed 2100 kPa gauge (300 psig) and may reach 34474 kPa gauge (5000 psig). D6 thus discloses inter alia operating the hydrolysis at temperature and pressure values lying within the ranges according to present claim 1. The ammonia generated can be used for various purposes. Reference is made to column 1, line 63 to column 2, line 22; column 2, lines 52 to 55; column 3, lines 36 to 45; column 7, line 68 to column 8, line 4; and column 6, line 68 to column 7, line 4. More particularly, for the specific purpose of NO_x reduction, the pressurised solution comprising the reaction products including dissolved ammonia may be injected into an exhaust gas stream. The injection of the liquid reaction media however leads to the undesirable side effects mentioned by the appellant. Alternatively, the pressurised reacted solution is first discharged through a pressure relief valve 5 to a flash drum 6 from where "low pressure" NH_3 vapour may be "recovered" for injection into the exhaust gas stream. In this respect, reference is made in particular to claims 1, 3, 5 and 9; figures 1, 4 and 5; column 3, lines 46 to 55; column 6, lines 61 to column 7, line 6; column 8, line 54 to column 9, line 29; column 11, lines 18 to 29. According to the latter embodiment (Figure 4) wherein ammonia is injected into the effluent as a gas, the ammonia gas is thus not separated at the operative pressure as required by part (b) of present claim 1. Moreover, D6 does not contain any quantitative indications as to the pressure to which it is decompressed in the flash drum or as to the "low pressure" at which the separated NH_3 gas is "recovered" from flash drum 6. Furthermore, D6 is silent about the provision of particular means suitable for withdrawing the ammonia gas at a controlled rate and for contacting it with the exhaust gas at a rate essentially matching the needs of NO_x removal.

In view of the mentioned differences and missing elements of information, and excluding inappropriate hindsight considerations, the skilled person confronted with the stated technical problem was thus not induced by D6 to modify the process of D8 such as to arrive at the process of claim 1.

3.4.7 D7 relates to processes for the hydrolysis of urea, wherein the hydrolysis products are introduced in a combustion effluent under conditions effective to reduce its nitrogen oxide concentration. The hydrolysis reaction is promoted by the application of heat and pressure and by operating at basic or acidic pH. The temperatures used are from about 138 to 260 °C (280 to 500 °F) and the urea solution is maintained under high pressures of more than 8274 kPa (1200 psi), although pressures down to 3103 kPa (450 psi) may be sufficient under acidic or basic conditions. According to one embodiment, the mixture reacted under heat and pressure may be passed to a decompression vessel 70 in which the pressure is lowered, causing separation into a liquid and a gaseous phase, which are then both introduced into the exhaust gas stream 100. However, the hydrolysed urea solution is more preferably introduced directly into the effluent stream. Reference is made to column 1, lines 6 to 11; column 3, lines 28 to 38; claims 1 to 3; Figure 1; column 4, line 30 to column 5, line 39; column 7, line 47 to column 8, line 29; and column 8, lines 36 to 64. D7 thus discloses an "in-line" system, wherein all the components of the reacted mixture, including its liquid and dissolved components, are injected into the effluent gas, as opposed to the process of claim 1, wherein the liquid phase reaction medium is retained in the reactor for further conversion (feature (c)). The injection of the liquid reaction media leads to the undesirable side effects mentioned by the appellant. Moreover, the process disclosed in D7 also differs from the process according to claim 1 (feature (b)) of the patent in suit in that the separation of the ammonia gas and the liquid reaction media is not carried out at the operating pressure of the hydrolysis reaction conduit 60. Again, as in the case of D6, no values are indicated concerning the lower pressure at which the hydrolysis gases may be withdrawn or discharged (see column 8, lines 52 to 64) from the decompression vessel 70.

Considering these differences and the missing elements of information, and excluding inappropriate hindsight considerations, the skilled person confronted with the stated technical problem was thus not induced by D7 to modify the process of D8 such as to arrive at the process of claim 1.

3.4.8 Document D9 discloses processes for the production of gaseous ammonia by hydrolysis of urea in the presence of an acid, in particular of a polyprotic acid such as phosphoric acid or sulphuric acid (claims 1 to 3). In the general description passages relating to the chemical reactions and process conditions that may be used in generating the ammonia gas (column 3, line 42 to column 4, line 55), it is inter alia indicated that the acid will be present in excess (column 3, line 55; column 4, line 14), that the temperature needed for the reaction ("Rxn.2" or "Rxn.4") leading to the release of NH_3 is preferably maintained, by the input of external heat, at a temperature of from 145°C up to 210°C (column 3, lines 60 to 65; column 4, lines 19 to 21), that the preferred acid is concentrated phosphoric acid present in great excess (column 4, lines 12 to 15 and lines 57 to 62), and that water is preferably added "as a reagent" (column 4, lines 15 to 16). The use of the ammonia produced is expressly not limited to NO_x reduction (see e.g. column 4, lines 65 to 67; column 5, lines 5 to 9). According to that part of the description actually describing a process for generating ammonia gas to be used in NO_x reduction (see Figure 1; column 4, line 58 to column 5, line 5), a mixture of water and urea is fed to a single reaction vessel containing concentrated liquid phosphoric acid. The vessel is maintained at a temperature greater than 150°C and the CO_2/NH_3 gas mixture produced is removed from the vessel. The gas mixture can be introduced into a gas flue to react with, and thereby remove nitrogen oxide gases contained in the flue gas.

Although D9 generally mentions that "the ammonia may be removed under pressure since the reaction is done at high temperature" (column 4, lines 21 to 23), no specific pressure values are indicated. In the board's view, a steam table like D10 is not as such sufficient to establish at which temperatures taken in the range indicated in D9 the corresponding pressures prevailing in the complex, multi-component reaction medium of D9, which comprises a large excess of - high-boiling - concentrated phosphoric acid as well as water, ammonia, carbon dioxide and intermediate products, would actually fall within the pressure range of present claim 1. As correctly acknowledged in the patent in suit (page 5, lines 33 to 35), D9 mentions the safety advantages of on site ammonia generation and that the ammonia so produced can inter alia be used for the removal of nitrogen oxides from combustion gas (see D9, claims 9 to 15). The authors of D9 however mainly aimed at providing a process for the quantitative conversion of urea to pure ammonia, and they found that whereas a strong base was unsuitable this aim could be achieved in a concentrated acid solution (see D9, column 1, line 65 to column 2, line 4; and column 3, lines 28 to 32). D9 is thus not primarily focussed on quantitative NO_x removal or, in other words, on matching of the amount of ammonia withdrawn from the reactor with the needs of NO_x removal of a flue gas. Hence it contains no indications concerning the pressures at which the ammonia may be removed from the reactor, and it does not disclose or suggest measures or means for maintaining the pressure in the reactor above a certain

elevated level during the withdrawal of ammonia, let alone in the context of NO_x removal. On the other hand, D9 contains no details whatsoever as to how the NH_3 containing gas produced in the reactor is actually to be withdrawn and brought into contact with the exhaust gas. In particular, it discloses no particular means or measures for withdrawing separated ammonia gas at a controlled rate and contacting it with the flue gas at a rate essentially matching the said needs. The appellant's allegation that such means were implicit to the process of D9 finds no support in this document and appears to be based on a hindsight reading thereof.
In view of these missing elements of information and the particularities of the process of D9, the latter document does not suggest solving the stated technical problem by modifying the process of D8 in a manner leading to the process of present claim 1.

3.5 The other documents cited in the appeal proceedings do not contain any additional information which in combination with D8 would point towards the process of claim 1.

3.6 Concerning the appellant's two other lines of attack on inventive step, the board comes to the following conclusions.

3.6.1 D2/D2T discloses a process for removing nitrogen oxides from a combustion gas stream using ammonia gas generated on site. This process differs from the process according to present claim 1 in that the hydrolysis is not carried out at a pressure in the range of present claim 1. The system disclosed in D2 also comprises a NO_x -monitoring device and control means acting on the liquid feed pumps and the heating means to respond to fluctuations in ammonia demand by increasing the NH_3 generation rate. Reference is made to Figure 1 of D2; and to D2T, the paragraph bridging pages 2 and 3; page 5, last paragraph; page 6, last paragraph; page 7, lines 1 to 16 and the last paragraph. It was common ground between the parties that D2 did not directly and unambiguously disclose operating the hydrolyser at a pressure above atmospheric pressure. Moreover, D2 does not disclose means such as a valve for withdrawing ammonia gas at a controlled rate from a pressurised enclosure. The process disclosed in D2 is thus even more remote from the claimed process than the one of D8. Hence, for reasons similar to those given above in connection with D8 as closest prior art, combinations of D2 as the closest prior art with any of D3, D6, D7 and D9 do not lead to the claimed process in an obvious manner.

3.6.2 The attack on inventive step based on D9 in view of the common general knowledge is not conclusive either. As already mentioned under point 3.4.8 herein above, D9 has not been shown to implicitly disclose directly and unambiguously a hydrolysis step operated at an elevated pressure maintained within the range according to present claim 1, not even at temperatures at the upper end of the range of 145 to 210 °C disclosed in D9. The argument of the appellant as presented in writing can thus not be accepted. Moreover, as also indicated under point 4.3.8, D9 contains no information having regard to some of the features recited in parts (d) and (e) of present claim 1. Therefore, taking the only embodiment in D9 actually describing the overall process with generation of NH_3 and its use in NO_x removal (Figure 1 and column 4, line 58 to column 5, line 5) as the closest prior art, and accepting, purely for the sake of argument, that the skilled person would consider it obvious to operate this particular process at a temperature at the higher end of the 145 to 210 °C range, such a process would still not necessarily comprise all the features of present claim 1. Consequently, excluding hindsight considerations, the claimed process is not obvious in view of D9 and the common general knowledge.

3.7 In view of the above the board concludes that the process of claim 1 and, consequently, of dependent claims 2 to 21 is based on an inventive step as required by Article 52(1) in conjunction with Article 56 EPC.

4. Since the appellant's main request is allowable, its first to third auxiliary requests need not be dealt with.

Order

For these reasons it is decided that:

The appeal is dismissed.

The registrar The chairman

C. Vodz G. Raths