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D E C I S I O N
of 19 December 1997

Case Number: T 0113/96 - 3.2.4

Application Number: 90102103.0

Publication Number: 0381236

IPC: F01N 3/20

Language of the proceedings: EN

Title of invention:
Method of removing nitrogen oxides in exhaust gases from a diesel engine

Patentee:
Nippon Shokubai Kagaku Kogyo Co Ltd

Opponent:
Bayerische Motoren Werke Aktiengesellschaft

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - no (main and first auxiliary requests)"
"Inventive step - yes (second auxiliary request)"
"New filed documents - no remittal"

Decisions cited:
-

Catchword:
Filing with the statement setting out the grounds of appeal, new documents reinforcing the line of attack already made before the first instance has to be considered as the normal behaviour of a losing party.

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Case Number: T 0113/96 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 19 December 1997

Appellant: (Opponent)
Bayerische Motoren Werke
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Patentabteilung AJ-3
80788 München (DE)

Representative:
-

Respondent: (Proprietor of the patent)
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Representative:
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 23 November 1995 rejecting the opposition filed against European patent No. 0 381 236 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: C. A. J. Andries
Members: H. A. Berger
J. P. B. Seitz

Summary of Facts and Submissions

I. The appellant (opponent) lodged an appeal, received on 20 January 1996, against the decision of the opposition division, dispatched on 23 November 1995, rejecting the opposition against the patent No. 0 381 236. The appeal fee was also paid on 20 January 1996. The written statement setting out the grounds of appeal was received on 22 March 1996.

II. Opposition was filed against the patent as a whole and based on Article 100(a) EPC (lack of inventive step). The following prior art documents were cited during the opposition proceedings and have again been taken into account in the appeal proceedings:

D1: DE-A-3 721 572

D2: EP-A-0 257 842

D3: SAE Report 710 835 (without Appendix)

D4: CRC Report No. 447 (without Appendix)

III. In addition the following prior art documents were cited during the appeal proceedings:

D6: SAE-Report 770 717 (pages 1 to 19)

D7: DE-A-2 843 335

D8: US-A-3 834 359

D9: WO-A-83/00057

IV. In response to a communication of the board, the respondent (proprietor of the patent) presented two auxiliary requests.

Oral proceedings were held on 19 December 1997 during which the respondent filed new claims 1 to 5, a new description and a new set of drawings for the second auxiliary request.

V. Claim 1 as granted (main request) reads as follows:

"A method of removing nitrogen oxides in exhaust gases from a diesel engine by using a catalyst in a reactor under the presence of ammonia, wherein one or more of engine power, fuel consumption amount of engine, temperature of engine intake air and exhaust gas temperature as selective factors are measured respectively as the measuring factors and the flow rate of ammonia is controlled based on said measured values and ammonia is supplied into an exhaust gas flow channel from the engine to the reactor, characterized in that
a humidity of intake air as a specific factor is measured, and the flow rate of ammonia is controlled also based on this specific factor."

Claim 1 of the first auxiliary request comprises the features of granted claims 1 and 6.

Claim 1 of the second auxiliary request comprises the features of granted claims 1 and 7 and reads as follows:

"A method of removing nitrogen oxides in exhaust gases from a diesel engine by using a catalyst in a reactor under the presence of ammonia, wherein one or more of engine power, fuel consumption amount of engine, temperature of engine intake air and exhaust gas temperature as selective factors are measured respectively as the measuring factors and the flow rate

of ammonia is controlled based on said measured values and ammonia is supplied into an exhaust gas flow channel from the engine to the reactor,
characterized in that
a humidity of intake air as a specific factor is measured, and the flow rate of ammonia is controlled also based on this specific factor, and in that ammonia is supplied in the flow channel at the upstream of a supercharger in the exhaust gas flow channel, the supercharger being upstream of the reactor downstream thereto."

VI. The appellant regards document D1 as the most relevant prior art document, which however does not disclose a correlation between the addition of NH_3 and the humidity of air. He argued that in this known control system the prevailing amount of NH_3 added to the exhaust gas is determined indirectly by measurements of engine parameters and the remaining amount of NH_3 is determined by a closed loop control circuit measuring the NO_x in the exhaust gas. It is obvious that the amount of NO_x measured by means of a sensor is already the amount reduced by the air humidity, and that the amount of NH_3 added to the exhaust is the amount based on this measured reduced amount of NO_x. The appellant further argued that it belongs to the general knowledge of the skilled person, and that it is known from documents D3, D4 and D6, that air humidity has a considerable influence on the formation of NO_x and it is even state of the art (see documents D7 and D8) to increase air humidity artificially by adding water to the combustion air for minimizing nitrogen oxides. No inventive step can therefore be seen in calculating the necessary amount of NH_3 on the basis of the reduced NO_x amount calculated with a factor of the air humidity. In the opinion of the appellant the method of claim 1 (main request) therefore is not patentable.

With regard to claims 1 of the first and the second auxiliary requests the appellant again drew attention to document D1 which discloses in Figure 1 a version in which the ammonia is supplied into the exhaust gas flow channel between a supercharger and the reactor (1) downstream thereof. The possibility of providing the reactor upstream of the supercharger is also described in document D1 (see column 8, lines 5 to 8). Since the ammonia supply must be upstream of the reactor, it must be upstream of the supercharger. According to the appellant, the methods of claims 1 of the first and second auxiliary requests are therefore obvious.

VII. The respondent considers document D9 as the most relevant prior art document since it discloses an open loop control system. Although the correlation between intake air humidity and NO_x content is known from the available prior art documents D3, D4 and D6, none of the references discloses or even hints at additionally controlling the added NH_3 according to the humidity of the intake air.

The respondent argued that the invention is in particular directed to diesel engines which usually have a high compression ratio and are in particular prone to NO_x-formation. Although document D9 also concerns a system for reducing nitrogen oxide emissions in diesel engines, this system cannot work quickly enough to remove NO_x properly and to prevent ammonia slip during transient engine operations. The skilled person however has no information on how to improve this known system.

The respondent further argued that the available prior art shows that no skilled person considered using the humidity of the intake air as an additional control factor in determining the amount of NH_3 to add to the exhaust gas, in the period of 18 years between 1971,

the date of publication of the documents D3 and D4, and the priority date of the present patent. The respondent is of the opinion that the citing of the three more references, D6 to D8, published within the 18 year period without disclosing or even suggesting the technical solution according to the characterising portion of claim 1, reinforces still further the inventiveness of claim 1 (main request).

As for documents D7 and D8, they both disclose adding water vapour or ammonia water (D8) to intake air or into the combustion chamber in order to reduce the NO_x emission amount. According to the respondent, it follows that if the skilled person, starting from the closest prior art, is faced with the problem of minimising the NO_x content of the exhaust gas while preventing escape of NH_3 from the catalyst, in order to control the noxious exhaust emission within legally prescribed limits, he would be motivated by document D7 or D8 to add water vapour to the intake air. Thus, documents D7 and D8 would direct him to a different technical solution from that of claim 1.

With regard to the auxiliary requests, the respondent is of the opinion that document D1 cannot lead to the method of claim 1 of either the first or the second auxiliary request.

VIII. Requests

The appellant (opponent) requested that the decision under appeal be set aside and the patent be revoked.

The respondent (patentee) requested:

1. that the appeal be dismissed and that the patent be maintained as granted (main request);

2. that the decision under appeal be set aside and that the patent be maintained on the basis of the first auxiliary request;

3. that the decision under appeal be set aside and that the patent be maintained on the basis of the second auxiliary request;

4. that the case be remitted to the first instance if the late filed documents D6 to D8 were to be considered by the board as prejudicial to the maintenance of the patent;

5. if the case were to be remitted to the first instance, an apportionment of the costs.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

The question of Article 123 EPC was not raised by the appellant. Since the main request and the first auxiliary request will be rejected due to lack of inventive step (see following paragraphs 6.1 to 8.2), it is appropriate to examine only the amendments of the second auxiliary request with regard to Article 123 EPC.

Claim 1 of the second auxiliary request mainly comprises the features of granted claims 1 and 7. The subject-matter of these claims is disclosed in claims 1 and 7 of the originally filed application, whereas the positioning of the reactor downstream of the supercharger is shown in Figures 10 to 13 of the

published patent specification and the originally filed drawings. The added features furthermore restrict the content of the granted claim 1.

The description and drawings were adapted to the new claims 1 to 5 by deleting the superfluous parts.

The amendments therefore satisfy Article 123 EPC.

3. *Novelty*

None of the cited prior art documents discloses a method with all the features of either claim 1 of the main, or of the first, or of the second auxiliary requests. The methods of claim 1 of all the requests therefore are new in the meaning of Article 54 EPC. Novelty was not disputed by the appellant.

4. *Closest prior art*

The closest prior art is disclosed in document D9 according to which the whole flow rate of ammonia is controlled based on the measured values of engine parameters, such as the fuel consumption amount of the engine (open loop control), which is the same control concept as that used in the present patent. According to document D1 however only the major part of NH_3 demand is calculated from engine parameters and added to the exhaust gas (open loop control), whereas the remaining NH_3 is controlled based on the measured NO_x exhaust gas concentration (closed loop control). The purpose of the control method of document D1 is to attain in a first step a fast but rough reduction of NO_x (see column 3, lines 58 to 66) without a NH_3 slip by means of an open loop control, and in a second step an exact limitation of the NO_x concentration in the exhaust gas (see column 3, lines 20 to 27) by the closed loop control. In the concept of document D1, an improvement of the

open loop control operation by adding the humidity factor seems to be superfluous since the exact ammonia amount is finally determined by the closed loop control. This prior art document, due to its different control concept, therefore is not as relevant as document D9.

5. *Problem and Solution*

5.1 Problem

The problem of the patent as published (main request) is (see column 2, lines 32 to 44) to provide a method capable of efficiently removing nitrogen oxides in exhaust gases from a diesel engine even upon abrupt changes of the conditions of exhaust gases, capable of coping with the change of the amount of nitrogen oxides due to the change of the combustion performance of the engine and capable of lowering the ammonia content after the removal of the nitrogen oxides as much as possible. This problem is also relevant for the first and second auxiliary requests.

5.2 Solution

By controlling the flow rate of ammonia based on the measured values of the engine parameters (open loop control) nitrogen oxides are removed even upon abrupt changes of the conditions of exhaust gases and by basing the flow rate of ammonia also on the specific factor of measured humidity of intake air, nitrogen oxides and ammonia slip are prevented as far as possible (main and first auxiliary requests).

By supplying ammonia to the exhaust gas flow channel at the upstream of the supercharger (second auxiliary request) the exhaust gases and ammonia are sufficiently mixed before reaching the reactor which is downstream

of the supercharger, thereby enabling an improvement of the reaction efficiency and a further enhancement of the efficiency for removing nitrogen oxide.

6. *Inventive step (main request)*

6.1 Document D9 (Figure 4) discloses a method of removing nitrogen oxides in exhaust gases from a diesel engine (see page 2, line 28) by using a catalyst (28) in a reactor (26) under the presence of ammonia (ammonia reservoir 34), wherein the fuel consumption amount (signal S3) and engine speed (signal S4) are measured (measuring factors) in order to define the nitrogen oxides emitted by the diesel engine involved. The flow rate of ammonia is controlled based on said defined value, whereafter ammonia is supplied into an exhaust gas flow channel from the engine to the reactor.

6.2 The influence of humidity of intake air on NO_x formation in an engine is well known and is disclosed in documents D3, D4 and D6. This significant effect of humidity is in particular described in documents D4 (see page 4, first paragraph of section IV "Discussion") and D6 (see page 4, left-hand column, section "Results and Statistical Analysis") with regard to diesel engines.

6.3 If, in an open loop control system as in the system according to document D9, the rate of ammonia is defined, based on an estimated or calculated amount of nitrogen oxides, which itself depends on engine parameters, it is obvious for a person skilled in the art that an improved result (i.e. less nitrogen oxides, reduced ammonia slip) will be obtained, with at least the best possible nitrogen oxides calculation (estimation), that means with the best approximation to reality. Such an improved calculation is only a matter of the demanded accuracy and its costs involved.

If a further improvement of the nitrogen oxides calculation is desired, it is obvious for a skilled person to take into account, as much as possible, parameters which are known to be able to influence the probable amount of NO_x in the engine exhaust gas. Since it is commonly known that the humidity of the intake air has an important influence on the NO_x formation, it is obvious for the skilled person who wants to improve the calculation of the amount of NO_x in the exhaust gases to take this specific factor into account.

6.4 The respondent is of the opinion that the flow rate of ammonia which is also controlled based on the measured humidity of the intake air, has a surprising effect on the reduction of the NO_x amount in the exhaust gas and on preventing ammonia slip during transient engine operation conditions, which would not have been known to the skilled person.

It is known however that particularly during transient operation conditions the closed loop control system, which needs a slow responding nitrogen oxide sensor, cannot cope with the rapid change of the amount of nitrogen oxides in the exhaust gas stream (see page 2, lines 3 to 10 of document D9). Document D9 therefore proposes the open loop control system because of its fast response. According to common general knowledge, the accuracy of such an open loop control system depends on the chosen engine parameters and also on the number of these parameters forming the input signals to this control system, for determining, via a calculation of the estimated amount of nitrogen oxides, the output signal measuring the ammonia amount. The skilled person facing the problem of improving the accuracy of ammonia output in an open loop control system therefore would consider the input parameters which have a significant influence onto the formation of NO_x in the engine and

therefore onto the necessary amount of ammonia. One of these parameters is according to documents D3, D4 and D6 obviously the humidity content in intake air.

The argument of the respondent that the skilled person would not consider these documents D3, D4 and D6 since they concern tests for generating factors used for comparing the efficiency of different engines, cannot be accepted. These documents clearly disclose the significance of the influence of the humidity on the NO_x-amount (see document D4, page 4, section IV "Discussion", first paragraph, and document D6, page 4, left-hand column, section "Results and Statistical Analysis", lines 6 to 8), and therefore would not be neglected when a skilled person tries to find parameters which can improve the accuracy of the NO_x-control.

The further argument of the respondent that there exist several parameters which could be taken into account in reducing the NO_x ammount and no hint is given to choose in particular the humidity as a parameter for the destination of the ammonia amount, also cannot be followed, since the significance of humidity in this respect is commonly known. It is therefore obvious to consider humidity when an improved NO_x calculation is wanted. If further positive effects occur then they are only a supplement to the advantages already expected.

6.5 It is true that the correlation between the humidity in the intake air and the NO_x concentration in the exhaust gas has been already known since 1971 and none of the cited documents discloses the use of this factor for determining the ammonia amount. However, the exact predetermination of the NO_x amount is not necessary in closed loop control methods in which the control is based on the **measured** NO_x concentration, which were apparently mainly used before the open loop control

system proposed in document D9 (see page 2, lines 3 to 10 and see filing date 1981). Although humidity has a significant influence on the amount of the formation of NO_x the more important influence thereon is engine power (see document D1, claim 1) or fuel consumption (see document D9) which is closely related to engine power. Such a factor of course is in particular taken into account for the determination of the ammonia amount at transient operation conditions, since the fast reaction of open loop control is in particular necessary during these transient conditions, i.e. change of load (see document D9, page 2, lines 3 to 10). However, as already indicated in above sections 6.1 to 6.4, for the improvement of this open loop control it does not involve an inventive step to use at least one additional significant factor, such as humidity.

6.6 Documents D7 and D8, to which the respondent also referred, clearly disclose the influence of artificially added water onto the NO_x-formation in an engine and show one way to reduce it. However, the skilled person confronted with the problem of increasing the accuracy of an open loop control system for ammonia supply into the exhaust gas flow in an embodiment according to document D9 would have no logical reason to reduce the NO_x formation by adding water into the inlet air or ammonia water into the cylinder, particularly since in that case he would go back to a closed loop control system which he wanted to avoid with the subject-matter of document D9.

6.7 The method of granted claim 1 (main request), which only claims in general terms the use of humidity as a specific factor in addition to another factor (such as fuel consumption amount) in order to control the flow rate of ammonia, therefore does not involve an inventive step (Article 56 EPC).

7. Claim 1 of the main request therefore is not patentable (Article 52 EPC), and the main request therefore has to be rejected.

8. *Inventive step (first auxiliary request)*

8.1 According to claim 1 of the first auxiliary request, ammonia is supplied into the flow channel in the exhaust gas flow channel between a supercharger and the reactor downstream thereto, in a further step in addition to the method of granted claim 1. Document D1 however already discloses the supply of ammonia between a supercharger and the reactor (see Figure 1). No surprising effect can be seen in this additional feature of claim 1 of the first auxiliary request in comparison with the prior art. Having also regard to the reasons brought forward with respect to granted claim 1 (see sections 6.1 to 6.7 above) the method of this claim therefore does not involve an inventive step.

8.2 Claim 1 of the first auxiliary request therefore is not patentable (Article 52 EPC), and also the first auxiliary request has to be rejected.

9. *Inventive step (second auxiliary request)*

9.1 According to claim 1 of the second auxiliary request, ammonia is supplied in the flow channel at the upstream of a supercharger in the exhaust gas flow channel, the supercharger being upstream of the reactor downstream thereto, in a further step in addition to the method of granted claim 1.

9.2 The only one of the cited documents which discloses the position of the ammonia supply into the exhaust gas flow in relation to a supercharger is document D1. This document discloses the supply of ammonia into the

exhaust flow between the supercharger and the reactor in a first version shown in Figure 1, and mentions in column 8, second paragraph the possibility of providing the reactor for the ammonia upstream of the supercharger for a second version. Since the ammonia must be supplied upstream of the reactor, the effect of an improved mixture of ammonia with the exhaust gas by the supercharger cannot be attained therewith. There is no hint given in this document D1 to provide the reactor downstream of the supercharger and to supply ammonia upstream thereof. The other cited prior art documents are not as relevant as document D1 with respect to the additional feature of claim 1 of the second auxiliary request and also could not lead to the method of this claim 1 (Article 56 EPC).

10. Therefore, claim 1 of the second auxiliary request can form the basis for the maintenance of the patent.

11. *Request for remittance of the case to the first instance*

Documents D6 to D8 were filed at the beginning of the appeal proceedings with the statement setting out the grounds of appeal. These documents were, in view of the impugned decision, rightly brought forward by the appellant in order to emphasize the relationship humidity-NO_x production. The filing of these documents does not form a new line of attack but only reinforces the existing line of attack which had not succeeded before the first instance. In other words these documents are completing the picture which was already presented to the first instance.

The board cannot see an abuse of the procedure in such an approach. On the contrary, the board wishes to emphasize that the filing of new documents in the framework of the existing case, in order to reinforce

the line of attack already made before the first instance has to be considered as the normal behaviour of a losing party, which under normal circumstances cannot lead to a different apportionment of costs, particularly if that filing is made at the earliest possible moment in the appeal proceedings, i.e. the filing of the statement setting out the grounds of appeal.

The board therefore took these documents into consideration to assess inventive step.

Apart from the fact that documents D7 to D8 disclose other aspects of the relation humidity-NO_x production, which are not of great importance for the present case, document D6 only confirms the teaching of documents D3 and D4 and no new arguments only based on this document D6 were brought forward. No surprising disadvantage for the respondent arose from the introduction of this document D6, so that the board has not found a convincing argument to remit the case to the first instance.

Therefore, the request for remittal of the case to the first instance for further prosecution is rejected.

12. Since the case is not remitted to the first instance for further prosecution, the request for apportionment of the costs is no longer relevant.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to maintain the European patent with the following version:

Claims: 1 to 5 of the second auxiliary request as filed during the oral proceedings on 19 December 1997.

Description: Columns 1 to 22 as filed during the oral proceedings on 19 December 1997.

Drawings: Figures 1 to 9 as filed during the oral proceedings on 19 December 1997.

The Registrar: The Chairman:

N. Maslin C. Andries