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D E C I S I O N
of 29 January 2002

Case Number: T 0017/99 - 3.2.4

Application Number: 92102266.1

Publication Number: 0499207

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Language of the proceedings: EN

Title of invention:

Control apparatus for speedily warming up catalyst in internal combustion engine

Patentee:

DENSO CORPORATION

Opponent:

Siemens VDO Automotive S.A.S.

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Main request and first auxiliary request: inventive step - no"

"Second auxiliary request: inventive step - yes"

Decisions cited:

T 0506/95, T 0298/93

Catchword:

-



Case Number: T 0017/99 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 29 January 2002

Appellant: Siemens VDO Automotive S.A.S.
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Representative: -

Respondent: DENSO CORPORATION
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Decision under appeal: Interlocutory decision of the Opposition Division
of the European Patent Office posted 9 November
1998 concerning maintenance of European patent
No. 0 499 207 in amended form.

Composition of the Board:

Chairman: C. A. J. Andries
Members: T. Kriner
C. Holtz

Summary of Facts and Submissions

- I. The Appellant (Opponent) lodged an appeal, received at the EPO on 28 December 1998, against the interlocutory decision of the Opposition Division posted on 9 November 1998 which maintained the European patent No. 0 499 207 in amended form. The appeal fee was paid simultaneously and the statement setting out the grounds of appeal was received at the EPO on 8 March 1999.
- II. Opposition was filed against the patent as a whole and based on Article 100(a) EPC. The Opposition Division held that the grounds for opposition cited in Article 100(a) EPC did not prejudice the maintenance of the patent as amended according to the main request submitted with letter of 18 September 1998.
- III. The following documents have been considered during the appeal proceedings:
- D1: US-A-4 007 590
- D2: EP-B-0 146 426
- D3: US-A-4 132 198.
- D6: US-A-4 103 486.
- IV. Oral proceedings took place on 29 January 2002.
- The Appellant requested that the decision under appeal be set aside and the patent in suit be revoked.
- The Respondent (Patentee) requested that the appeal be

dismissed, alternatively that the decision under appeal be set aside and that the patent be maintained on the basis of either the first auxiliary request submitted with letter of 26 July 1999 or the second auxiliary request, submitted in the oral proceedings on 29 January 2002.

V. Claim 1 of the main request reads as follows:

- "a) Control apparatus for an internal combustion engine (10) which is connected to a catalyst (38) disposed within an exhaust pipe of said engine (10) so as to purify emissions generated by said engine (10), said apparatus comprising:
- b) an engine operating condition detecting means (30 to 34, 36, 37) for detecting an operation condition of said engine;
- c) a fuel injection amount determining means (20) for determining an appropriate fuel amount in order to obtain an appropriate air-fuel ratio on the basis of said detected engine operating condition;
- d) an ignition timing determining means (20) for determining an appropriate ignition timing on the basis of said detected engine operating condition;
- e) a temperature condition determining means (20, 33) for determining whether a temperature of said catalyst (38) is reaching an operating temperature at which said catalyst (38) can effectively purify said emissions; and
- f) a warm-up means (20) for shortening the warm-up period of said catalyst (38);

characterized in that

- f1) said warm-up means (20) in response to an output signal of said temperature condition determining means which indicates that the temperature of said

catalyst (38) is lower than said operating temperature

- f2) is intermittently retarding said determined ignition timing for every other ignition cycle, or
- f3) is adjusting said determined fuel amount to a rich amount and to a lean amount with respect to said air-fuel ratio in such a way that excessive oxygen due to a lean combustion in said engine (10) and excessive carbon monoxide due to a rich combustion in said engine (10) are supplied to said catalyst (38) in order to increase the temperature of said catalyst by an oxidative reaction within said catalyst, and
- f2) is intermittently retarding said determined ignition timing for every other ignition cycle."

The letters a - f3 have been added by the Board of Appeal to simplify the reference to the features of the claim.

Claim 1 of the auxiliary request differs from claim 1 of the main request only in that the second alternative comprising both features f3 and f2 has been deleted. Claim 1 of the second auxiliary request differs from claim 1 of the main request only in that the first alternative comprising solely feature f2 (and not feature f3) has been deleted. Additionally the expression "operating condition" has been replaced by "operation condition" in features c and d of the second auxiliary request.

VI. In support of his request the Appellant relied essentially on the following submissions.

The closest prior art was represented by Figure 5 of

D6. This document disclosed a control apparatus for an internal combustion engine comprising all features of claim 1 according to all present requests, except the second portion of feature f which describes the purpose of the warm-up means. The engine operating detecting means according to feature b was formed by the cam (50) which turned at a speed corresponding to the engine speed and therefore detected the engine speed. Feature c was implicitly disclosed in D6 because it was evident that the engine shown in this document necessarily comprised a fuel injection amount determining means for determining an appropriate fuel amount. The means for retarding the ignition timing shown in D6 (140, 150, 160, 170) formed warm-up means according to the first portion of feature f. As shown in Figure 5, this warm-up means in response to an output signal (T) of a temperature condition determining means (81) which indicated that the temperature of said catalyst was lower than an operating temperature of the catalyst (80), intermittently retarded the regular ignition timing determined by ignition determining means (40, 50, 60) for every other ignition cycle, as described in features f1 and f2. Furthermore the description of D6 contained a hint to supply the combustion chambers alternately with a rich and a lean air-fuel ratio (see column 7, lines 22 to 26) in accordance with feature f3.

Consequently the apparatus of D6 differed from the subject-matter of claim 1 according to all present requests only in that the warm-up means did not work immediately after the start of the corresponding combustion engine for shortening the warm-up period of the catalyst. Nevertheless D6 gave the general teaching to provide a warm-up means which was intermittently

retarding the ignition timing for every other ignition cycle in order to rapidly heat a catalyst to its operating temperature. It was obvious for the skilled person that this teaching was not restricted to the operation of the catalyst after the starting period. Therefore, when confronted with the object of rapidly warming-up the catalyst after a cold start of the engine according to D6, he would use this teaching also during the starting period.

Additionally, the second alternative of claim 1 according to the main request which corresponded to the subject-matter of claim 1 according to the second auxiliary request, was obvious in the light of documents D2 and D3. D3 referred to a further control apparatus for an internal combustion engine which adjusted a predetermined fuel amount to a rich and to a lean amount as described in feature f3. However such a switching between a rich and a lean mixture inevitably resulted in an undesirable fluctuation of torque. Since D2 taught (for example in column 4, lines 29 to 34) that a fluctuation of torque as a result of a switching between different fuel mixtures could be avoided by an intermittent retardation of the ignition timing, it was obvious to provide a warm-up means which intermittently retarded the ignition timing and adjusted the fuel amount to a rich and to a lean amount according to features f2 and f3.

Consequently none of the apparatuses of the present requests was based on an inventive step.

VII. The Respondent disputed the appellant's views. His arguments can be summarised as follows:

The closest prior art was represented by D1 because this was the only document which disclosed a control apparatus as described in the preamble of claim 1 according to all present requests, and which referred to the warming-up of a catalyst after a cold start of a combustion engine.

D6 did not deal with the problem of warming up a catalyst but with the problem of preventing an excessive drop of the catalyst temperature when the engine was idling or running under a relatively light load. Consequently the skilled person would not consider D6, when confronted with the problem of rapidly warming up a catalyst.

But even if the skilled person took D6 into consideration, the teaching of this document could not lead him to the subject-matter of the present requests because D6 neither taught an intermittent retardation of the ignition timing for every other ignition cycle according to feature f2, nor an adjustment of the determined fuel amount according to feature f3. With respect to the retardation of the ignition timing, D6 disclosed merely a random retardation, and with respect to the adjustment of the fuel amount, D6 disclosed only the possibility to feed a first group of cylinders with a rich mixture and a second group of cylinders with a lean mixture as an alternative to the random retardation of the ignition timing.

Therefore D6 could not suggest any of the features f1, f2 and f3 as such, let alone the claimed combinations of these features.

D2 and D3 were also not suitable to lead the skilled

person in an obvious way to the subject-matter of claim 1 according to the second auxiliary request. Since none of these documents referred to a warm-up means, it was not sufficient to combine their teachings to reach the claimed apparatus. This required in addition to such a combination that the skilled person recognized the possibility of using the teachings of D2 and D3 in connection with a warm-up means in a control apparatus according to the preamble of claim 1.

Consequently the subject-matter of all present requests was based on an inventive step.

Reasons for the Decision

1. The appeal is admissible.
2. *Amendments*

Compared to the subject-matter of claim 1 as granted which comprised three alternatives (namely f1 + f3; f1 + f2; f1 + f2 + f3), the subject-matter of claim 1 of each of the present requests has been restricted by deleting one (main request) or two (auxiliary requests) of these alternatives. Since no new features have been added to the present claims (the terminology used in claim 1 according to the second auxiliary request has been made consistent), and the description has only been adapted to the wording of the second auxiliary request, all amendments meet the requirements of Articles 123(2) and (3) EPC.

3. *State of the art*

3.1 As admitted by the Respondent, D1 discloses a control apparatus as defined in the preamble of claim 1 according to all present requests, namely

- (a) a control apparatus for an internal combustion engine (10) which is connected to a catalyst (24) disposed within an exhaust pipe (22) of said engine so as to purify emissions generated by said engine, said apparatus comprising:
- (b) an engine operating condition detecting means (see column 2, lines 20 to 26) for detecting an operation condition of said engine;
- (c) a fuel injection amount determining means (28) for determining an appropriate fuel amount in order to obtain an appropriate air-fuel ratio on the basis of said detected engine operation condition (see column 2, lines 3 to 28);
- (d) an ignition timing determining means for determining an appropriate ignition timing on the basis of said detected engine operation condition (implicit);
- (e) a temperature condition determining means for determining whether a temperature of said catalyst is reaching an operating temperature (engine temperature: 30°C) at which said catalyst can effectively purify said emissions; and
- (f) a warm-up means (58, 62, 64, 44 and 48) for shortening the warm-up period of said catalyst.

When the temperature of the catalyst is lower than

said operating temperature, the warm-up means interrupt the fuel supply to at least one cylinder so that this cylinder is operated as an air pump. Since this method step cannot be regarded as an adjustment of the determined fuel amount to a rich amount and to a lean amount, and since D1 does not explicitly describe said ignition timing determining means, let alone the functioning of such means, D1 does not disclose any of the claimed combinations of features f1, f2 and f3.

3.2 D2 refers to

- (a) a control apparatus for an internal combustion engine (1), said apparatus comprising:
- (b) an engine operating condition detecting means (7, 8, 10) for detecting an operation condition of said engine;
- (c) a fuel injection amount determining means (6) for determining an appropriate fuel amount in order to obtain an appropriate air-fuel ratio on the basis of said detected engine operation condition (see column 3, lines 20 to 27);
- (d) an ignition timing determining means (6) for determining an appropriate ignition timing on the basis of said detected engine operation condition (see column 3, lines 40 to 44); and
- (e) a temperature condition determining means (11).

However, since the engine shown in this document is not connected to a catalyst, the control apparatus

according to D2 does not comprise a warm-up means for shortening the warm-up period of a catalyst (feature f) which could work according to features f1 - f3, and the temperature condition determining means is not provided for determining whether a temperature of the catalyst is reaching an operating temperature (second portion of feature e).

3.3 D3 discloses

- (a) a control apparatus for an internal combustion engine (10) which is connected to a catalyst (29) disposed within an exhaust pipe of said engine so as to purify emissions generated by said engine, said apparatus comprising:
- (b) an engine operating condition detecting means (116) for detecting an operation condition of said engine; and
- (d) an ignition timing determining means for determining an appropriate ignition timing on the basis of said detected engine operation condition (implicit).

The combustion engine shown in D3 comprises an air-fuel mixture control system (60) for controlling a carburetor so that it alternately or cyclically provides rich and lean air-fuel mixtures in order to obtain a so-called "rich-lean mixture type" exhaust gas reburning device. These mixtures are fed into an intake passage in synchronisation with the engine speed in such a manner that a first group of combustion chambers receives the rich air-fuel mixture and a second group of combustion chambers receives the lean air-fuel

mixture. As a result the engine produces two kinds of differently composed exhaust gases, one containing relatively large quantities of burnable components and the other one a relatively large quantity of air. This makes it possible for the catalyst to purify the exhaust gases with a small amount of secondary air and without a measure for increasing the temperature of the exhaust gases such as retarding the engine ignition timing (see column 8, lines 27 to 53).

Consequently the apparatus of D3 does not comprise a fuel injection amount determining means as described in feature c, no warm-up means as defined in features f - f3, and no temperature condition determining means according to feature e.

3.4 D6 discloses, in particular in its Figure 5

- (a) a control apparatus for an internal combustion engine which is connected to a catalyst (80) disposed within an exhaust pipe of said engine so as to purify emissions generated by said engine, said apparatus comprising:

- (c) a fuel injection amount determining means suitable for determining an appropriate fuel amount in order to obtain an appropriate air-fuel ratio (inevitable for the engine shown in Figure 5 and therefore implicitly disclosed in D6);

- (d) an ignition timing determining means (30, 31, 32, 40, 50, 60) suitable for determining an appropriate ignition timing;

- (e) a temperature condition determining means (81)

suitable for determining whether a temperature of said catalyst is reaching an operating temperature at which said catalyst can effectively purify said emissions; and

- (f) a warm-up means (140, 150, 160, 170), wherein
 - (f1) said warm-up means in response to an output signal of said temperature condition determining means which indicates that the temperature of said catalyst is lower than said operating temperature
 - (f2) is intermittently retarding said determined ignition timing for every other ignition cycle (see Figure 5: retarded ignition timing in cylinders 1, 2 and 3; column 6, lines 16 to 18 and 35 to 40).

The control system does however not comprise an engine operating condition detecting means according to feature b, and the warm-up means is not provided for shortening the warm-up period of said catalyst as required by the second portion of feature f and does not comprise feature f3.

The Appellant's argumentation according to which D6 did disclose these features is not convincing.

It is correct that the cam (50) turns at a speed which corresponds to the engine speed. As a result the cam forms a device which could be used to detect the engine speed by a separate detector, but it does not detect the engine speed or any other operation condition of the engine itself. Therefore it cannot be agreed that the cam (50) may be regarded as an engine operating

condition detecting means according to feature b.

The last sentence of the description (see column 7, lines 22 to 26) indicates that all the combustion chambers of the engine may be fed with a combustible mixture of an air to fuel ratio, or alternatively divided into two groups, one fed with a relatively rich mixture and the other with a lean mixture. Since these supply methods are not restricted to predetermined periods of the engine operation, the skilled man has no reason to assume that the latter method is intended to be used in connection with the warm-up means when the temperature of the catalyst shown in D6 drops below a predetermined temperature. Consequently D6 does not disclose a warm-up means which is adjusting a predetermined fuel amount according to feature f3.

4. *Inventive step*

- 4.1 According to the Case law of the Boards of Appeal of the European Patent Office, the closest prior art is that which is most suitable for the purpose claimed by the invention to be examined, and not that which has the most structural similarities with the solution as claimed (see T 506/95: paragraph 4.1). Ideally that purpose or objective should be something already mentioned in the prior art document as a goal worth achieving (see T 298/93: paragraph 2.2.2).

In the present case, only D1 refers to a control apparatus comprising warm-up means for shortening the warm-up period of a catalyst. None of the further documents cited by the Appellant deals with the warm-up of a catalyst. Since D1 additionally mentions the same object as the patent in suit, namely a rapid warm-up of

a catalyst (see column 1, lines 30 to 34), this document represents the closest prior art.

Since D6 does not address the object of a rapid warm-up of a catalyst, but the object of reheating a catalyst after its temperature dropped below a predetermined operation temperature, the Appellant's argumentation that this document represented the most relevant state of the art, is not convincing, although the control apparatus of D6 has the most structural similarities with the subject-matter of the patent in suit. If a person skilled in the art started from D6 to assess inventive step, he would modify, improve or adapt the known method, and would arrive at a modified, improved or adapted method of preventing an excessive drop of the catalyst temperature, and not a warm-up in the meaning of the patent in suit.

4.2 Starting from D1, the object to be achieved is to provide a control apparatus or an alternative control apparatus which is capable of a speedy warming-up of the catalyst so as to reduce the discharged amount of the hazardous components of the emissions into the atmosphere (see column 1, line 54 to column 2, line 1 of the patent specification).

4.3 Main request and first auxiliary request

4.3.1 According to the first alternative of the main request and according to the first auxiliary request this object is achieved by the provision of a warm-up means which in response to an output signal of said temperature condition determining means indicating that the temperature of said catalyst is lower than said operating temperature is intermittently retarding said

determined ignition timing for every other ignition cycle (features f1 and f2).

4.3.2 Such means for rapidly heating a catalyst when the exhaust gas temperature is (or drops) below an operating temperature of the catalyst is suggested by Figure 5 of D6 (see paragraph 3.4 above: feature f1 and f2). Although the heating means of D6 is not used for shortening the warm-up period of a catalyst, the skilled person recognizes that it could be used for this purpose. The use of the heating means according to Figure 5 of D6 in an apparatus according to D1 in order to achieve the object mentioned above (see paragraph 4.2) is therefore obvious.

4.3.3 The Respondent's statement that D6 disclosed merely a random retardation and not a retardation according to feature f2 is not convincing.

The sentence in column 3, lines 64 to 68 of D6 sets out that half of the number of the combustion chambers may be fired at a retarded ignition timing, each alternately with each of the remaining half to achieve a quick temperature recovery in the catalyst. This method of firing the combustion chambers corresponds to the operation of the ignition system shown in Figure 5 of D6 according to which the ignition timing retardation occurs in cylinders 1, 2 and 3 while the ignition in cylinders 4, 5 and 6 is not retarded (see column 6, lines 16 to 18, and 35 to 40). Since the firing sequence of the cylinders shown in Figure 5 is such that alternately one of the cylinders 1, 2, 3 and one of the cylinders 4, 5, 6 is fired (see sequence of distributor 60), the warm-up means (140, 150, 160, 170) according to Figure 5 is designed in such a way that it

is intermittently retarding the determined ignition timing (by items 40 and 50) for every other ignition cycle. Consequently feature f2 is disclosed in D6.

The Board does also not share the Respondent's opinion that the skilled person would not consider D6 when confronted with the problem of rapidly warming up a catalyst. It is true that D6 does not deal with the warm-up of a catalyst after a cold start of the corresponding combustion engine, but with the heating or warm-up of a catalyst when the exhaust gas temperature drops below the operation temperature of the catalyst. It is however obvious that the heating or warm-up procedure described in D6 does not only work to reheat a catalyst after a temperature drop, but is also capable to heat a catalyst after a cold start of the corresponding engine. Hence there is no reason why the skilled person, who is one and the same for both situations, should not consider the teaching of D6.

4.3.4 With respect to the above findings, it has to be concluded that the first alternative of claim 1 according to the main request and the subject-matter of claim 1 according to the first auxiliary request are not based on an inventive step.

4.4 Second auxiliary request

4.4.1 According to the second auxiliary request, the object underlying the patent in suit is achieved by the provision of a warm-up means which in response to an output signal of said temperature condition determining means indicating that the temperature of said catalyst is lower than said operating temperature is adjusting said determined fuel amount to a rich amount and to a

lean amount with respect to said air-fuel ratio in such a way that excessive oxygen due to a lean combustion in said engine and excessive carbon monoxide due to a rich combustion in said engine are supplied to said catalyst in order to increase the temperature of said catalyst by an oxidative reaction within said catalyst, and is intermittently retarding said determined ignition timing for every other ignition cycle (features f1, f2 and f3).

- 4.4.2 As shown in paragraph 4.3 above, the provision of features f1 and f2 is obvious. The additional provision of feature f3 is however not suggested by the state of the art cited by the Appellant.

D6 does not disclose any warm-up means which adjusts a predetermined fuel amount according to feature f3 (see paragraph 3.4 above), and D2 and D3 do not even refer to warm-up means for a catalyst (see paragraphs 3.2 and 3.3 above). Consequently none of these documents is suitable to suggest the use of a warm-up means according to feature f3, let alone according to a combination of features f2 and f3.

- 4.4.3 The Appellant's argumentation that a combination of the teachings of D3 and D2 would lead the skilled person in an obvious way to the subject-matter of the second auxiliary request is not convincing.

The Board agrees that D3 suggests the provision of a first group of combustion chambers with a rich air-fuel mixture alternately with a second group of combustion chambers with a lean air-fuel mixture (see column 8, lines 27 to 37), that such a switching between a rich and a lean mixture results in a fluctuation of torque

(because this is an inevitable effect), and that D2 suggests that such a fluctuation of torque should be avoided by an intermittent retardation of the ignition timing (see column 4, lines 29 to 34). However according to D3 it is explicitly not intended to combine the alternate provision of rich and lean fuel mixtures with a retardation of the ignition timing (see column 8, lines 47 to 50), and according to D2 the intermittent retardation of the ignition timing is excluded at low temperatures of the engine cooling liquid (see claims 10 and 11). Consequently there is no reason to combine the teachings of D3 and D2, let alone to use them in connection with a warm-up means for shortening the warm-up period of a catalyst.

Even if the skilled person considered a combination of D3 and D2, this would not lead him to the control apparatus according to claim 1 of the second auxiliary request. Although D3 suggest the supply of the combustion chambers alternately with a rich and a lean mixture, it does not suggest the adjustment of the normally used predetermined fuel amount to a rich and to a lean amount as claimed in feature f3. Firstly, D3 does not disclose any fuel injection amount determining means which could determine an appropriate fuel amount, and secondly it does not suggest the adjustment of a predetermined fuel amount, but only the switching between a rich and a lean mixture (see column 5, lines 20 to 24), defining thereby a completely different combustion system, namely the so-called "rich-lean mixture type".

4.4.4 The Board therefore comes to the conclusion that the subject-matter of claim 1 according to the respondent's second auxiliary request cannot be derived in an

obvious manner from the cited prior art and accordingly involves an inventive step (Article 56 EPC). This claim together with its dependent claims 2 to 10 and the amended description and drawings therefore forms a suitable basis for maintenance of the patent in amended form.

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 patent in the following version:

Claims: 1 to 10 according to the second auxiliary request submitted in the oral proceedings on 29 January 2002;

Description: columns 1 to 10 and 13 as granted; columns 11 and 12 submitted in the oral proceedings on 29 January 2002;

Drawings: Figures 1 to 14 as granted.

The Registrar:

The Chairman:

G. Magouliotis

C. Andries