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Datasheet for the decision of 22 December 2010

Case Number: T 0323/09 - 3.2.04

Application Number: 05425881.9

Publication Number: 1795738

IPC: F02M 47/02

Language of the proceedings: EN

Title of invention:
Fuel-injection system for an internal-combustion engine

Applicant:
C.R.F. Società Consortile per Azioni

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step (no) - undisclosed effects which cannot be taken into consideration for the assessment of an inventive step"

Decisions cited:
T 0386/89

Catchword:
-

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Case Number: T 0323/09 **-** 3.2.04

D E C I S I O N
of the Technical Board of Appeal 3.2.04
of 22 December 2010

Appellant: C.R.F. Società Consortile per Azioni
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 1 September 2008 refusing European application No. 05425881.9 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman: M. Poock
Members: A. de Vries
C. Heath

Summary of Facts and Submissions

I. This appeal is directed against the decision of the examining division of 1 September 2008 in which European patent application No. 05 425 881.9 was refused because the subject-matter of claim 1 lacked an inventive step.

The appeal was lodged on 7 October 2008 and the prescribed appeal fee was paid simultaneously. The statement of grounds of appeal was received on 9 January 2009.

II. The documents relevant for this decision are:

D1: DE-A-19 809 001;
D5: WO-A-0 127 465;
D11: JP-A-05 001 609 and Patent Abstracts of Japan thereof.

III. Oral proceedings before the board were held on 22 December 2010.

The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the request filed with letter of 1 December 2010 with claims 1 to 4.

IV. Claim 1 reads as follows:

"A pressurized fuel injection system for an internal combustion engine, comprising at least one fuel electroinjector (1) and an electromagnetic actuator

device (8) for a metering valve (16), said electroinjector (1) comprising:
- an injection nozzle (5) in communication with an injection chamber (6), and
- a needle (7) movable along an opening and closing strokes under the action of the fuel pressure in said injection chamber (6); said needle (7) being normally held in a closing position for closing said nozzle (5) and having, in said closing position, an active surface subject to the pressure of the fuel in said injection chamber (6); said active surface being defined by an external diameter (D_1) of said needle (7) and by an internal diameter (D_2) of sealing between said needle (7) and said nozzle (5);
said electromagnetic actuator device (8) comprising a rod (14), which is engaged with said needle (7) and has a portion (l4a) having a diameter (D_3) and normally pushed by the pressure of said fuel in a control chamber (15) associated to said metering valve (16); said control chamber (15) being equipped with an inlet duct (18) having a pre—set diameter (D_4) and with an outlet passage (24) having a diameter (D_5); said outlet passage (24) being controlled by said metering valve (16);
elastic means being provided for exerting on said needle (7) an action supplementary to that of said rod (14) towards the closing position;
said electromagnetic actuator device (8) being operable by an electrical control unit:
- with a first electrical command (C_3) to cause said needle (7) to perform a first opening displacement (A_3) followed by a closing displacement (B_3), to control a fuel pre-injection, and

- with at least a second electrical command (C_4) close to said first electrical command (C_3) to cause said needle (7) to perform a second opening displacement (A_4), to control a main fuel injection depending upon engine operating conditions, and
to start said second opening displacement (A_4) in a point (Q_3) of said closing displacement (B_3), resulting in a motion profile (P') without dwell time between said second opening displacement (A_4) and said closing displacement (B_3);
the fuel injection system being characterized in that:
- the ratio (D_5/D_4) between the diameter (D_5) of said outlet passage (24) and the diameter (D_4) of said inlet duct (18) is comprised between 0.7 and 1.4, in order to determine a certain rate of displacement of said needle (7);
- the ratio (D_3/D_1) between the diameter (D_3) of said portion (l4a) of the rod (14) and the external diameter (D_1) of said active surface is comprised between 1.05 and 1.2, in order to contribute to determine said certain rate of displacement;
- the ratio (D_1/D_2) between said external diameter (D_1) and said internal diameter (D_2) of said active surface is comprised between 1.85 and 2.35, in order to contribute to determine said certain rate of displacement; and
- said point (Q_3) is said closing position".

V. The arguments of the appellant can be summarised as follows:

The feature "being operable by an electrical control unit" could be amended in case that claim 1 would be found patentable but for this feature.

The subject-matter of claim 1 is novel. With respect to document D1 it was appreciated that the injectors shown in figures 3 and 9 have dimensions such that some ratios fall within the claimed ranges. However, since figures 3 and 9 show different embodiments, not all dimension ratios falling within the claimed ranges are known from one respective embodiment. Moreover, it does not disclose the claimed timing for the displacement of the needle. Document D5, as acknowledged in the oral proceedings before the board, discloses all features of claim 1 but the claimed timing for the displacement of the needle.

The subject-matter of claim 1 also involves an inventive step. The closest prior art is considered to be disclosed in documents D1 or D5. The subject-matter of claim 1 allows to achieve three common technical effects, i.e. to approximate in a satisfactory manner the levels L_1 and L_2 of the desired instantaneous flow curve of figure 9 of the present patent application, to improve the fuel dosing and metering accuracy, and to reduce the response time of the injector by avoiding the inertia of the injector needle during a dwell time between two subsequent lifts or injections. These effects are unexpected. Admittedly they are not disclosed in the application as filed.

The characterising feature that the second opening displacement is started at the endpoint of the closing stroke of the injector needle is not known in the prior art for achieving these effects. Figure 12 of document D11 shows a transitional state in which the main injection starts just after the pilot injection when

the mode of operation is switched from the pilot injection mode to the normal injection mode or vice versa in order to avoid a sudden engine torque shock due to a sharp increase in the pressure in a cylinder combustion chamber. This distinguishing feature could be considered as an inventive selection of the range disclosed in document D11.

Reasons for the Decision

1. The appeal is admissible.

2. Background

The subject-matter of claim 1 relates in general to internal combustion engines and in particular to diesel engines. In a diesel combustion process, fuel is injected into the hot compressed cylinder charge when the piston is around the upper dead centre (UDC). After an ignition delay period, the period between the fuel injection and its actual ignition, the (self-) ignition of the fuel starts and propagates with increasing conversion of energy. Typically, the fuel injection continues during this phase.

The ignition of the injected fuel leads to an abrupt combustion with a steep increase of the cylinder pressure in the initial stage of the combustion, causing noisy engine operation and increased NO_x in the exhaust gas.

As a countermeasure, the ignition delay period can be shortened by injecting a small amount of fuel prior to

the main injection; this is the so-called pilot injection. Since the fuel of the main injection is injected into the combusted fuel of the pilot injection, the ignition delay period is shortened and the cylinder pressure increases less abruptly so that less noise and NO_x emissions are generated. This is known from document D1, see in particular column 1, lines 1 to 22 and figure 6, and document D5, see in particular figure 5 and the corresponding description.

An alternative solution is known from document D1, see in particular figure 7. In contrast to having a pilot injection that is clearly separate from the main injection, figure 7 shows that no holding time is present in the movement of the valve needle between the pilot and the main injection (see figure 7 "DÜSENHUB"). The pilot injection is accomplished later, at a timing when, typically, the main injection starts, i.e. when the piston is around the UDC.

3. Inventive step

3.1 Claim 1 requires that "said electromagnetic actuator device (8) being operable by an electrical control unit". Thus the electrical control unit is not necessarily part of the claimed system, which must only be suitable for that purpose. Since the appellant has indicated to amend this feature, in case that the claim was found patentable but for this feature, the board in the following reads this feature as meaning that an electrical control unit is provided and is arranged to control the electromagnetic actuator device (8).

3.2 Closest prior art

3.2.1 Document D1

Figures 3 and 9 are of purely schematic nature and allow only the broadest of inferences to be made regarding relative dimensions. Thus, none of the ratios required by claim 1 can be said to be derivable from D1.

In figure 6, an injection scheme is shown which is used when the engine speed or load is in a normal operating region in which the pilot injection and the main injection are completely separate, i.e. there is a dwell time between the end of the pilot injection and the beginning of the main injection.

Figure 7 refers to a second operating region of the engine speed. In this region, the pilot and main injections overlap and the valve is not closed in between but remains open. Hence, the main injection does not start from a closed position of the valve needle at the end of the pilot injection.

3.2.2 Document D5

It is not disputed that this document discloses a fuel injection system with dimensions falling within the ranges claimed in claim 1. Figure 1 for example, is sufficiently detailed for relative dimensions to be inferred that are commensurate with the ratio ranges of claim 1.

Figure 5 shows a typical injection scheme in which the pilot and main injections are clearly separate.

3.2.3 From the foregoing it is concluded that the fuel injection system of document D5 has more features in common with the subject-matter of claim 1 than each of the embodiments of document D1 operated in either one of the operating regions. Consequently, the board considers D5 to represent the closest prior art.

3.3 Technical problem

3.3.1 The subject-matter of claim 1 is distinguished from the injection system of D5 by an electrical control unit providing an injection scheme, in which the main injection starts immediately after the pilot injection has ended and the needle is again in its closing position.

3.3.2 The appellant referred to three technical effects achieved with the subject-matter of claim 1, i.e. to approximate in a satisfactory manner the levels L_1 and L_2 of the desired instantaneous flow curve of figure 9 of the present patent application, to improve the fuel dosing and metering accuracy, and to reduce the response time of the injector by avoiding the inertia of the injector needle during a dwell time between two subsequent lifts or injections.

(a) However, effects of a described feature cannot be taken into account when determining the problem underlying the invention for the purpose of assessing inventive step, if they cannot be deduced by the skilled person from the application

as filed considered in relation to the closest prior art (T 386/89 of 24 March 1992, not published in OJ EPO).

(b) The appellant could not indicate a basis for these effects in the application as filed nor that these effects are associated with the distinguishing feature. Also the board was unable to identify such basis in the application. These effects are moreover not self-evident because the appellant has argued that they are unexpected.

Hence the board concludes that these effects cannot be deduced by the skilled person from the application as filed considered in relation to the closest prior art.

3.3.3 Therefore the objective technical problem is formulated on the basis of the effect clearly disclosed in paragraph 35 of the published application: to provide a pressurised fuel injection system for an internal combustion engine which approximates the flow rate curve of figure 9 in a satisfactory way.

3.4 Obviousness of the solution

3.4.1 In a diesel combustion process, the main injection has to start at a time (in terms of crank shaft degrees before or after UDC) such that the main combustion takes place when the piston has reached UDC or a little bit later. The main combustion should certainly not start when the piston is still in the compression stroke, because this could damage or even destroy the engine.

In contrast, when preceding the main by a pilot injection as set out above, a small amount of fuel is injected while the piston is still in the compression stroke. The amount is so small as to not damage the engine. However, the combustion of this small amount of fuel does result in a counter force acting against the upward movement of the piston. Whereas the pilot injection should therefore be such as to shorten the ignition delay and reduce the sudden increase in cylinder pressure, it should not be so much as to strongly affect the upward movement of the piston. The skilled person will therefore, as a matter of obviousness, strive to find an optimal balance between these opposing effects.

3.4.2 From the foregoing consideration, the board concludes that there is a strong incentive for the skilled person to minimize such counterforce.

(a) One obvious way would be to reduce the amount of pre-injected fuel. However, with this approach, the desired reduction of the ignition delay period may not be achievable.

Another possibility would be to reduce the time period between the pilot and the main injections so that the main injection starts immediately when the pilot injection ends or so that the pilot and main injections overlap.

(b) In the view of the board, it does not require inventive considerations to select the most promising of these possibilities and to operate

the system with the injection scheme as shown in figure 5 of the application, i.e. to start the main injection immediately after the pilot injection has ended and the needle is again in its closing position.

(i) This injection scheme is in fact a limit case of the known systems with clearly separate pilot and main injection (see documents D5 and D1, figure 6) or with overlapping injections (see document D1, figure 7). Neither document prescribed the exact amount of separation or overlap and the invention is merely directed at that singular case where main and pilot injection are neither truly separate nor overlap in time.

Since no particular effects distinguishing this injection scheme from the known ones are apparent from the application as filed, it must be assumed that the claimed solution is merely an arbitrary selection from obvious possibilities which requires only routine considerations by the skilled person for reviewing the respective advantages and disadvantages thereof.

(ii) Moreover, such a limit case is known from document D11 (figure 12) as an intermediate stage between the known operation schemes for reducing the effects on the driving moment when the system is switched from pilot-/main injection mode to the main

injection mode which is not excluded by the wording of claim 1.

3.5 In summary, the board concludes that the subject-matter of claim 1 does not meet the requirements of Article 56 EPC 1973.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

G. Magouliotis M. Poock