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**Datasheet for the decision
of 22 December 2010**

Case Number: T 2179/08 - 3.2.04

Application Number: 04425841.6

Publication Number: 1657422

IPC: F02D 41/20

Language of the proceedings: EN

Title of invention:

A method for controlling fuel injection in an internal combustion engine

Applicant:

C.R.F. Società Consortile per Azioni

Opponent:

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Headword:

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Relevant legal provisions:

EPC Art. 56

Relevant legal provisions (EPC 1973):

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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:

-



Case Number: T 2179/08 - 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 16 July 2008
refusing European application No. 04425841.6
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 16 July 2008 in which European patent application No. 04 425 841.6 was refused because the subject-matter of claim 1 lacked an inventive step.

The appeal was lodged on 16 September 2008 and the prescribed appeal fee was paid simultaneously. The statement of grounds of appeal was received on 12 November 2008.

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 set of claims 1 to 7 filed with letter of 1 December 2010.

IV. Claim 1 reads as follows:

"A method for controlling fuel injection in an internal combustion engine provided with a fuel electroinjector (1) comprising:

- an electromagnetic actuator (8); and
- an atomizer comprising an injection nozzle (5) and a pin (7) movable along opening and closing

strokes for opening and closing said nozzle (5) under the control of said electromagnetic actuator (8); the electroinjector (1) being operable to meter fuel by modulating in time opening of the pin (7) of the atomizer according to the pressure of fuel supplied to the electroinjector (1);

the method comprising

- operating said electromagnetic actuator (8) with a first electrical command (C_3) to cause said pin (7) to perform a first opening displacement (A_3) followed by a closing displacement (B_3), and
- operating said electromagnetic actuator (8) with at least a second electrical command (C_4) to cause said pin (7) to perform a second opening displacement (A_4) and to start said second opening displacement (A_4) in a 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 method being characterised in that said point (Q_3) is the end point of said closing stroke".

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

The subject-matter of claim 1 is novel. Neither document D1 nor document D5 disclose the characterising feature of claim 1, i.e. the claimed timing for the displacement of the pin.

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 L1 and L2 of the desired instantaneous flow curve of figure 3 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 pin during a dwell time between two subsequent lifts or injections. These effects were unexpected. Admittedly, they are not disclosed in the application as filed.

The characterising feature of claim 1 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 from 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 a method of controlling fuel injection in an internal combustion engine and in particular in 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 injections (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 Closest prior art

The board and the appellant agree that the methods known from documents D1 or D5 represent the closest prior art.

3.2 Technical problem

3.2.1 The subject matter of claim 1 is distinguished from these methods by its characterising feature, i.e. that the main injection starts immediately after the pilot injection has ended and the valve pin has reached the end point of its closing stroke.

3.2.2 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 3 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 pin 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. These effects are not self-evident because the appellant has argued that they are unexpected.

(c) 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.

3.2.3 Therefore the objective technical problem is formulated on the basis of the effect clearly disclosed in paragraph 29 of the published application to provide a method for controlling fuel injection in an internal combustion engine provided with a fuel electroinjector which approximates the flow rate curve of figure 3 in a satisfactory manner.

3.3 Obviousness of the solution

3.3.1 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 not to 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.

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

(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 3 of the application, i.e. to start the main injection immediately after the pilot injection has ended and the valve pin has reached the end point of its closing stroke.

(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.

3.4 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