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Case Number: T 0672/11 - 3.2.04

Application Number: 04009430.2

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Language of the proceedings: EN

Title of invention:
Fuel injection control device

Applicant:
Isuzu Motors Limited

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), 84, 54, 56

Keyword:
"Added subject-matter (no) - after amendment"
"Clarity (yes) - after amendment"
"Novelty and inventive step (yes) - after amendment"

Decisions cited:
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Catchword:
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Case Number: T 0672/11 - 3.2.04

D E C I S I O N
of the Technical Board of Appeal 3.2.04
of 10 July 2013

Appellant: (Applicant)
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Representative:
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted 6 October 2010 refusing European patent application No. 04009430.2 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman: A. de Vries
Members: E. Frank
C. Heath

Summary of Facts and Submissions

I. The appeal lies from the decision of the examining division dated 21 September 2010 and posted on 6 October 2010 to refuse European application No. 04 009 430.2 pursuant to Article 97(2) EPC. The examining division held that the subject-matter of claims 1 and 5 as filed on 14 September 2010 did not meet the requirements of Articles 84, 123(2), and 56 EPC in the light of EP 1 234 966 A (=D1) and EP 0 924 416 A (=D2).

II. The appellant (applicant) filed a notice of appeal on 9 December 2010, paying the appeal fee on the same day. The statement of grounds of appeal was filed on 16 February 2011.

III. A communication dated 6 March 2013 pursuant to Article 15(1) RPBA was issued together with a summons to attend oral proceedings. In response the appellant filed new amended claims together with an adapted description on 17 April 2013. Subsequently, the oral proceedings were cancelled. In response to a telephone attendance on 20 June 2013 the appellant further filed an adapted description, pages 3 and 4, on 25 June 2013.

IV. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the set of claims of the main request, alternatively on the basis of the set of claims of the auxiliary request, both filed on 17 April 2013.

V. The wording of claims 1 and 5 of the main request reads as follows:

"1. A diesel engine comprising a fuel injection control device in which fuel is injected into a combustion chamber (10) at an early stage rather than compression top dead center and fuel injected into the combustion chamber (10) is ignited in a target ignition timing fixed at compression top dead center, after a premixing period has elapsed following a completion of an injection of the fuel, comprising:

target pre-mixing period determining means (26) for determining the target pre-mixing period which is set so that NOx, smoke and HC emission reduce, within a range between 7° and 10° Crank Angle (CA) on the basis of engine operating conditions;

actual pre-mixing period detection means (26) for detecting an actual pre-mixing period; and

pre-mixing period adjustment means (26) for adjusting a pre-mixing period of the fuel by an adjustment of the fuel injection starting timing and the fuel injection pressure so that a difference between the actual pre-mixing period and the target pre-mixing period is eliminated."

"5. A diesel engine control method in which fuel is injected into a combustion chamber (10) at an early stage rather than compression top dead center and fuel injected into the combustion chamber is ignited in a target ignition timing fixed at compression top dead center, after a pre-mixing period has elapsed following a completion of a fuel injection, comprising the steps of:

determining a target pre-mixing period which is set so that NOx, smoke and HC emission reduce, within a range between 7° and 10° Crank Angle (CA) on the basis of engine operating conditions;

detecting an actual pre-mixing period; and

adjusting a pre-mixing period of the fuel by an adjustment of the fuel injection starting timing and the fuel injection pressure so that difference between the actual pre-mixing period and the target pre-mixing period is eliminated."

VI. The appellant submitted essentially the following arguments:

D1 applied to dual-fuel engines which needed a pilot diesel fuel injection to control the ignition of a main gaseous fuel charge. D1's entire discussion referred to the pilot fuel injection alone, but did not address a complete ignition cycle for a diesel engine as claimed in claims 1 and 5. Thus, the mixing period Dm of D1 could not be compared to the pre-mixing period of the present invention. Moreover, D1 did not disclose that the whole fuel injected to the combustion chamber was ignited in a target ignition timing fixed at compression top dead center (TDC) as required by claims 1 and 5. On the contrary, figure 11 of D1 showed that the heat release rate of the pilot combustion increased suddenly at about 6° or 7° before top dead center (BTDC). Furthermore, even if D2's ignition delay period could be regarded a pre-mixing period, this period was not defined, ie had no definite starting point, let

alone an ignition timing at TDC at its end point, and thus would lie within the fuel injection period. Therefore, neither D1 nor D2 could have led the skilled person to the subject-matter of claims 1 and 5.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*
(Articles 123(2) and 84 EPC)

2.1 Amended claims 1 and 5 are directed to a diesel engine and a diesel engine control method. They are, in the first place, based on original claims 1 and 8. The originally claimed fuel injection control is particularly suited for diesel engines: see paragraphs [0002],[0006], and [0025] of the application as filed. The newly added wordings in the first paragraph of claims 1 and 5, viz. that fuel is injected "at an early stage rather than compression top dead center" and that it is ignited "in a target ignition timing fixed at compression top dead center", are derivable from paragraphs [0004] to [0006], and [0043],[0044] and [0055] as filed. Moreover, a target pre-mixing period "which is set so that NOx, smoke and HC emission reduce, within a range between 7° and 10° Crank Angle" on the basis of engine operating conditions, is described in paragraph [0058] as filed. Finally, adjusting a pre-mixing period of the fuel "by an adjustment of the fuel injection starting timing and the fuel injection pressure so that a difference between the actual pre-mixing period and the target pre-mixing period is

eliminated" at the end of claims 1 and 5, is based on original claim 4 ("and" alternative) and paragraphs [0037] to [0040] as filed.

Therefore, the subject-matter of claims 1 and 5 of the main request meets the requirements of Article 123(2) EPC.

2.2 The description has been adapted accordingly, Article 84 EPC. Documents D1 and D2 were identified in the description and the relevant background art disclosed therein was briefly discussed, Rule 42(1)(b) EPC.

Moreover, the Board holds that the claims now clearly define the matter for which protection is sought, Article 84 EPC. In particular, the amendments using different or clarified terminology address all the points objected to as unclear in the decision under appeal.

3. *Novelty and inventive step*
(Articles 54 and 56 EPC)

4.1 Document D1 describes a closed loop control of the pilot fuel injection of a compression ignited *"dual fuel engine"*: cf. D1; abstract, paragraphs [0001], [0003], [0056], and figure 15. In the impugned decision, the *"mixing period Dm"* of D1 is compared with the pre-mixing period of the present application: cf. D1; paragraph [0007], lines 10 and 11; and paragraph [0041], lines 50 to 54.

4.2 The Board agrees with the examining division's view that a dual fuel engine of D1 may also be a typical *"true dual fuel engine"*, that is, the use of D1's dual fuel engine in diesel-only mode may also be permitted: cf. D1; paragraph [0003]. However, as argued by the appellant, D1 invariably describes a dual fuel engine which needs a pilot fuel injection to ignite the main (gaseous) fuel charge, cf. paragraph [0003], lines 29 to 30. Its entire discussion refers to the control and optimization of the pilot injection: cf. D1; abstract; see eg paragraphs [0009], [0012], and [0013]. Thus, it seems questionable whether the person skilled in the art would compare the optimized *"mixing period Dm"* of D1's pilot charge of the disclosed dual fuel engine for gaseous fuels with the pre-mixing period of an ignition cycle of a diesel engine as claimed in claims 1 and 5.

Furthermore, if D1 does consider pilot injection in a dual fuel engine operated on pure diesel (and comprising multi-stage injectors), there is no information derivable from D1 as to how the ignition intensity of the pilot charge has to be controlled when the engine is used in diesel-only mode. D1 only provides detailed information regarding a gas-fueled engine with diesel pilot injection. In the opinion of the Board, the effects of pilot diesel on the performance and emissions of such a true dual fuel engine may deviate from the described gas-fueled engine, and thus the parameters to optimize the *"mixing period Dm"* of D1's pilot charge.

4.3 However, assuming that the fuel injection control of a diesel engine of claims 1 and 5 may also constitute a pilot injection control of a dual fuel engine run on

pure diesel, and the optimized parameter control of the *"mixing period Dm"* of the pilot injection for the gas-fueled engine described in D1 could be likewise applied to pure diesel engines, the subject-matter of claims 1 and 5 differs from D1's disclosure in that in any event the pilot fuel injected into the combustion chamber is ignited in a target ignition timing fixed at compression top dead center (TDC). As argued by the appellant, D1 does not show that the pilot combustion occurs at TDC, but rather, that autoignition timing *"Ti"* is nearly constant at 6° crank angle (c.a.) and, thus, before TDC (BTDC): cf. D1; paragraphs [0041] and [0045]; and figure 11.

Equating the *"mixing period Dm"* in D1 with the target pre-mixing period as does the decision under appeal, this value, expressed in terms of the crank angle, is set approximately 7° or greater (cf. paragraph [0043], table 2, and figure 9). The problem underlying the distinguishing ignition timing basically can then be seen in the reduction of NOx and smoke (cf. paragraphs [0055] and [0056] of the original application).

4.4 Although the Board acknowledges that retarding of autoignition enhances ignition intensity which in turn leads to reduced emissions (cf. D1: paragraph [0007]), nevertheless to optimize the retarding of autoignition, ie the *"mixing period Dm"*, D1 consistently suggests that the beginning of the pilot fuel's autoignition *"Ti"* should be before TDC (BTDC), but never at TDC. See chapter *"3.Ignition Intensity Maximization"* from page 8 of D1 onwards, and in particular figure 11 of D1 and its corresponding paragraph [0045]. The subsequent

pilot fuel combustion occurs from about 7° to 2° BTDC, cf. paragraph [0045], lines 19 to 21.

Therefore, starting from the teaching of D1 and taking into consideration the skilled person's ordinary common technical knowledge, in the Board's view (and contrary to the examining division's decision on page 9, 3rd par.), he would not have any motivation to modify D1 such that autoignition *"Ti"* is fixed at TDC, if ignition intensity should be maximized to reduce NOx and smoke, thus to arrive at a target ignition timing control according to claims 1 and 5.

4.5 Document D2 describes a diesel engine comprising an ignition-delay-duration control device for adjusting an ignition delay duration depending on the engine operating condition, eg, its temperature (cold-engine warm-up period): cf.D2; abstract. The fundamental combustion concept is a so-called low-temperature premixed combustion. Preferably, in addition to premixed combustion due to ignition delay, swirl motion is created to reduce both NOx and particulate matter: cf. D2; abstract, paragraphs [0013], [0014], [0024] (lines 9 to 55), and figure 18. However, as argued by the appellant, D2 does not disclose or hint at a pre-mixing period according to claim 1, that is, a pre-mixing period which follows the completion of the fuel injection, and ends with the fuel ignition at TDC. Thus, the Board considers D2 not to be relevant in respect of the subject-matter of claims 1 and 5. Moreover, the remaining prior art cited in the European search report was not deemed relevant by the examining division, nor does the Board have any doubts in this regard.

4.6 Therefore the subject-matter of claims 1 and 5 of the main request fulfills the requirements of novelty and inventive step.

5. Since the main request is allowable, there is no need for the Board to consider the auxiliary request.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent based on the following application documents:

Description: page 1 as originally filed;
page 2 as filed on 17 April 2013;
pages 3,4 as filed on 25 June 2013;
pages 5 to 16 as originally filed;

Claims: 1 to 6 as filed as main request on 17 April 2013;

Drawings: figures 1 to 4 as originally filed.

The Registrar The Chairman

G. Magouliotis A. de Vries