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**Datasheet for the decision
of 20 June 2018**

Case Number: T 2325/16 - 3.2.04

Application Number: 11702487.7

Publication Number: 2529094

IPC: F02B23/06

Language of the proceedings: EN

Title of invention:
DIRECT INJECTION DIESEL ENGINES

Applicant:
Ricardo UK Limited

Headword:

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:



Beschwerdekammern
Boards of Appeal
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Case Number: T 2325/16 - 3.2.04

D E C I S I O N
of Technical Board of Appeal 3.2.04
of 20 June 2018

Appellant: Ricardo UK Limited
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Decision under appeal: **Decision of the Examining Division of the
European Patent Office posted on 17 May 2016
refusing European patent application No.
11702487.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman S. Oechsner de Coninck
Members: J. Wright
W. Van der Eijk

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal, received on 15 July 2016, against the decision of the examining division, dispatched on 17 May 2016, refusing the application No. 11702487.7. The appeal fee was also paid on the same day. The statement setting out the grounds of appeal was received on 12 September 2016.

II. The examining division came to the conclusion that the subject-matter of claim 1 lacked an inventive step and thus did not meet the requirements of Articles 52 and 56 EPC having regard to the state of the art as disclosed in documents:

D1: CN 201 074 556 Y
D2: US 6 997 158 B1
D3: WO 2004/057167 A1

The following documents are also cited in the international search report:

D4: AT 380 311 B
D5 EP 0945 602 A2

III. The appellant requested to set aside the decision under appeal and to order the grant of a patent on the basis of its main request or alternatively on the basis of its auxiliary request, both filed with the grounds of appeal. As an auxiliary measure oral proceedings were requested.

IV. In a communication following the summons to oral proceedings, the Board gave its provisional opinion regarding the requirements of Article 56 EPC.

- V. In its letter of 21 May 2018 the appellant indicated, that under the condition that the oral proceedings would be cancelled and a patent be granted, it would withdraw its main request and rely solely on its auxiliary request.
- VI. Oral proceedings were cancelled on 8 June 2018.
- VII. Claim 1 of the main request as now on file reads as follows:
"A direct injection diesel engine including a cylinder block (20) defining at least one cylinder which is closed by a cylinder head (22) and reciprocally receives a respective piston, the piston defining a combustion chamber comprising a recess (8, 10) formed in the piston crown (2), the recess being defined by a base (6) and a side wall (13, 14), a substantially conical or frusto-conical projection (5) upstanding from the base (6), the recess including a lower toroidal portion (8) furthest from the piston crown (2) and an upper portion (10) closest to the piston crown whose diameter increases towards the piston crown, the upper and lower portions being separated by an annular lip (12) of arcuate shape in axial cross section extending into the recess, the maximum depth (H) of the recess from the base (8) to the plane of the piston crown (2) being between 13 and 22% of the diameter of the piston, the cylinder head (22) carrying a fuel injector (32) which is situated substantially on the cylinder axis (14) and includes a plurality of fuel injection orifices, the recess in the piston crown being rotationally symmetrical about the axis of the piston in axial cross section, the cylinder communicating with two inlet valves and two exhaust valves in the cylinder head, the inlet valves being of the type arranged to induce swirl of the inflowing air

in the cylinder substantially about the cylinder axis, characterised in that the diameter of the upper portion (10) closest to the piston crown increases progressively towards the piston crown, that the included angle of the conical or frusto-conical projection is between 104° and 108° , that the diameter (B) of the lip is between 54 and 59% of the diameter of the piston, the diameter of the upper portion (10) of the recess increasing from 54 to 59% of the diameter of the piston at the line of minimum diameter of the lip to between 72 and 76% of the diameter of the piston at the line where the side wall (14) of the recess intersects the plane of the piston crown, that the conical or frusto-conical projection (5) merges with the base (6) along a circular line whose diameter (C) is between 38 and 44% of the diameter of the piston, that the line (h) of minimum diameter of the lip is situated at a distance of between 5 and 10% of the diameter of the piston from the plane of the piston crown and that the fuel injection orifices are so arranged that the fuel jets through them extend at an angle which diverges from the surface of the projection (5) by 15° to 19° , whereby the fuel jets impinge firstly on the arcuate side wall (13) of the lower portion (8) of the recess."

VIII. The Appellant argues as follows:

- Starting from D3 the subject-matter of claim 1 differs in that the upper portion of the recess closest to the piston crown has a diameter which progressively increases towards the piston crown, that the included angle of the conical or frusto-conical projection is between 104° and 108° , that the conical or frusto-conical projection merges with the base along a circular line whose diameter is between 38 and 44% of the diameter of the piston, that the line of minimum

diameter of the lip is situated at a distance between 5 and 10% of the diameter of the piston from the plane of the piston crown and that the fuel injection orifices are so arranged that the fuel jets through them extend at an angle which diverges from the surface of the projection by 15 to 19°, whereby the fuel jets impinge firstly on the arcuate side wall of the lower portion of the recess.

- Even if some of the parameters ranges could be seen as selections from D2 or D3, the combination of all these differing features overcome a problem not identified in D3, and imply the necessary inventive step to arrive at the subject-matter of Claim 1.

Reasons for the Decision

1. The appeal is admissible.

2. *Subject-matter of the invention*

The application concerns a diesel engine and especially the shape of the piston bowl receiving the direct injection. It is in particular sought to provide a four valve direct injection diesel engine in which the fuel/air mixture is mixed more intensively and thoroughly than previously, as well as to reduce the proportion of those particulates which become entrained in the layer of oil on the cylinder wall, with associated positive influence on efficiency and service life (p.4, 1.1-8). The solution is provided by a specific bowl shape as defined in claim 1 on the basis of numerous dimensional parameters, amongst which the shape and location of the upper lip, the injection angle with respect to the central cone, and the diameter of the transition from conical to curved toroidal portion play a particular role.

3. *Amendments*

The amended claim 1 according to the main request is now directed to a direct injection diesel engine including a cylinder block defining at least one cylinder which is closed by a cylinder head and reciprocably receives a respective piston, and adds to claim 1 as originally filed the features of claim 4, that generally concern the cylinder communicating with two inlet valves and two exhaust valves in the cylinder head, the inlet valves being of the type arranged to induce swirl of the inflowing air in the cylinder substantially about the cylinder axis, and the fuel injection orifices to be arranged such that the fuel jets through them extend at an angle which diverges from the surface of the projection by 15 to 19°. The Board therefore concludes that these amendments comply with the provisions of Art. 123(2) EPC.

4. *Novelty/inventive step*

Novelty was not at issue in the present case, and the board is also satisfied that none of the cited documents discloses all the features defined in claim 1.

4.1 *Closest prior art*

Both the examining division in its decision and the appellant use D3 as starting point for their inventive step argumentation.

D3 seeks to further reduce soot and NOx emission (page 3, paragraph 2), and discloses a piston (27) for a diesel engine, with a recess (28) in the piston crown, having a depth of 13 to 22% of the piston diameter (page 5, paragraph 1). The lower and upper portions of the recess are also separated by an arcuate lip (29) situated at a distance between 5 to 15 % of the recess

depth (page 7, lines 12-13). The bottom of the recess (32) is curved and comprises an apex (44) in the center (claim 13).

By contrast, D2 does not disclose any central fuel injector, let alone the fuel jets direction, nor does D1 disclose said features. In addition D1 also fails to disclose two inlet valves, and therefore lies even further away from the engine defined in claim 1.

The Board thus also finds D3 to represent the most promising starting point for applying the problem solution approach.

4.2 *Identification of differences*

The examining division correctly stated that the fuel jets from the central injector schematically visible in Figure 2B did not explicitly extend at an angle which diverges from the bottom surface of the recess by 15° to 19°.

In the Board's view, this however does not represent the sole difference. D3 discloses a curved bottom surface 32 without a clear delimitation as a circular line that connects the base with the central conical surface, let alone one at a diameter (C) between 38 and 44% of the piston diameter. In fact this also appears acknowledged by the examining division, as visible in the table under item 11 of its decision, that represents the disclosure of the dimensional parameters in the documents D1 to D3. There it is readily apparent, that the column concerning the diameter "C" is empty.

Moreover, most of the numerous dimensional parameters listed by the examining division in the table at the

end of page 2 of its decision are obtained by calculations, because D3 considers the relationship between the lip (D_T) and upper recess (D_1) diameters instead of their individual relationship with respect to the piston diameter, and the lip diameter is given with reference to the maximum inner recess diameter (D_B) instead of the piston diameter D (see page 8, last paragraph). In particular considering the upper recess diameter (D_1) described on page 7, lines 12-13 to be at most 20% above the dimension of the lip diameter (D_T), the skilled person, by applying this relationship to the largest diameter of 59% of the piston diameter for the lip diameter B , obtains a maximum value of $0,59 * 1,2 = 0,708 D$. Such a value does not reach the minimum value of 72% of the piston diameter required by claim 1 (see page 12, last but one line of claim 1). Therefore D3 lacks a direct and unambiguous disclosure for at least some of the parameters A, B, H or h defined in claim 1.

Therefore, in the process of identifying differences the skilled person is faced with a mixture of non disclosed features, such as the angle at which the fuel jets diverge from the surface of the projection and the diameter C that connects the base with the central conical surface, and selection of narrow dimensional ranges out of a wide -calculated- range obtained from other parameters or reference.

4.3 *Technical problem*

The divergence angle - also related to diameter C - of the fuel jets has the effect given in the application as filed on page 11, lines 1 to 11, namely to increase the residence time and enhance mixing of fuel and air. The general shape and size of the lip deriving from the combination of narrow dimensional parameters h, A and B

in relation to the crown surface has the effect given on page 11, lines 17-21 that the burning fuel/air mixture leaving the combustion chamber does so in a substantially vertically extending column which reduces contact of the mixture with the side wall of the cylinder.

A similar technical problem as identified on page 4, lines 1 to 8 of the application can thus be formulated as providing a direct injection diesel engine with further improved fuel/air mixing and a further reduced emission of soot.

4.4 *Obviousness of the solution*

The examining division has stated that none of the dimensional parameters was surprising or unusual, what might be the case for some taken in isolation. The examining division however did not identify precisely which parameter was known or derivable in combination with others from which piece of prior art. With respect to the effect of these dimensional parameters, the Board notes that at least the explicit effect of generating a central exhaust column of fuel air mixture avoiding too extensive contact with the piston during downstroke (see page 11, lines 17-21) is lacking from the prior art disclosure. The configuration of the lip of each of the cited document, does not allow the skilled person to immediately derive that such an effect would also take place.

Likewise the claimed subject-matter does not purely result from a selection invention because at least some dimensional ranges are not disclosed, such as the fuel jet angle, or lie outside the ranges, such as the lip location h , disclosed in D3. The other documents D2 or D1 cited against inventive step do not hint to select

any of these ranges because they are also undefined or define even wider ranges (compare A and B in D1 or D2).

Therefore the skilled person faced with the cited documents would not arrive at all the features missing from claim 1. Furthermore, the assumption that these dimensional parameters or their effects were part of the skilled person's knowledge has not been supported by evidence, nor does the Board have any other reason to believe this might be so.

4.5 *Other cited documents*

Further, considering the other cited documents, document D4 also fails to disclose a central injector (see single figure), therefore the skilled person is unable to derive the injection angle relative to the bowl base. As for D5, it does indeed describe a spray velocity V_{sp} and squish velocity V_s . However, neither their angle nor the location of the circular line where the conical projection merges with the base can clearly be derived, less so any hint to provide them.

4.6 The Board thus concludes that the subject-matter of claim 1 of the main request fulfils the requirements of novelty and inventive step, Article 52(1) with Articles 54(1) and 56 EPC.

5. The dependent claims 2 and 3 define further features of the piston of claim 1. These claims therefore also comply with the requirements of novelty and inventive step, Article 52(1) with Articles 54(1) and 56 EPC.

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:

Claims:

1 to 3 filed with letter of 12 September 2016 (former auxiliary request)

Description:

**Pages 1,2,3,5 to 11 filed with letter of 21 May 2018
Page 4 filed with letter of 31 May 2018**

Drawings:

Sheets 1/2-2/2 as published.

The Registrar:

The Chairman:



G. Magouliotis

S.Oechsner de Coninck

Decision electronically authenticated