

Internal distribution code:

- (A) [-] Publication in OJ
- (B) [-] To Chairmen and Members
- (C) [-] To Chairmen
- (D) [X] No distribution

**Datasheet for the decision
of 28 June 2017**

Case Number: T 0520/15 - 3.2.04

Application Number: 09014367.8

Publication Number: 2187017

IPC: F02B23/06, F02F3/26

Language of the proceedings: EN

Title of invention:

Diesel engine, piston for diesel engine and method of manufacturing a diesel engine

Applicant:

Mazda Motor Corporation

Headword:

Relevant legal provisions:

EPC Art. 56

Keyword:

Inventive step - (yes)

Decisions cited:

Catchword:



Beschwerdekammern
Boards of Appeal
Chambres de recours

European Patent Office
D-80298 MUNICH
GERMANY
Tel. +49 (0) 89 2399-0
Fax +49 (0) 89 2399-4465

Case Number: T 0520/15 - 3.2.04

D E C I S I O N
of Technical Board of Appeal 3.2.04
of 28 June 2017

Appellant: Mazda Motor Corporation
(Applicant) 3-1, Shinchi,
Fuchu-cho,
Aki-gun,
Hiroshima 730-8670 (JP)

Representative: Müller-Boré & Partner
Patentanwälte PartG mbB
Friedenheimer Brücke 21
80639 München (DE)

Decision under appeal: **Decision of the Examining Division of the
European Patent Office posted on 2 December 2014
refusing European patent application No.
09014367.8 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman S. Oechsner de Coninck
Members: E. Frank
C. Heath

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal, received on 27 January 2015, against the decision of the examining division, dispatched on 2 December 2014, refusing the application No. 09014367.8. The appeal fee was paid on 29 January 2015. The statement setting out the grounds of appeal was received on 24 February 2015.

In its decision the examining division came to the conclusion that the application did not meet the requirements of Articles 54 and 56 EPC.

II. In search and examination in particular the following documents were cited as state of the art and considered by the Board:

D1: US 7 389 76 B1

D2: EP 0 810 365 A1

D3: JP 11036868

D4: EP 2 063 081 A1

D5: US 2003/0015167 A1

D6: EP 1 561 924 A2

D7: WO 03/010423 A1

D8: EP 1 264 973 A2

III. In a communication accompanying a summons to oral proceedings, the board gave a preliminary opinion that the subject-matter of claim 1 of the then pending main and auxiliary requests did not involve an inventive step (Articles 52(1) and 56 EPC).

IV. In response to the board's communication, the appellant filed a new auxiliary request 2 by a letter of 29 May 2017.

V. Oral proceedings took place on 28 June 2017. At the end of a thorough debate on the case, the appellant made the second auxiliary request its main request.

VI. The appellant requests that the decision under appeal be set aside and that the application be granted on the basis of a main request filed during oral proceedings.

VII. Claims 1 and 8 of the main request read as follows:

"1. A diesel engine (10) comprising: a cylinder (12a); a piston (13) which reciprocates in said cylinder (12a); a cylinder head (14); a fuel injector (17; 177) which is arranged on said cylinder head (14) and injects fuel substantially radially approximately from a center of said cylinder (12a); a substantially circular cavity (30; 130) which is formed on a top (13a) of said piston (13); and a combustion chamber (11) which is defined by said top (13a) of said piston (13) including said cavity (30; 130), said cylinder (12a), and a face (14c) of said cylinder head (14) that faces said top (13a) of said piston (13), wherein a wall shape of said cavity (30; 130) on a cross section including a center axis (X-X) of said cylinder (12a) comprises an inward protruding portion (32; 132) located at the periphery of an opening (31; 131) of said top (13a) of said piston (13) for said cavity (30; 130), a center portion (34; 134) projecting toward said fuel injector (17; 117), and a peripheral portion (33; 133) which connects said inward protruding portion (32; 132) and said center portion (34; 134) and includes arcs having their centers on the inner side of said cavity (30; 130),

wherein said fuel injector (17; 117) and said cavity (30; 130) are configured so that fuel injected from said fuel injector (17; 117) directs to a proximity of the border between said inward protruding portion (32; 132) and said peripheral portion (33;133), wherein said peripheral portion (33; 133) consists of a first portion (33a; 133a) located farthestmost from said fuel injector (17; 117) among the entire peripheral portion, a second portion (33b; 133b) located between said inward protruding portion (32; 132) and said first portion (33a; 133a), and a third portion (33c; 133c) located between said first portion (33a; 133a) and said center portion (34; 134), wherein said first and third portions (33a, 33c; 133a, 133c) are arc-shaped, and wherein radii of arcs of said peripheral portion (33; 133) increase from said first portion (33a; 133a) to said third portion (33c; 133c), characterized in that said second portion (33b; 133b) is arc-shaped and radii of arcs decrease from said second portion (33b; 133b) to said first portion (33a; 133a), said second portion (33b; 133b) and said third portion (33c; 133c) are formed substantially symmetric with respect to a line (Y-Y) connecting a point (P) in said first portion (33a; 133a) located farthestmost from said fuel injector (17; 117) and an injection hole (17a; 117a) of said fuel injector (17; 117), and radii of arcs of the second portion (33b; 133b) and the third portion (33c; 133c) are substantially equal and the radius of the first portion (33a; 133a) is set to be smaller than the radius of the second and third portions (33b, 33c; 133b, 133c)."

"8. A method of manufacturing a diesel engine (10) comprising the steps of: providing a cylinder (12a);

providing a piston (13) which reciprocates in said cylinder (12a); providing a cylinder head (14); arranging a fuel injector (17; 177) on said cylinder head (14) and injecting fuel substantially radially approximately from a center of said cylinder (12a); forming a cavity (30; 130) on a top (13a) of said piston (13); and defining a combustion chamber. (11) by said top (13a) of said piston (13) including said cavity (30; 130), said cylinder (12a), and a face (14c) of said cylinder head (14) that faces said top (13a) of said piston (13),
forming a wall shape of said cavity (30; 130) on a cross section including a center axis (X-X) of said cylinder (12a) such that it comprises an inward protruding portion (32; 132) located at the periphery of an opening (31) of said top (13a) of said piston (13) for said cavity (30; 130), a center portion (34; 134) projecting toward said fuel injector (17; 117), and a peripheral portion (33; 133) which connects said inward protruding portion (32; 132) and said center portion (34; 134) and includes arcs having their centers on the inner side of said cavity (30; 130), configuring said fuel injector (17; 117) and said cavity (30; 130) such that fuel injected from said fuel injector (17; 117) directs to a proximity of the border between said inward protruding portion (32; 132) and said peripheral portion (33; 133),
providing said peripheral portion (33; 133) with a first portion (33a; 133a) located farthest from said fuel injector (17; 117) among the entire peripheral portion, a second portion (33b; 133b) located between said inward protruding portion (32; 132) and said first portion (33a; 133a), and a third portion (33c; 133c) located between said first portion (33a; 133a) and said center portion (34; 134),

wherein said first and third portions (33a, 33c; 133a, 133c) are arc-shaped, and
wherein radii of arcs of said peripheral portion (33; 133) increase from said first portion (33a; 133a) to said third portion (33c; 133c),
characterized by
forming said second portion (33b; 133b) in an arc-shape and decreasing from said second portion (33b; 133b) to said first portion (33a; 133a),
forming said second portion (33b; 133b) and said third portion (33c; 133c) substantially symmetric with respect to a line (Y-Y) connecting a point (P) in said first portion (33a; 133a) located farthestmost from said fuel injector (17; 117) and an injection hole (17a; 117a) of said fuel injector (17; 117), and
forming said second portion (33b; 133b) and said third portion (33c; 133c) such that radii of arcs of the second portion (33b; 133b) and the third portion (33c; 133c) are substantially equal and the radius of the first portion (33a; 133a) is set to be smaller than the radius of the second and third portions (33b, 33c; 133b, 133c)."

VIII. The Appellant argues as follows:

D2 is the most promising starting point for the problem solution approach. The skilled person would not obviously provide an arc shaped portion in the second portion that is of equal radius with the third portion and provides the claimed symmetry. D3 teaches away by providing instead a projection surface. He would not obviously provide such an arc shape with his own knowledge because many alternative modifications are possible and he would not expect any particular advantage in the claimed solution.

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 of fuel. It is in particular sought to provide the sufficient mixing of fuel with air, and reduce the exhaustion of soot towards the outside. The solution is provided by a specific bowl shape based on the key concept of providing a first, second and third arc shaped portions as further defined in the claims 1 and 8.

3. Amendments

Claims 1 and 8 of the main request have been amended with respect to claims 1 and 10 as filed in the following way. The claims are now drafted in the two part form in accordance with Rule 43(1) EPC, whereby the characterising portion further includes the additional features, whereby the second and third portions are formed substantially symmetric and are such that radii of arcs of the second portion and the third portion are substantially equal.

The features added in claims 1 and 8 whereby the second and third portions are formed substantially symmetric was defined in the dependent claim 3 as originally filed. Claims 1 and 8 further specify that the radii of arcs of the second portion and the third portion are substantially equal and the radius of the first portion is set to be smaller. This refined definition of the arc shaped first to third portions was disclosed on

page 10, lines 12 to 14 of the original description, and describes in more precise terms how the previously defined symmetry is obtained.

The Board therefore concludes that these amendments to claims 1 and 8 do not infringe Article 123(2) EPC.

4. Novelty

With the above added features the Board is satisfied that the documents D1, D2 and D4, belonging to the prior according to Art 54(3) EPC, brought forward by the examining division are no more relevant for novelty. This is particularly so as none of these documents disclose a bowl with three arc shaped portions having the claimed symmetry, and relationship between the radii of arc.

The other documents, in particular D5 and D7 do not disclose the fuel spray direction towards any particular portion of the bowl. D3, D6 and D8 do not show a curved shaped fuel spray catching portion having a radius according to claims 1 and 8.

Therefore the Board concludes that none of the above cited prior art is prejudicial to novelty of the subject-matter of claims 1 and 8, Article 54 EPC.

5. Inventive step

5.1 D2 (col 5, lines 21-49; figure) discloses a piston according to the preamble and thus a central cavity on the periphery of which an inward protruding portion is located, and a peripheral portion which connects said inward protruding portion and said center portion and includes arcs having their centers on the inner side of

said cavity, the peripheral portion (9) consists of a first portion (25) located farthestmost from said fuel injector (4), a second portion (23) located between said inward protruding portion and said first portion (25), and a third portion (27) located between said first portion and said center portion (30). D2 also deals with the behaviour of the mixture flow around the bowl curved wall (col 3, lines 4 to 12). Therefore the Board concurs with the appellant that D2 represents the most promising starting point for the problem solution approach, and claims 1 and 8 were logically cast in the two part form with respect to D2.

5.2 It is therefore also undisputed that the subject-matter of claim 1 differs from D2 by its characterising features according to which, in essence, the second portion is arc-shaped with radii of arcs decreasing from second portion to said first portion, the second portion and said third portion are formed substantially symmetric with respect to a line (Y-Y), and radii of arcs of the second portion and the third portion are substantially equal.

5.3 Technical problem

As explained on page 4, lines 11-16 (paragraph 12 of the "A" publication) the arc of the second portion that has a relatively large radius of curvature, reduces the angle between the fuel-injection direction and the tangential line of the wall surface where the fuel spray collides and prevents the fuel spray from spreading improperly widely when colliding with the wall surface. The axial symmetry provided by the substantially equal radii of arc between the second and third portions further allow the direction of the flowing from the outside to the inside of the piston can change smoothly and surely without improperly

spreading (sentence bridging pages 11 to 12 of the original description, paragraph 44 of the "A" publication).

The corresponding objective technical problem as proposed by the appellant could be formulated of proposing an improved bowl shape for a diesel engine that facilitates and smoothen the mixture of fuel and air, in view of reduced soot and NOx reduction.

5.4 Non obviousness of the solution:

As submitted by the appellant and evidenced in the simulations provided in his submissions (see pages 9 and 10, figures A and C of the appellant's letter of 29 May 2017), the advantage of providing a curvature in the second portion and the substantial axial symmetry obtained by the equal radii in the second and third portions allow for an initial acceleration of the flow of the mixture in the second portion and a radial acceleration of the flow of mixture along the first to third portion, whereby in the third portion a sufficient velocity of the flow is preserved.

The skilled person considering the overall shape of the bowl disclosed in D2, would need to modify the short straight conical portion of the corresponding second portion 23, such that its radius becomes equal to the third portion and extends substantially symmetrically with respect to a line between the injector 18 and the farthestmost point in the first portion.

The extent of modifications needed clearly goes beyond the skilled person's routine adaptation skills, especially as the effect provided by the specific radius of the arc shaped second portion matching the radius of the third portion, and the symmetry thus

obtained, would not have been expected by the skilled person as an obvious consequence.

- 5.5 D3 depicts a radially inwardly projecting surface 12 of the bowl to receive the fuel flow (see figure 2). This surface not only exhibits a complex curvature with varying radii different from the claimed for the second portion, but is also based on the principle of promoting shear forces of the fuel flow impacting on this surface. Therefore D3 teaches away from a smooth circumferential acceleration of the flow mixture.
- 5.6 The board cannot see that any other combination of the documents available to it, would lead to the subject-matter of claims 1 or 8. Therefore the subject-matter of claims 1 and 8 of the new main request involves an inventive step.
6. Claims 2 to 7 directly or indirectly depend on claim 1. Therefore the subject-matter of claims 1 to 7 of the new main request complies with the requirements of Article 56 EPC.
7. The Board is moreover satisfied that the other requirements of patentability of the new main request are also fulfilled.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is referred to the department of first instance with the order to grant a patent in the following version:

1. Claims 1 - 8 according to the Main Request (former Auxiliary Request 2 as filed with letter dated 29 May 2017).
2. Description pages 1, 9 - 17 as originally filed; pages 2 - 8 as filed with letter dated 29 May 2017.
3. Drawings 1 - 12 as originally filed.

The Registrar:

The Chairman:



M. Kiehl

S. Oechsner de
Coninck

Decision electronically authenticated