



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/SE96/00281 (22) International Filing Date: 4 March 1996 (04.03.96) (71)(72) Applicants and Inventors: CHOMIAK, Jerzy [PL/SE]; Glasmästaregatan 37, n.b., S-412 62 Göteborg (SE). JACOBSSON, Lisa [SE/SE]; Lemansgatan 4, S-412 60 Göteborg (SE). (74) Agents: GRAUDUMS, Valdis et al.; Albihn West AB, P.O. Box 142, S-401 22 Göteborg (SE).</p>		<p>(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i></p>
<p>(54) Title: ORIFICE SHAPE OF A FUEL INJECTOR</p> <p>(57) Abstract</p> <p>In order to improve the air-fuel mixing of a jet of fuel injected into an engine, the orifice of said fuel injector is shaped so as to be non-circular. The orifice is produced by spark erosion using a spark erosion electrode which has a non-circular cross-sectional shape.</p> <div data-bbox="798 1254 1340 1590" data-label="Image"> </div>		

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Title

5 Orifice shape of a fuel injector

Field of the invention

10 The invention relates to a fuel injector and a method of producing its orifice as defined in the preamble of claim 1 and claim 5.

Prior art

15 In compression-ignition (CI) engines liquid fuel is injected into the compressed air in the cylinder. The more rapid the fuel-air mixing and the more effective the fuel-air mixing, the greater the specific power and efficiency and the lesser the emissions and engine noise.

20 Due to this, much research has naturally gone into improving fuel-air mixing. In order to achieve the best results, injection pressures have been raised and smaller orifices have been used in the injectors. In some contemporary engines, the pressures are up to 1800 bar injection pressure with nozzle orifices down to 0.1mm diameter. Clearly this requires more expensive pumps, seals and conduits and makes the system more prone to failure. In particular, the danger of injector blockage increases as the injector orifice becomes smaller.

30 The object of the present invention is thus to achieve a fuel injector which is capable of achieving better fuel-air mixing characteristics preferably at lower cost.

Summary of the invention

35 The aforementioned object is solved by a fuel injector having the features defined in claim 1. Similarly, a method of manufacture of an orifice in a fuel injector is defined in claim 5.

Preferred features of the invention are defined in the dependent claims.

5 The non-circular orifice of the present invention results in fuel-air mixing which may be some five times or more better than a circular orifice injector having the same orifice cross-sectional area. Additionally, the production of, for example, an elliptical orifice by using present day, per-se known, methods of electro-erosion (spark-erosion) is no more expensive than for producing a circular orifice.
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Thus, the invention provides a simple yet overwhelmingly effective solution to a long-standing problem in the art of compression ignition engines. Similarly it is imaginable that the same technology could also be applied to direct injection engines working on the Otto cycle.
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The non-circular orifice has been found by the inventors to be successful partly since the single injected jet of fuel becomes bifurcated into two or more jets of fuel. Such bifurcation moreover will normally take place within a distance from the orifice corresponding to a few cross-sectional widths of the injection orifice. In other words, the separation will occur very quickly. The invention is however not limited to improved effects caused as a result of this phenomenon.
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Brief description of the figures

30 The invention will now be described in more detail with reference to the accompanying drawings, in which:

Fig. 1 shows a cross-sectional enlarged view of a portion of the wall of an injector body with an injection orifice.
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Fig. 2 shows an end view of Fig. 1 taken in the direction of arrow "A" according to one embodiment of the present invention comprising an elliptical orifice.

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Fig. 3 shows a further non-circular orifice shape similar to that in Fig. 2, with the exception being that the orifice is rectangular.

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Fig. 4 shows a still further non-circular orifice similar to that in Fig. 2, with the exception being that the orifice is triangular.

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Fig. 5 shows in Fig. 5a, a greatly enlarged frontal view of a nozzle orifice and, in Fig. 5b, a cross-sectional view through line V(b)-V(b) in Fig. 5a.

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Fig. 6 shows a further non-circular orifice shape formed by using a circular and a rectangular electrode in a spark erosion process.

Description of preferred embodiments

Fig. 1 depicts a small portion of the wall 1 of the nozzle body of an injector for a diesel engine. The drawing is not to scale, but merely serves as a pictorial representation. An orifice 2 is formed in the wall 1 by any suitable means, such as e.g. spark erosion.

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30

The orifice 2 in Fig. 1 is of any non-circular shape as viewed in the direction of the principal axis Z-Z of the orifice. In particular the orifice may have any of the shapes shown in Figs. 2, 3, 4 or 5. Other shapes are also imaginable.

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The principal axis will pass through the centre of the orifice in the case where the orifice is a symmetrical or

"right" shape. Thus, in Figs. 2 to 4 and Fig. 5a which depict the orifice head-on, the axis Z-Z therefore only appears as a point.

5 The use of an ellipse seems particularly preferable since it may be easily reproduced with accuracy.

The actual dimensions of the elliptical orifice 2 shown in Fig. 2 are not strictly important for the invention and the "x" and "y" dimensions of the ellipse may be suitably
10 chosen. For example the "x" dimension may be twice the "y" dimension. Whilst there is also no specific lower limit on the cross-sectional area of the orifice, the orifice would typically have a minimum cross-sectional area of 0.008 mm^2 ,
15 although a more easily usable and reliable size in vehicle applications would have a cross-sectional area of about 0.032 mm^2 . The invention is however not limited to such dimensions and will be chosen according to the design of the engine and pump system involved.

20

A rectangular orifice is shown in Fig. 3 and a triangular one in Fig. 4.

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In Fig. 5 an orifice has been chosen which has an outer wall 6 and a number of ramps 5 formed thereon or therein in any suitable manner. The outer wall 6 as depicted is only a schematic representation and, in the normal case, the wall 6 will merely be an integral part of the wall 1 depicted in Fig. 1. The ramps, in this embodiment, are
30 formed by cutting back the metal at the orifice and into the body of the injector to form a series of five recesses. Alternatively, or in addition to said recesses, the non-circular orifice shape may be formed by leaving portions of the orifice periphery within the border of an otherwise
35 circular shape orifice. In this way protuberances are formed.

The injectors having an orifice formed in accordance with this invention, have a much improved air-fuel mixing when compared with a circular nozzle orifice as used in the prior art having the same cross-sectional area.

5

The conventional method of forming small orifices in injectors is by spark erosion. The same technique, per se, can also be used with the present invention, although a different shape of electrode, traditionally formed of copper wire, must be formed to carry out the process. Thus the shape of the electrode (in cross-section) must be the same as the orifice to be formed. The dimensions of said electrode may however be marginally smaller than the orifice to be formed.

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In order to increase the irregularity of the orifice shape but still using only simple electrode shapes, an e.g. circular electrode might first be applied to form a circular orifice, followed in a separate step by a square or rectangular electrode of slightly larger dimension such that the peripheries of each of said shapes overlaps. In this way the spark erosion of the second electrode will form essentially triangular recesses 7 at four corners of the orifice interspersed with segments 8, as shown in Fig. 6. Other more complicated shapes may also be obtained by using two or more differently shaped electrodes. The order of use of the electrodes is of no importance.

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Whilst the invention has been described with reference to certain embodiments, it is to be understood that the invention is not limited to said embodiments and may be widely varied within the scope of the appended claims.

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CLAIMS

1. Fuel injector for injecting fuel into internal combustion engines, said fuel injector having a body with an injection orifice in the outer wall thereof, through which fuel is injected under pressure, said orifice having a principal axis, characterized in that said orifice has a substantially non-circular cross-sectional shape as viewed along said principal axis.
2. Fuel injector according to claim 1, characterized in that said non-circular shape is elliptical, square or triangular.
3. Fuel injector according to claim 1, characterized in that said non-circular shape is formed as a series of separate protuberances and/or recesses (5) formed at the outer wall of said injector.
4. A compression ignition engine, characterized in that it comprises one or more fuel injectors according to any one of the preceding claims.
5. Method of producing a non-circular orifice in a fuel injector as defined in any of claims 1 to 3, characterized in that said orifice is produced by spark erosion using a spark erosion electrode which has a non-circular cross-sectional shape corresponding to the non-circular shape of said orifice.
6. Method according to claim 5, characterized in that said orifice is produced in at least two spark erosion steps using differently shaped electrodes for each step, and in that each of said electrodes has a periphery which overlaps with the periphery of another of said electrodes, so that a superposed erosion shape results in the orifice.

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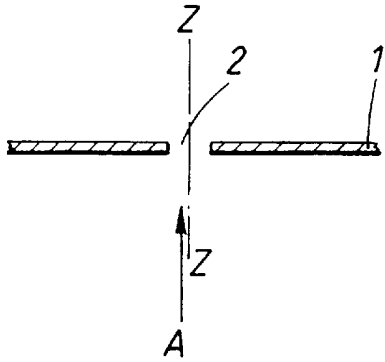


FIG. 1

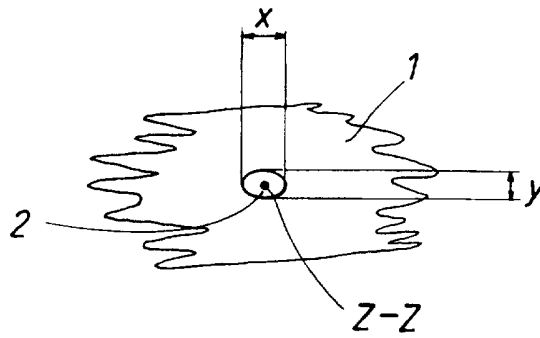


FIG. 2

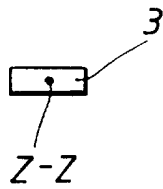


FIG. 3



FIG. 4

2/2

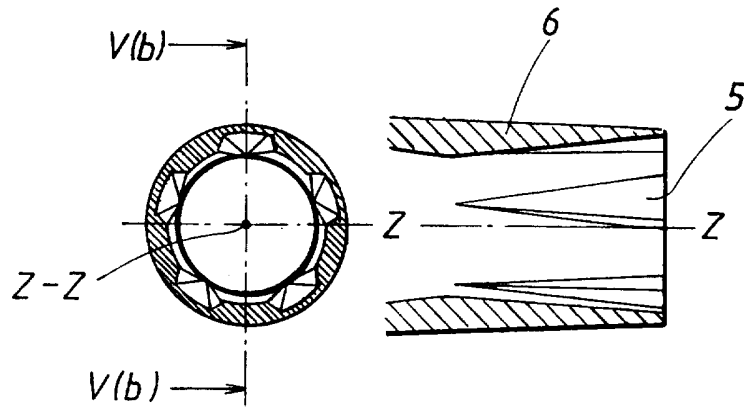


FIG. 5

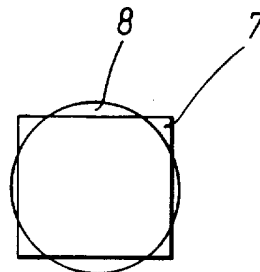


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 96/00281

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: F02M 61/18 // B23H 9/14, B23P 15/16 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC6: F02M, B23P, B23H		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CH 623892 A (MASCHINENFABRIK AUGSBURG-NÜRNBERG AKTIENGESELLSCHAFT), 30 June 1981 (30.06.81), abstract	1,2,4
A	--	5
X	DE 3321286 A1 (SOCIETE D'ETUDES DE MACHINES THERMIQUES S.E.M.T.), 29 December 1983 (29.12.83), abstract, figures	1,2,3,4
A	--	5
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	--	5,6
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Information on patent family members

01/04/96

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