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(54) **FUEL INJECTOR SPRAY HOLE**

KRAFTSTOFFINJEKTOR-SPRÜHLOCH

TROU DE PULVÉRISATION D'UN INJECTEUR DE CARBURANT

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Description

TECHNICAL FIELD

[0001] The present invention relates to a fuel injector and more particularly to the shape of injection holes arranged to spray fuel out of the nozzle of the fuel injector.

BACKGROUND OF THE INVENTION

[0002] Coking of injection holes is a known problem occurring in fuel injectors.

[0003] Many engineering efforts have been dedicated to resolving the injection hole coking problem, but the problem is still not fully resolved. Some of them are described below:

Coating the holes with a thin anti-coking film has been tested but has proven to be quickly damaged in a hot engine.

[0004] Also, WO2015052031 discloses hole design having divergent tapered outlet portion reducing the hole length. This design has proven to be more suitable for gasoline direct injection injectors where the spray penetration reduction is a major target.

[0005] Another design alternative is to have low taper and low rounding injection holes to ensure cavitation forming inside the injection hole at all injection conditions. The trade-off is that low taper and low inlet rounding holes usually have low hydraulic efficiency, which is disadvantageous for mixing, fuel economy, and soot emission.

[0006] Another idea is to use a special injection scheme forcing cavitation to be generated in order to clean the coking forming. For instance, commanding a low needle lift injection event after an interval of regular operation time forces cavitation generation in the injection hole. Fuel economy is a drawback of this injection scheme which can furthermore cause cavitation damage in the injector. DE102005019580, WO2013145451 and US20120138712 disclose prior art injection holes.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a nozzle body of a fuel injector, the body having a generally elongated shape extending along a main axis. The body has a peripheral wall defining an inner blind bore adapted to receive a needle valve, the body extending from a first end wherein opens the bore to a tip end wherein the peripheral wall closes forming a sac volume at the extremity of the bore. The nozzle body is further provided with injection holes arranged through the wall and extending from an inlet opening in the sac, to an outlet opening on the outer face of the wall.

[0008] Advantageously, in order to provide a hole design with high Cd and low coking deposit by generating wall cavitation in the injection hole, at least one of the injection holes comprises an inner portion and an outer portion, said two portions joining together in an intersection zone wherein the cross-section of the inner portion is smaller than the cross-section of the outer portion, so that said intersection area forms a step in the spray hole.

[0009] Particularly, the intersection zone has a short length, the step being abrupt.

[0010] Also, the step is a micro step comprised between 1 μm and 10 μm, and preferably between 2 μm and 5 μm to the radius.

[0011] The outer portion is tapered, the cross-section in the intersection zone being larger than the cross section of the outlet opening and, the length of the inner portion is longer than the length of the outer portion and, at least one of the injection holes comprises two steps such as, said hole comprises an inner portion, a first step, a middle portion, a second step and an outer portion.

[0012] In an embodiment, the inner portion is tapered, the cross-section of the inlet opening being larger than the cross-section in the intersection zone.

[0013] Also, the axial length of the inner portion is more than 2.5 time of the diameter of the injection hole outlet section.

[0014] Particularly, the length of the inner portion is preferably more than three time longer than the length of the outer portion.

[0015] The invention further extends to a nozzle assembly of a fuel injector, said assembly comprising a nozzle body as described above and a needle valve member axially arranged in the bore of the body.

[0016] The invention further extends to a fuel injector comprising a nozzle assembly as described above. More particularly the fuel injector may be a diesel fuel injector.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The present invention is described by way of non-limiting example with reference to the accompanying drawings in which:

Figure 1 is an section of a nozzle of a fuel injector, the section plan passing through an injection hole.
Figure 2 is a schematic view of the injection hole.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] A fuel injector 10 extending along a main axis X1 has a nozzle body 12 provided with a plurality of injection holes 14, each hole 14 extending along a hole axis X2 arranged in an axial plan containing the main axis X1. The injection holes 14 are pierced through the peripheral wall 16 of the nozzle body, the holes 14 extending from an inlet opening 18, having inlet cross-section S18, arranged in a sac volume 20 inside the nozzle body 12 to, an outlet opening 22, having cross-section S22, arranged on the outer face 24 of the peripheral wall 16.

[0019] A section of the injection hole 14 is represented on figures 1 and 2. As can be seen, the hole 14 has a

total length L14 divided in an inner portion 26 having length L26, an outer portion 28 having length L28, said two portions 26, 28, being aligned along the hole axis X2 and joining in an intersection zone 30 where the inner portion 26 has a cross-section SI30 smaller than the cross-section SO30 of the outer portion. This difference in cross-sections creates a step 32 between the inner and outer portions 26, 28, the aim of the step 32 being to disrupt, in use, the fuel flow and to generate wall cavitation and additionally turbulences along the peripheral face 34 of the outer portion 26, said wall cavitation and turbulences cleaning said peripheral face 34 from coking deposit.

[0020] Figure 2 details the shape of an alternative embodiment of a hole 14 successfully modelled and tested for generating wall cavitation and additionally turbulences and cleaning the outer portion 28 from coking deposition. Preferably, the length L26 of the inner portion 26 in the axial direction along X2 is more than 2.5 times of the diameter of the outlet section S22. In other words, the ratio of the length L26 of the inner portion 26 over the diameter of the outlet section S22 is preferably superior to 2.5. Preferably, the length L26 of the inner portion 26 is axially X2 longer than the length L28 of the outer portion 28. A ratio of three has provided good results considering that other length ratio smaller than ten have also proven good interest. A ratio closer to one substantially positions the intersection zone 30 in the middle of the hole, the turbulences created by the step 32 having to propagate along the length L28 of the outer portion that is half the total length L14 of the hole. To the other end a ratio of ten positions means that the outer portion 28 is very short, the intersection zone 30 being in the vicinity of the outlet opening 22, the outer portion 28 being just a tenth of the total length L14.

[0021] Furthermore, the inner portion 26 is slightly convergent, or tapered, as having the inlet opening 18 cross-section S18 a little larger than the intersection zone 30 opening cross-section SI30. The outer portion 28 is also slightly convergent, or tapered, the section of said outer portion diminishing from the cross-section SO30 in the intersection zone to the cross-section S22 of the outlet opening 22.

[0022] Alternatively, the shape of the hole 14 may have a portions lengths ratio L26/L28 larger than five, meaning the outer portion is quite short relative to the inner portion, and a ratio of the outer portion length over the outlet section diameter L28/S22 not larger than 1.5. In that alternative, the outer portion 28 can be parallel or even slightly divergent, with a taper smaller than 3 degrees, without significant disadvantage to the hydraulic efficiency of the nozzle or to the fuel spray momentum concentration. In term of dimensions, the step 32 of one to ten, but preferably two to five micrometers to the radius has proven to be efficient. In other words, provided a generally circular cross-section of the hole 14, the difference in diameters between the sections SI30, SO30 of the two portions 26, 28, joining in the intersection zone 30 is comprised between two to twenty, but preferably four and ten micrometers (μm).

[0023] In the figures the intersection zone 30 is represented conical but, considering a general hole diameter of approximately 100μm and a step of few microns, the intersection zone 30 can be any abrupt shape provided said step generates the required wall cavitation and additional turbulences. In other words, abrupt is to be interpreted as the length of the intersection zone 30 should be as small as possible, the sum of the lengths L26, L28, of the inner and outer portions being as close to the total length L14 of the hole.

[0024] In an alternative not represented, the injection hole 14 can be provided with several intersection zones creating several steps 32. For instance, each step generating, in use, wall cavitation that would clean the following hole portion.

LIST OF REFERENCES

[0025]

X1	main axis
X2	hole axis
S18	inlet section
S22	outlet section
L14	total length of the hole
L26	length of the inner portion
L28	length of the outer portion
SI30	section of the inner portion by the intersection zone
SO30	section of the outer portion by the intersection zone
10	fuel injector
12	nozzle body
14	injection holes
16	wall
18	inlet opening
20	sac
22	outlet opening
24	outer face of the nozzle
26	inner portion
28	outer portion
30	intersection zone
32	step
34	peripheral face of the outer portion

Claims

1. Nozzle body (12) of a fuel injector (10), said body having a generally elongated shape extending along a main axis (X1), the body having a peripheral wall (16) defining an inner blind bore adapted to receive a needle valve, the body extending from a first end wherein opens the bore to a tip end wherein the peripheral wall closes forming a sac (20) volume at the extremity of the bore, the nozzle body (12) being

further provided with injection holes (14) arranged through the wall (16) and extending from an inlet opening (18) in the sac (20), to an outlet opening (22) on the outer face (24) of the wall, wherein at least one of the injection holes (14) comprises an inner portion (26) and an outer portion (28), said two portions joining together in a short length intersection zone (30) wherein the cross-section of the inner portion is smaller than the cross-section (SO30) of the outer portion, so that said intersection area forms an abrupt step (32) in the injection hole (14) and wherein,
said step (32) is a micro step comprised between 1μm and 10μm, and preferably between 2μm and 5μm to the radius.
wherein the length (L26) of the inner portion (26) is longer (L26) than the length (L28) of the outer portion (28) and, **characterised in that** the outer portion (28) is tapered, the cross section (SO30) in the intersection zone being larger than the cross-section (S22) of the outlet opening and **in that** at least one of the injection holes (14) comprises two steps (32) such that said hole (14) comprises an inner portion (26), a first step (32), a middle portion, a second step (32) and an outer portion (28).

2. Body (12) as claimed in the preceding claim wherein the inner portion (26) is tapered, the cross-section (S18) of the inlet opening being larger than the cross-section (SI30) in the intersection zone.

3. Body (12) as claimed in any one of the preceding claims wherein the axial length (L26) of the inner portion (26) is more than 2.5 time the diameter of the injection hole outlet section S22.

4. Body (12) as claimed in any one of the preceding claims wherein the length (L26) of the inner portion (26) is preferably more than three time longer (L26) than the length (L28) of the outer portion (28).

5. Nozzle assembly of a fuel injector (10), said assembly comprising a nozzle body (12) as claimed in any one of the preceding claims and a needle valve member axially (X1) arranged in the bore of the body (12).

6. Fuel injector (10) comprising a nozzle assembly as claimed in claim 5.

7. Fuel injector (10) as claimed in claim 6, the injector being a diesel fuel injector.

Patentansprüche

1. Düsenkörper (12) eines Kraftstoffinjektors (10), wobei der Körper eine allgemein längliche Form hat, die sich entlang einer Hauptachse (X1) erstreckt, wobei der Körper eine Umfangswand (16) hat, die eine innere Sackbohrung definiert, die ausgebildet ist zur Aufnahme eines Nadelventils, wobei sich der Körper von einem ersten Ende, an dem die Bohrung öffnet, zu einem Spitzenende erstreckt, an dem sich die Umfangswand schließt und ein Beutelvolumen (20) an dem Ende der Bohrung bildet, wobei der Düsenkörper (12) weiter mit Einspritzlöchern (14) vorgesehen ist, die durch die Wand (16) hindurch angeordnet sind und sich von einer Einlassöffnung (18) in dem Beutel (20) zu einer Auslassöffnung (22) an der Außenseite (24) der Wand erstrecken,
wobei zumindest eines der Einspritzlöcher (14) einen inneren Abschnitt (26) und einen äußeren Abschnitt (28) aufweist, wobei die zwei Abschnitte in einer Schnittzone (30) kurzer Länge verbunden sind, wobei der Querschnitt des inneren Abschnitts kleiner als der Querschnitt (SO30) des äußeren Abschnitts ist, so dass der Schnittbereich eine abrupte Stufe (32) in dem Einspritzloch (14) bildet,
und wobei die Stufe (32) eine Mikrostufe ist, die zwischen 1 μm und 10 μm und vorzugsweise zwischen 2 μm und 5 μm zu dem Radius liegt,
wobei die Länge (L26) des inneren Abschnitts (26) länger (L26) ist als die Länge (L28) des äußeren Abschnitts (28), und **dadurch gekennzeichnet, dass** sich der äußere Abschnitt (28) verjüngt, wobei der Querschnitt (SO30) in der Schnittzone größer ist als der Querschnitt (S22) der Auslassöffnung, und dadurch, dass
zumindest eines der Einspritzlöcher (14) zwei Stufen (32) aufweist derart, dass das Loch (14) einen inneren Abschnitt (26), eine erste Stufe (32), einen Mittelabschnitt, eine zweite Stufe (32) und einen äußeren Abschnitt (28) aufweist.

2. Körper (12) gemäß dem vorhergehenden Anspruch, wobei sich der innere Abschnitt (26) verjüngt, wobei der Querschnitt (S18) der Einlassöffnung größer ist als der Querschnitt (SI30) in der Schnittzone.

3. Körper (12) gemäß einem der vorhergehenden Ansprüche, wobei die axiale Länge (L26) des inneren Abschnitts (26) mehr als das 2,5-fache des Durchmessers des Einspritzloch-Auslassabschnitts S22 beträgt.

4. Körper (12) gemäß einem der vorhergehenden Ansprüche, wobei die Länge (L26) des inneren Abschnitts (26) vorzugsweise mehr als dreimal länger (L26) ist als die Länge (L28) des äußeren Abschnitts (28).

5. Düsenanordnung eines Kraftstoffinjektors (10), wobei die Anordnung einen Düsenkörper (12) gemäß einem der vorhergehenden Ansprüche und ein Nadelventilelement aufweist, das in der Bohrung des Körpers (12) axial (X1) angeordnet ist.

6. Kraftstoffinjektor (10) mit einer Düsenanordnung gemäß Anspruch 5.

7. Kraftstoffinjektor (10) gemäß Anspruch 6, wobei der Injektor ein Dieselkraftstoffinjektor ist.

Revendications

1. Corps de buse (12) d'un injecteur de carburant (10), ledit corps ayant une forme généralement allongée s'étendant le long d'un axe principal (X1), le corps ayant une paroi périphérique (16) définissant un perçage borgne intérieur adapté pour recevoir une valve à pointeau, le corps s'étendant depuis une première extrémité dans laquelle s'ouvre le perçage jusqu'à une extrémité de pointe dans laquelle la paroi périphérique se ferme en formant un volume de sac (20) à l'extrémité du perçage, le corps de buse (12) étant en outre doté de trous d'injection (14) agencés à travers la paroi (16) et s'étendant depuis une ouverture d'entrée (18) dans le sac (20) jusqu'à une ouverture de sortie (22) sur la face extérieure (24) de la paroi,
dans lequel
l'un au moins des trous d'injection (14) comprend une portion intérieure (26) et une portion extérieure (28), lesdites deux portions se rejoignant ensemble dans une zone d'intersection (30) de courte longueur dans laquelle la section transversale de la portion intérieure est plus petite que la section transversale (SO30) de la portion extérieure, de sorte que ladite zone d'intersection forme un gradin abrupt (32) dans le trou d'injection (14), et
dans lequel ledit gradin (32) est un micro-gradin compris entre 1 μm et 10 μm, et de préférence entre 2 μm et 5 μm par rapport au rayon,
dans lequel la longueur (L26) de la portion intérieure (26) est plus longue que la longueur (L28) de la portion extérieure (28), et
caractérisé en ce que la portion extérieure (28) est effilée, la section transversale (SO30) dans la zone d'intersection étant plus grande que la section transversale (S22) de l'ouverture de sortie, et
en ce que l'un au moins des trous d'injection (14) comprend deux gradins (32), de telle façon que ledit trou (14) comprend une portion intérieure (26), un premier gradin (32), une portion médiane, un second gradin (32) et une portion extérieure (28).

2. Corps de buse (12) selon la revendication précédente, dans lequel la portion intérieure (26) est effilée, la section transversale (S18) de l'ouverture d'entrée étant plus grande que la section transversale (S130) dans la zone d'intersection.

3. Corps de buse (12) selon l'une quelconque des revendications précédentes, dans lequel la longueur axiale (L26) de la portion intérieure (26) est plus de 2,5 fois le diamètre de la section de sortie (S22) du trou d'injection.

4. Corps de buse (12) selon l'une quelconque des revendications précédentes, dans lequel la longueur (L26) de la portion intérieure (26) est de préférence plus de trois fois plus longue (L26) que la longueur (L28) de la portion extérieure (28).

5. Ensemble formant buse d'un injecteur de carburant (10), ledit ensemble comprenant un corps de buse (12) selon l'une quelconque des revendications précédentes, et un élément formant valve à pointeau (X1) agencé dans le perçage du corps (12).

6. Injecteur de carburant (10) comprenant un ensemble formant buse selon la revendication 5.

7. Injecteur de carburant (10) selon la revendication 6, ledit injecteur étant un injecteur pour carburant diesel.

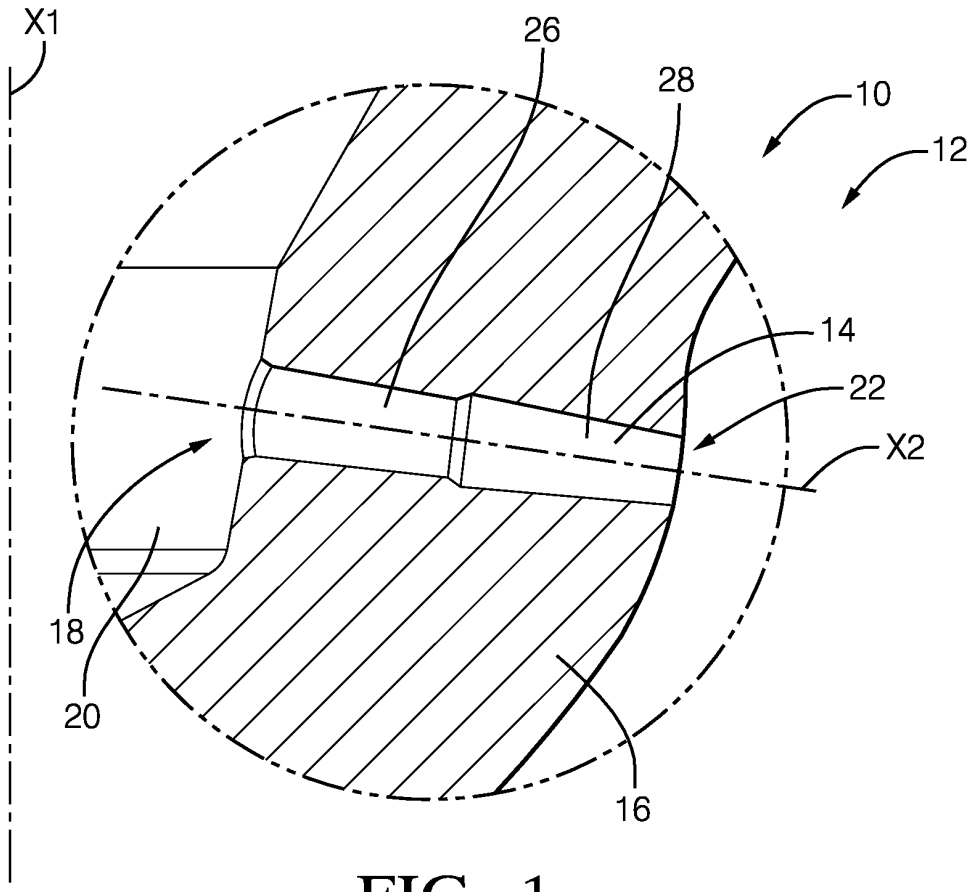
X1
26
28
10
12
14
22
X2
18
20
16

FIG. 1

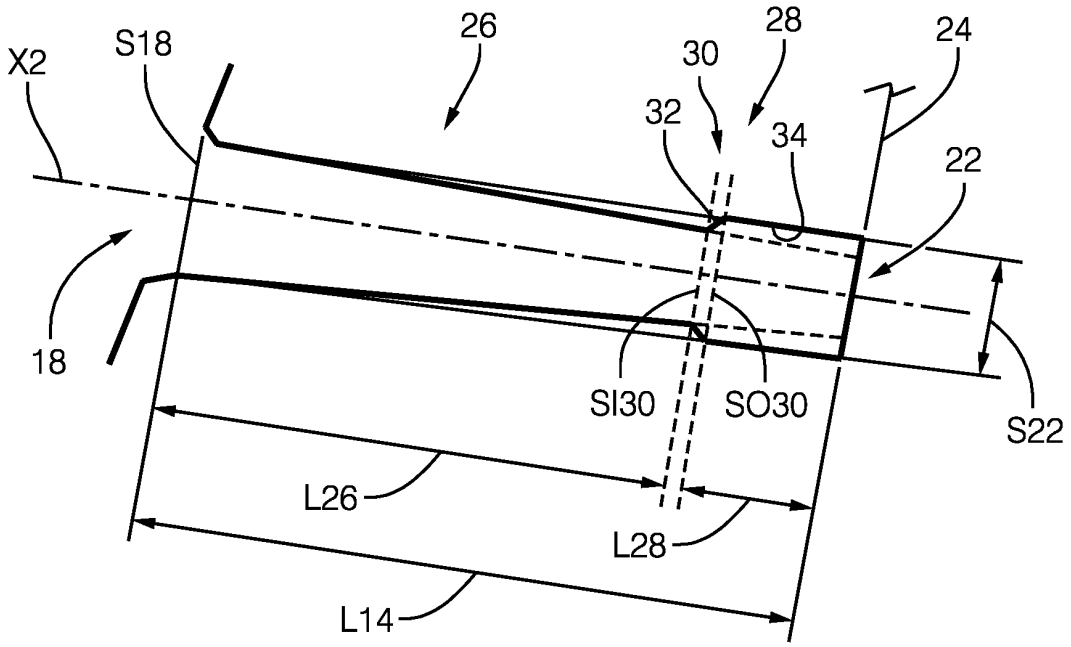
X2
S18
26
30
28
24
32
34
22
18
SI30
SO30
S22
L26
L28
L14

FIG. 2

REFERENCES CITED IN THE DESCRIPTION

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- DE 102005019580 **[0006]**
- WO 2013145451 A **[0006]**
- US 20120138712 A **[0006]**