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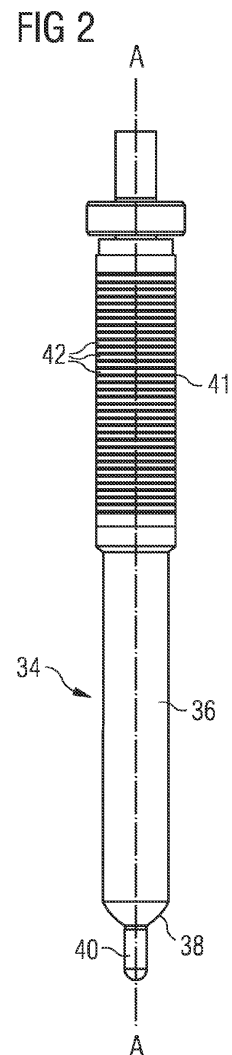
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(54) **Nozzle needle for a fuel injector and fuel injector**

(57) The present disclosure refers to a nozzle needle (34) adapted to be used in a fuel injector (10). The nozzle needle comprises a first cylindrical part (36) formed with an abutment surface (38) at or proximal to a terminal end. The abutment surface is shaped to abut on a valve seat surface formed on an injector body, within which the nozzle needle is moveable. The nozzle needle is formed as a unitary member from a ceramic material.



Description

Technical Field

[0001] The present disclosure refers to a nozzle needle adapted to be used in a fuel injector and further refers to a fuel injector comprising an injector body formed with a bore for accommodating and movably guiding the nozzle needle.

Background

[0002] EP 0 961 025 A1 discloses a fuel injector comprising an injector body formed with a bore for accommodating and movably guiding a nozzle needle. The bore is formed with a valve seat at one end, which valve seat forms a transition from the bore to a sac chamber or blind hole volume having a smaller diameter than the bore. The sac chamber is communicated to the outside via a nozzle outlet. The valve seat is formed with a conical surface. The terminal end of nozzle needle is half spherical and is configured to abut on the valve seat. A portion of the valve body may be provided with a heat insulating layer made from a ceramic material.

[0003] EP 0 677 656 B1 discloses a fuel injector with a wear resistant nozzle needle assembly including a needle or plunger body formed from a wear resistant material and a tip formed from a wear resistant ceramic for being reciprocally seated on a seat surface of the fuel injector. The ceramic tip is secured to the needle body by a press-fit.

[0004] When alternative fuels such as pyrolysis oil or low sulfur fuels are used in diesel engines, wear might be caused due to deposits and/or the aggressive chemical behavior of such fuels.

[0005] The present disclosure is directed, at least in part, to improving or overcoming a problem of one or more aspects of prior fuel injectors, e.g., durability and/or ease of assembly.

Summary of the Disclosure

[0006] According to one aspect of the present disclosure, a nozzle needle adapted to be used in a fuel injector may comprise a first cylindrical part formed with an end surface at or proximal to a terminal end. The end surface is adapted for sealing abutment on a valve seat surface formed on an injector body, within which the nozzle needle is movable. The nozzle needle is formed as a single or unitary member from a ceramic material, preferably entirely from the ceramic material.

[0007] According to a further aspect of the present disclosure, a fuel injector may comprise an injector body formed with a bore for accommodating and moveably guiding the nozzle needle according to the first aspect of the present disclosure as mentioned above, wherein a cylindrical extension of the nozzle needle projects from the end surface, is coaxial with an axis of the first cylin-

drical part and has a diameter smaller than the diameter of the first cylindrical part. In addition, the bore of the injector body is formed with a valve seat at one end, which valve seat forms a transition from the bore to a sac chamber that has a smaller diameter than the bore and is in fluid communication with the outside via at least one nozzle outlet. The cylindrical extension of the nozzle needle protrudes into the sac chamber.

[0008] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0009] The accompanying drawings, which are incorporated herein and constitute part of the specification, illustrate an exemplary embodiment of the disclosure and, together with the description, serve to explain the principles of the disclosure.

[0010] Fig. 1 shows a longitudinal section through a fuel injector,

[0011] Fig. 2 shows an elevational view of a nozzle needle accommodated in the fuel injector according to Fig. 1 and

[0012] Fig. 3 shows an enlarged partial view of the nozzle needle shown in Fig. 2.

Detailed Description

[0013] An exemplary embodiment of a fuel injector and a nozzle needle (plunger) will be described in the following with reference to Figs. 1 to 3. The same reference numerals are used for corresponding elements.

[0014] The fuel injector is designed so as to have a central axis A-A extending in the axial or longitudinal direction of the fuel injector and may comprise a housing member 12 and an injector body 14. The injector body 14 may comprise an inner body member 16 and a cap member 18. The inner body member 16 may be made from metal and may comprise a through bore 20, which is coaxial with the axis A-A. The cap member 18 may cover almost the entire inner body member 16 and may be made from a heat insulating material, preferably from a ceramic material, more preferably entirely from a ceramic material.

[0015] As can be seen from Fig. 1, the housing member 12 may be a hollow cylindrical part formed with a radially inwardly protruding flange 22 at its lower end.

[0016] The inner body member 16 may be a hollow cylindrical member having an outer diameter that increases stepwise from its lower end towards its upper end according to Fig. 1. A radially outwardly protruding flange 24 is formed at the upper end.

[0017] The inner surface of the cap member 18 may contact the outer surface of the inner body member 16 and the upper end as shown in Fig. 1 may have with an outwardly protruding flange 26.

[0018] For assembling the housing member 12, the

inner body member 16 and the cap member 18, an outer circumferential surface of flange 24 may be formed with an external thread, which may be screwed into an internal thread formed on the inner surface of the housing member 12 in order to clamp the flange 26 of the cap member 18 between the flange 24 of the inner body member 16 and the flange 22 of the housing member 12.

[0019] Referring still to Fig. 1, a lower end portion of the bore 20 may be formed with a tapering or conical seat surface 28, which seat surface 28 constitutes a transition from the bore 20 to a sac chamber or blindhole 30, which constitutes an extension of the bore 20 having a smaller diameter than the bore 20.

[0020] The sac chamber 30 may be formed, in part, by the metallic body member 14 and, in part, by a cylindrical recess defined in an inner surface of a lower end wall of cap member 18. The sac chamber 30 may communicate with the outside via at least one nozzle outlet 32 that penetrates through cap member 18.

[0021] A nozzle needle 34 may be accommodated and movably guided within the bore 20.

[0022] As can be better seen in Fig. 2, the nozzle needle 34 may comprise a first cylindrical part 36, having an abutment surface 38 formed on one end. The abutment surface 38, the function of which will be described below, forms a transition from the first cylindrical part 36 of the nozzle needle 34 to a cylindrical extension 40 having a smaller diameter than the first cylindrical part 36.

[0023] The nozzle needle 34 is formed as a generally cylindrical part with axis A-A and may comprise a second cylindrical part 41 having a greater diameter than the first cylindrical part 36; the second cylindrical part 41 may be formed with a plurality of circumferential grooves 42.

[0024] As can be seen in Fig. 1, the nozzle needle 34 may be formed as a single or unitary member (entirely) from a ceramic material and may be inserted into the bore 20. The inner diameter of the bore 20 is designed such that the second cylindrical part 40 is accommodated in the bore without any significant clearance between the inner wall of bore 20 and, the outer circumferential surfaces of the ribs formed between the respective grooves 42.

[0025] A clearance, forming a fluid chamber 44 may be defined between the first cylindrical part 36 and the inner wall of bore 20. Fuel may be supplied to the fuel chamber 44 under pressure via a bore (not shown) that punctures through the upper part of the inner body member 16 generally in the axial direction and leads into a supply chamber 46 formed by a section of the bore 20 having an enlarged diameter.

[0026] Fig. 3 shows a portion of the lower part of nozzle needle 34, in which the abutment surface 38 forms a transition between the first cylindrical 36 and the extension 40 and may have a convex or preferably spherical shape. The ring-like or annular abutment surface 38 is pressed against the seat surface 28 of inner body member 16 by a spring (not shown), which urges the nozzle needle 34 in the downward direction according to Fig. 1.

Due to the convex or preferably spherical shape of the abutment surface 38 and the conical shape of the seat surface 28, a fluid-tight sealing contact is ensured between seat surface 28 and the abutment surface 38 as to reliably and completely block the flow of fuel between the fluid chamber 44 and the sac chamber 30.

[0027] As is generally known in the art, when the fluid chamber 44 is supplied with fuel under pressure, the nozzle needle 34 will be pressed upwardly against the force of a spring (not shown) so that the abutment surface 38 will no longer contact the seat surface 28. As a result, fuel is injected or exhausted through the nozzle outlet(s) 32. As soon as the pressure in the fluid chamber 44 decreases or the nozzle needle 34 is urged downwardly by an additional force, the nozzle needle 34 moves downwardly, so that the ring surface 38 abuts against seat surface 28 to close the injector, i.e. stop the fuel flow.

[0028] The extension 40 and the sac chamber 30 are dimensioned such that the extension 40 nearly completely fills the volume of the sac chamber 30 when the ring surface 38 contacts the seat surface 28 so that substantial no additional fuel is injected into a combustion chamber within a cylinder of the combustion engine as soon as the injector closes. The volume of the sac chamber 30 not filled by the extension 41 when the ring surface 38 contacts the seat surface 28 may be, e.g., less than 55%, and more preferably less than 22% of the volume of the sac chamber 30.

Industrial Applicability

[0029] With the fuel injector as described before, there is little or no risk that the nozzle needle 34 will stick or seize within bore 20 due to polymerization of pyrolysis oil used as a fuel. Further, because the nozzle needle is made from a ceramic material, there is no increased wear when no fuel is acting as a lubricant e.g. low sulfur fuels, notwithstanding the small tolerances between the nozzle needle and the injector body. Further, there is no risk of corrosion of the needle surface due to chemically aggressive fuels having, e.g., pyrolysis oil. Further, the nozzle needle may be easily manufactured because it is a unitary member made from a ceramic material, preferably entirely from a ceramic material.

[0030] The ceramic material of the nozzle needle may be one of zirconium dioxide or aluminum dioxide preferably including the additives CaO; MgO or Y_2O_3 to improve the material stability and improve the technical characteristics of the zirconium dioxide or aluminum dioxide base material.

[0031] Because the abutment surface 38 has a convex or preferably a spherical shape, the sealing abutment between the end surface 38 and the seat surface 28 is ensured over a long lifetime of the fuel injector.

[0032] The nozzle needle 34 preferably comprises the second cylindrical part 41, which has a diameter greater than the diameter of the first cylindrical part 36 and which is formed with a plurality of circumferential grooves 41.

Therefore, the nozzle needle 34 may be precisely guided within bore 20 with almost no clearance between the second cylindrical part 41 and the inner wall of bore 20, thereby minimizing or even preventing fuel leaks while providing only low friction between the nozzle needle and the body member.

[0033] Due to the cylindrical extension 41 of the nozzle needle 34 that protrudes into the sac chamber 30 and nearly completely fills the volume of the sac chamber, the amount of injected fuel will be precisely controlled and any drippings of fuel from the nozzle outlet(s) can be avoided.

[0034] The injector body preferably comprises a metallic inner body member, formed with the bore, and a ceramic cap member covering at least a tip portion of the metallic inner body member including the valve seat and a portion of the sac chamber. Another portion of the sac chamber and the at least one nozzle outlet may be formed in the ceramic cap member. Any fuel within the injector body is prevented from being overheated by this ceramic cap member.

[0035] The cylindrical extension 40 may have e.g. a length in the range of 2 to 9 mm.

[0036] The fuel injector including the nozzle needle as described above may be modified in various ways without extending beyond the scope of the present disclosure. For example, the ceramic cap member 18 of Fig. 1 may cover only a tip part of the inner body member 16 or may be completely omitted. Furthermore, the sac chamber 30 and the at least one nozzle outlet 32 may be formed entirely by the metallic inner body member 16, which solely constitutes the injector body 14 in case the cap member 18 is omitted.

[0037] Furthermore, the nozzle needle 34 may be formed without the extension 40, in which case the entire end face of the nozzle needle 34 may be formed as a convex or spherical abutment surface.

[0038] The nozzle needle 34 may be formed without the plurality of grooves 42. A plurality of nozzle outlets 32 may be provided and arranged symmetrically around the axis A-A with e.g. a further optional nozzle outlet 32 that is coaxial with axis A-A.

[0039] For closing (moving downward) the nozzle needle 34, one or more of the following may be provided: a cam mechanism, an electromagnetic mechanism, a piezoelectric mechanism or any other, e.g. hydraulic mechanism that closes the injector even if the fuel pressure in the fluid chamber 44 remains constant, or is not sufficient to force the annular surface 38 to seat on the valve seat surface 28.

[0040] Although the preferred embodiments of the invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. A nozzle needle adapted to be used in a fuel injector, which nozzle needle (34) comprises a first cylindrical part (36) formed with an abutment surface (38) at or proximal to a terminal end, which abutment surface is shaped to sealingly abut on a valve seat surface (28) formed on an injector body (14), within which the nozzle needle is movable, said nozzle needle (34) is formed as a unitary member from a ceramic material.
2. The nozzle needle according to claim 1, wherein the ceramic material comprises at least one of zirconium dioxide and aluminum oxide.
3. The nozzle needle according to claim 2, wherein the ceramic material comprises at least one of CaO; MgO or Y₂O₃ as an additive.
4. The nozzle needle according to any one of claims 1 to 3, wherein the abutment surface (38) has a convex shape.
5. The nozzle needle according to any one of claims 1 to 3, wherein the abutment surface (38) has a spherical shape.
6. The nozzle needle according to any one of claims 1 to 5, further comprising a second cylindrical part (41), that has a diameter greater than the diameter of the first cylindrical part (36), extends from the end of the first cylindrical part that is opposite to the terminal end formed with the abutment surface (38), has a plurality of circumferential grooves (42) formed thereon and is adapted to be movably guided within a bore (20) of the injector body.
7. The nozzle needle according to any one of claims 1 to 6, wherein a cylindrical extension (40) projects from the abutment surface, is coaxial with an axis of the first cylindrical part (36) and has a diameter smaller than the diameter of the first cylindrical part.
8. A fuel injector comprising an injector body (14) formed with a bore (20) for accommodating and movably guiding the nozzle needle (34) according to claim 7 and anyone of claims 1 to 6, which bore (20) is formed with a valve seat (28) at one end, which valve seat forms a transition from the bore (20) to a sac chamber (30) having a smaller diameter than said bore and being in fluid communication with the outside via at least one nozzle outlet (32), wherein said cylindrical extension (40) protrudes into said sac chamber (30).
9. The fuel injector according to claim 8, wherein the injector body (14) comprises a metallic inner body

member (16), having said bore (20) formed therein, and a ceramic cap member (18) covering at least a tip portion of the metallic inner body including the valve seat (28) and a portion of the sac chamber (30), and wherein another portion of the sac chamber and the at least one nozzle outlet are formed in the ceramic cap member. 5

10. The fuel injector according to claim 8 or 9, wherein the cylindrical extension (40) has a length in the range of 2 to 9 mm. 10

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FIG 1

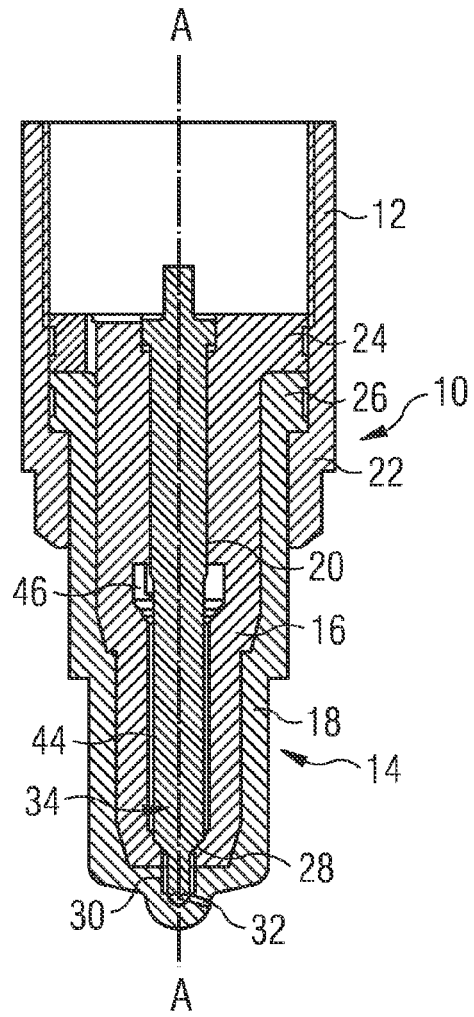


FIG 2

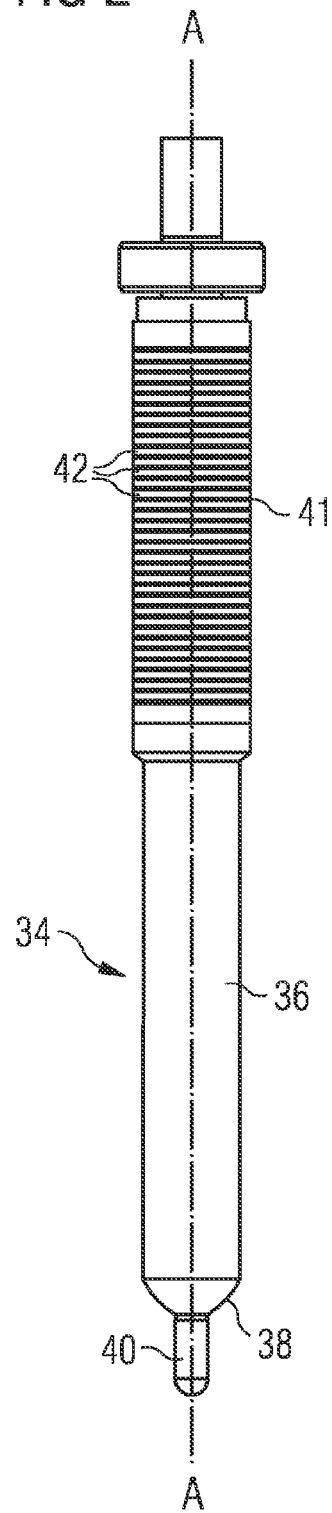
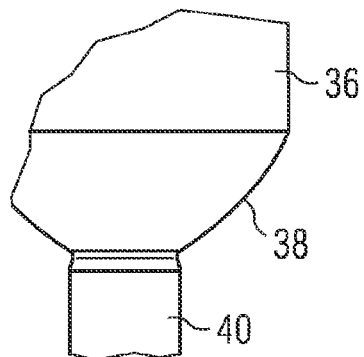


FIG 3





EUROPEAN SEARCH REPORT

Application Number
EP 11 15 4313

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 11 15 4313

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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