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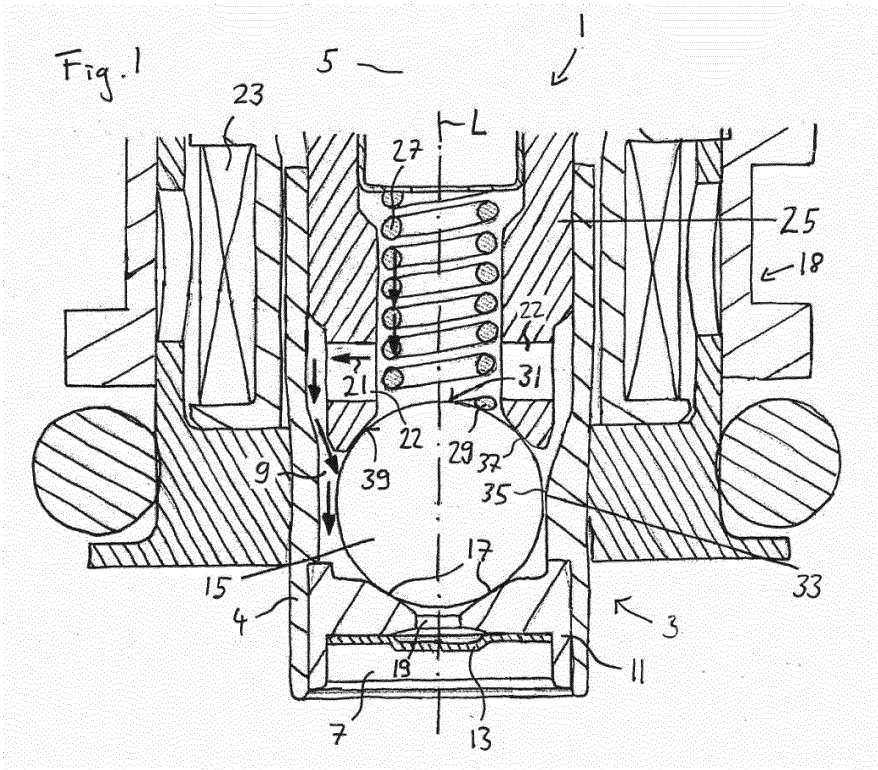
(54) **VALVE ASSEMBLY FOR AN INJECTION VALVE, INJECTION VALVE AND COMBUSTION ENGINE**

(57) A valve assembly (3) for an injection valve (1) comprises
- a valve body (4) with a central longitudinal axis (L) comprising a cavity (9) with a fluid inlet portion (5) and a fluid outlet portion (7),
- a sealing ball (15) axially moveable in the cavity (9), the sealing ball (15) interacting with a valve seat (17) at the fluid outlet portion (7) to prevent a fluid flow through the fluid outlet portion (7) in a closing position and to release the fluid flow through the fluid outlet portion (7) in further positions, wherein the sealing ball (15) serves as an armature for an electro-magnetic actuator unit (18) of the injection valve (1).



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Description

[0001] The present invention relates to a valve assembly for a fluid injection valve, an injection valve and a combustion engine with a number of injection valves. The fluid injection valve may in particular be an injection valve for injecting fuel into a combustion engine, in particular a multipoint fuel injection valve for injecting fuel into the intake ports upstream of each cylinder's intake valve.

[0002] A valve assembly for a fluid injection valve usually comprises a valve body comprising a cavity with a fluid inlet portion and a fluid outlet portion and a valve needle axially moveable in the cavity. The valve needle prevents a fluid flow through the fluid outlet portion in a closing position and releases the fluid flow through the fluid outlet portion in further positions. The valve needle may be actuated by an electromagnetic actuation unit.

[0003] Injection valves for port fuel injections (or multi point injections), which require a relatively low fuel pressure, are disclosed in DE 10 2010 062 126 A1.

[0004] One application for these injection valves could be very small displacement engines, which are used in lawnmowers or brush cutters. However, these applications require exceptionally compact injectors.

[0005] It is an object of the present invention to provide a space-saving valve assembly for an injection valve, an injection valve and a combustion engine with such a valve assembly.

[0006] These objects are achieved by means of a valve assembly for an injection valve, an injection valve and a combustion engine according to claims 1, 9 and 10.

[0007] Advantageous embodiments and developments are objects of the dependent claims.

[0008] According to a first aspect of the invention, a valve assembly for an injection valve is provided, comprising a valve body with a central longitudinal axis. The valve body comprises a cavity with a fluid inlet portion and a fluid outlet portion. The valve assembly further comprises a sealing ball axially moveable in the cavity. The sealing ball interacts with a valve seat at the fluid outlet portion to prevent a fluid flow through the fluid outlet portion in a closing position and to release the fluid flow through the fluid outlet portion in further positions. The sealing ball serves as an armature for an electro-magnetic actuator unit of the injection valve.

[0009] The valve assembly has the advantage, that the injector size is reduced considerably. The size reduction is achieved not only by minimizing single components, but by integrating functions of several components in a single component. Thus, a considerable reduction in size, weight and cost is achieved. Moreover, the manufacturing process is simplified.

[0010] Instead of a sealing ball and an armature, the valve assembly comprises one component which performs both tasks. To achieve this, the sealing ball is on the one hand suitably formed to seal the fluid outlet portion. On the other hand, the sealing ball comprises a magnetic material suitable to react to a magnetic field to cause the injection valve to open.

[0011] To put it differently, the electro-magnetic actuator unit of the injection valve has a movable core, i.e. the armature, the movable core having a generally spherical shape and comprising a sealing area which is in sealing contact with the valve seat in the closing position. The movable core is represented by the sealing ball. The magnetic circuit of the electro-magnetic actuator unit may expediently comprise the pole piece and the sealing ball.

[0012] Because of the reduced size, the valve assembly may be used in very small displacement engines. In one embodiment, a gap between the sealing ball and the pole piece is 1 mm or less, preferably 500 μm or less, for example 200 μm or less, when the sealing ball is in the closing position. In one development, the gap is at least 20 μm or larger, in particular 50 μm or larger.

[0013] According to one embodiment, the sealing ball has an upper side facing away from the fluid outlet portion, the upper side being in contact with a calibration spring biasing the sealing ball towards the fluid outlet portion. An end of the calibration spring remote from the sealing ball is in particular positionally fix relative to the valve body; for example it is seated against a spring seat which is positionally fix to the valve body and in particular press-fitted into the pole piece.

[0014] This embodiment has the advantage, that no valve needle is required. The sealing ball performs the additional task of the valve needle by interacting with the calibration spring. By omitting the valve needle, a further considerable reduction in size, weight and cost is achieved.

[0015] According to one embodiment, a first guiding structure is provided for the axial movement of the sealing ball by a number of protrusions of the valve body extending towards the perimeter of the sealing ball. For example, three or more protrusions can be provided around the perimeter of the sealing ball, the protrusions being integral with the valve body or being fixed to the valve body.

[0016] The first guiding structure may be the only guide for the sealing ball. Unlike a valve needle, the sealing ball does not extend in longitudinal direction and therefore does not require several guiding points. Due to the spherical geometry of the sealing ball, tilt of the moving element is eliminated.

[0017] According to one embodiment, the valve assembly comprises a pole piece for the electro-magnetic actuator unit and a second guiding structure is provided for the axial movement of the sealing ball by a concave impact face on a lower side of the pole piece.

[0018] The impact face is defined as the surface part of the pole piece, with which the sealing ball comes into contact. A concave impact surface has the advantage, that it effects a centering of the sealing ball and that the impact face is relatively large compared to a flat surface so that wear is reduced.

[0019] The sealing ball may comprise a ferritic material. This has the advantage that its magnetic perform-

ance is very good, i.e. the magnetic force is maximized and the pressure range of the injection valve is increased.

[0020] Alternatively the sealing ball may comprise a martensitic material. Martensitic material can be used to reduce wear in lifetime that would lead to higher leak and flow shift. Generally, the magnetic performance of an armature comprising martensitic material is lower compared to ferritic material. For some applications, however, the durability of martensitic material may be more important than the magnetic performance.

[0021] It is also possible to combine a ferritic and a martensitic material for the sealing ball. For example, the sealing ball could have a hard shell comprising martensitic material and a softer core comprising ferritic material.

[0022] According to one embodiment, the sealing ball and/or an impact face on a lower side of a pole piece comprise a protective coating. In particular, the protective coating can be a hardening coating to reduce wear. The coating can comprise chrome or tungsten carbon carbide (WCC) and may be applied by any suitable process, e. g. plating.

[0023] According to one embodiment, a high-stiffness spring is provided to suspend the sealing ball in a maximum opening position without contact to a pole piece of the valve assembly. This "no hard stop"-principle can be achieved by setting the lift of the injector high enough and by operating the injecttor in extended ballistic. This reduces noise and wear and eliminates the necessity of a hardening coating on the pole piece.

[0024] According to an aspect of the invention, a fluid injection valve is provided with the described valve assembly. In particular, the fluid injection valve can be a multi point injection valve, also known as port fuel injector. The injection valve has the advantages described above in connection with the valve assembly. The overall dimensions of the injector are reduced considerably.

[0025] According to a further aspect of the invention, a combustion engine with a number of the described fluid injection valves is provided. According to one embodiment, the engine is a small displacement engine with a displacement of less than 300 cc, in particular with less than 200 cc.

[0026] The engine could be suitable for a lawnmower (e.g. 140-190 cc) or a brush cutter (e.g. 30-50 cc).

[0027] However, the use of the injection valve is not limited to small displacement engines. The injection valve could be used in a larger engine as well.

[0028] Further advantages, advantageous embodiments and developments of the valve assembly for an injection valve, the fluid injection valve and the engine will become apparent from the exemplary embodiments which are described below in association with a schematic figure.

[0029] The only figure shows a cross section of the lower part of an injection valve according to one embodiment of the invention.

[0030] The fluid injection valve 1 shown in figure 1 is in particular suitable for dosing fuel to an internal combustion engine.

However, the invention could be used in other types of injection valves, too.

[0031] The injection valve 1 comprises a valve assembly 3. The valve assembly 3 comprises a valve body 4 with a central longitudinal axis L. The valve body 4 comprises a cavity 9. The cavity 9 has a fluid outlet portion 7. The fluid outlet portion 7 communicates with a fluid inlet portion 5 which is provided in the valve body 4. The fluid inlet portion 5 and the fluid outlet portion 7 are in particular positioned at opposite axial ends of the valve body 4. A flow path for fuel is formed in the cavity 9 from the fluid inlet portion 5 to the fluid outlet portion 7 and indicated in figure 1 by a number of arrows 21.

[0032] The injection valve 1 further comprises a sealing ball 15 axially moveable in the cavity 9. The sealing ball 15 interacts with a valve seat 17 at the fluid outlet portion 7 to prevent a fluid flow through the fluid outlet portion 7 in a closing position of a valve. The valve seat 17 is formed by a valve seat body 11. The valve seat body 11 is welded to the valve body 4 and has a central opening 19 and is arranged adjacent to a nozzle plate 13 which comprises a nozzle. The nozzle plate 13 may be welded to the valve seat body 11.

[0033] In a closing position of the injection valve 1, the sealing ball 15 seals the central opening 19 by interacting with the valve seat 17 and blocking the flow path for fuel through the fluid outlet portion 7.

[0034] In an opening position of the injection valve 1, the sealing ball 15 is lifted from the valve seat 17 and unblocks the central opening 19 in order to allow a fuel injection through the nozzle.

[0035] The injection valve 1 comprises an electromagnetic actuator unit 18 for the sealing ball 15. The actuator unit 17 comprises a solenoid 23 and a pole piece 25. The injection valve 1 does not comprise a separate armature. Instead, the sealing ball 15 serves as an armature for the electromagnetic actuator unit 18. Thus, the sealing ball 15 is formed of a magnetic material, e.g.
ferritic or martensitic material, and is arranged in such a distance from the solenoid 23, that it is influenced in the way described below by the magnetic field built up by energizing the solenoid 23.

[0036] The injection valve 1 does not comprise a valve needle. Instead, the sealing ball 15 itself is preloaded by a calibration spring 27, which is arranged in the cavity 7 at the side of the sealing ball 15 facing the fluid inlet portion 9. A lower part 29 of the calibration spring 27 is supported by an upper side 31 of the sealing ball 15. Thus, the calibration spring 27 exerts a force on the sealing ball 15 acting in the direction towards the fluid outlet portion 7 and forcing the sealing ball 15 onto the valve seat 17 in a closing position of the valve 1.

[0037] When the solenoid is energized, the resulting magnetic field pulls the sealing ball upwards away from the fluid outlet portion 7 opening the central opening 19. When the solenoid is deenergized, the sealing ball 15 is

forced onto the valve seat 17 by the calibration spring 27 closing the central opening 19.

[0038] The sealing ball 15 is guided in its axial movement by a first guiding structure 33 formed by the valve body 4. The first guiding structure 33 comprises a number of protrusions 35, e.g. three or more, the protrusions 35 extending from the valve body 4 inwards towards the sealing ball 15.

[0039] In the cross section of figure 1, only one protrusion 35 is visible. The protrusions 35 may be evenly spaced around the perimeter of the sealing ball 15.

[0040] A second guiding structure 37 is provided by the concave impact face 39 on a lower side of the pole piece 25. The concave impact face 39 has the effect that it centers (and thereby guides) the sealing ball 15 and distributes the force of impact of the sealing ball 15 over a wider area.

[0041] In the pole piece 25, a number of passages 22 are formed in order to allow fluid flow to pass from the fluid inlet portion, through the calibration spring 27 and the passages 22 into the cavity 9 near the valve seat 17. Since the first guiding structure 33 comprises a number of separate protrusions 35, there are vertical channels formed between adjacent protrusions 35 to let fluid flow pass beside the sealing ball 15.

[0042] The sealing ball 15 can comprise a protective (e.g. hardening) coating on its surface. Likewise, the impact face 39 can comprise a protective coating. Alternatively, a "no hard stop"-principle could be used to avoid contact between the sealing ball 15 and the impact face 39.

Claims

1. Valve assembly (3) for an injection valve (1), comprising

- a valve body (4) with a central longitudinal axis (L) comprising a cavity (9) with a fluid inlet portion (5) and a fluid outlet portion (7),
- a sealing ball (15) axially moveable in the cavity (9), the sealing ball (15) interacting with a valve seat (17) at the fluid outlet portion (7) to prevent a fluid flow through the fluid outlet portion (7) in a closing position and to release the fluid flow through the fluid outlet portion (7) in further positions,

wherein the sealing ball (15) serves as an armature for an electro-magnetic actuator unit (18) of the injection valve (1).

2. Valve assembly (3) according to claim 1,
wherein a gap between the sealing ball (15) and a pole piece (25) of the electro-magnetic actuator unit (18) is 1 mm or less when the sealing ball (15) is in the closing position.

3. Valve assembly (3) according to one of the preceding claims,
wherein the sealing ball (15) has an upper side (31) facing away from the fluid outlet portion (7), the upper side (31) being in contact with a calibration spring (27) biasing the sealing ball (15) towards the fluid outlet portion (7).

4. Valve assembly (3) according to one of the preceding claims,
wherein a first guiding structure (33) is provided for the axial movement of the sealing ball (15) by a number of protrusions (35) of the valve body (4) extending towards the perimeter of the sealing ball (15).

5. Valve assembly (3) according to one of the preceding claims,
wherein the valve assembly (3) comprises a pole piece (25) for the electro-magnetic actuator unit (18) and a second guiding structure (37) is provided for the axial movement of the sealing ball (15) by a concave impact face (39) on a lower side of the pole piece (25).

6. Valve assembly (3) according to one of the preceding claims,
wherein the sealing ball (15) comprises a ferritic material.

7. Valve assembly (3) according to one of the preceding claims,
wherein the sealing ball (15) comprises a martensitic material.

8. Valve assembly (3) according to one of the preceding claims,
wherein the sealing ball (15) and/or an impact face (39) on a lower side of a pole piece (25) comprise a protective coating.

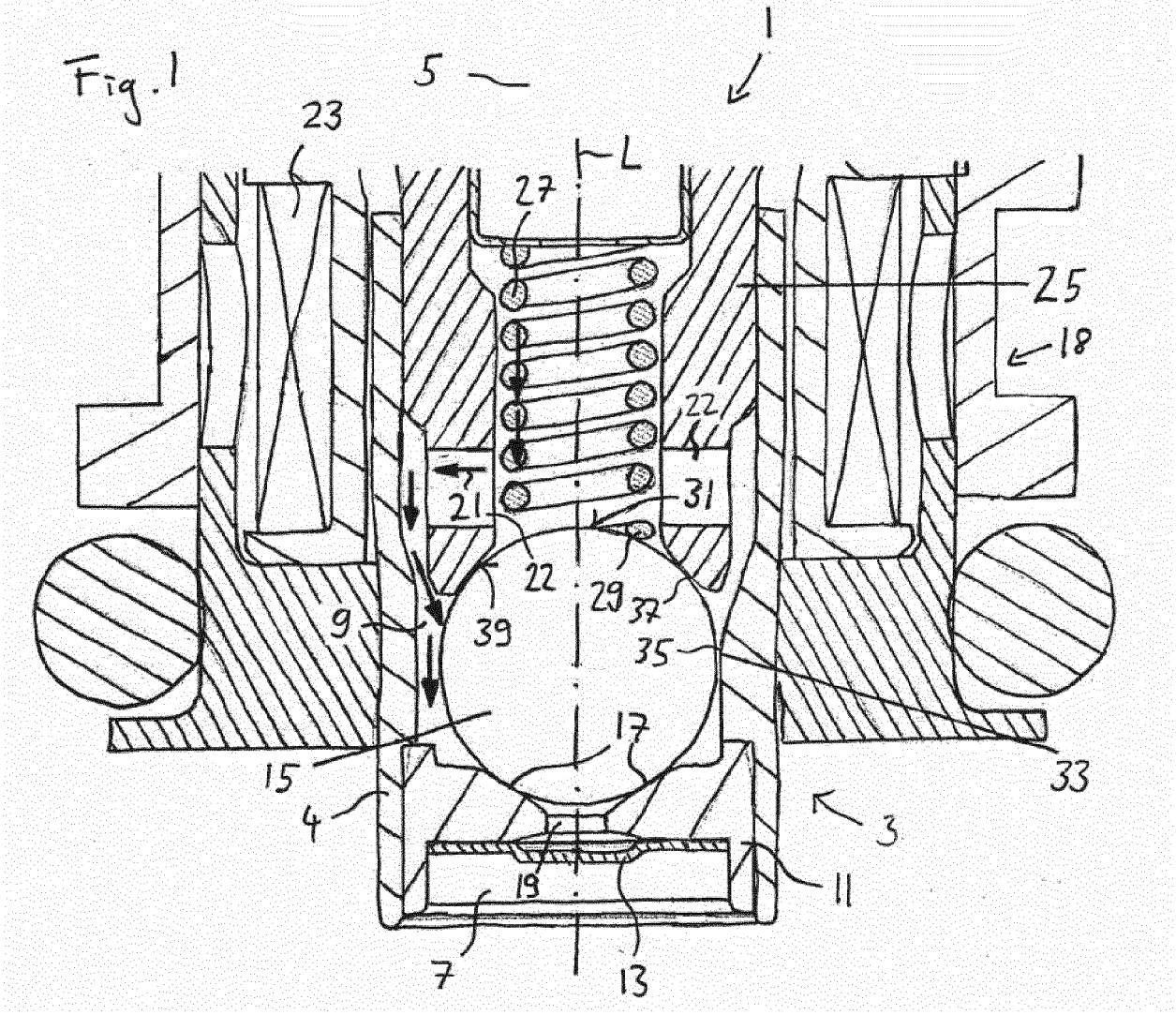
9. Valve assembly (3) according to one of the preceding claims,
wherein a high-stiffness spring is provided to suspend the sealing ball (15) in a maximum opening position without contact to a pole piece (25) of the valve assembly.

10. Fluid injection valve (1) with a valve assembly (3) according to one of the preceding claims.

11. Combustion engine with a number of fluid injection valves (1) according to claim 10.

12. Combustion engine according to claim 11, wherein the engine is a small displacement engine with a displacement of less than 300 cc.

Fig. 1



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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 2662

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	5 January 2017	Hermens, Sjoerd

CATEGORY OF CITED DOCUMENTS

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