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(54) **A CONTROL VALVE FOR FUEL INJECTOR AND A FUEL INJECTOR**

(57) A fuel injector and a control valve used in it are disclosed. The control valve comprises: a valve seat (1) defining a valve seating surface (3) and a fuel passage (2) extending through the valve seating surface (3), the fuel passage (2) being in communication with an injection valve of the fuel injector and forming a pressure releasing path which is provided for controlling the operation of the injection valve; and a valve element (4) moveable in a

longitudinal direction and configured to cooperate with the valve seat (1) to open and close the fuel passage (2); wherein the fuel passage (2) comprises a first passage (2a) and a second passage (2b), both extending in the longitudinal direction, and an a turn-back passage (2d,2e,2f) continuously joined between the first (2a) and second (2b) passages. Erosion of the valve element (4) can be suppressed.

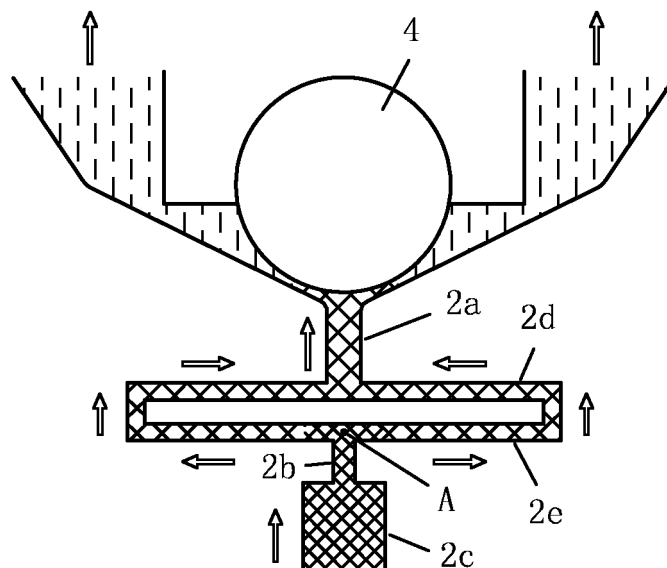


Figure 7

Description

Technical Field

[0001] The disclosure relates to a control valve used in a fuel injector as well as a fuel injector, in particular a diesel common rail injector, comprising such a control valve.

Background Art

[0002] A fuel injector generally comprises a control valve and an injection valve, the fuel injection actions of the injection valve being controlled by switching the control valve between its opened and closed states. Figure 1 schematically shows a partial structure of such a control valve, the control valve comprising a valve seat 1 which is formed with a fuel passage 2 and a valve seating surface 3, a spherical valve element 4 which cooperates with the valve seating surface 3 to achieve the opening and closing of the fuel passage 2, and a holding block 5 which accommodates a portion of the valve element 4. When the valve element 4 is pushed by the holding block 5 to be biased against the valve seating surface 3, pressure accumulation of the fuel in the injection valve is effected. Once the pushing force from the holding block 5 disappears, the valve element 4 leaves the valve seating surface 3, and a portion of the fuel in the injection valve flows into the control valve via the fuel passage 2 so that a pressure difference is established in the injection valve and thus a fuel injection action of the injection valve is initiated. The fuel passage 2 comprises a first passage 2a, a second passage 2b and a third passage 2c arranged in sequence in a longitudinal direction, as can be seen in Figure 2. The first passage 2a has a diameter smaller than that of the third passage 2c, and the second passage 2b has a diameter smaller than that of the first passage 2a.

[0003] When the fuel passage 2 is opened, the valve element 4 is impacted by the fuel introduced from the injection valve via the fuel passage 2. As a result, after a long term service, a portion of the valve element 4 that faces towards the fuel passage 2 may be eroded under the impaction of a high pressure jet of fuel, especially fuel in gas state generated in the jet, so an erosion portion 6 will be formed, as shown in Figure 2. For the reason that the valve element 4 is spherical, the valve element 4 may rotate slowly and randomly. When the erosion portion 6 is turned to a location facing towards the valve seating surface 3, the valve element 4 cannot close the fuel passage 2 effectively, which impedes the pressure accumulation in the fuel in the injection valve and thus causes malfunction of the fuel injector.

Summary of the Invention

[0004] An object of the disclosure is to make improvements to the fuel injector to alleviate or prevent the above

problems caused by the erosive impacting of the valve element in the prior art.

[0005] For this end, there provides a control valve, according to one aspect of the disclosure, that can be used in a fuel injector, the control valve comprising: a valve seat defining a valve seating surface and a fuel passage extending through the valve seating surface, the fuel passage being in communication with an injection valve of the fuel injector and forming a pressure releasing path which is provided for controlling the operation of the injection valve; and a valve element moveable in a longitudinal direction and configured to cooperate with the valve seat to open and close the fuel passage; wherein the fuel passage comprises a first passage and a second passage, both extending in the longitudinal direction, and a turn-back passage continuously joined between the first and second passages.

[0006] According to a possible embodiment of the disclosure, the first passage faces towards the valve element, and the second passage has a flow area smaller than that of the first passage.

[0007] According to a possible embodiment of the disclosure, the valve seat comprises a first portion and a second portion which are assembled together, one of the first and second portions being formed with a projection, the other one of the first and second portions being formed with a recess, the projection being inserted and fitted in the recess, the first passage and the turn-back passage being formed in the projection, and the second passage being formed in the second portion.

[0008] According to a possible embodiment of the disclosure, the turn-back passage comprises a first transverse segment continuous with the first passage, a second transverse segment continuous with the second passage, and a longitudinal segment connecting the first transverse segment with the second transverse segment.

[0009] According to a possible embodiment of the disclosure, the first transverse segment is formed by a transverse through hole in the projection, the second transverse segment is formed by a transverse groove on an end surface of the projection, and the longitudinal segment is formed by a longitudinal groove on a side surface of the projection.

[0010] According to a possible embodiment of the disclosure, the turn-back passage comprises a pair of turn-back passages opposite to each other in a transverse direction, the pair of turn-back passages comprising two first transverse segments formed by a common transverse through hole in the projection, two second transverse segments formed by a common transverse groove on the end surface of the projection, and two longitudinal segments formed respectively by two longitudinal grooves on opposite side surfaces of the projection.

[0011] According to a possible embodiment of the disclosure, the first passage is connected to a joining portion between the two first transverse segments, and the second passage is connected to a joining portion between

the two second transverse segments.

[0012] According to a possible embodiment of the disclosure, the fuel passage further comprises a third passage connected between the second passage and the injection valve, the third passage has a flow area larger than that of the first passage.

[0013] According to a possible embodiment of the disclosure, the valve element comprises a solid sphere.

[0014] The disclosure in another aspect provides a fuel injector which comprises a control valve described above and an injection valve assembled to the control valve; wherein the fuel injection action of the injection valve is controlled in responsive to the opened/closed state of the control valve.

[0015] According to a possible embodiment of the disclosure, the fuel injector comprises a diesel common rail injector.

[0016] According to a possible embodiment of the disclosure, the injection valve comprises an injection valve cavity and a valve needle disposed in the injection valve cavity, the valve needle being configured to have a structure for operation in responsive to a pressure difference generated in the injection valve cavity when the control valve is being opened.

[0017] According to the disclosure, by forming an elongated segment for the fuel passage in the valve seat of the control valve, the fuel jet in the fuel passage may impact the valve element at a reduced pressure, and no gas-state fuel will be generated in the fuel jet, so the erosion of the valve element will be avoided or suppressed effectively. In this way, the fuel passage of the control valve, which is in a closed state, can be tightly closed effectively, and the function of the control valve can be reliably maintained in a long term.

Brief Description of the Drawings

[0018]

Figure 1 is a partial schematic sectional view of a control valve used in a fuel injector according to prior art.

Figure 2 is a schematic view for explaining the corrosion of the valve element of the control valve shown in Figure 1.

Figure 3 is a schematic sectional view of a fuel injector according to a possible embodiment of the disclosure.

Figure 4 is a partial schematic sectional view of a valve seat of a control valve of the fuel injector shown in Figure 3.

Figures 5 and 6 are schematic sectional views of two portions of the valve seat.

Figure 7 is a schematic view for explaining the fuel flowing state in the control valve of the disclosure.

Detailed Description of Preferred Embodiments

[0019] Some possible embodiments of the disclosure will be described with reference to the drawings.

[0020] Figure 3 shows in partial a fuel injector for injecting fuel into an engine according to a possible embodiment of the disclosure, in particular a fuel injector used in a common rail type diesel injection system. The fuel injector comprises a control valve and an injection valve which is assembled together, for example, assembled in a common fuel injector casing 8 (not illustrated in detail). The improvements made in the disclosure relate to the control valve, and so Figure 3 shows only corresponding portions relevant to the control valve. The injection valve is assembled to a front side (lower side in Figure 3) of the control valve, facing towards the engine. The control valve is switchable between an opened state and a closed state. The fuel injection actions of the injection valve are controlled by the opened and closed states of the control valve.

[0021] The control valve has a central axis extending in a longitudinal direction, and comprises a valve seat 1 in which a fuel passage 2 is formed, and a valve seat cavity defined by a valve seating surface 3 and an inner peripheral surface 7. The fuel passage 2 has a front end (lower end in Figure 3) opened into an injection valve cavity of the injection valve and a back end (upper end in Figure 3) opened into the valve seat cavity. High pressure fuel that is supplied into the injection valve cavity can flow into the valve seat cavity via the fuel passage 2 to achieve partial pressure relief in the injection valve cavity. The valve seating surface 3 is formed between the fuel passage 2 and inner peripheral surface 7. Both the valve seating surface 3 and inner peripheral surface 7 are conical surfaces, with the valve seating surface 3 having a bigger cone angle than the inner peripheral surface 7.

[0022] The control valve further comprises a valve element 4, preferably having a spherical shape, the valve element 4 being disposed in the valve seat cavity, facing the valve seating surface 3, and fitting with the valve seating surface 3 to achieve the opening and closing of the fuel passage 2. The cone angle of the valve seating surface 3 facilitates the centering of the valve element 4.

[0023] The control valve further comprises a holding block 5, which is located axially behind the valve element 4 and is formed with an accommodating recess, the accommodating recess having a shape corresponding to the outer shape of a first or substantially back half portion of the valve element 4 for accommodating the first portion of the valve element 4, and a substantially front half portion of the valve element 4 being exposed and facing the valve seating surface 3 and the fuel passage 2. The two portions of the valve element 4 may be formed to be integral with each other, or be formed separately and

then assembled to each other.

[0024] The control valve further comprises an intermediate ring 9 disposed behind the valve seat 1 and a guiding tube 10 disposed behind the intermediate ring 9. The guiding tube 10 comprises a tubular portion 10a extending in the axial direction and a flange member 10b extended radially outwards from a front end of the tubular portion 10a, the flange member 10b being formed with a plurality of through holes 10c extending therethrough axially.

[0025] The control valve further comprises an assembling sleeve 11 disposed behind the flange member 10b, the assembling sleeve 11 being fixed in the fuel injector casing 8 by screw threads or other means. A circular space is formed between the assembling sleeve 11 and the tubular portion 10a. In addition, a front end of the valve seat 1 is biased against a corresponding step in the fuel injector casing 8. In this way, the valve seat 1, the intermediate ring 9 and the guiding tube 10 are clamped together in the axial direction by means of the assembling sleeve 11.

[0026] The control valve further comprises an armature core 12 having a main body in the form of a cylinder extending in the axial direction and a circular flange 12a formed adjacent to a front end of the main body or assembled thereto and extending radially. The main body of the armature core 12 inserts through an inner hole in the tubular portion 10a in an axially slidable manner, with the circular flange 12a being in front of the flange member 10b and mainly within an internal space of the intermediate ring 9. The internal space of the intermediate ring 9 is in fluid communication with the circular space between the assembling sleeve 11 and the tubular portion 10a via the through holes 10c, and the internal space of the intermediate ring 9 is also in fluid communication with the valve seat cavity.

[0027] The front end of the main body of the armature core 12 is adhered to a back end of the holding block 5. A back end (not shown) of the main body of the armature core 12 extends out of a back end of the tubular portion 10a. A compressive spring 13 is disposed in the circular space between the assembling sleeve 11 and the tubular portion 10a, the compressive spring 13 having a front end biased against a back end surface of the flange member 10b and a back end applying an axially backward pushing force to the back end of the main body of the armature core 12 via an element or structure not shown.

[0028] The control valve further comprises a magnetic coil which generates an axially forward pushing force in the armature core 12 by electric-magnetic induction in an energized state. The forward pushing force generated in the magnetic coil overcomes a backward pushing force provided by the compressive spring 13 and the fuel pressure in the fuel passage 2 so that the armature core 12 is in an advanced position as shown in Figure 3 and thus pushes the valve element 4 against the valve seating surface 3 via the holding block 5 to close the fuel passage 2 and achieve the closed state. In this position, the back

end surface of the circular flange 12a is separated from a front end surface of the flange member 10b by a small axial distance. For the sake of clarity, this axial distance is shown in a larger scale in Figure 3, but it is very small in actual. Once the magnetic coil is de-energized, the forward pushing force generated by the magnetic coil disappears, and the armature core 12 is moved axially backwards under the backward pushing force of the compressive spring 13 and the fuel pressure in the fuel passage 2 until the back end surface of the circular flange 12a comes into contact with the front end surface of the flange member 10b. Meanwhile, the valve element 4 moves axially backwards together with the armature core 12 under the action of the fuel pressure in the fuel passage 2 to leave the valve seating surface 3 and open the fuel passage 2, so the control valve is switched to the opened state.

[0029] The injection valve comprises a valve needle (not shown) disposed in its injection valve cavity, and the opening and closing of the injection valve is controlled by the axial movement of the valve needle to perform fuel injection. When the magnetic coil in the control valve is energized so that the control valve comes into the closed state shown in Figure 3, the fuel (for example, comes from a common rail) supplied into the injection valve cavity is under a pressure accumulation state, so that ultimately every portion of the injection valve cavity becomes under high pressure, and then the valve needle in the injection valve closes the injection valve. After that, the magnetic coil in the control valve is de-energized so that the control valve comes into the opened state, so a portion of the fuel in the injection valve cavity flows into the control valve via the fuel passage 2. This results in lowering down of the pressure of the fuel behind the valve needle, so that a pressure difference appears between front and back sides of the valve needle. Under this pressure difference, the valve needle moves backwards to open the injection valve, so a fuel injection action is performed. The fuel that flows into the control valve via the fuel passage 2 will then flow through the valve seat cavity, the internal space of the intermediate ring 9, the through holes 10c, and the circular space between the assembling sleeve 11 and the tubular portion 10a in sequence, and finally flows back to a fuel tank. Then, the magnetic coil in the control valve is energized again so that the control valve comes to the closed state again, and thus the injection valve is switched to the pressure accumulation state until the fuel pressures at the front and back sides of the valve needle become the same level. Now the valve needle closes the injection valve under the action of a returning element for the valve needle. Then, the next fuel injection action will be performed.

[0030] It is noted that, since there is a fuel film between the armature core 12 and the holding block 5, and the holding block 5 is always subjected to a fuel pressure from the fuel passage 2 (directly, or transmitted from the valve element 4 to the holding block 5), the holding block 5 always keeps to be adhered to the armature core 12

when the armature core 12 moves.

[0031] When the control valve is switched from closed state to the opened state, as the valve element 4 leaves the valve seating surface 3 axially backwards, the high pressure fuel comes from the injection valve via the fuel passage 2 will impact the valve element 4 in the form of a jet flow. In the control valve according to prior art, the jet carries a very high impact force, and gas-state fuel is contained in the jet, which result in the portion of the valve element 4 which faces towards the fuel passage 2 is eroded under the impaction. As shown in Figure 4, according to a possible embodiment of the disclosure, the fuel passage 2 comprises a first passage 2a, a pair of turn-back passages, a second passage 2b and a third passage 2c arranged in sequence in the back to front direction. The first passage 2a, the second passage 2b and the third passage 2c extend in the longitudinal direction along the central axis. The first passage 2a has a back end facing towards the valve element 4, forming a valve hole of the control valve. The front end of the third passage 2c extends to the injection valve cavity of the injection valve. The front end of the second passage 2b is connected to the back end of the third passage 2c, and the second passage 2b has a diameter smaller than that of each of the first passage 2a and the third passage 2c to form a throttle portion in the fuel passage 2. The pair of turn-back passages are continuous between the front end of the first passage 2a and the back end of the second passage 2b, and the two turn-back passage are disposed to be opposite to each other in a transverse direction perpendicular to the central axis, and are preferably substantially symmetric with each other. Each turn-back passage comprises a first transverse segment 2d extending transversely from the front end of the first passage 2a, a second transverse segment 2e extending transversely from the back end of the second passage 2b, and a longitudinal segment 2f continuous between the transversely outer ends of the first transverse segment 2d and the second transverse segment 2e. The first transverse segment 2d and the second transverse segment 2e are parallel with each other and are much longer than the longitudinal segment 2f.

[0032] For facilitating forming the turn-back passages in the valve seat 1, according to the disclosure, the valve seat 1 is divided into two portions, a first back portion 1a and a second front portion 1b. With reference to Figures 5 and 6, the first portion 1a has a front end surface formed with a projection 14 protruded forwardly, and the second portion 1b has back end surface formed with a recess 15 recessed forwardly. The projection 14 and the recess 15 have shapes complementary with each other and dimensions fitting with each other, so that the projection 14 can be inserted and fitted in the recess 15 to achieve the assembled state of the first portion 1a and the second portion 1b as shown in Figure 4, in which the front end surface of the first portion 1a abuts tightly against the back end surface of the second portion 1b, and the side surfaces and the front end surface of the projection 14

closely contact the side walls and the bottom wall that define the recess 15.

[0033] The first passage 2a and the pair of turn-back passages are formed in the first portion 1a, and the second passage 2b and the third passage 2c are formed in the second portion 1b.

[0034] Specifically, in the first portion 1a, the two first transverse segments 2d of the pair of turn-back passages are formed by a transverse through hole in the projection 14, the two second transverse segments 2e are formed by a the transverse groove on the front end surface of the projection 14, and the two the longitudinal segments 2f are formed by longitudinal grooves on transversely opposite side surfaces of the projection 14. The first passage 2a extends to the joining portion between the two first transverse segments 2d from the valve seat cavity.

[0035] In the second portion 1b, the second passage 2b is formed to extend to the third passage 2c from the recess 15. In the assembled state of the first portion 1a and the second portion 1b, the back end of the second passage 2b is in fluid communication with the joining portion between the two second transverse segments 2e.

[0036] It is appreciated that, as an alternative solution, the projection 14 with the pair of turn-back passages may be formed on the second portion 1b, while the recess 15 is formed in the first portion 1a.

[0037] By adding the pair of turn-back passages in the fuel passage 2, the length of the fuel passage 2 is significantly increased. In addition, since the first transverse segment 2d and the second transverse segment 2e extend transversely, the flow direction of the fuel changes several times. Thus, the flow field of the fuel in the fuel passage 2 is changed remarkably.

[0038] The flow state of the fuel in the control valve has been studied by analysis and simulation experiments. As shown in Figure 7, during the valve opening operation, high pressure fuel from the injection valve enters the third passage 2c and the second passage 2b, is divided into the pair of turn-back passages and then converged in the first passage 2a, and finally flows into the valve seat cavity via the gap between the valve element and the valve seating surface.

[0039] The fuel is in a high pressure state in the third passage 2c and the second passage 2b, so the fuel in the joining portion (marked by "A" in Figure 7) between two second transverse segment 2e is still at a high pressure. However, the high pressure fuel here impacts on the projection 14, and has no effect on the valve element 4. Then, the fuel changes direction several times in the pair of turn-back passages and the first passage 2a so the pressure of the fuel reduces gradually. When the fuel reaches the back end of the first passage 2a, the pressure and speed of it are both reduced, thus the fuel applies a smaller impact force on the valve element 4. After that, the fuel comes into the valve seat cavity and becomes gas state at a low pressure. The flow path of the fuel is schematically marked by arrows in Figure 7.

[0040] An additional effect resulted from the above

pressure reducing and direction changing solution is that no gas-state fuel is existed in the first passage 2a.

[0041] For the reason that the valve element 4 is subjected to reduced fuel impaction force and there is no impaction of gas-state fuel during the valve opening operation of the control valve, the portion of the valve element 4 that faces the fuel passage 2 is not likely to be eroded. The valve element 4 always effectively guarantee that the fuel passage of the control valve is closed when the control valve is in the closed state, so the function of the control valve can be maintained in a long time. As a result, the service time of the control valve, or even of the whole fuel injector, can be prolonged.

[0042] It is appreciated that those skilled in the art can make various modifications to the described structure according to the theory of the disclosure. For example, the number of the turn-back passages is not limited to a pair, and one, three or more can be adopted. Further, the shape of the turn-back passage is not limited to the illustrated one. In addition, depending on the machining technique, the two-part form of the valve seat 1 may not be used; rather, the portions of the fuel passage 2 may be formed directly in the valve seat 1 which is in the form of a single part. Other changes to the structural details of the control valve can also be conceived.

[0043] Although the disclosure has been described above with reference to some preferred embodiments, the disclosure is not limited to the described details. Various modifications to the details can be made without departing from the spirit of the disclosure.

Claims

1. A control valve used in a fuel injector, comprising:

a valve seat (1) defining a valve seating surface (3) and a fuel passage (2) extending through the valve seating surface (3), the fuel passage (2) being in communication with an injection valve of the fuel injector and forming a pressure releasing path which is provided for controlling the operation of the injection valve; and
a valve element (4) moveable in a longitudinal direction and configured to cooperate with the valve seat (1) to open and close the fuel passage (2);

wherein the fuel passage (2) comprises a first passage (2a) and a second passage (2b), both extending in the longitudinal direction, and a turn-back passage continuously joined between the first and second passages.

2. The control valve of claim 1, wherein the first passage (2a) faces towards the valve element (4), and the second passage (2b) has a flow area smaller than that of the first passage (2a).

3. The control valve of claim 2, wherein the valve seat (1) comprises a first portion (1a) and a second portion (1b) which are assembled together, one of the first and second portions being formed with a projection (14), the other one of the first and second portions being formed with a recess (15), the projection (14) being inserted and fitted in the recess (15), the first passage (2a) and the turn-back passage being formed in the projection (14), and the second passage (2b) being formed in the second portion (1b).

4. The control valve of claim 3, wherein the turn-back passage comprises a first transverse segment (2d) continuous with the first passage (2a), a second transverse segment (2e) continuous with the second passage (2b), and a longitudinal segment (2f) connecting the first transverse segment with the second transverse segment.

5. The control valve of claim 4, wherein the first transverse segment (2d) is formed by a transverse through hole in the projection (14), the second transverse segment (2e) is formed by a transverse groove on an end surface of the projection (14), and the longitudinal segment (2f) is formed by a longitudinal groove on a side surface of the projection (14).

6. The control valve of claim 4, wherein the turn-back passage comprises a pair of turn-back passages opposite to each other in a transverse direction, the pair of turn-back passages comprising two first transverse segments (2d) formed by a common transverse through hole in the projection (14), two second transverse segments (2e) formed by a common transverse groove on the end surface of the projection (14), and two longitudinal segments (2f) formed respectively by two longitudinal grooves on opposite side surfaces of the projection (14).

7. The control valve of claim 6, wherein the first passage (2a) is connected to a joining portion between the two first transverse segments (2d), and the second passage (2b) is connected to a joining portion between the two second transverse segments (2e).

8. The control valve of claim 1 or 2, wherein the valve element (4) is a solid sphere.

9. A fuel injector comprising a control valve and an injection valve assembled to the control valve, the injection valve performing a fuel injection action in responsive to the open/close state of the control valve; wherein the control valve comprises a control valve of any one of claims 1-8.

10. The fuel injector of claim 9, wherein the fuel injector is a diesel common rail injector; and wherein the injection valve comprises an injection valve cavity and

a valve needle disposed in the injection valve cavity, the valve needle being configured to have a structure for operation in responsive to a pressure difference generated in the injection valve cavity when the control valve is opened.

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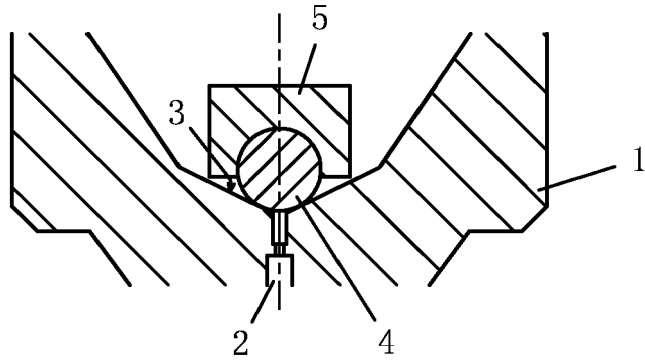


Figure 1

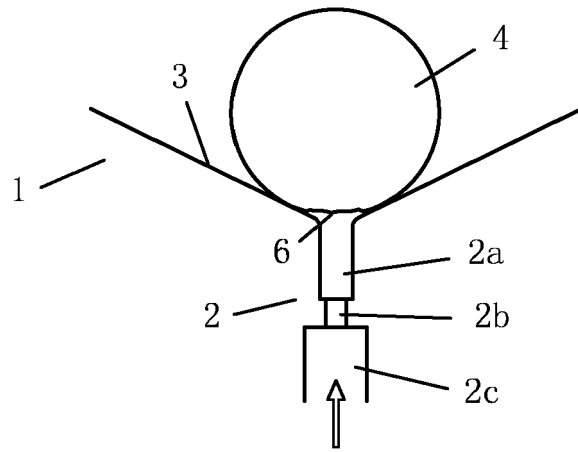


Figure 2

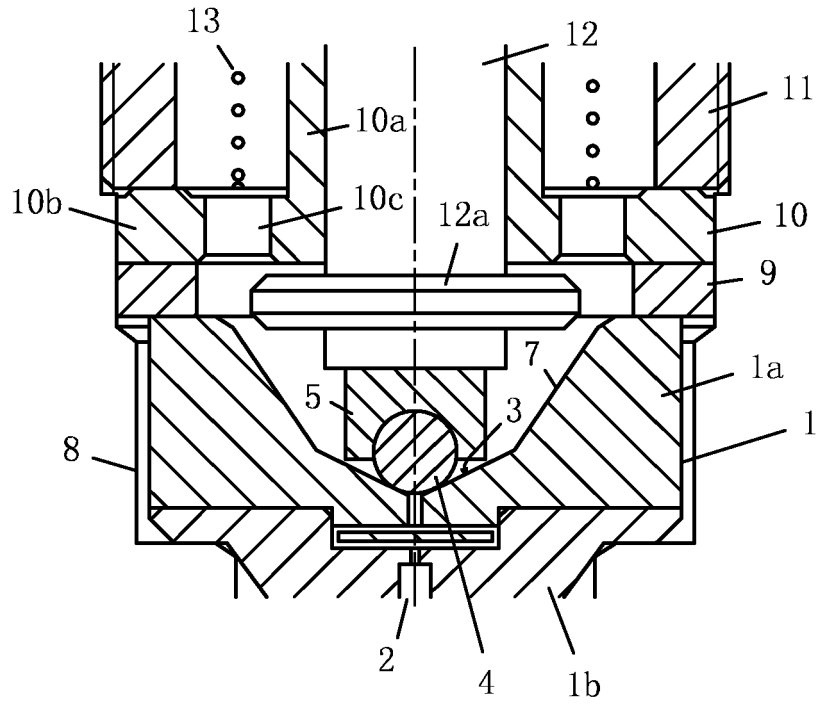


Figure 3

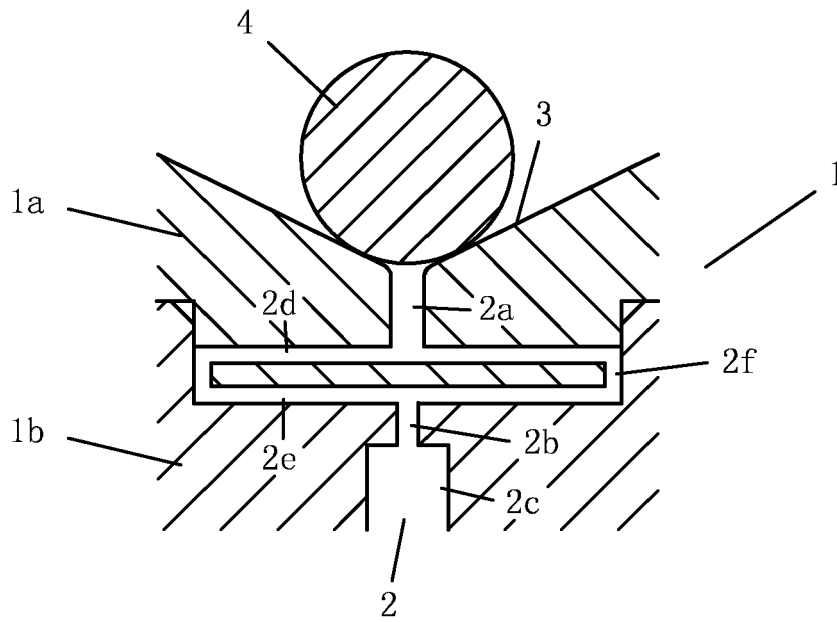


Figure 4

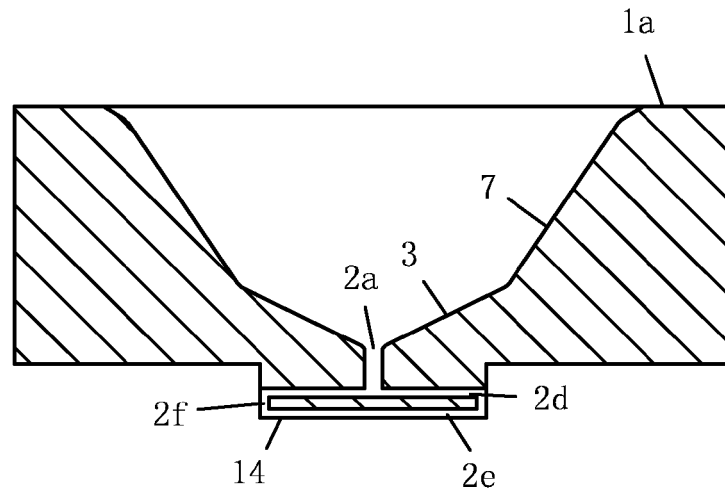


Figure 5

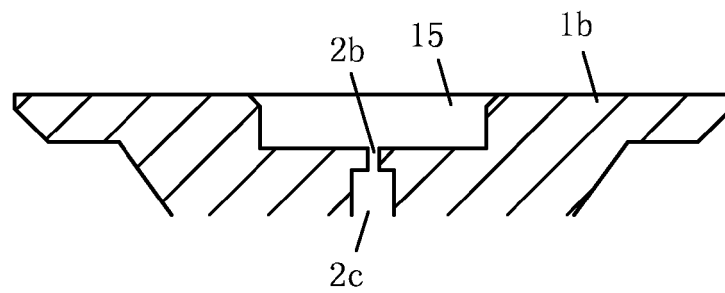


Figure 6

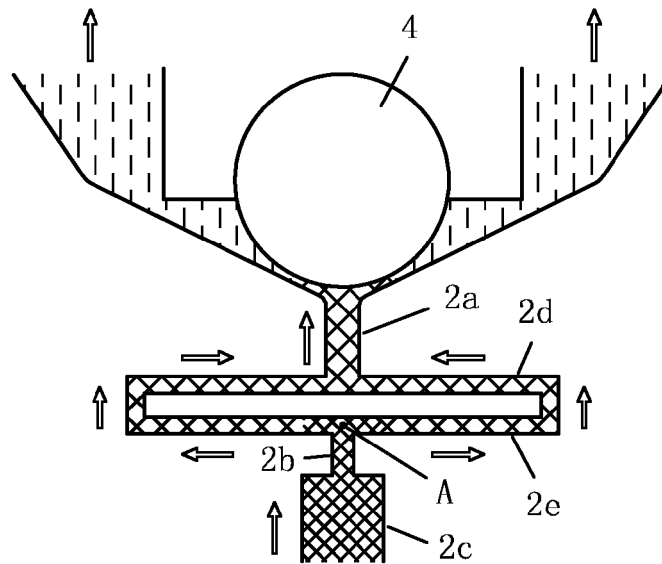


Figure 7