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(54) VALVE SEAT BODY FOR A FLUID INJECTOR OF AN INTERNAL COMBUSTION ENGINE

(57) A valve seat body (120) for a fluid injector (100) of an internal combustion engine, wherein the valve seat body (120) extends in axial direction along a central longitudinal axis (160), wherein the valve seat body (120) comprises a plurality of flow holes (340) through which fluid flows from an inlet portion of the flow holes (340) to

an outlet portion of the flow holes (340) when the fluid injector (100) is in operation, and wherein the valve seat body (120) comprises an inner surface (200) which is configured to form a sealing edge (270) between the inner surface (200) and a valve needle of the fluid injector (100) when the fluid injector (100) is in operation.

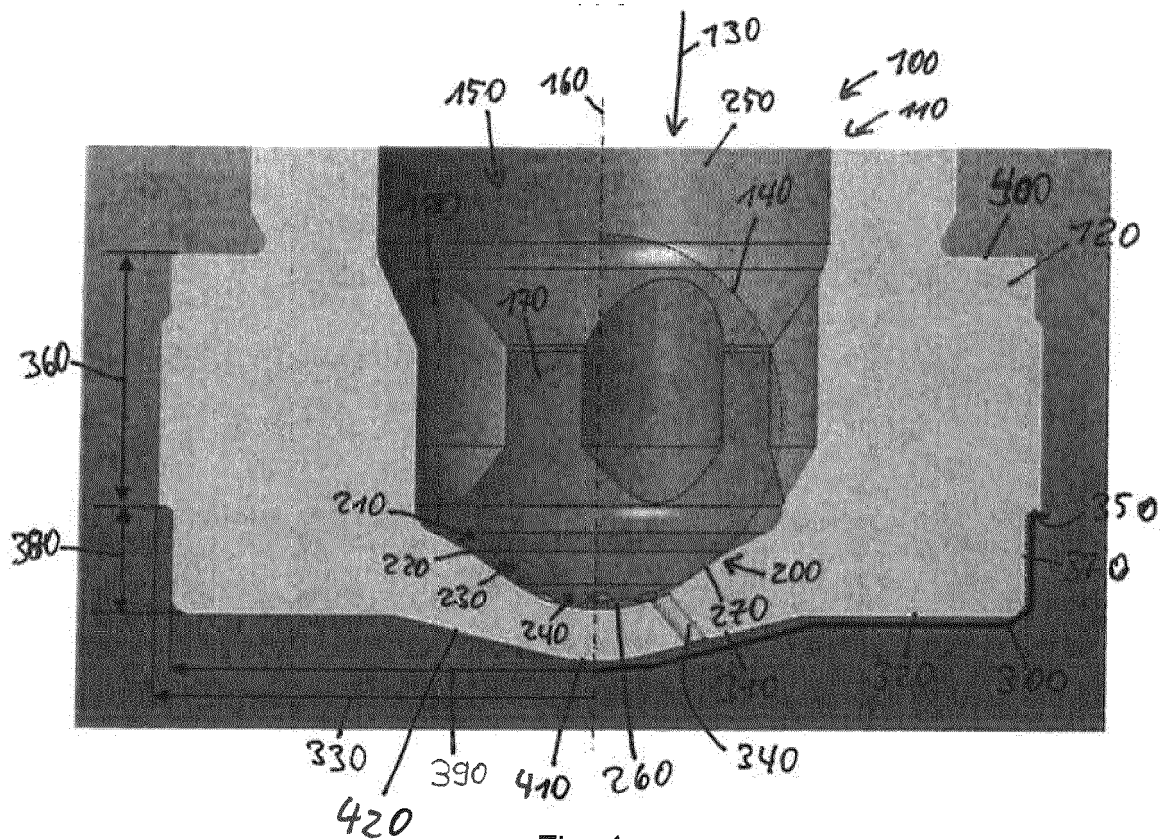


Fig. 1

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Description

[0001] The invention relates to a valve seat body for a fluid injector of an internal combustion engine wherein the valve seat body extends in axial direction along a central longitudinal axis, and wherein the valve seat body comprises a plurality of flow holes through which fluid flows when the fluid injector is in operation.

[0002] Fluid injectors are in widespread use, in particular for internal combustion engines, where they may be arranged in order to doze a fluid or fuel amount into an intake manifold of the internal combustion engine or directly into a combustion chamber of a cylinder of the internal combustion engine.

[0003] Due to increasingly strict legal regulations concerning the admissibility of pollutant emissions by internal combustion engines, which are arranged for example in vehicles, it is necessary to take actions in various ways in order to reduce these pollutant emissions.

[0004] One possible starting point to reduce the pollutant emissions and in particular to reduce particle emissions is to increase the fluid pressure inside the fluid injector. Conventional fluid injectors are designed to operate at a fluid pressure of below 10 MPa. If the fluid pressure is increased inside the fluid injector it is possible to reduce pollutant emissions caused by the internal combustion engine. The increased fluid pressure inside the fluid injector requires a change of the design of the fluid injector. An important part is the valve seat body. The valve seat body is arranged at an outlet portion of the fluid injector. The valve seat body comprises flow holes which are arranged to inject fluid inside the fluid injector into the internal combustion engine. The valve seat body forms together with a valve needle of the fluid injector a fluid-tight sealing edge between the valve needle and the valve seat body so that the fluid inside the fluid injector cannot flow out of the fluid injector. The valve needle is arranged displaceable inside the fluid injector and is therefore designed to allow the fluid to flow out of the fluid injector through the flow holes of the valve seat body when the valve needle is displaced away from a closing position or to create the fluid-tight sealing edge when the valve needle is in the closing position.

[0005] The combination of the valve needle and the valve seat body during the operation of the fluid injector is therefore responsible for an accurate fluid release out of the fluid injector. If the fluid pressure inside the fluid injector is increased the requirements on the valve needle and especially on the valve seat body change due to the reason that these parts have to handle the higher fluid pressure.

[0006] An object of present disclosure is to create a valve seat body for a fluid injector of an internal combustion engine which facilitates a reliable and precise function in particular with a high fluid pressure.

[0007] The object is achieved by a valve seat body comprising the features of the independent claim. Advantageous embodiments of the valve seat body and a

fluid injector comprising the valve seat body are specified in the dependent claims.

[0008] A valve seat body for a fluid injector of an internal combustion engine is specified. Further, a fluid injector for an internal combustion engine comprising the valve seat body is specified. The fluid injector is in particular a fuel injector. It may preferably be provided for injecting fuel directly into a combustion chamber of the internal combustion engine.

[0009] The valve seat body extends in axial direction along a central longitudinal axis. The valve seat body comprises a plurality of flow holes. The valve seat body comprises, in one embodiment, two flow holes and in another embodiment for example five or six flow holes. The flow holes are arranged in the valve seat body so that the fluid inside the fluid injector can flow out of the fluid injector through the flow holes when the valve seat body is arranged at the fluid injector and when the fluid injector is in operation. The flow holes comprise for that reason an inlet portion and an outlet portion. The inlet portion of the flow holes is arranged upstream of the outlet portion of the flow holes. The valve seat body is configured such that the fluid flows out of the flow holes through the valve seat body along a main fluid flow direction. The main fluid flow direction is substantially parallel to the central longitudinal axis and is directed from an inlet portion of the valve seat body to an outlet portion of the valve seat body. The inlet portion of the valve seat body is the portion or area of the valve seat body where the fluid flows into the valve seat body, and the outlet portion of the valve seat body is the portion or area of the valve seat body where the fluid flows out of the valve seat body when the valve seat body is in operation. The main fluid flow direction through the valve seat body is therefore substantially directed from the inlet portion of the flow holes of the valve seat body to the outlet portion of the flow holes of the valve seat body when the flow holes are substantially parallel to the central longitudinal axis.

[0010] The valve seat body further comprises an inner surface which is configured to form a sealing edge between the inner surface and a valve needle of the fluid injector when the fluid injector is in operation. The inner surface is the surface of the valve seat body which forms together with other parts of the fluid injector a fluid cavity of the fluid injector when the valve seat body is arranged in the fluid injector. The inner surface is in addition the surface which is configured to be in contact with the valve needle during operation of the fluid injector. The valve needle of the fluid injector is configured to be in contact with the inner surface of the valve seat body to create a fluid-tight sealing edge between the valve needle and the inner surface to inhibit a fluid flow out of the flow holes of the valve seat body. The valve needle is in addition configured to be displaced away from the inner surface of the valve seat body to release the fluid flow out of the fluid injector through the flow holes during operation of the fluid injector.

[0011] The inner surface of the valve seat body com-

prises, according to the present disclosure, a first truncated cone surface which is coaxially arranged with respect to the central longitudinal axis. The radius of the first truncated cone surface decreases along the main fluid flow direction. The first truncated cone surface forms according to the present disclosure a portion of a cavity in the valve seat body. The radius of the first truncated cone surface decreases along the main fluid flow direction. This means in particular that the cavity formed by the first truncated cone surface tapers in diameter along the main fluid flow direction.

[0012] The inner surface of the valve seat body further comprises a second truncated cone surface which is arranged adjacent to the first truncated cone surface. The second truncated cone surface is in addition coaxially arranged with respect to the central longitudinal axis and the radius of the second truncated cone surface decreases along the main fluid flow direction. The second truncated cone surface is further arranged adjacent to the smallest radius of the first truncated cone surface. The smallest radius of the first truncated cone surface is the deepest cavity point in the valve seat body created by the first truncated cone surface. The second truncated cone surface is adjacent to the smallest radius of the first truncated cone surface and creates therefore an even deeper portion of the cavity into the valve seat body. In other words, the second truncated cone surface is arranged downstream of the first truncated cone surface. The radius of the second truncated cone surface decreases along the main fluid flow direction. This means that the portion of the cavity formed by the second truncated cone surface tapers in diameter along the main fluid flow direction.

[0013] According to the present disclosure, a first angle between the first truncated cone surface and the central longitudinal axis differs from a second angle between the second truncated cone surface and the central longitudinal axis. The first angle is the angle between the shell line of the first truncated cone surface and the first truncated cone axis. The shell line is the line which generates, when rotated by 360 degrees, the shell of the geometric form, for example the shell of the truncated cone. The cone axis of the first truncated cone surface falls together with the central longitudinal axis due to the reason that the first truncated cone surface is arranged coaxially with the central longitudinal axis. The second angle is the angle between the shell line of the second truncated cone surface and the second truncated cone axis. The second truncated cone axis falls also together with the central longitudinal axis due to the reason that the second truncated cone surface is arranged coaxially with respect to the central longitudinal axis. The difference between the first angle and the second angle creates a change in the gradient of the cavity formed by the first truncated cone surface and the second truncated cone surface.

[0014] The inner surface of the valve seat body further comprises a spherical surface which is arranged adjacent to the second truncated cone surface. The spherical sur-

face is also arranged coaxially with respect to the longitudinal axis. The spherical surface extends from the smallest radius of the second truncated cone surface to the longitudinal axis. The spherical surface is in particular a segment of the surface of a sphere. According to one embodiment, the spherical surface extends partially along the main fluid flow direction. According to the present disclosure the spherical surface is arranged adjacent to the second truncated cone surface. This means in particular that the spherical surface borders the smallest radius of the second truncated cone surface.

[0015] The spherical surface extends according to one embodiment from the deepest point of the cavity formed by the second truncated cone surface even deeper into the valve seat body and forms therefore an even deeper portion of the cavity. The cavity in the valve seat body formed by the inner surface is therefore formed by the first truncated cone surface, the second truncated cone surface and the spherical surface. The spherical surface creates the bottom of the cavity due to the reason that the spherical surface extends from the smallest radius of the second truncated cone surface to the longitudinal axis. According to another embodiment, the inner surface comprises one or more additional surfaces which are arranged coaxially with respect to the central longitudinal axis and which extend from the largest radius of the first truncated cone surface in opposite direction with respect to the main fluid flow direction. The additional surfaces form therefore a portion of the cavity of the valve seat body. It is also conceivable that a transition surface or a transition edge or a plurality of transition surfaces are arranged between the largest radius of the first truncated cone surface and the at least one additional surface. The transition edge could be a rounding or a chamfer.

[0016] According to the present disclosure, the inlet portion of each flow hole is arranged at the inner surface downstream of the sealing edge. This means in particular that if the valve needle is in contact with the inner surface and forms the sealing edge to create the fluid-tight seal no fluid located inside the fluid injector upstream of the sealing edge can flow out of the fluid injector through the flow holes of the valve seat body. If the valve needle is displaced away from a closing position in which the valve needle is in contact with the inner surface, then the fluid inside the fluid injector can flow out of the fluid injector through the flow holes of the valve seat body.

[0017] With the inner surface according to the present disclosure it is possible to create a relatively small sac volume. The sac volume is the free volume between the inner surface downstream of the sealing edge and the valve needle when the valve needle is in contact with the inner surface. A small sac volume minimizes the amount of fluid eventually remaining on the outlet portion of the flow holes after an injection cycle of the fluid injector. This reduces the undesired amount of fluid injected and helps therefore to reduce the fluid/fuel consumption and helps to meet emission standards. In addition, due to the reason that the first truncated cone surface and the second

truncated cone surface and the spherical surface are arranged adjacent to each other no so-called "sac edge" is created which would increase the sac volume. The sac edge is an edge on the inner surface downstream of the sealing edge which is substantially parallel to the central longitudinal axis and which forms a cylindrical surface which forms a cavity. The inner surface according to the present disclosure formed by the first truncated cone surface, the second truncated cone surface and the spherical surface reduces the sac volume and therefore reduces the fluid eventually remaining on the outlet portion of the flow holes after an injection cycle of the fluid injector. With the design of the inner surface according to the present disclosure the inner surface does not comprise a sac edge which is conventionally formed by the cylindrical surface extending in axial direction.

[0018] Due to the reason that the inner surface does not comprise a sac edge, the fluid flow along the inner surface, when the valve needle is displaced away from the inner surface is not affected by the sac edge which creates undesired eddy currents in the fluid flow. Overall, the fluid flow along the inner surface when the valve needle is displaced away from the inner surface is improved by the design of the inner surface according to the present disclosure. The improved fluid flow helps in addition to improve the efficiency of the valve seat body and the fluid injector and reduces therefore pollutant emission. A particular smoothened fluid flow along the inner surface of the valve seat body and out of the flow holes of the valve seat body is achievable. This is achieved due to the arrangement of the first truncated cone surface, the second truncated cone surface and the spherical surface according to the present disclosure. Overall, the valve seat body allows to achieve particular less pollutant emissions, especially particle emissions and therefore to meet emission standards due to the design of the inner surface according to the present disclosure.

[0019] According to one embodiment, the second truncated cone surface is arranged tangentially to the spherical surface. This means that the virtual shell line of the second truncated cone surface touches the spherical surface in one and only one point. This makes the transition from the second truncated cone surface to the spherical surface very smooth. The very smooth transition between the second truncated cone surface and the spherical surface creates an improved fluid flow along the inner surface from the second truncated cone surface to the spherical surface. A particular advantageous fluid flow is achievable which helps to enhance the overall efficiency of the valve seat body and therefore of the fluid injector. In addition, the sac volume in flow direction below the sealing edge can be reduced due to the tangentially orientation of the spherical surface to the second truncated cone surface. A particular good efficiency of the valve seat body and the fluid injector is therefore achievable.

[0020] According to one embodiment, the first angle between the first truncated cone surface and the central longitudinal axis is larger than the second angle between

the second truncated cone surface and the central longitudinal axis. This means that the inclination of the first truncated cone surface is smaller than the inclination of the second truncated cone surface. With this configuration it is possible to direct the fluid flow along the inner surface very smoothly from the area circumferentially around the valve needle to the fluid flows along the inner surface when the fluid injector is in operation. In particular, it is possible to reduce the flow diameter along the inner surface very smoothly which helps to improve the fluid flow dynamics and to reduce the flow losses in the fluid flow.

[0021] According to one embodiment, the profile of the inner surface from the largest radius of the first truncated cone surface to the central longitudinal axis is continuously differentiable. This means that the profile of the inner surface from the largest radius of the first truncated cone surface to the central longitudinal axis does not comprise any portion, for example steps or kinks, which make the profile differentiable but not continuously differentiable or even not differentiable. With the profile of the inner surface according to this embodiment the fluid flow along the inner surface is particular smooth. A particular improved fluid flow is therefore achievable.

[0022] According to one embodiment, a first transition edge is arranged between the first truncated cone surface and the second truncated cone surface. The transition edge is a chamfer or a rounding. According to this embodiment, a chamfer or a rounding is arranged between the first truncated cone surface and the second truncated cone surface. A particular smooth transition between the first truncated cone surface and the second truncated cone surface is achievable and a particularly advantageous fluid flow characteristic along the inner surface from the first truncated cone surface to the second truncated cone surface is therefore achievable. This could help to reduce fluid flow losses due to for example eddies induced in the fluid flow by an edge between the first truncated cone surface and the second truncated cone surface.

[0023] According to one embodiment, at least one of the flow holes has at least two different diameters along its extension. This means in particular, that the flow hole comprises a step along its axial extension. Such a flow hole is conventionally called a stepped flow hole. A particular good injection quality out of the flow hole according to this embodiment is achievable.

[0024] According to one embodiment, the valve seat body comprises an outer surface wherein a normal of the outer surface is orientated in the main fluid flow direction. The outer surface is the surface which comprises the outlet portion of the flow holes of the valve seat body. The outer surface is therefore for example orientated towards a combustion chamber of an internal combustion engine when the valve seat body is arranged in a fluid injector which is arranged in an internal combustion engine. The outer surface according to this embodiment comprises a flat ring surface and a protrusion surface.

According to this embodiment, the flat ring surface is arranged coaxially with respect to the central longitudinal axis and the flat ring surface extends from a valve seat body diameter to the protrusion surface. The valve seat body diameter is for example the largest valve seat body diameter.

[0025] According to this embodiment, the flat ring surface is arranged coaxially with respect to the central longitudinal axis. This means in particular that the center axis of the flat ring surface is coaxially to the central longitudinal axis. The center axis is the axis around which the profile of the flat ring surface is rotated by 360 degree to create the flat ring surface. In addition, also the center axis of the protrusion surface is coaxially with the central longitudinal axis. The center axis is the axis around which the profile of the protrusion surface is rotated by 360 degree to create the protrusion surface. The protrusion surface extends from the flat ring surface to the central longitudinal axis. The outer surface according to this embodiment comprises the flat ring surface and the protrusion surface. The flat ring surface extends in radial direction with respect to the central longitudinal axis according to one embodiment starting from the protrusion surface in a rectangular manner. The protrusion surface projects beyond the flat ring surface in the main fluid flow direction. According to one embodiment, each of the outlet portions of the flow holes are arranged in the protrusion surface. According to one embodiment, the flat ring surface comprises a rounding or a chamfer at its outer edge.

[0026] According to one embodiment, the profile of the outer surface from the largest radius of the flat ring surface to the central longitudinal axis is continuously differentiable and the profile of the protrusion surface follows at least partially the profile of the inner surface. According to this embodiment the outer surface does not comprise any portion or area which create a profile of the outer surface which is not continuously differentiable. With an outer surface according to this embodiment the fluid flows out of the flow holes can be guided in a particular advantageous manner. In addition, a particular small valve seat body is formed. According to this embodiment, the protrusion surface follows at least partially the profile of the inner surface. Because of this, it is possible to achieve a structural robustness for the desired fluid pressure by minimizing the required thickness.

[0027] According to one embodiment, the flat ring surface extends radially from its radial outer end to a virtual axial extension of the largest radius of the first truncated cone surface as radial inner end. The virtual axial extension is a virtual cylinder which is coaxially arranged with respect to the central longitudinal axis, wherein the radius of the virtual cylinder is the same as the largest radius of the first truncated cone surface.

[0028] According to another embodiment, the flat ring surface extends radially from its radial outer end to a virtual axial extension of a valve needle ball of a valve needle when the valve seat body is arranged in a fluid injector as radial inner end. The virtual axial extension in

this case is a virtual cylinder which is coaxially arranged with respect to the central longitudinal axis, wherein the radius of the virtual cylinder is the same as the radius of the valve needle ball. A particular small valve seat body is achievable according to this embodiment.

[0029] According to one embodiment, the whole flat ring surface is positioned in axial direction with respect to the central longitudinal axis further downstream than the whole inner surface with respect to the main fluid flow direction. In other words, the flat ring surface is arranged in main fluid flow direction further away from the inlet portion of the valve seat body than the inner surface. When the valve seat body according to this embodiment is arranged in a fluid injector which is arranged in an internal combustion engine, then the whole flat ring surface is arranged towards the respective combustion chamber. During operation of the combustion chamber the flat ring surface can reach particular high temperatures which vaporize the fluid which eventually remains on the outer surface after an injection cycle. A particular good injection efficiency is therefore achievable.

[0030] According to one embodiment comprises the outer surface the flat ring surface, the protrusion surface and a cylindrical portion. According to this embodiment, the cylindrical portion is arranged coaxially with respect to the central longitudinal axis. The cylindrical portion extends from the outer radial edge of the flat ring surface in opposite direction of the main fluid flow direction with a specific height. When the valve seat body is arranged in an internal combustion engine, the flat ring surface of the valve seat body projects beyond the surface which limits the combustion chamber at the side of the valve seat body by the height of the cylindrical portion. The whole outer surface is inside the combustion chamber. According to this embodiment it is in particular possible to achieve high temperatures of the outer surface which vaporize the fluid which eventually remains on the outer surface after an injection cycle.

[0031] According to another embodiment, the outer surface of the valve seat body comprises a circular corona, the cylindrical portion, the flat ring surface and the protrusion surface. The outer surface according to this embodiment starts from the circular corona which is placed at a first distance from a valve body upper flat surface and which is arranged coplanar with a surface of the combustion chamber when the valve seat body is arranged in the combustion chamber. In other words, the circular corona is arranged flush with the surface of the combustion chamber, when the valve seat body is arranged in the combustion chamber. The cylindrical portion extends from radial inner edge of the circular corona to the radial outer edge of the flat ring surface. The height of the cylindrical portion is according to this embodiment the distance of which the flat ring surface projects beyond the surface of the combustion chamber when the valve seat body is arranged in the combustion chamber. The cylindrical portion and the circular corona are arranged coaxially with respect to the central longitudinal axis. The

circular corona creates a reduction of material of the cylindrical portion compared to the largest valve seat body diameter. Therefore, the diameter of the cylindrical portion is smaller than the largest valve seat body diameter. It is in particular easily possible to arrange the valve seat body in the internal combustion engine according to this embodiment due to the circular corona.

[0032] According to one embodiment, the fluid injector may be received in a receptacle bore of a cylinder head, the cylinder head comprising the combustion chamber limiting surface. The receptacle bore has an opening located in the combustion chamber limiting surface. The fluid injector, when mounted in the cylinder head, extends through the opening into the combustion chamber in such fashion that the outer surface is offset in the main fluid flow direction relative to the opening with the cylindrical portion, the flat ring surface and the protrusion surface. During operation of the combustion chamber, the outer surface can reach high temperatures which vaporize the fluid which eventually remains on the outer surface after an injection cycle. A particular good injection efficiency is therefore achievable. In addition, it is possible to reduce the emissions, in particular particle emissions.

[0033] According to one embodiment, the protrusion surface of the outer surface comprises a first truncated cone and a spherical surface which is arranged tangentially with the first truncated cone. According to another embodiment, the protrusion surface of the outer surface comprises the first truncated cone surface, a second truncated cone surface and a spherical surface, wherein the surfaces forming the protrusion surface of the outer surface are arranged coaxially with respect to the central longitudinal axis. The radius of the first truncated cone surface, according to this embodiment, decreases along the main fluid flow direction. The second truncated cone surface is according to this embodiment arranged adjacent to the smallest radius of the first truncated cone surface and the radius of the second truncated cone surface of the protrusion surface decreases along the main fluid flow direction. The angle between the first truncated cone surface and the central longitudinal axis differs, according to this embodiment, from the angle between the second truncated cone surface of the protrusion surface and the central longitudinal axis. The spherical surface of the protrusion surface is arranged, according to this embodiment, adjacent to the second truncated cone surface of the protrusion surface, wherein the spherical surface extends from the smallest radius of the second truncated cone surface to the longitudinal axis. According to this embodiment, it is advantageously achievable that the outer surface follows the inner surface which helps to improve the injection spray of the fluid flow out of the flow holes. According to another embodiment, the radial inner edge of the flat ring surface is arranged adjacent to the largest radius of the first truncated cone surface. According to yet another embodiment, a rounding or a chamfer is arranged between the radial inner edge of the flat ring surface and the first truncated cone surface of the pro-

trusion surface and/or between the first truncated cone surface and the second truncated cone surface of the protrusion surface. According to another embodiment is the second truncated cone surface of the protrusion surface arranged tangentially to the spherical surface of the protrusion surface. A particular thin wall in the area of the flow holes is according to this embodiment achievable while fulfilling structural requirements as well as a particular short flow hole length for an optimized fluid spray.

[0034] According to one embodiment, the first truncated cone surface, the second truncated cone surface and the spherical surface of the protrusion surface follows at least partially the profile of the inner surface. Because of this it is possible to increase the wall thickness in the area of the flow holes and adjust their length as desired to fulfill structural requirements and to optimize the fluid spray out of the flow holes.

[0035] According to the present disclosure, a fluid injector for an internal combustion engine comprises a valve seat body with the features according to the present disclosure.

[0036] According to one embodiment, the sealing edge of the fluid injector is formed between the second truncated cone surface of the inner surface of the valve seat body and the valve needle of the fluid injector. According to this embodiment of the fluid injector, the first truncated cone surface is completely arranged upstream of the sealing edge and the spherical surface of the inner surface is completely arranged downstream of the sealing edge with respect to the main fluid flow direction.

[0037] According to this embodiment, it is conceivable that the second truncated cone surface of the inner surface is divided by the sealing edge into a first portion which is arranged upstream of the sealing edge and a second portion which is arranged downstream of the sealing edge with respect to the main fluid flow direction. It is also conceivable that the sealing edge is arranged almost at the largest radius of the second truncated cone surface or almost at the smallest radius of the second truncated cone surface. If this is the case, the second truncated cone surface is either completely arranged upstream of the sealing edge or downstream of the sealing edge with respect to the main fluid flow direction.

[0038] According to one embodiment, the sealing edge of the fluid injector is formed between the inner surface and a spherical valve needle ball of the valve needle of the fluid injector. The spherical valve needle ball is a spherical ball or a part of a spherical ball which is arranged at a tip of the valve needle and which engages with the valve seat body to form the sealing edge when the valve needle is in the closed position to inhibit the fluid flow out of the flow holes of the valve seat body. The spherical surface of the valve needle ball which engages with the inner surface of the valve seat body creates in an advantageous manner the fluid-tight sealing edge. A particular good sealing quality is therefore achievable.

[0039] According to one embodiment, the spherical valve needle ball has a diameter of between 1,9 mm and

2,7 mm. Such a relatively small spherical valve needle ball helps to reduce the required installation space of the spherical valve needle ball. Because of this, it is possible to reduce the overall size of the valve seat body which reduces the installation space of the valve seat body in the fluid injector. Because of the reduced size of the valve seat body, it is also possible to reduce the size of the fluid injector. In addition, it is with the relatively small diameter of the spherical valve needle ball possible to create a relatively small sealing edge diameter. A particular good sealing quality, especially at high fluid pressure, is, according to this embodiment, achievable. Due to the reason that the valve needle ball diameter is reduced, the diameter of the guiding surface is also reduced. Therefore, the radial distance between the guiding surface and the sealing edge is also reduced. A particular stress reduction in the valve seat body in the area between the inner surface and the outer surface near the central longitudinal axis. This further creates the possibility to minimize the thickness of this area with respect to the structural robustness.

[0040] According to one embodiment the radius which forms the spherical surface of the valve seat body is the same or smaller than the radius of the spherical surface of the spherical valve needle ball. According to this embodiment, it is possible that the sac volume is even further reduced. In addition, it is according to this embodiment possible, to create a fluid flow volume along the inner surface and the spherical valve needle ball to the flow holes without any sharp edge which may induce eddies in the fluid flow. A particular good fluid flow is achievable. This helps to improve the fluid flow along the inner surface and the spherical valve needle ball if the valve needle is displaced away from the inner surface to enable the fluid flow out of the flow holes. Because of this it is possible to improve the overall efficiency of the fluid injector especially with the high pressurized fluid inside the fluid injector.

[0041] Further advantageous embodiments of the present disclosure will become apparent from the detailed description of exemplarily embodiments in connection with the figures. In the figures:

- Fig. 1 shows a schematic cross-section of a fluid injector according to a first exemplary embodiment with a valve seat body according to a first exemplary embodiment,
- Fig. 2 shows a schematic cross-section of a valve seat body according to a second exemplary embodiment,
- Fig. 3 shows a schematic cross-section of a valve seat body according to a third exemplary embodiment,
- Fig. 4 shows a schematic cross-section of a valve seat body according to a fourth exemplary em-

bodiment,

- Fig. 5 shows a schematic cross-section of a valve seat body according to a fifth exemplary embodiment,
- Fig. 6 shows a schematic cross-section of a valve seat body according to a sixth exemplary embodiment,
- Fig. 7 shows a schematic cross-section of a valve seat body according to a seventh exemplary embodiment,
- Fig. 8 shows a schematic cross-section of a valve seat body according to an eight exemplary embodiment.

[0042] Fig. 1 shows a valve assembly 110 of a fluid injector 100. The valve assembly 110 comprises a valve seat body 120 and a valve needle (not shown). The valve needle comprises a valve needle ball 140. The valve needle ball 140 is shown in a transparent half section. The valve seat body 120 comprises further a valve seat body cavity 150. The valve seat body 120 extends in axial direction along a central longitudinal axis 160. The valve seat body 120 comprises a plurality of flow holes 340 through which fluid flows from an inlet portion of the flow holes 340 to an outlet portion of flow holes 340 along a main fluid flow direction (130) when the fluid injector 100 is in operation. The valve seat body 120 is partially hollow and comprises further an inner surface 200. The inner surface 200 is the surface which forms the valve seat body cavity 150.

[0043] The inner surface 200 comprises a first truncated cone surface 210, a second truncated cone surface 230 and a spherical surface 240. A first transition edge 220 is arranged between the first truncated cone surface 210 and the second truncated cone surface 230. The transition edge 220 shown in fig. 1 is a rounding. The rounding smoothens the transitions between the first truncated cone surface 210 and the second truncated cone surface 230. The first truncated cone surface 210, the second truncated cone surface 230 and the spherical surface 240 are arranged coaxially with respect to the central longitudinal axis 160. The first truncated cone surface 210 and the second truncated cone surface 230 are arranged so that the radius of each truncated cone surface 210, 230 decreases along a main fluid flow direction 130. The main fluid flow direction 130 is in particular directed along the central longitudinal axis 160 from an inlet portion of the fluid injector 100 to an outlet portion of the fluid injector 100.

[0044] The spherical surface 240 is arranged adjacent to the second truncated cone surface 230 and the spherical surface 240 extends from the smallest radius of the second truncated cone surface 230 to the central longitudinal axis 160 and forms the bottom of the valve seat

body cavity 150. According to this embodiment the second truncated cone surface 230 is arranged tangentially to the spherical surface 240.

[0045] As it can be seen in fig. 1 the first angle between the first truncated cone surface 210 and the central longitudinal axis 160 is larger than the second angle between the second truncated cone surface 230 and the central longitudinal axis 160. As it can be seen further in fig. 1 a sealing edge 270 is formed between the valve needle ball 140 of the valve needle and the second truncated cone surface 230. When the valve needle ball 140 contacts the inner surface 200 and creates the sealing edge 270 on the inner surface 200, then the valve seat body cavity 150 is divided into a first cavity volume 250 which is arranged upstream of the sealing edge 270 with respect to the main fluid flow direction 130 and a second cavity volume / sac volume 260 which is arranged downstream of the sealing edge 270 with respect to the main fluid flow direction 130. The inlet portion of each flow hole 340 is arranged towards the second cavity volume / sac volume 260 downstream of the sealing edge 270 so that the fluid flow out of the fluid injector can be inhibited by the valve needle when the valve needle is in contact with the inner surface 200.

[0046] The valve seat body 120 according to fig. 1 shows a plurality of guiding surfaces 170 in the valve seat body cavity 150 which extend along the central longitudinal axis and which are arranged to guide the valve needle and in particular the valve needle ball 140. The valve seat body 120 further comprises flow channels 180 which are arranged to allow fluid to flow along the valve needle ball 140 to the sealing edge 270.

[0047] As it can be seen in fig. 1 the valve seat body 120 comprises further an outer surface 300 which comprises a protrusion surface 310, a flat ring surface 320, a cylindrical portion 370 and a circular corona 350. The outer surface 300 according to this embodiment starts from the circular corona 350 which is placed at a first distance 360 from a valve body upper flat surface 400 and which is arranged coplanar with a surface of the combustion chamber when the valve seat body 120 is arranged in the combustion chamber. In other words, the circular corona 350 is arranged flush with the surface of the combustion chamber, when the valve seat body 120 is arranged in the combustion chamber. The first distance 360 is according to one embodiment 1,7 mm. The cylindrical portion 370 extends from the radial inner edge of the circular corona 350 to the radial outer edge of the flat ring surface 320. The height 380 of the cylindrical portion 370 from the circular corona 350 to the flat ring surface 320 is according to this embodiment between 0,5 mm and 1 mm, preferably between 0,6 and 1 mm. The height 380 of the cylindrical portion 370 is according to this embodiment the distance of which the flat ring surface 320 projects beyond the surface of the combustion chamber when the valve seat body 120 is arranged in the combustion chamber. The cylindrical portion 370 is arranged coaxial with respect to the central longitudinal axis 160.

The cylindrical portion 370 has according to this embodiment a diameter 390 which is between 4,7 mm and almost the largest valve seat body diameter 330 which is the radial outer edge of the circular corona 350. The largest valve seat body diameter 330 is according to one embodiment between 5,9 mm and 8 mm. Therefore, the radial outer edge of the circular corona is between 5,9 mm and 8 mm. The flat ring surface 320 extends in radial direction rectangular with respect to the central longitudinal axis 160 from the longitudinal end of the cylindrical portion 370 which faces the combustion chamber when the valve seat body 120 is arranged in the combustion chamber to the protrusion surface 310. The protrusion surface 310 extends along the central longitudinal axis in main fluid flow direction 130 out of the flat ring surface 320. The protrusion surface 310 comprises according to this embodiment an outer truncated cone surface 420 which is adjacent to the flat ring surface 320 and a spherical surface 410 which is tangentially arranged to the outer truncated cone surface 420. The spherical surface 410 extends from the outer truncated cone surface 420 to the central longitudinal axis 160.

[0048] Fig. 1 shows only one flow hole 340 in cross section view which extends from the second cavity volume / sac volume 260 through the valve seat body 120 to the outer surface 300 of the valve seat body 120. The thickness from the inner surface 200 to the outer surface 300 at the central longitudinal axis 160 is according to the embodiment shown in fig. 1 between 0,29 mm to 0,36 mm. The embodiment shown in fig. 1 is for example used for fluid pressure inside the valve seat body cavity 150 of more than 30 MPa in particular for 35 MPa.

[0049] The number, size, diameter and taper of the flow holes 340 may differ in different embodiments. For example, the total number of flow holes 340 is five, six, seven or eight.

[0050] Fig. 2 shows a longitudinal section view of a valve seat body 120 according to a second exemplary embodiment. In contrast to the first exemplary embodiment the valve seat body 120 according to the second exemplary embodiment comprises a flow hole 340 which has two different diameters along its extension. Such flow holes are also called stepped flow hole 345. With such stepped flow holes, it is possible to adjust the fluid spray properties. According to this embodiment, the thickness from the inner surface 200 to the outer surface 300 at the central longitudinal axis 160 is larger compared to the embodiment shown in fig. 1. This thickness is according to this embodiment for example between 0,4 mm and 0,48 mm. Despite this thickness is due to the stepped flow hole 345 a good fluid spray achievable. The embodiment shown in fig. 2 is for example used for fluid pressure inside the valve seat body cavity 150 of more than 30 MPa in particular for 35 MPa. The outer truncated cone surface 420 according to this embodiment has compared to first exemplary embodiment a larger inclination.

[0051] Fig. 3 shows a longitudinal section view of a valve seat body 120 according to a third exemplary em-

bodiment. In contrast to the first and second exemplary embodiment the valve seat body 120 according to the third exemplary embodiment shows two flow holes 340 in section view which are directed in different directions. The first flow hole is substantially arranged parallel to the central longitudinal axis 160 and the second flow hole 340 is arranged with an angle of about 35° with respect to the central longitudinal axis 160. The thickness between the inner surface 200 and the outer surface 300 according to this embodiment is compared to the embodiment shown in fig. 1 and fig. 2 larger and is able to guarantee structural integrity with the high fuel pressure inside the valve seat body cavity 150. This thickness is according to this embodiment for example between 0,4 mm and 0,48 mm. The embodiment shown in fig. 3 is for example used for fluid pressure inside the valve seat body cavity 150 of more than 45 MPa in particular for 50 MPa.

[0052] Fig. 4 shows a longitudinal section view of a valve seat body 120 according to a fourth exemplary embodiment. In contrast to the second exemplary embodiment the valve seat body 120 according to the fourth exemplary embodiment has a larger thickness between the inner surface 200 and the outer surface 300 at the central longitudinal axis 160 than the second exemplary embodiment and the valve seat body 120 is therefore able to guarantee structural integrity with the higher fuel pressure inside the valve seat body cavity 150. This thickness is according to this embodiment for example between 0,49 mm and 0,56 mm. Despite this thickness is due to the stepped flow hole 345 a good fluid spray achievable. The embodiment shown in fig. 4 is for example used for fluid pressure inside the valve seat body cavity 150 of more than 45 MPa in particular for 50 MPa.

[0053] Fig. 5 shows a longitudinal section view of a valve seat body 120 according to a fifth exemplary embodiment. In contrast to the first exemplary embodiment the valve seat body 120 according to the fifth exemplary embodiment shows two flow holes 340 in a cross-sectional view. The flow holes 340 shown in fig. 5 are arranged symmetrically with respect to the cross-section view. The valve seat body 120 of fig. 5 comprises according to this embodiment six flow holes 340. In addition, the diameter 390 of the cylindrical portion 370 is equal to the largest valve seat body diameter 330. Therefore, the outer surface 300 according to this embodiment includes the cylindrical portion 370, the flat ring surface 320 and the protrusion surface 310. When the valve seat body 120 according to this embodiment is arranged in the internal combustion engine, the flat ring surface 320 projects beyond the surface of the combustion chamber starting from the longitudinal end of the cylindrical portion 370 which faces away from the combustion chamber. The height 380 of the cylindrical portion 370 extends from the first distance 360 to the flat ring surface 320 and is according to this embodiment between 0,5 mm and 1 mm, preferably between 0,6 mm and 1 mm. According to this embodiment no material reduction is created by the circular corona 350 as shown in other embodiments.

Therefore, the material on the outer edge of the flat ring surface 320 of the valve seat body 120 is increase, which helps to enhance the heat flux from the combustion chamber to the valve seat body 120. Therefore, a particular good evaporation of fluid / fuel which eventually remains on the tip after an injection cycle is achievable.

[0054] Fig. 6 shows a longitudinal section view of a valve seat body according to a sixth exemplary embodiment. In contrast to the second exemplary embodiment, the diameter 390 of the cylindrical portion 370 according to the seventh embodiment is equal to the largest valve seat body diameter 330.

[0055] Fig. 7 shows a longitudinal section view of a valve seat body according to a seventh exemplary embodiment. In contrast to the third exemplary embodiment, the diameter 390 of the cylindrical portion 370 according to the seventh embodiment is equal to the largest valve seat body diameter 330.

[0056] Fig. 8 shows a longitudinal section view of a valve seat body according to an eighth exemplary embodiment. In contrast to the fourth exemplary embodiment, the diameter 390 of the cylindrical portion 370 according to the eighth exemplary embodiment is equal to the largest valve seat body diameter 330.

Claims

1. A valve seat body (120) for a fluid injector (100) of an internal combustion engine, wherein the valve seat body (120) extends in axial direction along a central longitudinal axis (160), wherein the valve seat body (120) comprises a plurality of flow holes (340) through which fluid flows from an inlet portion of the flow holes (340) to an outlet portion of the flow holes (340) when the fluid injector (100) is in operation, and wherein the valve seat body (120) comprises an inner surface (200) which is configured to form a sealing edge (270) between the inner surface (200) and a valve needle of the fluid injector (100) when the fluid injector (100) is in operation, wherein the inner surface (200) comprises:

- a first truncated cone surface (210) which is coaxially arranged with respect to the central longitudinal axis (160) and wherein the radius of the first truncated cone surface (210) decreases along a main fluid flow direction (130),
- a second truncated cone surface (230) which is arranged adjacent to the smallest radius of the first truncated cone surface (210) and coaxially with respect to the central longitudinal axis (160), wherein the radius of the second truncated cone surface (230) decreases along the main fluid flow direction (130), wherein a first angle between the first truncated cone surface (210) and the central longitudinal axis (160) differs from a second angle between the second truncated cone surface (230) and the central longitudinal axis (160).

cated cone surface (230) and the central longitudinal axis (160), and

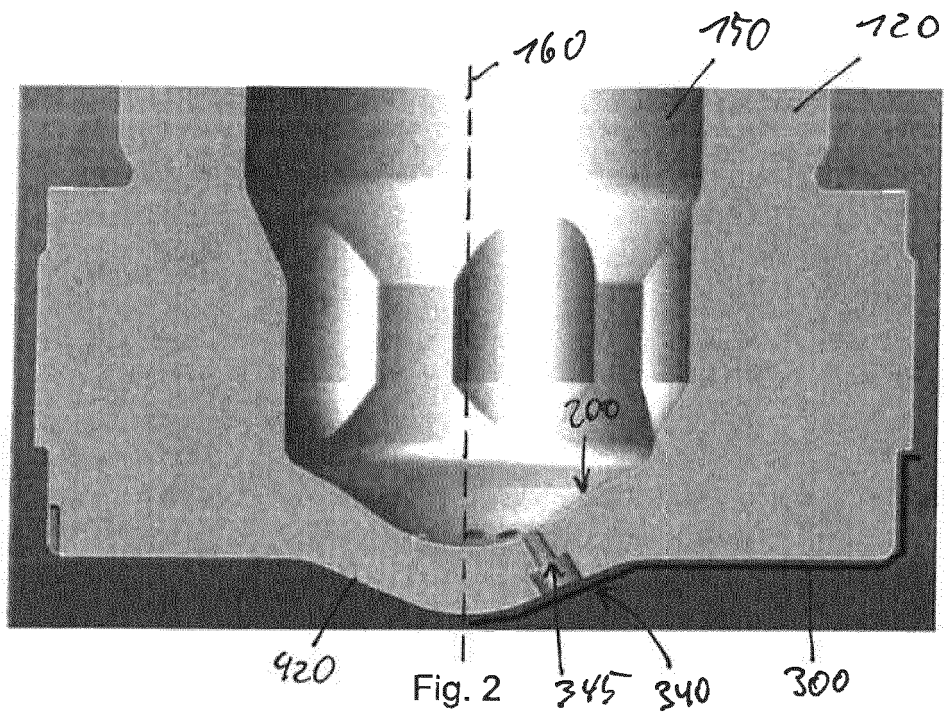
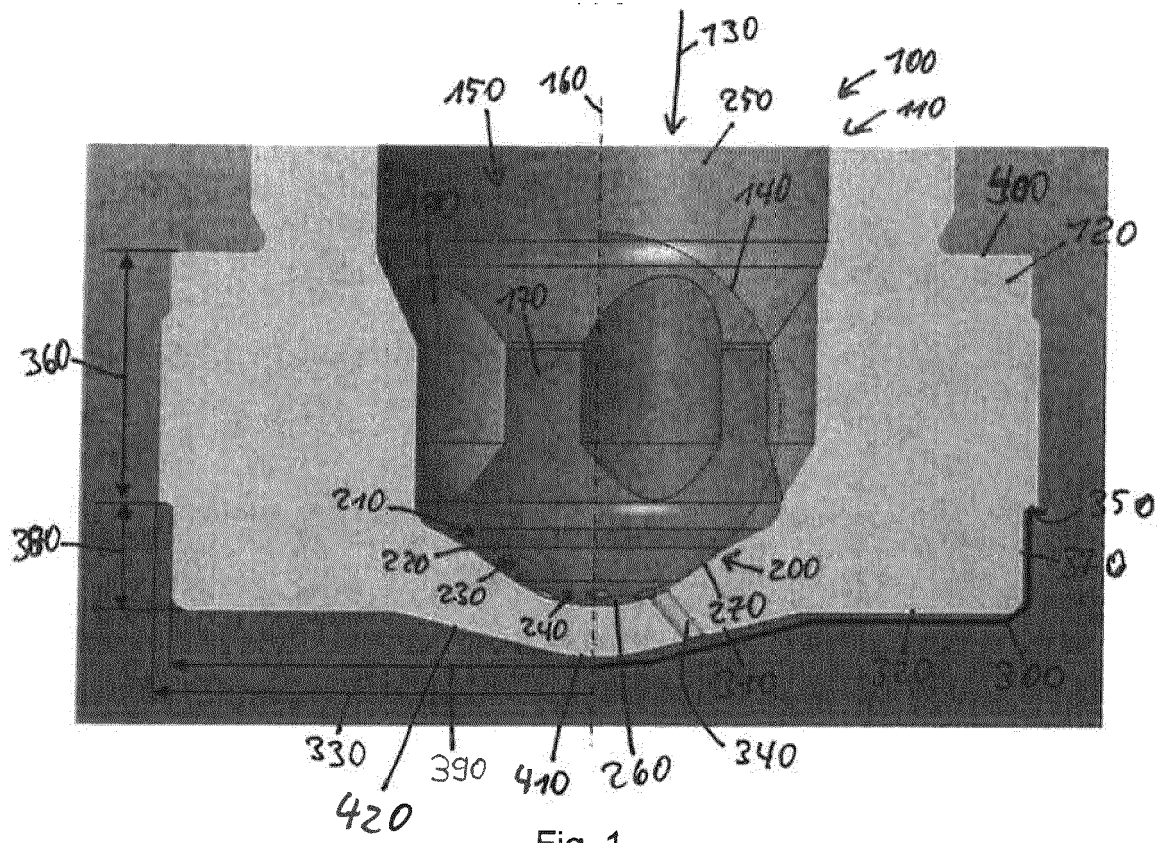
- a spherical surface (240) which is arranged adjacent to the second truncated cone surface (230) and which is coaxially arranged with respect to the longitudinal axis (160), wherein the spherical surface (240) extends from the smallest radius of the second truncated cone surface (230) to the longitudinal axis,

wherein the inlet portion of each flow hole (340) is arranged at the inner surface (200) downstream of the sealing edge (270).

2. The valve seat body (120) according to claim 1, wherein the second truncated cone surface (230) is arranged tangentially to the spherical surface (240).
3. The valve seat body (120) according to any one of the preceding claims, wherein the first angle between the first truncated cone surface (210) and the central longitudinal axis (160) is larger than the second angle between the second truncated cone surface (230) and the central longitudinal axis (160).
4. The valve seat body (120) according to any one of the preceding claims, wherein a profile of the inner surface (200) from the largest radius of the first truncated cone surface (210) to the central longitudinal axis (160) is continuously differentiate.
5. The valve seat body (120) according to any one of the preceding claims, wherein a first transition edge (220) is arranged between the first truncated cone surface (210) and the second truncated cone surface (230), and wherein the transition edge (220) is a chamfer or a rounding.
6. The valve seat body (120) according to any one of the preceding claims, wherein at least one of the flow holes (340) has at least two different diameters along its extension.
7. The valve seat body (120) according to any one of the preceding claims, wherein the valve seat body (120) comprises an outer surface (300), wherein a normal of the outer surface (300) is orientated in axial direction away from the inner surface (200), wherein the outer surface (300) comprises a flat ring surface (320), a cylindrical portion (370) and a protrusion surface (310), wherein the flat ring surface (320), the protrusion surface (310) and the cylindrical portion (370) are arranged coaxially with respect to the central longitudinal axis (160), wherein the protrusion surface (310) extends from the central longitudinal axis (160) to the flat ring surface (320) and projects beyond the flat ring surface (320), wherein the flat ring surface (320) extends from the protrusion sur-

face (310) to the cylindrical portion (370), wherein the cylindrical portion (370) extends from the outer radial edge of the flat ring surface (320) in opposite direction of the main fluid flow direction with a specific height.

8. The valve seat body (120) according to claim 7, wherein the profile of the outer surface (300) from the largest radius of the flat ring surface (320) to the central longitudinal axis (160) is continuously differentiable and the profile of the protrusion surface (310) follows at least partially the profile of the inner surface (200).
9. The valve seat body (120) according to claim 7 or 8, wherein the flat ring surface (320) extends radially from its radial outer edge to a virtual axial extension of the largest radius of the first truncated cone surface (210).
10. The valve seat body (120) according to any one of the claims 7 to 9, wherein the flat ring surface (320) is positioned in axial direction with respect to the central longitudinal axis (160) further downstream than the whole inner surface (200) with respect to the main fluid flow direction (130).
11. A Fluid injector (100) for an internal combustion engine comprising a valve seat body (120) according to any one of the preceding claims.
12. The fluid injector (100) according to claim 11, wherein the sealing edge (270) is formed between the second truncated cone surface (230) of the inner surface (200) and the valve needle of the fluid injector (100).
13. The fluid injector (100) according to any one of the claims 11 or 12, wherein the valve needle comprises a spherical valve needle ball (140), and wherein the sealing edge (270) is formed between the inner surface (200) and the spherical valve needle ball (140) of the valve needle of the fluid injector.
14. The fluid injector (100) for an internal combustion engine, according to claim 13, wherein the spherical valve needle ball (140) has a diameter of between 1,9 mm and 2,7 mm.
15. The fluid injector (100) for an internal combustion engine, according to claim 13 or 14, wherein the radius which forms the spherical surface (240) of the valve seat body (120) is the same or smaller than the radius of the spherical valve needle ball (140).



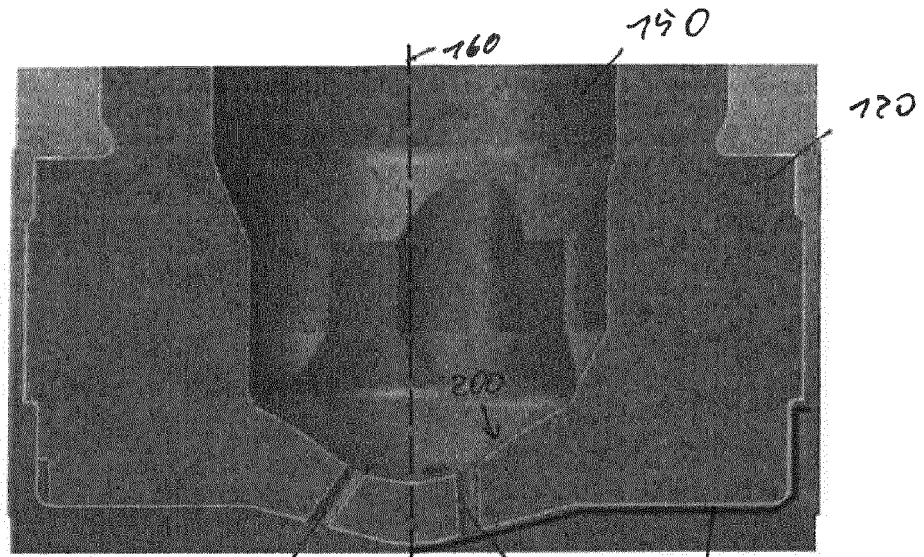


Fig. 3

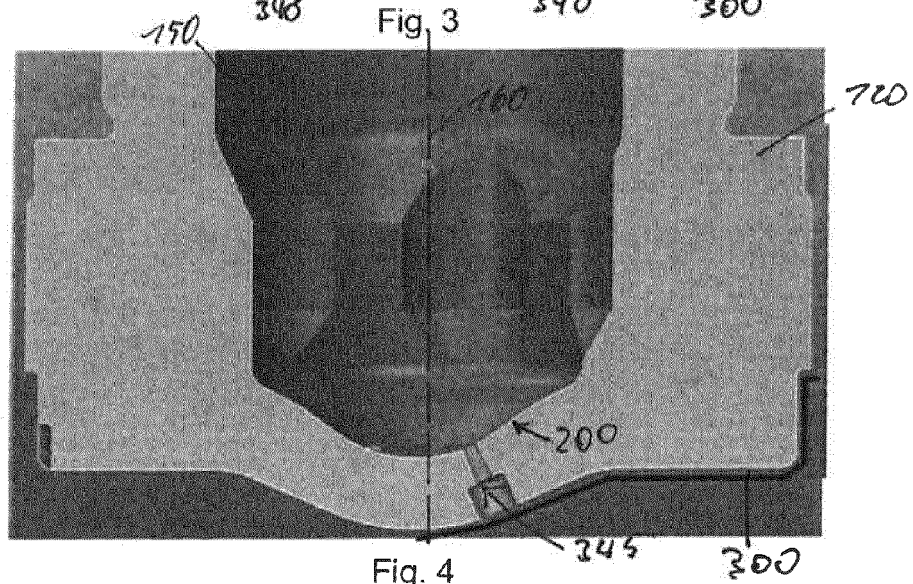


Fig. 4

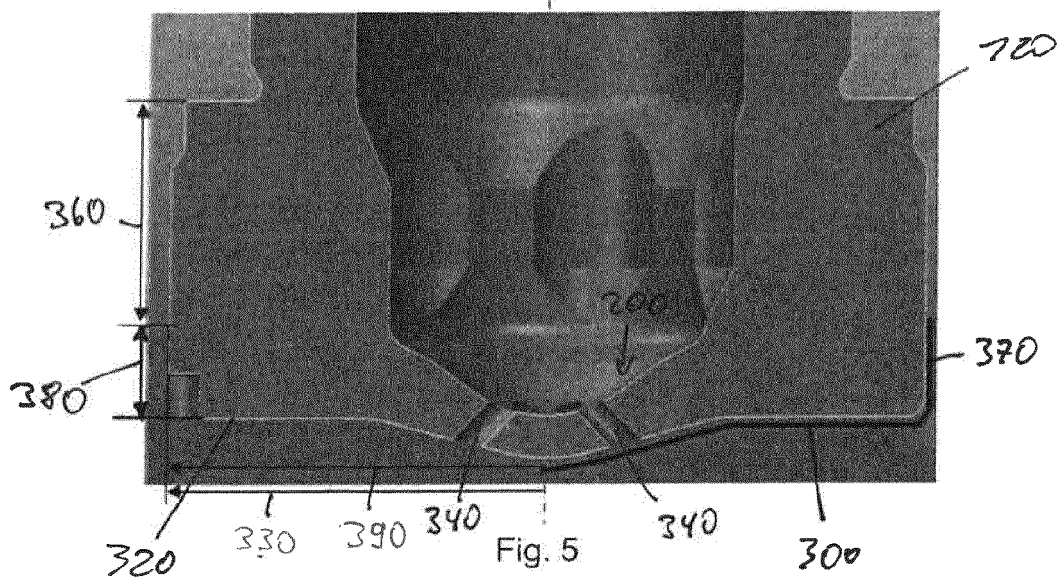
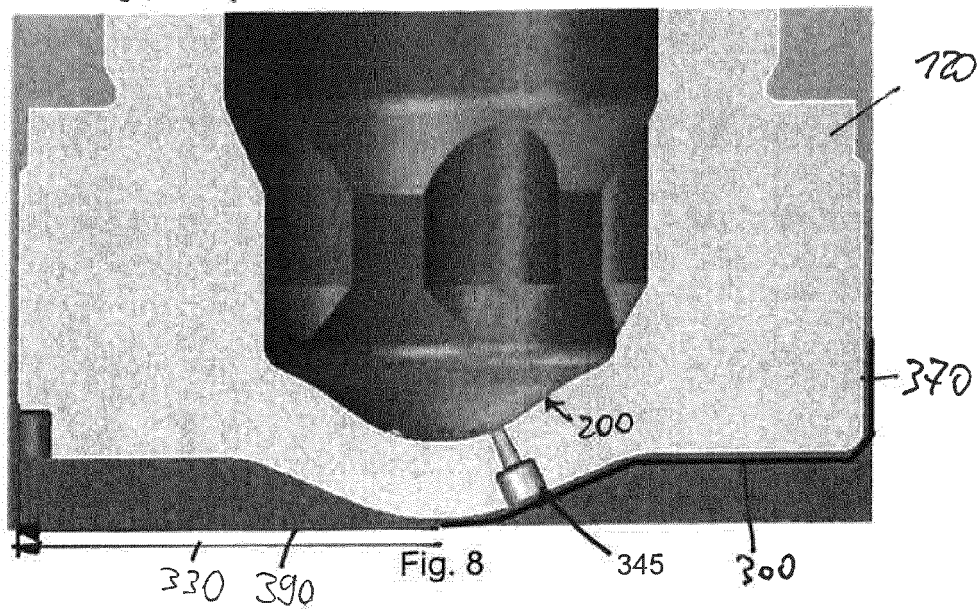
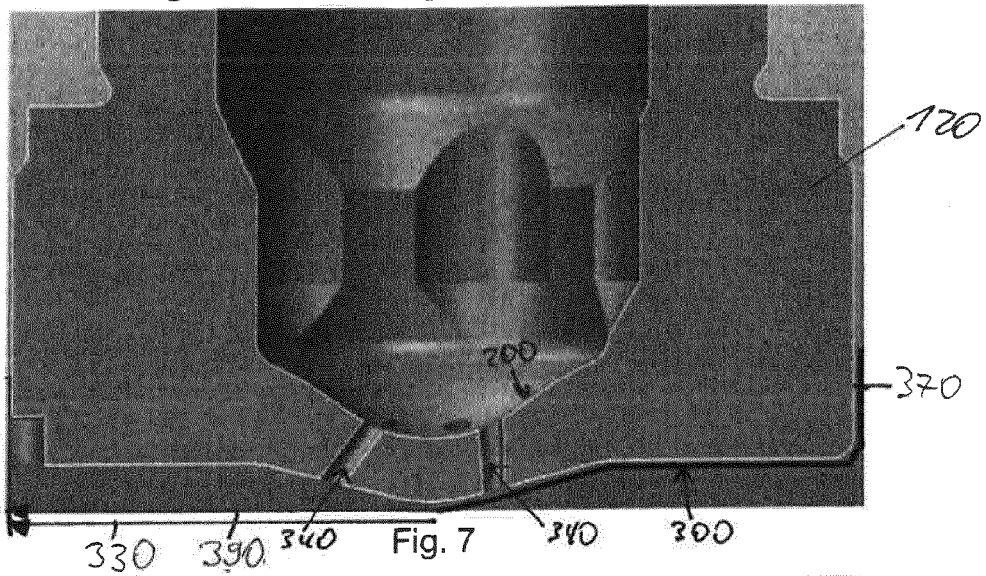
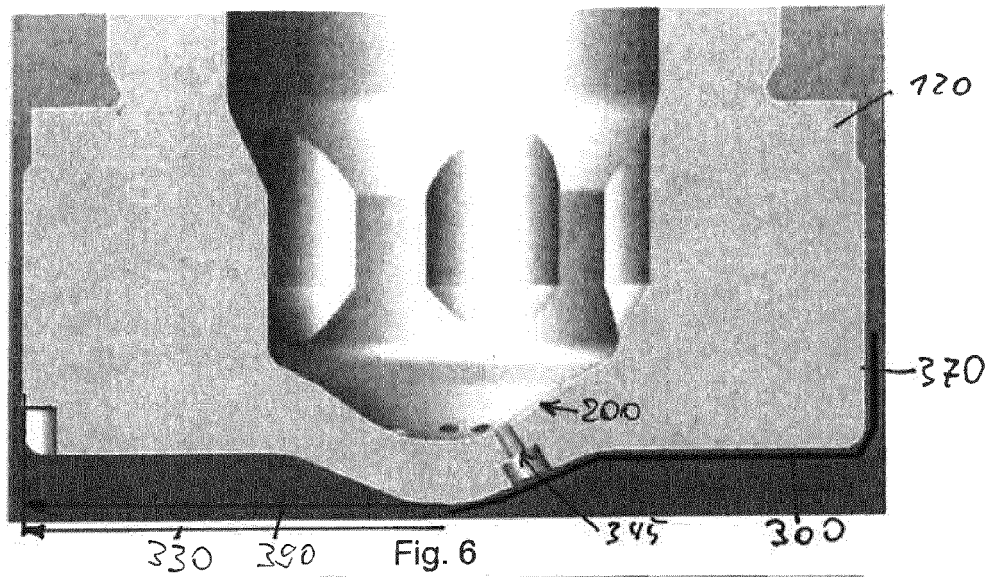


Fig. 5





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Application Number
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Place of search		Date of completion of the search	Examiner
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