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FUEL INJECTION DEVICE

The invention relates to a fuel injection device for internal combustion engines, in particular large two-stroke diesel engines, comprising a nozzle head protruding into an associated combustion chamber, arranged eccentrically in relation to the axis of the combustion chamber; said nozzle head comprising a blind borehole through which fuel can be admitted, with several nozzle bores emanating from said blind borehole; said nozzle bores being able to be controlled up or down by a slide element arranged in the blind borehole; said slide element being preferably axially slidable as a result of the fuel pressure, against the action of a return device; with said nozzle bores, for generating a mutual injection jet, being arranged in a borehole row facing the circumferential area of the blind borehole, in relation to the axis of the blind borehole arranged approximately at the same height; with at least the axes of the outer nozzle bores of the row of boreholes being inclined inward in a radial arrangement in relation to the axis of the blind borehole, so as to achieve an acute diverging angle of the injection jet.

A fuel injection device of this type is known from EP 0 606 371 B1. In the case of large two-stroke diesel engines with a central outlet valve provided in the cylinder head, as a rule the fuel injection device needs to be arranged in the region of the periphery of the combustion chamber. The nozzle bores of the nozzle head are arranged in such a way that a main injection direction emanating from one side of the nozzle head results. So as to avoid large lateral

dispersion of the injection jet, the nozzle bores, in relation to the axis of the blind borehole are not arranged radially but instead are aligned towards the main direction of injection. This results in differing lengths of the nozzle bores and in various borehole lengths across the circumference of individual boreholes. At the same time it results in large variations in margin angles in the region of the inner ends of the nozzle bores. Thus there are widely varying conditions for the entry of fuel into the individual nozzle bores and accordingly varying speeds and quantities of throughput. In particular in the region of the outer nozzle bores of a borehole row comprising several nozzle bores arranged side by side, the conditions are particularly unfavourable because of the widely differing wall lengths across the circumference of the individual boreholes. As a consequence of wall friction, which is particularly high in the region of the outer flanks, there is a particularly unstable current flow resulting in the injection jet taking along only a small quantity of air. This results in poor mixture formation and thus poor combustion which causes increased fuel consumption and increased emission of pollutants.

Based on the above, it is thus the object of the present invention to improve a device of the type mentioned in the introduction, using simple and cost-effective means, so that good combustion and thus low fuel consumption and low pollutant emission can be achieved.

According to the invention, this object is met in that at least some of the nozzle bores are associated with inlet chambers emanating from the blind borehole, with the inside diameter of said inlet chambers being larger than the diameter of the nozzle bores and with said inlet chambers being configured in such a way that all nozzle bores of the row of boreholes are at least similar in length.

These measures ensure that in all nozzle bores almost the same conditions can be achieved for unhindered fuel entry. Thus by means of the entry chambers, it is advantageous if case lengths can be achieved which do not change across the circumference of the individual nozzle bores. Likewise, approximately the same lengths of boreholes for all nozzle bores can be achieved. Thus the measures according to the invention result in an advantageous way in averaging out wall friction and current flow rates, thus overall resulting in a stable injection jet. In particular as a result of stabilisation in the region of the outside nozzle bores of a row of boreholes, the transport of a comparatively large amount of air taken along by the injection jet is ensured. This leads to the expectation of good mixture formation and thus good combustion, resulting in low fuel consumption and low pollutant emission as well as low fouling of the engine. The measures according to the invention thus completely eliminate the disadvantages described in the introduction.

Advantageous embodiments and effective improvements of the generic measures are stated in the subordinate claims. It is thus effective if an entry chamber is associated with the outer nozzle bores of a row of boreholes. It is in the area of the outer nozzle bores of a row of boreholes that the largest effect can be achieved by means of the entry chambers according to the invention, because up to now, it was this area of the outer nozzle bores which was characterised by a most unstable mixture flow.

According to a first advantageous embodiment, the entry chambers are configured as recesses of hemispherical cross-sectional shape, in the nozzle head. The hemispherical recesses advantageously permit the creation of exactly identical margin angles across the entire circumference of a nozzle bore. It is effective if the hemispherical recesses are arranged such that their centre coincides with

the axis of the respectively associated nozzle bore, so that said nozzle bore is centred with reference to the associated entry chamber.

Shaping the entry chambers as hemispherical recesses of the nozzle head also ensures that it is possible in a simple way to associate a respective entry chamber with each nozzle bore, without the nozzle head having to be excessively weakened as a result of this.

There is a further advantage in that the hemispherical recesses may be arranged such that in the region of two adjacent recesses, a remaining stay is formed which can serve as a guide stay for the slide element, thus protecting said slide element against wear.

In another advantageous embodiment of the generic measures, the entry chambers are shaped as ring-segment shaped recesses in the nozzle head. This makes for particularly economic production. In addition this embodiment makes it possible to achieve comparatively easily, margin angles matched to 90 degrees, in the transition area between a nozzle bore and the associated inlet chambers.

There is a further advantage in that a middle group of nozzle bores flanked by other nozzle bores can be associated with a common entry chamber, without the nozzle head being excessively weakened.

In an improvement of the generic measures, a step-shaped enlargement in the cross-section, preferably formed by a step-shaped punch-out, may be provided at the outer end of the nozzle bore. This results in an advantageous way in a delimitation surface surrounding the outer end of the nozzle bores, along the normal axis. This ensures that interference to the jet is avoided, thus stabilising the jet which favours the transport of air. These stated

measures thus reinforce the already mentioned basic advantages of the present invention.

Further advantageous embodiments and effective improvements of the generic measures are stated in the remaining subordinate claims and are provided in more detail in the following exemplary description by means of a drawing, as follows:

Figure 1 is a section through an injector according to the invention, of a large two-stroke diesel engine;

Figure 2 is a horizontal section in the region of the nozzle bores, through the nozzle head of an injector of a large two-stroke diesel engine, of an embodiment with hemispherical entry chambers;

Figure 3 is an example with ring-segment shaped entry chambers in a representation corresponding to that of Figure 2; and

Figure 4 is a section along the line IV/IV of Figure 3.

The principal design and function of large two-stroke diesel engines are known per se and thus require no further explanation in the present context.

The injector shown in Figure 1 comprises a cylindrical outer case 2 tapering at the front, comprising a nozzle head 4 with a blind borehole 3. The rear flange of said nozzle head 4 is supported by a front collar of the outer case 2. The rear end of the nozzle head 4 is connected to a guide bush 5 accommodated in the outer case 2; said guide bush 5 comprising a through-borehole 6 coaxially arranged in relation to the blind borehole 3 of the nozzle head 4. Said through-borehole comprises a step-shaped throat, shaped as a valve seat 7 which interacts with a valve body

8 which protrudes away from a shaft 9 arranged in the guide bush 5. The diameter of the valve body 8 is smaller than the diameter of the shaft 9 so that a ring space 10 surrounding the valve body 8 and forming part of the borehole 6 results.

The shaft 9 is connected to a central borehole 11 connected to a fuel line, through which borehole 11, fuel can be admitted; said borehole 11 being connected with the ring space 10 via plunge boreholes 12. The valve body 8 is pushed to the seal seat 7 by the action of a return spring (not shown) interacting with the shaft 9. If there is a corresponding increase in pressure of the fuel present in the ring space 10, the valve body 8 is lifted off the associated seal seat 7, resulting in a connection between the region through which fuel can be admitted and the blind borehole 3 of the nozzle head 4.

In its lower section, the nozzle head 4 comprises several nozzle bores 13 arranged side-by-side at approximately the same height, aligned transversely to the axis of the blind borehole 3, with fuel being injectable into an associated combustion chamber by way of said nozzle bores 13. In order to ensure that, after closing the passage controlled by the valve body 8, fuel can no longer emanate from the nozzle bores 13, a ring-shaped slide element 15 connected with the valve body 8 by means of a rod 14 has been provided in the blind borehole 3, with the lower edge of said slide element 15 forming a control edge overtravelling the nozzle bores 13 which are arranged in such a way that the nozzle bores 13 are opened if the valve body 8 is lifted off the associated valve seat 7; and with the nozzle bores 13 being closed if the valve body 8 rests against the valve seat 7. Figure 1 shows this position.

In order to be able to inject the necessary quantity of fuel, several nozzle bores 13, laterally offset in relation

to each other in the direction of the axis of the blind borehole 3, have been provided, said nozzle bores 13 being arranged at approximately the same height, as is shown in Figures 2 and 3. The nozzle bores 13 can be arranged along the normal axis or, as shown in Figure 4, can be slightly inclined towards the outside. Since the injection jet generated jointly by the nozzle bores 13 should not diverge too much, the nozzle bores 13 are not radially arranged in relation to the axis of the blind borehole 3, but instead are directed towards the main injection direction in relation to a radial line, resulting in a smaller angle of diversion or angle of dispersion.

If the nozzle bores 13 were to lead through to the blind borehole 3 without any change in cross section, there would be very widely differing inflow characteristics to the individual nozzle bores 13 and also within individual nozzle bores 13. In particular the two outer nozzle bores 13 of the borehole row comprising four side-by-side nozzle bores 13 provided in this location, would be significantly longer than the inner nozzle bores 13, with differing lengths also resulting in the region of these outer nozzle bores 13 across their circumference. These conditions would result in poor combustion and thus high fuel consumption and high pollutant emission etc. To avoid this, entry chambers 16 emanating from the blind borehole 3 are associated with said nozzle bores 13, with the inside diameter of said entry chambers 16 being larger than the diameter of the nozzle bores 13.

In the embodiment according to Figure 2, hemispherical recesses 17 of the nozzle head 4 are provided to form the above-mentioned entry chambers emanating from the blind borehole 3. The hemispherical recesses 17 can simply be produced by electrolytic material removal by means of a device operating according to the EDM (electrical discharge

machining) process. The nozzle bores 13 themselves are bored simply by means of a laser beam.

The hemispherical recesses 17 forming an entry chamber are arranged such that their centre is positioned on the axis of the associated nozzle bore 13. In this way there is centring of the nozzle bores 13 in relation to the associated entry chamber. Such centring ensures that in the area of the transition between the entry chamber and the nozzle bore 13 a margin angle results which remains approximately the same across the entire borehole diameter, as indicated at point 18 in Figure 2.

The adjacent nozzle bores 13 of associated hemispherical recesses 17 are dimensioned such that a stay 19 remains between two adjacent hemispherical recesses 17, said stay 19 being able to act as a guide stay for the ring-shaped slide element 15, so that said ring-shaped slide element 15 can be reliably supported also in the area of the entry chambers, which is advantageous to achieve longevity.

In particular cases it is sufficient if an entry chamber 16 is associated only with the two outer nozzle bores 13. In the preferred embodiment upon which Figure 2 is based, entry chambers formed by hemispherical recesses 17 are associated with all nozzle bores 13 so that particularly good combustion conditions and thus particularly favourable fuel consumption can be expected.

In the embodiment shown in Figure 3, entry chambers 4 configured as ring-segment shaped recesses 20 of the nozzle head 4 are associated with the nozzle bores 13. The radii of the ring-segment shaped recesses 20 are adapted to the nozzle bore(s) 13 such that in the transition area between the entry chamber and the nozzle bore 13 a margin angle of as nearly as possible 90° results, as is indicated in Figure 3 item 21.

It would be imaginable to arrange an entry chamber of its own, formed by a ring segment 20, to every nozzle bore 13. In the example shown a common entry chamber formed by a ring segment 20 is associated with the two central nozzle bores 13. This ring segment 20 corresponds to a section of a ring groove, coaxial to the axis of the blind borehole 3 of the nozzle head 4, with said ring segment 20 being delimited by the adjacent ring segments 20 of smaller diameter, associated with the two outer nozzle bores 13.

These outer ring segments 20 are arranged such that their centre is located on the axis of the respectively associated nozzle bore 13 so that it is centred in relation to the associated entry chamber. This contributes to averaging out the inflow characteristics across the entire borehole diameter. The centre of the ring segment 20 associated with the two central nozzle bores 13 is located in the region between the two axes of the two associated nozzle bores 13.

In the region of the outer end of the nozzle bores 13 in the example shown in Figures 3 and 4, a punched-out part 22 of larger diameter than the nozzle bores 13 is provided. Said punched-out part 22 leads to a step-shaped cross-sectional enlargement with a ring area 23, aligned with the borehole axis and surrounding the end of the borehole. The punched-out part 22 ensures that the jet emanating from the nozzle bore 13 is not subject to any interference.

It would of course also be imaginable to provide punched-out parts of the type mentioned above also with the embodiment according to Figure 2.

Above, two embodiments of the invention have been described in more detail but without limitation to these. Thus it would be imaginable to associate part of the nozzle bores 13 with entry chambers formed by hemispherical recesses 17

and another part with entry chambers formed by one or several ring-segment shaped recesses 20, for example such that the outer nozzle bores 13 are associated with an entry chamber formed by hemispherical recesses 17 and that the inner nozzle bores 13 are associated with a common entry chamber formed by a ring-segment shaped recess 20.

CLAIMS

1. A fuel injection device for internal combustion engines, in particular large two-stroke diesel engines, comprising a nozzle head (4) protruding into an associated combustion chamber, arranged eccentrically in relation to the axis of the combustion chamber; said nozzle head (4) comprising a blind borehole (3) through which fuel can be admitted, with several nozzle bores (13) emanating from said blind borehole (3); said nozzle bores (13) being able to be controlled up or down by a slide element (15) arranged in the blind borehole (3); said slide element (15) being preferably axially slidable as a result of the fuel pressure, against the action of a return device; with said nozzle bores (13), for generating a mutual injection jet, being arranged in a borehole row facing the circumferential area of the blind borehole (3), in relation to the axis of the blind borehole (3) arranged approximately at the same height; with at least the axes of the outer nozzle bores (13) of the row of boreholes being inclined inward in a radial arrangement in relation to the axis of the blind borehole (3), so as to achieve an acute diverging angle of the injection jet, characterised in that at least part of the nozzle bores (13) are associated with inlet chambers (16) emanating from the blind borehole (3), with the inside diameter of said inlet chambers (16) being larger than the diameter of the nozzle bores (13) and with said inlet chambers (16) being configured in such a way that all nozzle bores (13) of the row of boreholes are at least similar in length.
2. A fuel injection device according to claim 1, characterised in that the case length of the nozzle

bores (13) remains essentially unchanged across their circumference.

3. A fuel injection device according to claim 1 or 2, characterised in that all nozzle bores are essentially identical in length.
4. A fuel injection device according to one of the preceding claims, characterised in that an entry chamber (16) is associated with at least the outer nozzle bores (13) of a row of nozzle bores.
5. A fuel injection device according to one of the preceding claims, characterised in that the entry chambers are at least partly shaped as recesses (17) of approximately hemispherical cross-sectional shape, in the nozzle head (4).
6. A fuel injection device according to claim 5, characterised in that an entry chamber shaped as a hemispherical recess (17) is associated with each nozzle bore (13).
7. A fuel injection device according to one of the preceding claims 5 or 6, characterised in that the centre of each hemispherical recess (17) forming an entry chamber is located on the axis of the respectively associated nozzle bore (13).
8. A fuel injection device according to one of the preceding claims 5 to 7, characterised in that a guide stay (19) is provided between adjacent entry chambers formed by hemispherical recesses (17).
9. A fuel injection device according to one of the preceding claims, characterised in that the entry

chambers are at least in part configured as ring-segment shaped recesses (20) of the nozzle head (20).

10. A fuel injection device according to claim 9, characterised in that a middle group of nozzle bores (13) flanked by other nozzle bores (13) is associated with a common entry chamber formed by a ring-segment shaped recess (20).
11. A fuel injection device according to one of claims 9 or 10, characterised in that the centre of the ring-segment shaped recess (20) forming an entry chamber associated with a nozzle bore (13) is aligned on the axis of the respectively associated nozzle bore (13).
12. A fuel injection device according to one of the preceding claims, characterised in that the walls of the nozzle bores (13) and the associated entry chambers encompass an angle of at least approximately 90° .
13. A fuel injection device according to one of the preceding claims, characterised in that at the outer end of the nozzle bores (13) a step-shaped cross-sectional enlargement formed by a punched-out part (22) is provided.
14. A fuel injection device according to claim 13, characterised in that the punched-out part (22) comprises an inner delimitation surface (23) arranged along the normal axis of the associated nozzle bore (13).