

### VALVE ARRANGEMENT FOR CHARGE EXCHANGE PROCESS

The invention relates to a valve arrangement for the charge exchange process of combustion engines, especially large two-cycle diesel engines.

Experience has shown that the valves used until now for the charge exchange process have a very limited service life because the known arrangements are very prone to blowouts. These blowouts tend to originate in the indentations created in the mating surfaces, which are formed by combustion residues that get trapped between the mating surfaces. If several such indentations are created and connected to one another, the result is a small channel between the combustion chamber and the gas line, through which the gases created in the combustion chamber can escape from the combustion chamber in the form of a sharp jet. Because of the high ignition pressure, said gas jet reaches a very high speed. In combination with the relatively high temperature, the result is the effect of a cutting jet, which leads to rapid destruction.

In the past, there have already been attempts to prevent this problem by widening the opposing contact surfaces of the valve seat and the valve disk. However, the results were not satisfactory because wide contact surfaces prevent the combustion residue trapped between them from escaping, so that the combustion residues are necessarily pressed into the contact surfaces. Furthermore, with wide contact surfaces, there is also a relatively strong heat transfer between the valve disk and the seat. However, contrary to the valve disk, which is made of high temperature-resistant material and can handle high temperatures, said valve seat is generally made of hardened steel. A strong heat transfer may lead to structural changes and accordingly to a loss of hardness.

EP 24 890 B describes a valve arrangement for charge exchange processes where an annular chamber is provided upstream of the conical surfaces of the valve seat and the valve disk that come into contact. Said annular chamber is supposed to take up the air that does not participate in the combustion. This is expected to cool the seat and lead to a drop in temperature of the gases escaping from the combustion chamber. Although this measure delays the blowout, the measure by itself is not sufficient to completely prevent a blowout.

SU 1 768 770 A1 describes a valve arrangement for charge exchange processes where a continuous groove is provided in the area of the cone surface of the valve disk, which is laterally delimited by continuous raised projections. The groove is supposed to be generated by a plastic material deformation by means of a tool that can be pressed on and has a semicircular profile, which does not allow for much depth. Accordingly, the groove has a depth of only about 0.1 mm and is therefore relatively shallow. The groove, which is pressed into the cone surface of the valve disk, is supposed to take up the combustion residues. However, because of the low depth of the groove, there is a risk that the residue is compressed in the groove and the groove therefore fills up relatively quickly. As a result, the groove loses its effect and the feared indentations are created anyway. In addition, the filled groove leads to a relatively large contact surface between the valve disk and the valve seat, which may impermissibly heat up the valve seat and leads to a loss of hardness. This known arrangement therefore also has an insufficient service life.

Both JP 59 196 913 A and JP 59 190 414 A respectively disclose a valve arrangement for the charge exchange processes of combustion engines where an annular continuous material recess is provided in the area of at least one of

the opposing cone surfaces of the valve seat and the valve disk. However, the mating surfaces separated in this way are relatively wide and therefore not suitable for breaking up accumulations of combustion residue. Rather, it must be feared that the combustion residues accumulated on the aforementioned mating surfaces are pressed into said mating surfaces.

Proceeding from the aforementioned, it is therefore the object of the present invention to improve a valve arrangement for the charge exchange process of combustion engines with simple and cost-efficient means in such a way that a long service life is achieved.

The object of the invention is attained with the combination in accordance with Claim 1.

What is proposed is a valve arrangement for the charge exchange process of combustion engines, especially large two-cycle diesel engines, having a stationary valve seat that encompasses an assigned flow channel, and a valve part that is movable relative to said valve seat, which comprises a valve disk that can be placed sealingly against said valve seat, whereby several spaced, annular continuous narrow mating surfaces are provided in the area of at least one of the opposing cone surfaces of the valve seat and the valve disk, which are, at least on one side, delimited by an annular continuous material recess and developed as ground surfaces with sharp lateral edges, and the total width of all narrow mating surfaces of a part of the charge exchange process valve arrangement is 0.5 % to 2 % of the mean diameter of the assigned cone surface.

These measures lead advantageously to very narrow mating surfaces with edges that serve as break up edges for accumulating combustion residue. Accumulating combustion residue is therefore broken up at the edges of the narrow

mating surfaces. The annular continuous material recesses that delimit the narrow mating surfaces can be worked in very deeply in an advantageous manner, thus obtaining a very large clear opening. The combustion residue that reaches the recesses delimiting the mating surfaces after it is broken up by the sharp edges of the narrow mating surfaces is therefore not trapped in the recesses, but can escape uncompressed. Advantageously, it must therefore no longer be feared that the material recesses that laterally delimit the mating surfaces will fill up. Another advantage of the measures in accordance with the invention is that they will lead only to very small contact surfaces between the valve seat and the valve disk and to a relatively large gap outside of said small contact surfaces, which severely limits the heat transfer from the valve disk, which is relatively hot, to the seat. Because the recesses that laterally delimit the narrow mating surfaces are not filled due to their large clear opening, this is advantageously a long-term effect. The low heat transfer ensures that the valve seat, which is generally made of hardened steel, remains relatively cool and no structural changes and thus no loss of hardness must be feared. This advantage is further enhanced by the fact that any gap formed by a material recess according to the invention can function as a chamber to take up air that doesn't participate in the combustion and thus can provide additional cooling for the valve seat. The combination in accordance with the invention therefore leads to the overall expectation of a long service life of the valve arrangement.

Advantageous embodiments and useful advancements of the overriding measures are listed in the subordinate claims. Thus, it can be useful if at least the valve seat has annular continuous narrow mating surfaces. This simplifies the production because the valve seat, which is comprised of hardened steel, can be worked relatively simply with chip removal prior to hardening. It furthermore ensures

that the cone surface of the valve disk can simply be reground, if necessary, without causing any changes in the depth of the recesses that delimit the narrow mating surfaces. Thus, this also leads to a simple maintenance of the valves.

The depth of the recesses that delimit a respective mating surface is advantageously larger than the expected thickness of the combustion residue. This ensures that the combustion residue is not pressed into the aforementioned recesses and compressed in said recesses or fills out said recesses, but rather that the combustion residue is dependably broken up and can escape. At the same time, this leads to a relatively large capacity of the aforementioned recesses so that there is much air in said recesses which does not participate in the combustion and can therefore cool the valve seat. In tests performed with large two-cycle diesel engines, good results were achieved with a recess depth of more than 1 mm, preferably up to 3 mm.

An especially preferable measure may be that the first narrow mating surface viewed from the direction of the combustion chamber is delimited by a material recess on the side facing the combustion chamber, which recess is connected to the combustion chamber by a small gap when the valve arrangement is closed and preferably has a relatively large capacity compared to a downstream material recess. Despite the gap connection to the combustion chamber, the air taken up herein does not participate in the combustion and leads to a good cooling of the valve seat.

At the same time, the gap leads to a blast in the chamber formed by the respective relatively large material recess, which further improves the cooling effect and leads to a dependable flushing of the cone surfaces, thus preventing the accumulation of combustion residue that was previously broken up by the edges of the adjacent narrow mating

surface. This further increases the advantages of the overriding measures.

In a further advancement of the overriding measures, the tilt angle of the opposing cone surfaces of the valve seat and the valve disk can deviate from one another, preferably by  $0.5^{\circ}$ . This leads to especially narrow opposing contact surfaces and therefore to an especially low reciprocal heat transfer as well as a very good breakup of the affected combustion residue.

Other advantageous embodiments and useful advancements of the overriding measures are stated in the remaining subordinate claims and can be found in the following description of examples and in the drawing.

The drawings described in the following show:

Figure 1 a charge exchange process valve arrangement, partially in section, and

Figure 2 a detail from Fig. 1 on an enlarged scale compared to Fig. 1

The fields of application for the invention are combustion engines with charge exchange valves, preferably large two-cycle diesel engines having a large exhaust valve arranged in the cylinder head. The principal structure and the mode of functioning of such engines are generally known and therefore do not require any detailed explanation in the present context.

The charge exchange process valve arrangement in Fig. 1, which can be an exhaust valve arrangement of the aforementioned type, has a valve seat 3 that is assigned to a stationary component 1, in the aforementioned example of a large two-cycle diesel engine to the cylinder head, and

arranged at the input of an assigned gas channel 2, in the aforementioned example at the input of the waste gas channel, to encompass the same, and valve portion 4 that is mobile relative to the aforementioned, having a valve disk 6 arranged on a lower end of a shaft 5 acting with an actuation device (not shown here), which can be positioned sealingly at the valve seat 3. The valve seat 3 and the valve disk 6 have facing cone surfaces 7 and/or 8, which can be positioned in partially sealing position.

In the present case, the valve seat 3 is formed onto a seat part 9, which is inserted into the assigned stationary component 1, which in the aforementioned example is the cylinder head. Said seat part is made of hardened steel. The seat part 9, which contains the valve seat 3, is cooled by cooling channels (not shown here) loaded with coolant, which are arranged in component 1 to retain the hardness of the hardened steel. The mobile valve part 4 can be comprised completely or at least in the area of the valve disk 6 of a highly temperature-resistant material that does not require any cooling. Thus, the valve seat 6 has a higher temperature during operation than the valve seat 3.

The cone surfaces 7, 8 of the valve seat 3 and the valve disk 6 do not mutually rest on one another over their total width, but rather only in the area of at least one relatively narrow annular continuous mating surface 10. In the shown example, two such mating surfaces 10, which are spaced from one another in axial direction, are arranged within the upper and lower edges of the respective assigned cone surface 7 and/or 8.

Said cone surfaces are delimited at least on one side by annular continuous material recesses 11 and/or 11a created by chip removal, which practically form annular continuous chambers. The material recesses 11, 11a form webs 12, and the upper side of said webs forms a respective mating

surface 10. The cross-section of the webs 12 is appropriately tapered towards the respective mating surface 10. The mating surfaces 10 are developed as ground surfaces, thus ensuring a precise support on a counter surface that acts therewith and is also ground. A rougher surface may be provided in the area of the material recesses 11, 11a.

The material recesses 11, 11a form relatively large chambers where no combustion residue can remain. Said combustion residue falls out of the aforementioned chambers and can therefore escape with the waste gas, meaning that there is no risk of creating indentations. The narrow mating surfaces 10 break up the combustion residue that reaches that area, which makes it easier for the combustion residue to escape. This effectively prevents the formation of indentations and passages that are the starting point for blowout holes. At the same time, there are relatively small contact surfaces between the relatively hot valve disk 6 and the valve seat 7, which is held at a lower temperature. There is no risk that the valve seat 7 is heated up noticeably by the valve disk 6 and the hardened valve seat 3 will therefore not lose its hardness. The chambers formed by the relatively deep recesses 11 can furthermore take up a relatively large amount of air that does not participate in the combustion and thus provides a further cooling effect.

The profile that forms the mating surfaces 10 with material recesses 11, 11a and webs 12 can be provided in the area of the cone surface 8 of the valve disk or in the area of the cone surfaces 7, 8 of the valve seat and the valve disk. In the shown, preferred example, the mating surfaces 10 are provided only in the area of the cone surface 7 of the valve seat 3. The material recesses 11, 11a can be produced advantageously prior to the hardening of the seat part 9. The mating surfaces 10 can be ground after the hardening.

The cone surface 8 of the valve disk 6 is also developed as a ground surface that is reground from time to time. This can be done easily without changing the depth of the profile of the material recesses 11, 11a. As far as the material recesses 11, 11a are provided at the side of the valve disk, they would have to be deepened during regrinding. Because the mating surfaces 10 are developed as ground surfaces, they lead to sharp lateral edges 13, as is shown in Figure 2. Said sharp lateral edges are capable of breaking up combustion residue in a knife-like manner.

The width  $b$  of the annular continuous narrow mating surfaces 10 has been chosen such that the total width of all of these mating surfaces 10 of a part of the valve arrangement, in this case the valve seat 3, is dimensioned such that the total width of all mating surfaces 10 of a cone surface 7 and/or 8 is respectively 0.5 % to 2 %, preferably 1 % to 1.5 %, of the mean diameter of the respective cone surface 7 and/or 8. The number of the available mating surfaces 10 can be appropriately chosen such that the resulting width  $b$  of the individual mating surface 10 is no more than 2 mm. During testing, this yielded good results.

The depth  $t$  of the material recesses 11, 11a that form the lateral limits of the mating surfaces 10 should be chosen greater than the expected thickness of the combustion residue. In most cases, the lower limit is around 0.4 to 0.5 mm. Appropriately, the depth  $t$  can be at least 1 mm, preferably more than 1 mm. In tests with large two-cycle diesel engines, a depth of up to 3 mm yielded good results. In the shown example, the depth  $t$  of the material recess 11 provided between the two mating surfaces 10, i.e., the material recess 11 downstream of the mating surface 10 near the combustion chamber, approximately corresponds to the width  $b$ .

In simple cases, all of the material recesses 11, 11a assigned to the mating surfaces 10 can have the same depth. In the shown, preferred embodiment, the material recess 11a, which delimits the mating surface 10 on the combustion chamber side when viewed from the direction of the combustion chamber, i.e., the material recess 11a upstream of the first mating surface 10, is significantly deeper and accordingly also more voluminous than the material recess 11 downstream of the first mating surface 10. In the shown example, the cross-section surface of the material recess 11a is approximately five times as large as the cross-section surface of the material recess 11. This therefore also results in a relatively large capacity of the material recess 11a. When the valve arrangement is closed, said material recess 11a is connected to the adjacent combustion chamber by a narrow gap 14. The gap 14 is so narrow that the air contained in the material recess 11a does not participate in the combustion. However, the combustion pressure nevertheless leads to a blast in the material recess and therefore to a good cooling of the surrounding material of the part of seat 9, which appropriately contains material recess 11a, and at the same time to a good flushing of cone surface 8 of valve disk 6 with unburned air. The same applies to the mating surfaces 10 in the initial phase of the opening motion of the valve disk 6.

The tilt angle  $\alpha$  of the cone surfaces 7, 8 relative to the valve axis  $a$  can be selected to correspond to the requirements of the specific case, for example in a range of  $30^\circ$  to  $75^\circ$ . A range of  $45^\circ$  to  $60^\circ$  is preferred. A small angle  $\alpha$  leads to relatively steep cone surfaces 7, 8 and therefore to high pressure forces. Thus, the lower range may be advantageous in that case. The cone surfaces 7, 8 may deviate from one another by an angle of  $0.5^\circ$ , and the angle  $\alpha$  of the cone surface 7 on the side of the valve seat is larger by approximately  $0.5^\circ$  than the angle  $\alpha$  of the

cone surface 8 on the side of the valve disk, thus creating a gap that opens radially outward. This measure can further improve the aforementioned knife effect.

CLAIMS

1. A valve arrangement for the charge exchange process of combustion engines, especially large two-cycle diesel engines, having a stationary valve seat (3) that encompasses an assigned flow channel (2), and a valve part (4) that is movable relative to said valve seat, comprising a valve disk (6) that can be placed sealingly against the valve seat (3), and several spaced annular continuous narrow mating surfaces (10) provided in the area of at least one of the opposing cone surfaces (7, 8) of the valve seat (3) and the valve disk (6), which are, at least on one side, delimited by an annular continuous material recess (11, 11a) and are developed as ground surfaces with sharp lateral edges (13), and the total width of all narrow mating surfaces (10) of a part of the charge exchange process valve arrangement is 0.5 % to 2 % of the mean diameter of the assigned cone surface (7 and/or 8).
2. The charge exchange process valve arrangement in accordance with claim 1, characterized in that at least the valve seat (3) has at least one annular continuous narrow mating surface (10).
3. The charge exchange process valve arrangement in accordance with claim 1, characterized in that the valve seat (3) and/or the valve disk (6) have at least one respective annular continuous narrow mating surface (10).
4. The charge exchange process valve arrangement in accordance with claim 1, characterized in that the total width of all narrow mating surfaces (10) of a part of the charge exchange process valve arrangement

is 1 % to 1.5 % of the mean diameter of the assigned cone surface (7 and/or 8).

5. The charge exchange process valve arrangement in accordance with claim 1, characterized in that the width b of a mating surface (10) is no more than 2 mm.
6. The charge exchange process valve arrangement in accordance with claim 1, characterized in that the depth t of each material recess (11, 11a) delimiting a mating surface (10) is greater than the thickness of the expected combustion residue.
7. The charge exchange process valve arrangement in accordance with claim 6, characterized in that the depth t of each material recess (11, 11a) delimiting a mating surface (10) is at least 1 mm, preferably up to 3 mm.
8. The charge exchange process valve arrangement in accordance with claim 1, characterized in that the first narrow mating surface (10) viewed from the direction of the combustion chamber is delimited on the side of the combustion chamber by a material recess (11a) which is connected to the combustion chamber by a narrow gap (14) when the valve arrangement is closed.
9. The charge exchange process valve arrangement in accordance with claim 8, characterized in that the material recess (11a) that is connected to the combustion chamber has a greater depth and cross-section surface than a downstream material recess (11).
10. The charge exchange process valve arrangement in accordance with claim 1, characterized in that the

tilt angle of the opposing cone surfaces (7, 8) of the valve seat (3) and the valve disk (6) is different and preferably deviate from one another by approximately  $0.5^{\circ}$ .