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Method and apparatus for a suction valve of the plate-type
of construction

The invention relates to a method of operating a suction valve of the plate-type of construction in accordance with the features of claim 1. The invention relates to an apparatus for carrying out the method in accordance with the features of claim 6.

An electromagnetically controlled suction valve of the plate-type of construction is known from the patent specification DE-679 714. There, the valve plate serves as an armature of an electromagnet, so that the position of the valve plate can be determined by a control of the magnet coil. This known suction valve has the disadvantage that the valve plate has the tendency to stick to the magnetic yoke of the electromagnet which does not permit any reliable, and in particular rapid operation of the suction valve.

Furthermore, it is necessary to arrange a magnetic insulation relative to the valve seat, in order to prevent the valve plate serving as an armature sticking at the valve seat. This magnetic insulation has the disadvantage that the application is costly and that the blows brought about by the valve plate bring about substantial wear of the magnetic insulation which greatly shortens the servicing interval for the suction valve.

It is the object of the present invention to propose a more economical suction valve which is better controllable.

This object is satisfied by a method in accordance with the

features of claim 1. The dependent claims 2 to 5 relate to further advantageous developments of the method. The object is further satisfied by an apparatus in accordance with the features of claim 6. The dependent claims 7 to 14 relate to further advantageous developments of the apparatus of the invention.

This object is in particular satisfied with a method such that the valve plate is held by an electromagnet arranged in the catcher, and such that the electromagnet is controlled with a decaying alternating current for the release of the valve plate, in order to at least partly demagnetise the valve plate, so that the valve plate is reliably released from the valve catcher and does not stick to the valve seat. The apparatus of the invention has a valve catcher with a magnet coil, and also a control device in order to control the magnet coil, and in particular to supply it with a decaying alternating current.

The invention will be described in detail with reference to embodiments. There are shown:

Fig. 1 an exploded drawing of a suction valve with the plate-type of construction;

Fig. 2 an electronic control device;

Fig. 3a a cross-section through a ring body of the valve catcher;

Fig. 3b a further cross-section through a ring body of a valve catcher with a damper plate and a valve plate;

Fig. 3c a further cross-section through a ring body of a valve catcher with a damper plate and a valve plate;

Fig. 3d a cross-section through a further embodiment of a ring body of a valve catcher;

Fig. 4 a control diagram for a suction valve of the plate-type of construction;

Fig. 5 a control diagram for a further method of controlling a suction valve of the plate-type of construction;

Fig. 6 a further embodiment of a suction valve with a valve plate consisting of a plurality of ring-shaped valve plate parts.

Fig. 1 shows in an exploded drawing a suction valve 1 comprising a valve seat 2 which is also termed a valve seat plate, a valve plate 3, a damper plate 4 and a catcher 6. These parts are held together by a common central screw 7. The damper plate 4 has openings 4d for the passage of a spring 5 which is arranged to act between the catcher 6 and the valve plate. The suction valve 1 can also be operated with, or also without, a damper plate 4. The valve catcher 6 has a plurality of ring bodies 6a which are all connected together. Each ring body 6a has a groove 6b extending in the circumferential direction, with electrical conductors being arranged in the ring groove 6b and forming a magnet coil 9.

Fig. 3a shows a cross-section through a ring body 6a with the ring groove 6b, so that the ring body 6a adopts the shape of a yoke 6c of a ring body magnet. A magnet coil 9 is arranged in the ring groove and forms an electromagnet. The ring body 6a in accordance with embodiment of Fig. 3a has a cover layer 9a at the side facing the valve plate 3 which hermetically seals off the inner space occupied by the

magnet coil relative to the outside, in order to protect the magnet coil 9 from contamination or noxious gases. the magnet coil 9 is controlled by a control device 8, so that a magnetic field is formed and the valve plate 3 is attracted by this magnetic field. The valve plate 3 forms the armature of the electromagnet.

Fig. 2 shows the control device 8 which has a modulation device 8a, with the control device being connected via electrical lines 8b to an angle of rotation sensor and via further electrical lines 8b to the magnet coil or magnet coils 9.

In Fig. 4 there is shown a schematic course of the measurement signals processed by the control device 8 and of the control signals that are generated. Time t or the angle of rotation ω of the piston compressor are shown on the horizontal axis. In the uppermost diagram, the position of the valve is shown in the two operating states open and closed, in the middle diagram there is shown an angle of rotation signal from the angle of rotation sensor, and in the lower diagram there is shown the magnet current I transmitted by the control device 8 to the magnet coil. A magnetisation current is applied to the coil 9 in response to a signal of the angle of rotation transducer 10 and causes the valve plate 3 to be attracted by the valve catcher 6, so that the valve is open. During this, the control device 8 executes a first control phase 11a which brings about a magnetisation of the valve catcher 6. The suction valve 1 can now be held open over a time period which can be selected as desired. The signal of the angle of rotation sensor 10 is again preferably used for the closing of the suction valve 1, with the control device 8 introducing after this signal a second control phase 11b of the electromagnet 9 in that a decaying alternating current

which is supplied to the magnet coil 9 is produced by means of a modulation device 8a, in order to demagnetise the valve plate 3 and/or the valve catcher 6. Through the demagnetisation any form of holding force between the valve plate 3 and the valve catcher 6 is prevented. In particular, sticking together of the two parts as a result of residual magnetic forces is prevented. On closing of the suction valve 1, the valve plate 3 is pressed against the valve seat 2. During this, the valve plate 3 comes directly into contact on the valve seat 2, so that a direct contact exists between the two metallically formed components. As the valve plate 3 was previously demagnetised, there is no danger of the valve plate 3 sticking to the valve seat 2. The valve seat 2, the valve plate 3, and the valve catcher 6 customarily consist of a stainless steel with hard magnetic characteristics. No magnetically insulating materials are arranged between the valve seat 2, the valve plate 3, and the valve catcher 6, so that the demagnetisation of the valve plate 3 and of the valve catcher 6 is advantageous in order to ensure fault-free operation of the suction valve 1. The control method of the invention for the magnet coil 9 with a modulation device 8a for the demagnetisation has, moreover, the advantage that the demagnetisation can be carried out in a very short period of time, which enables very rapid switching times of the suction valve 1. The suction valve 1 is in particular controllable in such way that during a predetermined number of rotations, for example of a compressor, the valve 1 can be kept open and that the valve 1 can be operated during a further arbitrarily selectable number of rotations in an automatic opening and closing working mode. Thus, it is possible to steplessly regulate the delivery quantity of the suction valve 1.

Fig. 5 shows a further schematic course of a control method, and also the position of the valve 1. The elapsed time t ,

or the angle of rotation ω of a piston compressor which is equivalent to the time, is shown on the horizontal axis. The angle of rotation signal is measured with the angle of rotation sensor 10. The operating behaviour of the suction valve 1 in conjunction with a piston compressor is known. In particular it is known that after a fixed angle of rotation Δ relative to the angle of rotation signal the valve is completely open and the valve plate 3 contacts the valve catcher 6. The magnet coil 9 is then first activated by the control device 8 with a magnet current I in a first control phase 11a, when the valve 1 is fully open and the valve plate 3 contacts the valve catcher 6. In this way, the valve plate 3 can be very reliably held with a relatively low magnetic force. During an automatic operation of a piston compressor, a valve plate 3 contacts the valve catcher 6 during an angle of rotation of for example 120 degrees. After an angle of rotation signal a decaying alternating current is then supplied to the magnet coil 9 by the control device 8 in a second control phase 11b, where it is ensured that the total second control phase 11b will take place in a range of angular rotation in which the valve plate 3 would contact the valve catcher 6 during automatic operation. In this way the valve plate plate 3 is not prematurely separated from the range of influence of the magnet coil 9 during the second control phase 11b and the valve plate 3 can be fully demagnetised.

The suction valve 1 of Fig. 1 can be equipped with or without a damper plate 4. The control method of Fig. 5 was described for a suction valve 1 without a damper plate 4. Should the suction valve 1, however, also have a damper plate 4, then in the control method of Fig. 5 the damper plate 4 is arranged between the valve plate 3 and the valve catcher 6, so that with the fully open valve 1, the damper plate 4 contacts the valve catcher 6 and the valve plate 3

contacts the damper plate 4. Otherwise nothing changes with respect to the control method.

Fig. 3b shows a further cross-section through a ring body 6a formed as a yoke 6c of a ring body magnet. In this illustrated embodiment the suction valve has a damper plate 4, with the damper plate 4 consisting of a plurality of ring bodies 4 which are connected together as shown in Fig. 1. The ring body 4a is designed in accordance with the embodiment 3b in such a way that the side facing the yoke 6c of the ring body magnet is of U-shape. This design causes the magnetic flux to increasingly flow via the valve plate 3, whereby the valve plate 3 can be better attracted by the magnet coil 9.

Fig. 3c shows a further embodiment of a suction valve 1 with damper plate 4. In order to improve the magnetic flux between the yoke 6c of the ring body magnet and the valve plate 3, the ring body 4a of the damper plate 4 has a gap 4c while forming two ring body parts 4b as illustrated in Fig. 1. The gap 4c advantageously extends concentrically to the central screw 7.

Fig. 3d shows a further cross-section through a ring body 6a with the yoke 6c of the ring body magnet being of V-shaped design, so that the whole magnet coil 9 is embedded in an insulating cover layer 9a.

For the operation of the suction valve 1, at least a single magnet coil 9 arranged in the valve catcher 6 is necessary. A plurality of magnet coils 9 arranged in the concentrically extending ring bodies 6a is advantageously used in order to bring about a greater force on the valve plate 3. These magnet coils 9 can be controlled by the control device 8 in such a way that all the magnet coils generate a magnetic

field extending with the same polarity, or also in such a way that adjacently disposed magnet coils generate a magnetic field of opposite polarity. The apparatus of the invention for the actuation of a valve plate 3 of the suction valve of the plate-type of construction 1 includes at least one valve catcher 6, and also an electronic control device 8. This apparatus can be assembled together with a valve seat 2, a valve plate 3 and also spring elements 5 into a suction valve 1. In this respect, the apparatus of the invention is also suitable for already existing suction valves in order to convert these into a controllable suction valve 1. In this respect, the existing valve catcher 6 is replaced by the valve catcher 6 with magnet coils 9 as shown in Fig. 1 and the magnet coils connected to the control device 8. Thus, an existing suction valve 1 can be modified in a simple and cost favourable manner. The apparatus of the invention and the suction valves 1 find uses, in particular with piston compressors. The apparatus of the invention makes it possible to steplessly change and regulate the delivery quantity of each individual compressor space of a piston compressor independently of the other compression spaces.

Fig. 6 shows a further embodiment of a suction valve 1 comprising a valve seat 2 and a valve plate 3, with the valve plate 3 consisting of a plurality of individual concentrically disposed ring-like valve plate parts 3a, 3b and also a catcher 6 with magnet coils 9 arranged in the ring body 6a of the catcher 6. The springs 5, which press the valve plate parts 3a, 3b against the valve seat 2 in the rest position, are not illustrated. On actuating the magnet coils 9, the valve plate parts 3a, 3b, 3c respectively disposed beneath the coil 9 are attracted by the U-shaped ring body 6a lying above it. The magnet coils 9 are jointly controllable (energisable), so that all valve plate parts

3a, 3b, 3c are operable reacting in the same sense. The magnet coils 9 are also controllable such that the one valve plate parts 3a, 3b, 3c, for example the valve plate parts 3a, 3b are held at the valve catcher 6 by the actuation of the magnet coil 9, while the valve plate part 3c opens and closes with normal mobility, since the magnet coil 9 arranged above the valve plate part 3c is not activated.

The valve plate parts 3a, 3b, 3c are manufactured from a ferromagnetic material, such as iron, or of a ferromagnetic plastic, or of a plastic containing a ferromagnetic metal.

Patent Claims

1. Method for the stepless regulation of the delivery of a suction valve (1) of the plate-type of construction, comprising a valve plate (3) which is actuated by an electromagnet (9) arranged in a valve catcher (6), wherein the electromagnet (9) is so controlled that in a first control phase (11a) the valve plate (3) firmly contacts the valve catcher (6), or a damper plate (4) arranged between the valve catcher (6) and the valve plate (3) and is blocked, and in that in a second control phase (11b) the electromagnet (9) is controlled by a decaying alternating current, in order to at least partly demagnetise the valve plate (3), so that the valve plate (3) is released.
2. Method in accordance with claim 1, characterised in that the electromagnet (9) is activated when the valve plate (3) is located in an open state.
3. Method in accordance with claim 2, characterised in that the electromagnet (9) is only then activated or deactivated when the valve plate (3) contacts the valve catcher (6) on its own or together with a damper plate (4).
4. Method in accordance with one of the claims 1 to 3, characterised in that the electromagnet (9) is so controlled that the valve plate (3) remains open for a predetermined number of cycles of a compressor and is operated free-running over a predetermined number of cycles without the action of the electromagnet (9).
5. Method in accordance with one of the claims 1 to 4, characterised in that the valve plate (3) consists of a



plurality of valve plate parts (3a, 3b) arranged concentric to one another which are individually or jointly controlled by the electromagnets (9).

6. Apparatus for the actuation of a valve plate (3) of a suction valve (1) of the plate-type of construction using a method in accordance with one of the claims 1 to 5, comprising a valve catcher (6), and also an electronic control device (8), with the valve catcher (6) being formed of a ring body (6a) which has a ring groove (6b) extending in the circumferential direction, and also a magnet coil (9) arranged in the ring groove (6b), so that the ring body (6a) forms a yoke of a ring body magnet (6c) of an electromagnet, and wherein the magnet coil (9) is connected to the control device (8) in order to attract the valve plate (3) forming the armature of the electromagnet.
7. Apparatus in accordance with claim 6, characterised in that the electronic control device (8) has at least one modulation device (8a) which generates a decaying alternating current which can be applied to the magnet coil (9) in order to demagnetise the yoke (6c) of the ring body magnet and/or the valve plate (3) serving as the armature.
8. Apparatus in accordance with claim 6 or claim 7, characterised in that the valve catcher (6) has a plurality of concentrically arranged ring bodies (6a) with magnet coils (9), and in that the magnet coils (9) can be controlled by the control device (8) to have the same polarity or the opposite polarity.
9. Suction valve of the plate-type of construction (1) comprising a valve seat (2), a valve plate (3) with



valve springs (5), and also an apparatus in accordance with one of the claims 6 to 8, wherein the valve plate (3) and the valve seat (2) are directly placeable on top of one another.

10. Suction valve of the plate-type of construction (1) in accordance with claim 9, characterised in that a damper plate (4) is arranged between the valve plate (3) and the valve catcher (6).
11. Suction valve of the plate-type of construction (1) in accordance with claim 9 or claim 10, characterised in that the damper plate (4) has a plurality of concentrically extending ring bodies (4a) which are all connected together and which are of U-shape at the side facing the valve catcher (6).
12. Suction valve of the plate-type of construction (1) in accordance with claim 9 or claim 10, characterised in that the damper plate (4) has a plurality of concentrically extending ring bodies (4a) which are all connected to one another, with at least one ring body (4a) consisting of two ring body parts (4b) which are separated by a preferably concentrically extending gap (4c).
13. Suction valve of the plate-type of construction (1) in accordance with one of the claims 9 to 12, characterised in that the valve seat (2), the valve plate (3), and the valve catcher (6) consist of stainless steel, in particular of steel with hard magnetic characteristics.
14. Suction valve of the plate-type of construction (1) in accordance with one of the claims 9 to 13, characterised in that the valve plate (3) consists of a plurality of



individual valve plate parts (3a, 3b) which are of ring-like shape, and which are arranged extending concentrically to one another.

15. Piston compressor with an apparatus in accordance with one of the claims 6 to 14 are operated with a method in accordance with one of the claims 1 to 5.

