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(54) Benævnelse: **Cylindrisk symmetrisk volumetrisk maskine**

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US-A- 2 765 114
US-B1- 6 361 292

DESCRIPTION

[0001] The present invention is related to a cylindrical symmetric volumetric machine.

[0002] A volumetric machine is also known under the (English) name: "positive displacement machine".

[0003] More specifically, the invention is related to machines such as expanders, compressors, and pumps with a cylindrical symmetry comprising two rotors, namely an inner rotor which is rotatably mounted into an outer rotor.

[0004] Such machines are already known and are described, for example, in US 1.892.217. It is also known that the rotors may have a cylindrical or conical shape.

[0005] It is known that such machines may be driven by an electric motor.

[0006] Hereby, a rotor shaft of a motor rotor will drive a rotor shaft of the inner or outer rotor, whereby use is made of gears, couplings, belt drives, or similar to realise a transmission between both rotor shafts.

[0007] Such machines are very voluminous and consist of many parts of the motor, compressor, or expander rotors and associated housings.

[0008] As a consequence, the 'foot print' or space consumption of the machine is relatively large.

[0009] The machine will also be relatively expensive, due to the many parts and due to a resultingly more expensive assembly. Another disadvantage is the need for a lot of shaft seals and bearings in order to seal all parts and to mount these parts rotatably into the housings.

[0010] The seals pose a risk if they would fail, while the bearings entail losses.

[0011] The document US 6,361,292 discloses a volumetric machine with a rotatable outer rotor and an inner rotor which outer rotor is driven by an electric motor arranged on the outer circumference of the outer rotor.

[0012] The document US 2,765,114 discloses a volumetric machine with a fixed stator and a rotor that is conically shaped in longitudinal view and that is driven by an outside motor that is connected to the rotor by a shaft.

[0013] The purpose of che present invention is to provide a solution to one or more of the foregoing and/or other disadvantages. The present invention concerns a cylindrical symmetric volumetric machine according to claim 1.

[0014] An advantage is that there is no need for a transmission between the outer rotor and the moror stator or motor rotor, as the motor stator is directly driving the outer rotor, such that less parts are needed.

[0015] Another advantage is that, due to mounting of the electric moror around the outer rotor, the foot print of the machine may be diminished, and the machine is made smaller and more compact.

[0016] Furthermore, less shaft seals are needed, which increases the reliability of the machine.

[0017] In addition, less bearings are needed, which results in less losses and, consequently, a more efficient machine.

[0018] In a practical embodiment, the motor rotor and the outer rotor are arranged as a whole or form a whole.

[0019] The motor rotor and the outer rotor may, for example, be directly joined together by means of a press fitting, by welding, or similar.

[0020] This embodiment has as advantage that a standard outer rotor may be used.

[0021] In another practical embodiment, the outer rotor serves as motor rotor.

[0022] This will ensure that the machine may be made even more compact, as if a number of parts will not be present anymore, as functions of parts or components are combined, i.e. certain parts are shared.

[0023] With the intention of better showing the characteristics of the invention, some preferred embodiments of a cylindrical symmetric volumetric machine according to the invention are described hereinafter by way of example, without any limiting nature, with reference to the accompanying drawings, wherein:
figure 1 schematically shows a machine according to the invention.

[0024] The schematically shown machine 1 in figure 1 is in this case a compressor device.

[0025] It is according to the invention also possible that the machine 1 is an expander device. The invention may relate to a pump device as well.

[0026] The machine 1 is a cylindrical symmetric volumetric machine 1, also called "cylindrical symmetric positive displacement machine". This means that the machine 1 exhibits a cylindrical symmetry, i.e. the same symmetric properties as a cone.

[0027] The machine 1 comprises a housing 2 which is provided with an inlet 3 for the suction of gas to be compressed and an outlet 4 for compressed gas. The housing 2 defines a chamber 5.

[0028] In the housing 2 of the machine 1, two cooperating rotors 6a, 6b are located in this chamber 5, namely an outer rotor 6a which is rotatably mounted into the housing 2 and an inner rotor 6b which is rotatably mounted into the outer rotor 6a.

[0029] Both rotors 6a, 6b are provided with lobes 7 and are able to turn onto each other in a cooperative way, whereby between the lobes 7 a compression chamber 8 emerges whose volume is reduced by rotation of the rotors 6a, 6b, such that the gas which is caught in this compression chamber 8 is compressed. The principle is very similar to known tangent cooperative screw rotors.

[0030] The rotors 6a, 6b are mounted by means of bearings into the machine 1, whereby the inner rotor 6b is mounted at one end 9a into the machine 1. In this case, only one bearing 10 is applied to mount the inner rotor 6b into the housing 2 of the machine 1. This bearing 10 is an axial bearing to bear axial force that is exerted an the inner rotor 6b. This axial force will be directed to the left.

[0031] The other end 9b of the inner rotor 6b is, as it were, supported or borne by the outer rotor 6a.

[0032] The outer rotor 6a is in the shown example at both ends 9a, 9b mounted by means of bearings in the machine 1. Hereby, use is made of at least one axial bearing 12. This will be able to bear the axial forces to which the outer rotor 6a is exposed. The other bearing 11 by which the outer rotor 6a is mounted into the housing 2, may be another type of bearing than an axial bearing.

[0033] Due to this simple bearing arrangement, losses with respect to the bearings 10, 11, 12 may be kept as small as possible.

[0034] In the shown example, the rotors 6a, 6b have a conical shape, whereby the diameter D, D' of the rotors 6a, 6b decreases in an axial direction X-X'. This is not a necessary condition for the invention, the diameter D, D' of the rotors 6a, 6b may also be a constant or vary in another way in the axial direction X-X'.

[0035] Such shape of the rotors 6a, 6b is appropriate both for a compressor as an expander device. The rotors 6a, 6b may alternatively also have a cylindrical shape with a constant diameter D, D'. These may then have either a variable pitch such that there is an incorporated volume ratio, in the case of a compressor or expander device, or a constant pitch, in the case the machine 1 is a pump device.

[0036] An axis 13 of the outer rotor 6a and an axis 14 of the inner rotor 6b are not parallel, but

are positioned under an angle a, whereby these axes 13, 14 cross each other in a point P.

[0037] This is not a necessary condition for the invention. For example, if the rotors 6a, 6b have a constant diameter D, D', the axes 13, 14 may indeed be parallel.

[0038] Although the axes 13, 14 are positioned under an angle α, these are fixed axes 13, 14. This means that, during the rotation of the rotors 6a, 6b, the axes 13, 14 will not be displaced or moving with respect to the housing 2 of the machine 1. The axes 13, 14 will, in other words, not perform an orbiting movement.

[0039] This has as advantage that no additional provisions need to be made, such as special gears to ensure a correct relative movement between both rotors 3a, 3b.

[0040] Furthermore, the machine 1 is also provided with an electric motor 15 which will drive the rotors 6a, 6b. This motor 15 is provided with a motor rotor 16 ana a motor stator 17.

[0041] According to the invention, the electric motor 15 is mounted around the outer rotor 6a, whereby the motor stator 17 is directly driving the outer rotor 6a.

[0042] In the example shown, this is realised as the outer rotor 6a is serving as motor rotor 16 as well.

[0043] In other words: one part of the machine 1 will perform two functions, namely the function of outer rotor 6a and the function of motor rotor 16.

[0044] In this way, the motor stator 17 will directly drive the outer rotor 6a.

[0045] This has as a consequence that the machine 1 will comprise less parts, such that the machine 1 will be more compact and Less complex.

[0046] As the motor stator 17 of the electric motor 15 is typically generating a cylindrical symmetric rotating field to drive the motor rotor 16, this motor rotor 16, and thus in this case also the outer rotor 6a, needs to exhibit a cylindrical symmetry.

[0047] As the outer rotor 6a is taking over the function of the motor rotor 16, the motor 15 does not add any additional rotating parts to the machine 1. For this reason, there are therefore also no additional bearings and similar with associated losses.

[0048] The magnets 18 of the electric motor 15 are in this case preferably embedded in the outer rotor 6a. These magnets 18 may be permarent magnets. It is of course also possible that these magnets 18 are not embedded in the outer rotor 6a, but are for example mounted onto an outer side thereof.

[0049] Instead of an electric motor 15 with permanent magnets (i.e. a synchronous permanent

magnet motor), an asynchronous induction motor may also be applied, whereby the magnets 18 are replaced by a squirrel cage armature. By means of induction from the motor stator 17, a current is induced in the squirrel cage armature.

[0050] On the other side, the motor 15 may also be of the reluctance type or induction type or a combination of types.

[0051] As can be seen in the figure, the electric motor 15 extends along only a part of a length L of the rotors 6a, 6b, whereby the motor 15 is located at an end 9b with a smallest diameter D.

[0052] This means that the magnets 18 are located at the end 9b of the rotors 6a, 6b with a smaller diameter D. It is of course also possible that the magnets 18 and the motor 15 are located at the other, larger end with a diameter D'.

[0053] This will entail even an additional space saving, such that the machine 1 becomes even more compact.

[0054] In order to make the machine 1 as compact as possible, a maximal diameter E of the motor 15 is preferably maximally twice, preferably maximally 1,7 times, and more preferably maximally 1,5 times the maximal diameter D' of the outer rotor 6a.

[0055] The invention is however not limited to these aforementioned dimensions. Alternatively, the maximal diameter D' of the outer rotor 6a may, for example, be larger than an inner diameter F of the motor stator 17. In order to make machine 1 even more compact, the maximal diameter D' of the outer rotor 6a may be larger than the maximal diameter E of the motor 15, i.e. the outer diameter of the motor stator 17. If the outer rotor 6a is made by means of injection moulding, the magnets 18 are preferably co-moulded in tne outer rotor 6a during the injection moulding process.

[0056] It is, amongst others, due to this feature in combination with the fact that the motor 15 is located at the end 9b of the rotors 6a, 6b with the smallest diameter D, that the maximal diameter E of the motor 15 may be kept so stall. The smaller the maximal diameter E of the motor 15, the more compact the final machine 1 and the smaller the foot print of the machine 1.

[0057] Of course, it is not excluded that other parts of the machine 1, such as for example the inner rotor 6b, are made by means of injection moulding as well.

[0058] The motor stator 17 is mounted around the outer rotor 6a in an enveloping manner, whereby the former is in this case located in the housing 2 of the machine 1.

[0059] By mounting the motor 15 into the housing 2 of the machine 1, no special motor housing needs to be provided and tne machine 1 may be arranged more compactly. Moreover,

there is also no need for seals between the motor 15 and the rotors 6a, 6b.

[0060] Moreover, in this way, the lubrication of the motor 15 and the rotors 6a, 6b may be controlled together, as they are located in the same housing 2, and consequently are not isolated from each other.

[0061] It is of course also possible that the housing 2 is arranged in such a way that it may also serve as housing 2 of the motor 15, or that a separate housing 2 is provided for the motor 15 which may be attached to the housing 2 of the rotors 6a, 6b.

[0062] Although in the shown example the outer rotor 6a of the machine 1 serves as the motor rotor 16, it is also possible that the motor rotor 16 and the outer rotor 6a are arranged as a whole or that they form a whole, for example as they are directly joined together by means of a press fitting, by welding, or similar.

[0063] The operation of the machine 1 is very simple and as follows.

[0064] During the operation of the machine 1, the motor stator 17 will drive the motor rotor 16 in the known way.

[0065] As in this case the outer rotor 6a serves as the motor rotor 16, it will thus be driven.

[0066] The outer rotor 6a will drive the inner rotor 6b with it, in the same way as a known oil-injected screw compressor with a male and a female screw rotor, whereby for example the male screw rotor is driven by a motor 15.

[0067] Due to the rotation of the rotors 6a, 6b, gas will be sucked in from the inlet 3, which will end up in a compression chamber 8 between the rotors 6a, 6b. When the gas is sucked in from the inlet 3, it will flow along the motor rotor 16 and the motor stator 17 according to the arrows P in figure 1, and in this way ensure the cooling of the motor 16.

[0068] By means of the rotation, the compression chamber 8 is displaced towards the outlet 4, and will at the same time decrease in volume in order to ensure a compression of the gas in this way.

[0069] The compressed gas may then leave the machine 1 through the outlet 4.

[0070] During the operation, liquid will be injected into the machine 1, to cool and/or lubricate the parts. These parts are, amongst others, the bearings 10, 11, 12, the inner and outer rotors 6a, 6b, the windings of the motor stator 17, ...

[0071] Hereto, the machine 1 is provided with a liquid injection circuit, not shown in the figures. This liquid may, for example, be oil, whether or not a synthetic oil.

[0072] Hereby, liquid will also be injected in the chamber 5, which will ensure lubrication and sealing between the inner and outer rotor 6a, 6b.

[0073] Through the outlet 4, this liquid will leave the machine 1, together with the compressed gas. The liquid may be separated from the gas by means of a separator, and be recovered.

[0074] It is of course also possible that the machine 1 is liquid-free, and that the lubrication is done by means of tat instead of oil.

[0075] The present invention is by nc means limited to the embodiments described as an example and shown in the figures, but a cylindrical symmetric volumetric machine according to the invention may be realised in all kinds of forms and dimensions, without departing from the scope of the invention.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US1892217A **[0004]**
- US6361292B **[0011]**
- US2765114A **[0012]**

Patentkrav

1. Cylindrisk symmetrisk volumetrisk maskine (1), hvilken maskine (1) omfatter to samvirkende rotorer (6a, 6b), nemlig en udvendig rotor (6a), som er roterbart monteret i maskinen (1), og en indvendig rotor (6b), som er roterbart monteret i den udvendige rotor (6a),
hvor maskinen (1) er forsynet med en elektrisk motor (15) med en motorrotor (16) og en motorstator (17) til at drive den udvendige og den indvendige rotor (6a, 6b),
hvor den elektriske motor (15) er monteret omkring den udvendige rotor (6a),
hvor motorstatoren (17) direkte driver den udvendige rotor (6a),
kendetegnet ved, at den udvendige rotor (6a) og den indvendige rotor (6b) har en konisk form, og
den elektriske motor (15) strækker sig langs kun en del af en længde (L) af den udvendige rotor (6a) og den indvendige rotor (6b), hvor motoren (15) er anbragt ved en ende (9b) af den indvendige rotor (6b) med en mindste diameter (D).

2. Maskine ifølge krav 1, **kendetegnet ved, at** motorrotoren (16) og den udvendige rotor (6a) er indrettet som en helhed.

3. Maskine ifølge krav 1, **kendetegnet ved, at** den udvendige rotor (6a) fungerer som motorrotoren (16).

4. Maskine ifølge krav 3, **kendetegnet ved, at** den elektriske motor (15) er forsynet med permanentmagneter (18), som er indlejret i den udvendige rotor (6a).

5. Maskine ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** den indvendige rotor (6b) og den udvendige rotor (6a) har akser (13, 14), som er positioneret under en vinkel (α) i forhold til hinanden, hvorved disse akser (13, 14) krydser hinanden.

6. Maskine ifølge krav 5, **kendetegnet ved, at** akserne (13, 14) af den indvendige rotor (6b) og den udvendige rotor (6a) er faste akser, der ikke drejer rundt.

7. Maskine ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** den indvendige rotor (6b) er monteret ved en ende (9a) i maskinen (1) ved hjælp af lejer.

8. Maskine ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** den udvendige rotor (6a) er monteret i maskinen (1) ved hjælp af mindst et aksialleje (11).

9. Maskine ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** maskinen (1) er en ekspander, kompressor eller pumpeindretning.

10. Maskine ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** den udvendige rotor (6a) er fremstillet ved hjælp af sprøjtestøbningsteknikker.

11. Maskine ifølge krav 4 og 10, **kendetegnet ved, at** magneterne (18) er medstøbt i den udvendige rotor (6a) under sprøjtestøbningsprocessen.

12. Maskine ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** maskinen (1) er forsynet med et hus (2), hvor motoren (15) er monteret i huset (2), eller hvor huset (2) også fungerer som hus (2) for motoren (15).

13. Maskine ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** en maksimal diameter (E) af motoren (15) er maksimalt to gange, fortrinsvis maksimalt 1,7 gange og mere foretrukket 1,5 gange en maksimal diameter (D') af den udvendige rotor (6a).

DRAWINGS

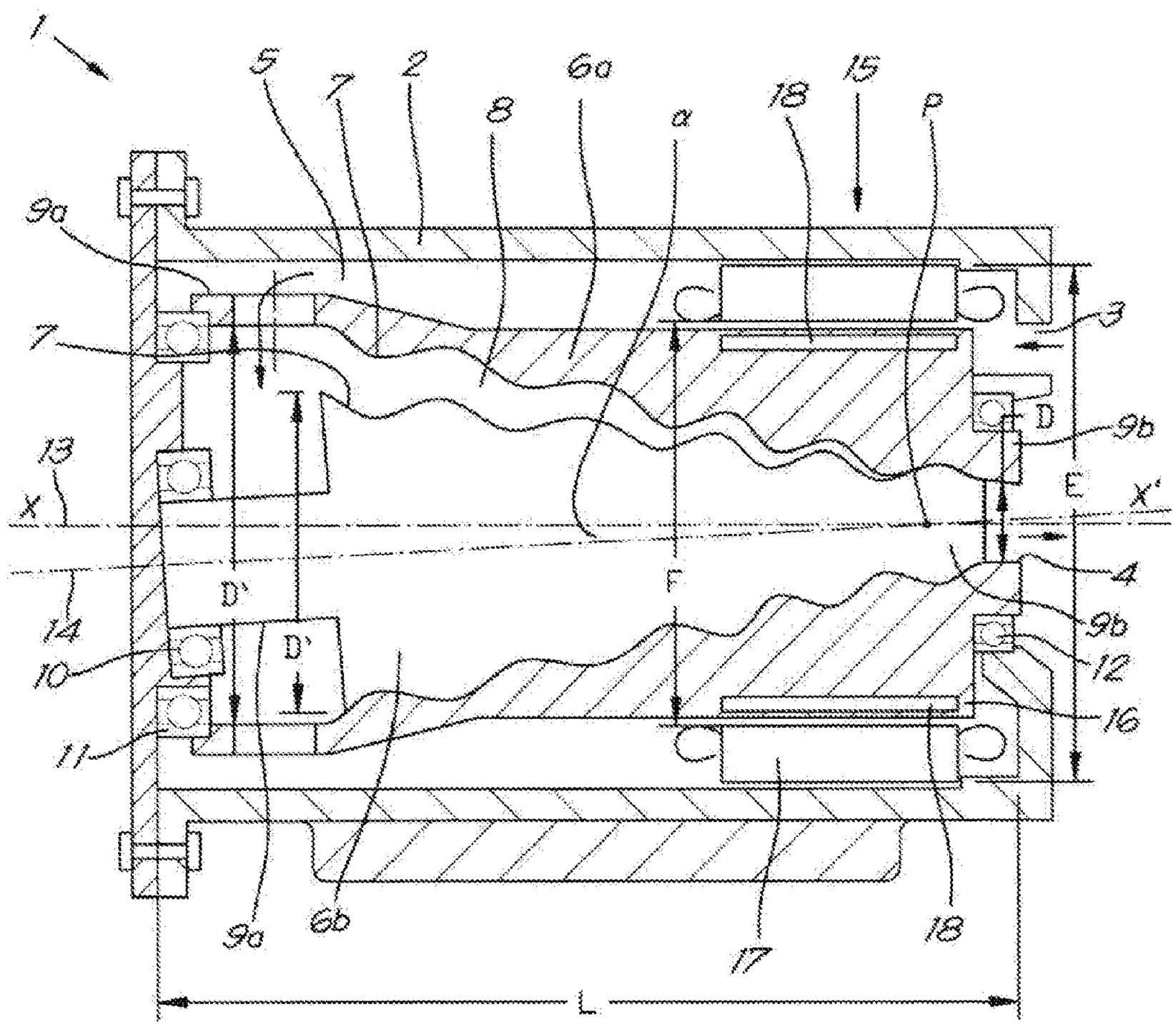

Fig. 1