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Displacement machine for compressible media

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The invention relates to a displacement machine for compressible media, in particular a dry-running vacuum pump, having at least two shafts with rotors which are designed as helical profile bodies and whose
10 profiles intermesh like gears during the rotation and run free of contact relative to one another, the lead of the helical profile bodies decreasing from the inlet to the outlet.

In a known displacement machine of this type (DE
15 195 30 662 A), two intermeshing profile bodies are used. The latter enclose a certain volume at the inlet end, and this volume then moves to the outlet end during rotation of the rotors. In the process, compression takes place, since the lead decreases and
20 thus the enclosed delivery volume becomes smaller towards the outlet end. In this way, the compressible medium is delivered from the inlet end to the outlet end and compressed in the process. The continuously changing lead certainly produces the compression but
25 has the following disadvantages.

Since the lead decreases immediately at the inlet end, the delivery volume is smaller than would correspond to the lead directly at the inlet end. This leads to a restriction in the suction capacity. On the
30 outlet side, on account of the decreasing lead and reduction in the delivery volume up to the end of the rotors, compression still takes place continuously, so that there are pressure differences between the instantaneously last delivery volume not yet opened and
35 the following delivery volume, and these pressure differences, via unavoidable gaps between the rotors and the walls, give rise to a backflow of the medium into the delivery volume following from the inlet side or into the following delivery volumes, as a result of

which the delivery capacity is likewise reduced. For the power input, the volume of the delivery chamber at the instant of opening at the outlet end is decisive. Since this volume, on account of the constantly
5 decreasing lead, has not yet assumed the value which corresponds to the lead at the outlet end, a considerable loss of efficiency results.

The object of the invention is to provide a displacement machine of the type mentioned at the
10 beginning which exhibits a more favourable pumping behaviour and in which the delivery capacity is increased.

The solution according to the invention consists in the fact that the helical profile bodies are of
15 double-start design, and the leads at the inlet end and outlet end of the helical profile bodies are constant, and in between the lead decreases continuously from the larger lead at the inlet end to the smaller lead at the outlet end.

20 The lead is therefore constant at the inlet end. As a result, the original delivery volume is of the size corresponding to the lead at the inlet end. This delivery volume is not decreased by the lead decreasing immediately. The region having a constant lead at the
25 inlet end advantageously extends over at least one turn (360°). A constant lead is also provided again at the outlet end and is smaller than the lead at the inlet end. As a result, the abovementioned problems of the backflow are very greatly reduced, since an essentially
30 constant pressure prevails over one turn or even several turns. The final pressure of the pump is thus also reduced. At the same time, the power input is reduced on account of the smaller delivery volume.

Located between the two regions having constant
35 leads is the section in which the lead at the inlet end is reduced to the markedly smaller lead at the outlet end. This profile is the most favourable from thermodynamic aspects.

Displacement machines are certainly known in which the rotors at the inlet end and outlet end in each case have constant leads (GB 2 227 057 B, EP 0 183 380 B1). However, these displacement machines are intended for the delivery of liquids which may contain entrapped gas. Since liquids cannot be compressed to an appreciable degree, the gap widths between the rotors and the wall of the delivery space must be dimensioned in such a way that liquid can flow during the compression through the gaps in accordance with the pressure difference back to the inlet side. So that a reasonable pumping action is nonetheless achieved, regions having a constant lead are provided at the inlet end and outlet end, and these regions deliver the liquid normally without compression, since otherwise no reasonable pumping action could be achieved on account of the requisite large gap widths referred to. Since these pumps are not of the generic type and the problems with the delivery of liquid are completely different than in the case of compressible media, the displacement machines according to the invention cannot be inferred at all from these pumps.

In addition, as far as can be seen, the rotors of the previously known displacement machines are single start. In the displacement machine according to the invention, the helical rotors are double-start in order to be able to be balanced more effectively, which is absolutely necessary for high rotational speeds. In addition, the heat dissipation is increased due to the better distributed gap flows. This heat dissipation is not problematic in the liquid-delivering displacement machines of the prior art.

The leads at the inlet end and outlet end are advantageously constant over at least one turn. For compressing gases or for achieving a good vacuum, it is especially advantageous if the lead at the outlet end is constant over at least two turns. This results not only in better sealing and less backflow but also in better dissipation of the heat of compression. In a

dry-running vacuum pump, the heat of compression due to the reduction in volume and the heat of compression due to the ingress of external air at the outlet end no longer occur at the same point and can therefore be
5 dissipated more effectively.

The number of turns over which the lead is constant depends on the desired operating conditions of the pump.

An especially favourable behaviour of the
10 displacement machine, in particular within the vacuum range, is obtained if provision is made for the shafts to each be driven by separate electric motors, the angular positions of the shafts being determined with resolvers, on the basis of the signals of which the
15 motors are electronically synchronized, and the shafts having gears which intermesh and whose angular clearance is less than that of the profile bodies. The rotors are therefore not driven via gear units but are driven in a completely non-contact manner by separate
20 electric motors, the purpose of the gears merely being to prevent the sensitive surfaces of the rotors from coming into contact and being damaged in the event of failure of the electronic synchronization. Instead, the gears will come into contact first, which causes no
25 problems, in particular if they are provided with an appropriate surface.

If a differential control for the speed of the motors is provided, the pumpability and the reliability of the pump will be further increased. For example, if
30 liquid penetrates into the pump, both rotors are uniformly affected; the difference will change only slightly. On the other hand, if the control were to be carried out at a preset value independently for both rotors, very large speed changes would have to be
35 effected at both rotors if the rotors are suddenly braked by penetrating liquid.

Three-phase motors having a permanently magnetic rotor as drive have proved to be especially expedient for operation.

The invention is described below with reference to an advantageous embodiment and the attached drawings, in which:

Fig. 1 schematically shows the construction of a displacement machine in which the invention may be used; and

Fig. 2 shows profile bodies according to the invention, which may be used in connection with the displacement machine of Figure 1.

As shown in Fig. 1, two shafts 3, to which intermeshing profile bodies 4 are fastened, are mounted with bearings 2 in a pump casing 1 composed of a plurality of parts, the profile bodies 4 drawing in the medium to be delivered in the pump space 5 from the top through a connection 13 and discharging it at the bottom through openings (not shown). The shafts 3 and the profile bodies 4 are driven by electric motors 6, a separate electric motor 6 being provided for each shaft 3. Two intermeshing gears 7 are provided at the bottom on the shafts 3. The motors 6 are electronically synchronized by means of resolvers 8. In adverse operating conditions, if the electronic synchronization is insufficient, the gears 7 come into contact first, since they have a smaller angular clearance than the rotors 4. Normally, however, the gears 7 are not in contact, so that lubrication of these gears may be dispensed with.

Rotors according to the invention, in which the lead decreases from top (inlet end) to bottom (outlet end), are shown in Fig. 2. In the inlet region, the lead S_1 has a constant value over at least one turn. The same applies to the lead S_3 at the outlet end, which is also constant there but substantially smaller than the lead S_1 at the inlet end. In this case, the region of constant lead S_3 advantageously extends over at least two turns of the rotors 4. Between inlet end with lead S_1 and outlet end with lead S_3 , the lead S_2 changes continuously from the value S_1 to the value S_3 .

Patent claims

1. Displacement machine for compressible media, in particular a dry-running vacuum pump, having at least
5 two shafts (3) with rotors (4) which are designed as helical profile bodies (4) and whose profiles intermesh like gears during the rotation and run free of contact relative to one another, the lead of the helical profile bodies decreasing from the inlet to the outlet,
10 characterized in that the helical profile bodies (4) are of double-start design, and in that the leads (S_1 , S_3) at the inlet end and outlet end of the helical profile bodies (4) are constant, and in between the lead (S_2) decreases continuously from the larger lead
15 (S_1) at the inlet end to the smaller lead (S_3) at the outlet end.
2. Displacement machine according to Claim 1, characterized in that the leads (S_1 , S_3) at the inlet end and outlet end are constant over at least one turn.
- 20 3. Displacement machine according to Claim 2, characterized in that the lead (S_3) at the outlet end is constant over at least two turns.
4. Displacement machine according to Claims 1 to 3, characterized in that the shafts (3) are each driven by
25 separate electric motors (6), the angular positions of the shafts (3) being determined with resolvers (8), on the basis of the signals of which the motors (6) are electronically synchronized, and the shafts (3) having gears (7) which intermesh and whose angular clearance
30 is less than that of the profile bodies (4).
5. Displacement machine according to Claims 1 to 4, characterized in that it has a differential control for the speed of the motors (6).
6. Displacement machine according to Claims 1 to 5,
35 characterized in that the motors (6) are three-phase motors having a permanently magnetic rotor.

