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Displacement machine for compressible media

5 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 configured as profiled bodies and whose
profiles engage with one another in the manner of
10 gearwheels during rotation and run without contact
relative to one another, each of the shafts being
driven by its own electric motor, the angular positions
of the shafts being determined by synchro resolvers, on
the basis of whose signals the motors are
15 electronically synchronized, and the shafts having
gearwheels, which engage with one another and whose
angular clearance is smaller than that of the profiled
bodies.

For a long time, it was usual to synchronize
20 the rotors of such displacement machines by means of
gearwheels, only one motor being normally provided. It
was, however, necessary to lubricate the gearwheels so
that it was only possible to avoid pollution of the
pumped medium by means of a very high level of
25 complication in the sealing of the gear relative to the
rotors and the actual pump space. However, the
corresponding seals wear out so that the pump had to be
taken apart in more or less regular intervals in order
to replace the seals.

30 These problems are avoided, in a pump of the
type mentioned at the beginning (US-5 836 746), by each
of the rotors being driven by its own electric motor
and these being electronically synchronized. The
angular positions of the two shafts are continuously
35 determined by synchro resolvers. The synchro resolver
signals are supplied to an electronic unit, which
drives the two electric motors synchronously in such a
way that the rotors cannot come into contact. In order
to ensure - under adverse operating conditions with the

synchronization operating inaccurately - that the rotors do not come into contact, which would lead to damage to the surfaces of the same; a gearwheel is provided on each shaft in this pump. The two
5 gearwheels engage with one another and have a smaller angular clearance than the profiled bodies. If, therefore, the electronic synchronization fails, the gearwheels, which run without contact in normal operation, come into contact first. The profiled
10 bodies, however, still cannot come into contact because they have an angular clearance which is greater than that of the gearwheels.

One problem in a displacement machine of this type consists in setting the rotors and gearwheels in
15 such a way that, during operation, the flanks of both rotors and gearwheels have the largest possible distance apart. In the ideal case, the position of the rotors and the gearwheels should be such that the rotors take up an angular position relative to one
20 another which is located in the centre between the two angular positions at which contact occurs. The same applies to the gearwheels. In normal operation, the displacement machine would then be operated with this "null position". This setting, however, is very
25 difficult to effect. A setting operation by mechanical means is laborious and inaccurate because the angular clearance between the gearwheels and between the rotors is only very small, and must only be very small, so that the gap between the profiled bodies, through which
30 a reverse flow occurs during pumping, is as small as possible.

In a displacement machine of the type mentioned at the beginning (US-5,417,551 A), setting of the gearwheels to the average of the angular positions at
35 which the gearwheels come into contact does in fact occur. The citation does not, however, show how the critical setting can be achieved such that the average of the two angular settings at which the flanks of the rotor come into contact coincides with the average of

the corresponding angular positions of the gearwheels. It is only then, however, that unproblematic operation is possible. The citation only describes how the average of the angular positions of the gearwheels is set. It is then assumed that the average values for the rotors and the average values for the gearwheels coincide. It is, indeed, stated that the clearance of the gearwheels on one side must not be larger than that on the other because otherwise the rotors would come into contact. Such a problem, however, only occurs if the central points of the rotors and the gearwheels do not coincide. If this problem occurs, this can only take place by a relative angular adjustment between the rotors and the gearwheels but no information on such an adjustment is provided by the citation. In addition, such an adjustment may not be possible because the gearwheels are located far within the machine, the angular sensors are located more or less at the end of the corresponding shaft and the gearwheel and rotor of the corresponding angular sensor are not directly connected to one another.

The object of the invention consists in creating a displacement machine, of the type mentioned at the beginning, in which the "null position" of the rotors and the gearwheels can be set simply, rapidly and accurately by means of the synchro resolvers.

The solution according to the invention consists in the fact that at least one of the gearwheels is directly connected to the rotor of the synchro resolver of its shaft and both together are releasably connected as a unit to the shaft.

The setting of the "null position" and of the flank clearance takes place, in accordance with the invention, in the following way. One rotor, to which the gearwheel and the synchro resolver are releasably fastened, is first held steady. The gearwheel can then execute a rotary motion relative to the shaft of this one rotor. The other rotor is then rotated in both rotational directions as far as a position in which the

flanks of the profiled bodies come into contact. The two contact angles are measured, and the rotor with its gearwheel fastened to it is set to the central position between these two angles and held steady.

5 The first rotor, likewise, is still held steady. The gearwheel of the first rotor, however, is now rotated in both directions to the point where, in each case, it comes into contact with the gearwheel of the other rotor. The contact angles are likewise again
10 established. The gearwheel is then set to the central value between these two contact points and firmly connected to the corresponding shaft; it is, in particular, firmly clamped by tightening bolts. Both the rotors, or profiled bodies, and the gearwheels are
15 therefore located exactly in the central position between the two positions in which they are in contact or would be in contact. This is the null position used to carry out the synchronization, the control being carried out in such a way that the relative position of
20 the two shafts, rotors and gearwheels corresponds, as far as possible, to this value during continuous operation.

The gearwheels are advantageously attached at one shaft end because they are then particularly easily
25 accessible, which facilitates the fastening of the initially loosened gearwheel to its shaft.

The displacement machine advantageously has a differential control for the rotational speed of the motors. Well-synchronized operation has already been
30 achieved by the synchronization according to the invention, by means of the setting of the flank clearance and the "null position". The operational behaviour is further improved if the two rotors are synchronized not to an independently specified required
35 value but, rather, if the synchronization takes place mainly on the basis of differences in the angular positions. If, for example, liquid penetrates into the pump space, the rotors are greatly retarded because the density of the liquid is approximately a thousand times

greater relative to gases with the retardation, however, taking place approximately equally for both rotors. Compensation for possibly occurring differences can then be provided by means of the
5 synchronization. This would not be the case if the synchronization were to take place to an externally specified value. However, an additional external control does, of course, occur in order to permit input of the desired rotational speed. This control,
10 however, which acts in the same sense on both motors, is relatively slow so that rapid rotational speed differences are obviated by the differential control.

It has been found particularly expedient for the drive if the motors are three-phase motors with
15 permanent magnet rotors.

The invention is described below using an advantageous embodiment with reference to the attached drawings. In these:

- 20 Fig. 1 shows, in cross section, a displacement machine according to the invention; and
Fig. 2 shows an enlarged representation of the arrangement, according to the invention, of the synchro resolvers.

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As is shown in Fig. 1, two shafts 3 are supported by bearings 2 in a pump housing 1, which is built up from a plurality of parts. Fastened to the shafts 3 are profiled bodies 4, which engage in one
30 another and, in the pump space 5, induce from above the medium to be pumped through a connection 13 and expel the medium at the bottom through openings which are not shown. The shafts 3 and the profiled bodies 4 are driven by electric motors 6, a separate electric motor
35 6 being provided for each shaft 3. Two gearwheels 7, which engage in one another, are provided at the bottom on the shafts 3. The motors 6 are electronically synchronized by means of synchro resolvers 8. In the case of adverse operating conditions, if the electronic

synchronization is not sufficient, the gearwheels 7 come into contact first because they have an angular clearance which is smaller than that of the rotors 4. The gearwheels 7 do not normally come into contact so that it is possible to dispense with lubrication of these gearwheels.

Fig. 2 shows an excerpt from the representation of Fig. 1 to an enlarged scale. On the right-hand shaft 3, the gearwheel 7 is connected to the synchro resolver rotor 9, which can be rotated relative to the shaft 3. The gearwheel 7 can, in turn, be fixed on the shaft 3 by means of the clamping element 13. The rotor 11 of the synchro resolver 8 is arranged on the sleeve 9 whereas the stator 12 of the synchro resolver 8 is arranged to be fixed relative to the housing.

In order to set the ideal position or the null position of both the rotors 4 and the gearwheels 3, the rotor 4 and its shaft 3 on the right-hand side in Fig. 1 are first held steady, the bolt 10 being loosened so that the right-hand gearwheel 7 can rotate. The left-hand shaft 3 is then rotated in both directions until the rotors 4 come into contact, these two contact angles being determined by means of the synchro resolver 8. The left-hand shaft 3 is then set to the average value between these two contact points. The right-hand shaft 3 of the right-hand rotor continues to be held steady. The gearwheel 7 located on the right is then moved in both directions until it comes into contact with the left-hand gearwheel. The two contact angles are measured by means of the right-hand synchro resolver 8. The gearwheel 7 is then set to the average value between these two angles and is tightened by means of the bolt 10. The two rotors 4 and the two gearwheels 3 are therefore located in the central position between the contact points. The operation is then synchronized to this value of the relative angles.



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 configured as profiled bodies (4) and whose profiles engage with one another in the manner of gearwheels during rotation and run without contact relative to one another, each of the shafts (3) being driven by its own electric motor
10 (6), the angular positions of the shafts (3) being determined by synchro resolvers (8), on the basis of whose signals the motors (6) are electronically synchronized, and the shafts (3) having gearwheels (7), which engage with one another and whose angular
15 clearance is smaller than that of the profiled bodies (4), characterized in that at least one of the gearwheels (7) is directly connected to the rotor (11) of the synchro resolver (8) of its shaft (3) and both together are releasably connected as a unit to the
20 shaft (3).
2. Displacement machine according to Claim 1, characterized in that the gearwheels (7) are attached at one shaft end.
3. Displacement machine according to Claim 1 or 2,
25 characterized in that it has a differential control for the rotational speed of the motors (6).
4. Displacement machine according to Claims 1 to 3, characterized in that the motors (6) are three-phase motors with permanent magnet rotors.