US 20150098853A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2015/0098853 A1

(43) Pub. Date: Apr. 9, 2015

Müller et al.

(54) SCREW-TYPE POSITIVE DISPLACEMENT MACHINE

(71) Applicant: **Ateliers Busch SA**, Chevenez (CH)

(72) Inventors: **Didier Müller**, Delemont (CH); **Théodore Iltchev**, Grandvillars (FR)

(21) Appl. No.: **14/400,614**

(22) PCT Filed: **May 27, 2013**

(86) PCT No.: **PCT/EP2013/060887**

§ 371 (c)(1), (2) Date: **Nov. 12, 2014**

(30) **Foreign Application Priority Data**

May 25, 2012 (EP) PCT/EP2012/059876

Publication Classification

(51) **Int. Cl.**

F04C 2/10 (2006.01)

F04C 15/00 (2006.01)

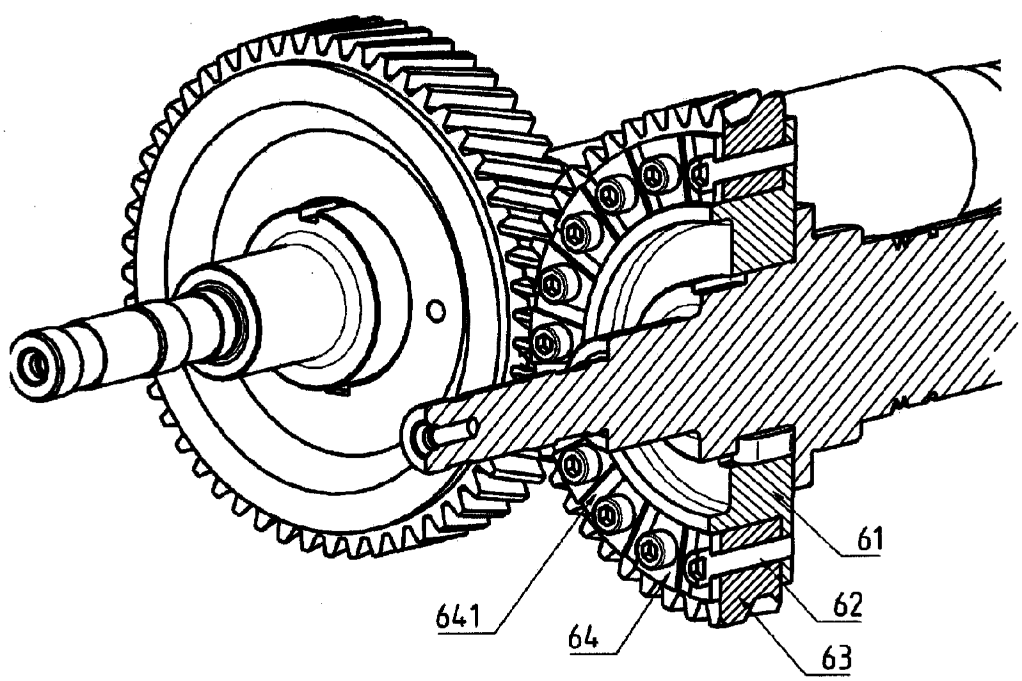
F04C 2/08 (2006.01)

(52) **U.S. Cl.**

CPC ***F04C 2/102*** (2013.01); ***F04C 2/084*** (2013.01); ***F04C 15/0096*** (2013.01)

(57) **ABSTRACT**

A screw-type positive displacement machine includes a housing with a first rotor and a second rotor which are mounted to rotate in the housing and which are driven in directions which are the opposite of one another. The positive displacement machine has a first motor and a second motor arranged in a drive casing and connected to the housing in such a way that the first rotor is driven by the first motor and the second rotor is driven by the second motor. Typically, the first motor and/or the second motor is an asynchronous motor.



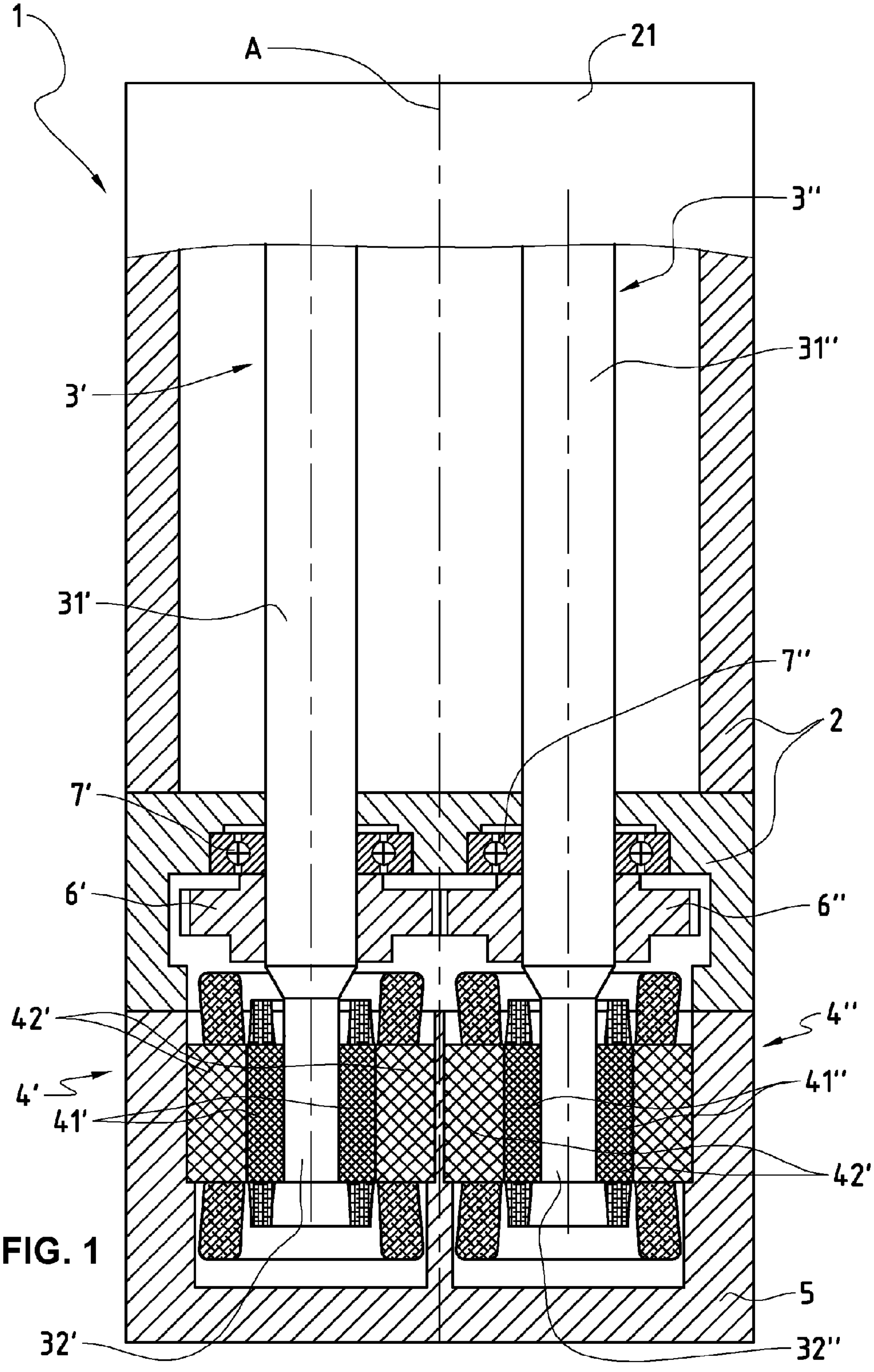


FIG. 1

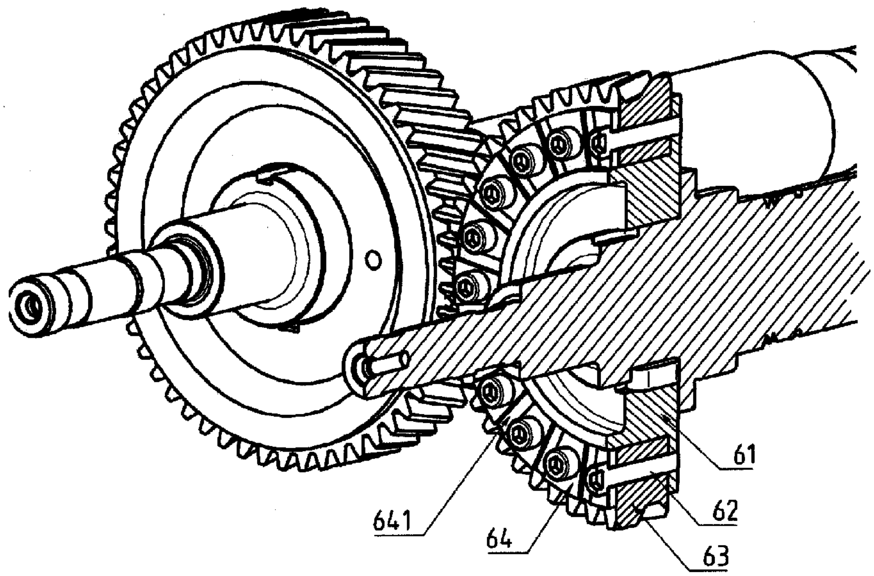


FIG. 2

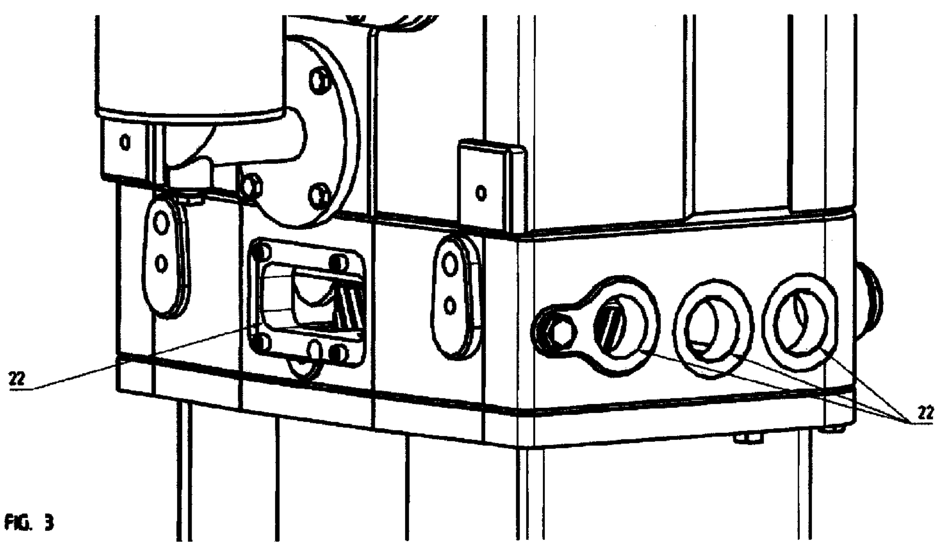


FIG. 3

SCREW-TYPE POSITIVE DISPLACEMENT MACHINE

TECHNICAL FIELD OF THE INVENTION

[0001] This invention relates to an improved screw-type positive displacement machine. More specifically, this invention relates to a positive displacement machine comprising a housing with a first rotor and a second rotor which are mounted to rotate in the housing and are which are driven in directions that are opposite of one another.

STATE OF THE ART

[0002] In the field of vacuum technology, rotary positive displacement machines have been used for a number of years and serve as machines for pumping compressible gases. Among these machines, the pumps referred to as "screw type" are used in particular. They typically comprise a housing and two twin rotors, mounted to rotate in this housing and driven in directions which are opposite of one another. The rotors of this type of pump are constituted by parts of screw shape, i.e. parts comprising a core which bears one or more threads whose pitch can be constant or variable along the longitudinal dimension of the rotor.

[0003] The structure and the functioning of this type of pump are well known by one skilled in the art of the technical field of vacuum and a detailed description of these pumps will therefore not be given here.

[0004] The rotors in a conventional screw pump are normally driven by an asynchronous electric motor. An asynchronous motor is typically composed of two main pieces, i.e. a stator in a ferromagnetic material which serves as support and which includes a winding connected to the network or to a variable speed drive, and a rotor in the form of a cylinder, likewise in a ferromagnetic material, which is fixed to the stator by bearings. The rotor comprises a winding made up of short-circuited conductors. The conductors of the rotor are passed through by currents induced by the magnetic field which is created by the stator currents.

[0005] Just like for a screw pump, the structure and the operation of the asynchronous motors are well known by one skilled in the technical field of vacuum. A more detailed description of these motors will thus be omitted.

[0006] Conventionally, one of the two pump screws is directly connected to the rotor of the asynchronous motor in such a way that it is automatically driven by the motor. Of course it is also possible to add a connection piece between the rotor of the motor and the shaft of the rotor, but it is important to note that the rotation of the rotor of the motor is transmitted in a direct way to one of the rotors of the pump. Thanks to a gearing which connects the two screws of the pump, the rotation of the first screw which is directly driven by the motor is directly transmitted to the other screw.

[0007] The advantages of this conventional structure reside particularly in the fact that the two screws of the pump can be driven by a single motor. Moreover the synchronization of the movements of the two rotors in the pump is automatically ensured by the fact that it is the rotation of the first screw which is transmitted to the other screw through the gearing connecting the two screws.

[0008] However this conventional structure also has big disadvantages, particularly caused by the need for lubrication of the gearing. In fact, concerning a gearing which transmits large moments, it is known that the wheels in the gearing are subjected to moments on the order of several kNm, which makes a good lubrication with mineral oil or grease absolutely necessary. Now, lubricated gearing means more complicated maintenance. On the other hand, the presence of oils or greases can negatively influence the performance of the pump, in particular in applications requiring a strict level of hygiene (for example in the food or pharmaceutical industry).

[0009] To overcome these problems it has already been proposed to modify a screw pump by replacing the drive having a single asynchronous motor such as described further above with a drive having two synchronous motors.

[0010] An asynchronous motor, exactly like a synchronous motor, is made up of a rotating part (or the rotor) and a fixed part (or the stator). In contrast to an asynchronous motor, the rotor in a synchronous motor is set in rotation by a magnetic field which is provided either by permanent magnets or by coils which are fed in d.c. current. As a general rule, the rotor in low power motors uses permanent magnets while electromagnets are used in motors with higher power.

[0011] Again one skilled in the art knows perfectly the structure and operation of synchronous motors and it does not seem necessary to give a more detailed description.

[0012] In a configuration with two synchronous motors, each of the two rotors (or screws) of the pump is driven by one of the two motors. The synchronization of the movements of the two rotors is achieved directly through the two motors. In fact, as the speed of rotation of the synchronous motors corresponds by default to the speed of rotation of the rotating field, it is easy to control the speed of rotation of the two screws using a corresponding control module. Thanks to this combined control module for the two motors, the speed of rotation of the two rotors of the pump can be synchronized.

[0013] However, synchronous motors are generally more expensive than asynchronous motors. Moreover the realization of the control module for the two synchronous motors also results in a considerable increase in costs of the pump. At the same time these control electronics must be integrated in the housing of the pump, which considerably increases the bulk of the pump.

SUMMARY OF INVENTION

[0014] The object of the present invention thus aims to overcome the aforementioned disadvantages and to provide a screw-type positive displacement machine which is at the same time less complex, less bulky and also less expensive than the machines of known type.

[0015] Another object of the present invention is to propose a screw-type positive displacement machine which is absolutely free of any lubricant which could pollute the pumped fluids.

[0016] These set objects of the invention are attained with a screw-type positive displacement machine comprising a housing with a first rotor and a second rotor which are mounted to rotate in the housing and which are driven in directions opposite of one another, the positive displacement machine comprising a first motor and a second motor which are arranged in a drive casing and which are connected to the housing in such a way that the first rotor is driven by the first motor and the second rotor is driven by the second motor.

[0017] The advantage of this invention, among other things, resides in particular in the fact that the rotors of the positive displacement machine proposed are driven individually. Owing to such individual driving, the two rotors can be driven more precisely and in a way more adapted to the concrete needs of the particular use.

[0018] In one particular embodiment of the invention, the first motor and/or the second motor is an asynchronous motor. This embodiment of the invention has the advantage, among other things, that the use of asynchronous motors makes the production of the positive displacement machine much less expensive than in the case of use of synchronous motors such as proposed in the state of the art. Moreover an asynchronous motor can typically be maintained and controlled in a much easier way than a synchronous motor having a comparable level of performance.

[0019] In another embodiment of the present invention, the rotary part of the first motor is connected to the first rotor and/or the rotary part of the second motor is connected to the second rotor. The advantage of this embodiment of the present invention can be found, among other things, in the simple construction of the positive displacement machine. In fact, the rotors (the rotary parts) of the motors can be directly connected to the rotors of the machine, but it is also possible to insert one or more connection elements between the rotary parts of the motors and the rotors of the pump.

[0020] In a noteworthy way, a first synchronization wheel and a second synchronization wheel, which mesh with one another, are provided, connected to the first rotor and second rotor respectively. Thanks to these synchronization wheels, a synchronized movement of the two rotors of the positive displacement machine is possible even in the case of stopping of one of the two motors. In fact, as the two synchronization wheels are connected to two rotors and as they mesh at all times in movement, a non-synchronized rotation of the two rotors is not possible. Thus damage to the screws is also not possible.

[0021] In another preferred embodiment of the present invention, the contact surface between the first synchronization wheel and the second synchronization wheel is not lubricated. The advantage of this embodiment of the invention is, among other things, that it allows a positive displacement machine to be achieved absolutely free of any lubricant. Owing to this fact, such machines can also be used in sensitive applications where elevated standards of hygiene must be respected. Also these machines are simpler to maintain since they do not need draining or other procedures for the lubricant.

[0022] Another embodiment of the present invention foresees that the surface of the teeth of the first synchronization wheel and/or of the second synchronization wheel is covered by a layer of material having a low coefficient of friction. This embodiment is advantageous, among other things, because it produces synchronization wheels which are able to support the transmission of elevated moments between them, owing to the fact that the friction at the surface of contact of the two wheels is diminished. The suitable materials to be used as covering are different types of metals and/or alloys (for example alloys of iron, of copper, of tin, of lead, etc.) as well as ceramic or different synthetic substances (such as, for example, Teflon®, etc.).

[0023] In a noteworthy way, the machine comprises a starter to synchronize the startup of the first motor and of the second motor. The advantage of this embodiment of the present invention resides, among other things, in a coordinated operation of the motors. Thanks to such a coordinated startup, the parameters of operation of the two motors (for example the speed of rotation, but also other parameters) can be synchronized to the maximum.

BRIEF DESCRIPTION OF DRAWINGS

[0024] The particular features and the advantages of the invention will appear with more details within the context of the description which follows with example embodiments given by way of illustration and in a non-limiting way with reference to the attached drawings which represent schematically:

[0025] FIG. **1**: a partial view and a section of an example realization of a positive displacement machine according to one embodiment of the present invention;

[0026] FIG. **2**: a view in perspective of an end of the rotors of a positive displacement machine according to one embodiment of the present invention, one of the two rotors of which is shown in section; and

[0027] FIG. **3**: a view of part of the outer body of the positive displacement machine according to one embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0028] As already mentioned, FIG. **1** is a schematic and sectional illustration of an example embodiment of a positive displacement machine according to the present invention. In this first figure, only the most important elements have been shown. One skilled in the art will nevertheless be able to understand that the positive displacement machine according to the invention necessarily has other elements so that it is able to be operational.

[0029] The positive displacement machine **1** in FIG. **1** comprises essentially a housing **2** which encloses two rotors **3'** and **3"**. The housing **2** of the machine **1** can be made as one sole piece or, as represented in FIG. **1**, can be made up of different pieces. Typically the housing **2** is open toward one side, and a cover **21** is used to close the housing **2** in order to create a closed chamber.

[0030] The rotors **3'**, **3"** each comprise a shaft **31'**, **31"** on which are installed two screws (not shown) with specific profiles. Generally the two screws of the rotors **3'**, **3"** are symmetrical with respect to the middle axis A of the machine **1**. In operation of the machine **1**, the rotors **3'**, **3"** are driven in rotation in directions opposite of one another. The principle of drive of the rotors **3'**, **3"** in the positive displacement machine **1** will be explained further below.

[0031] Integral with the housing **2** of the machine **1** is a drive casing **5** which comprises two motors **4'** and **4"**. Of course it is also conceivable to have two different drive casings, one for each of the motors **4'**, **4"**, or a completely different solution.

[0032] The motors **4'**, **4"** are asynchronous electric motors. These two asynchronous motors **4'**. **4"** are composed of rotors **41'**, **41"** and stators **42'**, **42"**. While the stators **42'**, **42"** are immobile (and typically integral) with respect to the drive casing **5**, the rotors **41'**, **41"** are set in rotation (and represent in this way rotary parts of the motors **4'**, **4"**) owing to the magnetic fields created by the currents in the stators **42'**, **42"** which induce currents in the windings of the rotors **41'**, **41"**. These well-known elements of asynchronous motors are not represented in FIG. **1** since one skilled in the art is absolutely able to grasp their placement and their way of operating in an actual motor.

[0033] The shafts **31'**, **31"** of the rotors **3'**, **3"** taper toward the motors **4'**, **4"** in the tapered zones **32'**, **32"**. These zones **32'**, **32"** of the rotors **3'**, **3"** are connected to rotors (to rotary parts) **41'**, **41"** of the motors **4'**, **4"** and can thus rotate directly with them. Naturally it is also possible to have a solution with intermediate transmission pieces which are situated between the rotors **3'**, **3"** and the motors **4'**, **4"**. In this way each of the two rotors **3'**, **3"** is driven by a different asynchronous motor.

[0034] The rotors **3'**, **3"** are typically supported in rotation by bearings **7'**, **7"** which are accommodated between the drive casing and enclosed chamber by the housing **2**. Of course solutions are possible comprising another variant of positioning of bearings.

[0035] Considering that the rotation of the rotor **3'** and the rotation of the rotor **3"** of the machine **1** must be synchronized to ensure correct functioning of the machine **1**, synchronization wheels **6'**, **6"** are provided, integral with the rotors **3'** and **3"**, respectively. In the normal case the teeth of the synchronization wheels **6'**, **6"** are not normally supposed to transmit moments between the two rotors **3'**, **3"**. As opposed to friction of the components and the variations in the rotors' charges, small moments to be counterbalanced may nevertheless appear. This is particularly possible owing to the symmetry—albeit in opposite direction—of the left part (with the rotor **3'** and the motor **4'**) and the right part (with the rotor **3"** and the motor **4"**) of the machine **1**.

[0036] In fact, during the startup of the motors **4'**, **4"**, the rotors **41'**, **41"** thereof are set in rotation and drive the rotors **3'**, **3"** of the machine **1**. A priori, the rotation of the rotor **3'** is absolutely independent of the rotation of the rotor **3"** since the motors **4'**, **4"** are both perfectly independent asynchronous motors. In this sense, owing to the symmetry of the two sides of the machine **1** and also to a likewise equal distribution of the charges, an almost synchronous rotation of the two rotors **3'**, **3"** is obtained, even without external influences. Of course it is preferable to use motors **4'**, **4"** of the same type, preferably from the same producer, having all the operation parameters identical (for example nominal speed, etc.) to make uniform as much as possible the parameters able to have an influence on the synchronization. In order to increase still further the synchronism between the motors **4'**, **4"**, a starter (not shown) can moreover be provided in order to be able to carry out a simultaneous startup of the motors **4'**, **4"**. Of course other solutions are likewise possible.

[0037] In this case the synchronization wheels **6'**, **6"** serve instead to ensure a synchronization of the movements even in the case of a failure of one of the two motors. To ensure that the rotation of the two rotors **3'**, **3"** will remain identical before the startup of the broken-down motor, the wheels **6'**, **6"** play the role of a "conventional" gearing and transmit the moments from one rotor to the other. Thanks to this structure, the machine **1** can continue to operate for the time it takes for a gradual stop and without risk for the whole installation.

[0038] The object of the invention is to make operational the pump equipped with an asynchronous motor for each rotor. These motors then rotate in a manner non-synchronized electronically with the gear train having a dry synchronization or a synchronization not lubricated with oil.

[0039] This object of the present invention is attained with the aid of a structure of the positive displacement machine such as described above.

[0040] However, to reduce the friction between the teeth of the synchronization wheels **6'**, **6"** and consequently the attrition and the development of heat in the situations when these teeth enter into contact anyway, several steps with subtle technical choices can be envisaged. These different steps and technical choices then result in a certain number of preferred embodiments of the present invention.

[0041] It is in particular possible to define teeth of the synchronization wheels **6'**, **6"** through calculation by optimizing certain parameters of which the most important are in particular the sliding speed and the mechanical efficiency of the transmission. Likewise, different suitable materials can be used in order to increase the desired performance of the wheels **6'**, **6"**, i.e. steels of different types (for example blister steel, nitrided steel, carbon-nitrided steel, tool steel, etc.) as well as different synthetic or plastic materials.

[0042] Likewise suitable thermal treatments can be applied to the materials of the wheels **6'**, **6"** to obtain increased hardness of the surface but also of the depth at the middle of the teeth. Moreover, in a noteworthy way, to improve the coefficient of friction, conceivable are suitable machining and finishing aiming at a good precision of the teeth but also microfinishing enabling the smoothest possible surface state to be obtained. It goes without saying that suitable machining and finishing can also be used to put the surfaces in necessary state to carry out the application of thin layers of coatings.

[0043] One or more successive coatings, including PVD and CVD-type coatings which do not adversely affect the steels already treated having increased hardness, and which bring still greater hardness can also be applied to improve the coefficient of friction and to reduce attrition.

[0044] Likewise the application of minimal lubrication with grease in suitable apportioning and cycles can also be envisaged to improve the performance of the positive displacement machine according to the present invention.

[0045] In the case of use of synthetic or plastic materials for one or the other of the gearings, the selection thereof requires a calculation optimizing the mechanical resistance while taking account of the sliding speed and the mechanical efficiency of the transmission. In this case it will be possible to have one gearing of plastic material and the other gearing in steel in different embodiments (finishings, coatings, etc.), again with the objective of reducing the friction, from which the reduction of heat is brought about which is the critical factor for the synthetic or plastic materials.

[0046] Some supplementary data on these different measures to be taken are also visible in FIGS. **2** and **3**.

[0047] As already mentioned, FIG. **2** shows an end of the rotors of the positive displacement machine, one of the two rotors being represented in section. Represented in this FIG. **2** is a toothing in plastic **63** which is fixed on a hub of steel **61** and held by a cover of metal **64**. This structure is locked by the screws **62**. In order to remove the heat from the plastic toothing **63**, these screws can in particular be in a number greater than really necessary for the mechanical fixation. In fact, these screws **62** pass through the plastic toothing **63** and are in contact therewith in such a way as to serve as heat sinks collecting thermal units and conducting them to the exterior faces of the hub **61** and of the cover **64**. As likewise shown in FIG. **2**, the exterior face of the cover **64** and/or the face of the hub **61** can have grooves **641** which, through the rotation, serve to facilitate heat exchange with the air.

[0048] Also, as shown in FIG. **3**, in the body of the positive displacement machine according to the present invention one or more openings **22** of suitable shape and positioning can be provided to allow the circulation of the air inside of the machine to thus improve removal of the heat.

[0049] Of course the present invention is subject to a number of variations as regards its implementation. Although diverse embodiments have been described it is understood that it is not conceivable to identify in an exhaustive way all the possible embodiments. It is of course conceivable to replace one means described by another equivalent means without departing from scope of the present invention. All these modifications form part of the common knowledge of one skilled in the art in the technical field of vacuum.

1. Screw-type positive displacement machine comprising a housing with a first rotor and a second rotor mounted to rotate in the housing and driven in directions opposite of one another,

characterized in that the positive displacement machine comprises a first motor and a second motor arranged in a drive casing and connected to the housing in such a way that the first rotor is driven by the first motor and the second rotor is driven by the second motor.

2. Positive displacement machine according to claim **1**, characterized in that the first motor and/or the second motor is an asynchronous motor.

3. Positive displacement machine according to claim **1**, characterized in that the rotary part of the first motor is connected to the first rotor and/or the rotary part (**41"**) of the second motor is connected to the second rotor.

4. Positive displacement machine according to claim **1**, further comprising a first synchronization wheel and a second synchronization wheel, which mesh with one another, connected to the first rotor and second rotor respectively.

5. Positive displacement machine according to claim **4**, characterized in that a contact surface between the first synchronization wheel and the second synchronization wheel is not lubricated.

6. Positive displacement machine according to claim **4**, characterized in that the surface of the teeth of the first synchronization wheel and/or of the second synchronization wheel is covered by a layer of material having a low coefficient of friction.

7. Positive displacement machine according to claim **1**, characterized in that the machine comprises a starter to synchronize the startup of the first motor and of the second motor.

8. Positive displacement machine according to claim **4**, characterized in that the first synchronization wheel and/or the second synchronization wheel has a composite structure.

9. Positive displacement machine according to claim **8**, characterized in that the composite structure of the first synchronization wheel and/or of the second synchronization wheel consists in a toothing in a first material and a hub in a second material.

10. Positive displacement machine according to claim **8**, characterized in that the composite structure of the first synchronization wheel and/or of the second synchronization wheel comprise a toothing and at least one screw allowing the heat to be extracted from the toothing.

11. Positive displacement machine according to claim **8**, characterized in that the composite structure of the first synchronization wheel and/or of the second synchronization wheel comprise at least one groove permitting heat exchange with the air.

12. Positive displacement machine according to claim **9** wherein said first material is a plastic material and said second material is steel.

* * * * *