A ROTARY DISPLACEMENT PUMP WITH VANES, SUITABLE FOR OPERATING WITH SCARCE OR ABSENT LUBRICATION

Abstract: A rotary displacement pump with vanes, which comprises a body (2), a pumping chamber defined within the body (2) by a peripheral wall (3) having a cylindrical shape with a circular cross section, and comprises a rotor (4) that carries vanes (5) and can be put in eccentric rotation within the pumping chamber, wherein a freely rotatable annular member (11) is installed inside the cylindrical peripheral wall (3) and defines a pump operating space (C) wherein rotates the vanes carrying rotor (4), the end portions of the vanes (5) being put in radial slipping contact against the inner surface of the rotatable annular member (11). Preferably, between the pumping chamber wall (3) of the pump and the outer surface of the freely rotatable annular member (11) there is left free a cavity (12), and this cavity (12) is put in communication with a delivery connection (10) of the pump. A freely rotatable disc (14) may be placed between at least an axial end of the vane carrying rotor (4) and the corresponding end wall of the pumping chamber, forming a cavity (15) which is put in communication with a delivery connection (10) of the pump. Preferably, the pump is coupled with an own electric motor (16) for driving the same.
DESCRIPTION

A ROTARY DISPLACEMENT PUMP WITH VANES, SUITABLE FOR OPERATING WITH SCARCE OR ABSENT LUBRICATION

BACKGROUND OF THE INVENTION

The subject of this invention is a rotary displacement pump with vanes, having provisions intended to allow its operation even in conditions of scarce or absent lubrication. This pump is mainly suitable for pumping air, and in particular manner for operating as a vacuum pump for use in the automotive field.

In the rotary displacement pumps with vanes, the slipping of the vane end portions against the wall of the pumping chamber requires an effective lubrication in order to ensure good performances, reliability and duration of the pump. The lubrication should be provided from outside, except in the particular cases in which the liquid moved by the pump has per se suitable lubricant properties, and in any event when the pumped fluid is air or another gas. The need for supplying a lubrication from outside involves installation, management and maintenance costs, as well as energy and oil consumption. Moreover, the presence of lubricating oil within the pumping chamber involves a pollution of the pumped fluid and the possible need for providing means for purifying the same. In the case of an overheating, the issue of vapors which are harmful or in any way undesirable is possible. In special conditions, as in the case of a cold start, of a reverse rotation of the pump and in general when a peak of torque arises, the presence of a lubricant causes or worsens the consequent damaging effects.

Some dry pumps are known, which are embodied by a technology using auto-lubricant materials based on carbon or based on synthetized materials having high porosity and impregnated with lubricant, however the cost of such pumps is high, and their reliability and duration is not satisfying.

Another drawback of the pumps taken in consideration resides in a certain noise caused by the slipping of the vanes against the surfaces of the pumping chamber.
BRIEF SUMMARY OF THE INVENTION

The main object of this invention is therefore to provide a rotary displacement pump with vanes which, by a suitable selection of the materials but without having recourse to special technologies, should be capable of operating in a correct manner even in the conditions of scarce or absent lubrication.

Such a pump offers several advantages. In particular, because no lubricant is present within the pumping chamber, no issue of oil is noticed in the pumped fluid and therefore there is no possibility of dispersing lubricant in the environment, and no issue of vapors takes place due to heating. It is not needed to supply lubricant oil to the pump, and therefore it is not necessary to provide any means for supplying the lubricant. The consumption of the energy for operating these means and the consumption of lubricant are avoided.

Another object of the invention is to reduce the pump noise produced by the vane slipping.

Still another object of the invention is to provide a pump for use in the automotive field that does not require to be operated by a mechanic connection to the vehicle engine, and therefore is mainly suitable for electric or hybrid vehicles, as well as for the application with usual gasoline or diesel engines when there is the need for simplifying the installation, or for reducing the costs and consumptions, or for installing the pump with a larger freedom of choice of the position thereof.

It is also an object of the invention to provide a pump for use in the automotive field which can be operated in the only periods in which its operation is needed, thus reducing the consumed energy and the wear of the component parts.

The main invention object is attained by a rotary displacement pump with vanes, which comprises a body, a pumping chamber defined within said body by a peripheral wall having a cylindrical shape with a circular cross section, and a rotor that carries vanes and can be put in eccentric rotation within said pumping chamber, characterized in that a freely rotatable annular member is installed inside said cylindrical peripheral wall and defines a pump operating space wherein rotates said vanes carrying rotor, the vane end por-
tions being put in radial slipping contact against the inner surface of said ro-
tatable annular member.

In this manner, the rotatable annular member is dragged in rotation by the friction of the vane end portions slipping against it with different speeds, and the total slipping is reduced in a substantial way with respect to the slipping that takes place in a conventional pump, wherein the vane end portions slip against the unmovable wall of the pumping chamber. In effect, the slipping of the vane end portions against the rotatable annular member is only that produced by the differences among the tangential speeds of these end portions, whereas in a conventional pump the slipping of the vane end portions against the unmovable wall of the pumping chamber is produced by the entire tangential speed of the vane end portions.

This substantial reduction of the slipping makes possible a correct operation with a scarce lubrication and even in the absence of any lubrication. As a consequence, the advantages stated hereinabove are attained.

Moreover, the substantial reduction of the slipping correspondingly reduces the pump noise, because the contact among the vanes and the chamber wall is mediated by the rotatable annular member, and this allows avoiding costly soundproofing provisions.

The rotatable annular member, under action of the vanes, can rotate in continuous or intermittent manner, depending on the materials used in the embodiment of the component parts, on the coupling tolerances and on the operating conditions.

Preferably, between the pumping chamber wall of the pump and the outer surface of said freely rotatable annular member there is left free a cav-
ity, and this cavity is put in communication with the delivery connection of the pump.

In this way the pumped fluid forms a fluid cushion between the wall of the pumping chamber and the annular member, thus reducing the slipping and the clearances.

Preferably, a freely rotatable disc is placed between at least one axial end of the vane carrying rotor and the corresponding end wall of the pumping chamber, and a cavity is left free between said rotatable disc and said end wall of the pumping chamber, and is put in communication with the delivery connection of the pump.
Also in this case, the pumped fluid forms a fluid cushion between the end wall of the pumping chamber and the rotatable disc, by reducing the slipping and the clearances. The freely rotatable disc is pushed and maintained against the rotor and the vanes, and in this manner the axial clearance is reduced to a minimum and is optimized, with a consequent advantage for the pump performance.

It is of advantage that the pump is coupled with an own electric motor for driving the same. In this manner the pump is free from the need to be connected to an engine as that of a vehicle, its installation is simplified and is free from restrictions, and this is of particular importance in the installation on a vehicle. Particularly, such a pump can be advantageously installed on electric or hyrid vehicles, wherein it is not possible or suitable to couple the pump to a vehicle driving engine.

Moreover, it is easy to provide control systems intended for operating the pump only when its operation is needed, by allowing rest periods with consequent reduction of the consumptions and the wear of the component parts. In this way, a reduction of the consumed energy can be attained, that amounts from the 70% to the 90% with respect to a pump mechanically driven by a vehicle driving engine.

The pump according to the invention is mainly suitable for pumping air or gases, and in particular for the application in the automotive field as a vacuum pump intended to supply depression to a pneumatic servomotor for assistance to the braking, or to other apparatuses or pneumatic actuators which need to receive a depression.

However the features according to the invention can also be applied in different fields, for example to hydraulic displacement pumps using a cylindrical pumping chamber, and in general in those cases in which there is a request for operating in conditions of scarce or absent lubrication by working on fluids having a low lubricating capacity.

**BRIEF DESCRIPTION OF THE DRAWINGS**

These and other features, objects and advantages of the subject of this invention will appear more clearly from the following description of an embodiment, being a non limiting example, with reference to the appended drawings, wherein:
Figure 1 represents a side view of a pump according to the invention, coupled with its own driving electric motor.

Figure 2 is an axial view thereof from an end.

Figure 3 shows a cross section of the pump taken along line III-III of Figure 1.

Figures 4 and 5 show two longitudinal sections of the pump, taken along line IV-IV and respectively line V-V of Figure 3.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

The pump according to the invention is mainly suited for the use as a vacuum pump in the automotive field, and for this reason the following description refers to such application, but is is to be understood that this application is in no way exclusive and that the features of the invention may be adopted in many other applications of displacement pumps.

The shown pump is of a kind having two vanes, but the same conceptions may be applied in pumps having more that two vanes, or in a pump having a single vane with movable end portions, depending on the geometrical characteristics and the performances required by any particular application of the pump.

The pump is supported by an interface 1 and it has an outer body 2 having an inner surface 3 that is cylindrical, has a circular cross section whose center lies on an axis A which can be the general axis of the pump, and delimitates a pumping chamber. In the pumping chamber is installed a rotor 4 which carries the vanes 5. Rotor 4 can be put in rotation by means of a driving joint 6. Rotor 4 and the driving joint 6 are installed around an axis B which is parallel to the pump axis A and is far from it of a distance E, that represents the eccentricity of the pump. In a wall of the pumping chamber is made a suction opening 7 communicating with a suction connection 8, and is also made a delivery opening 9 communicating with a delivery connection 10.

In a conventional pump, the outer end portions of the vanes 5 are put at radial contact with the inner surface 3 which defines the pumping chamber. The operation of such a pump is well known; the displacement of the vanes 5, resulting from the eccentric rotation of rotor 4 (in the case of the drawing, a rotation in the clockwise direction according to Figure 3) causes a fluid suction through the opening 7 from the suction connection 8, displaces the
sucked fluid along the space C by compressing the same, and then discharges the compressed fluid through the opening 9 and the delivery connection 10.

According to the main feature of the invention, a freely rotatable annular member 11 is installed inside the inner surface 3 of the pump body 2, and it defines within the pumping chamber an inner operating space wherein the rotor 4 and the vanes 5 are housed. Therefore, the outer end portions of the vanes 5 do not radially contact the inner surface 3 of the pump body 2, but they contact the inner surface of the annular member 11. Apart from this difference, the pump operation does not anyway differ from the above membered operation of a conventional pump.

During the rotation of rotor 4 with the vanes 5, the outer end portions of the vanes are at frictional contact against the annular member 11, and because this latter is freely rotatable it follows the vane rotation, however with a certain slip, because the end portions of the vanes have always different tangential speeds, except in a symmetry position. However the total slip, produced only by the differences in tangential speed of the vanes and not by their absolute speeds, is reduced in a substantial way with respect to the slip which takes place when (as in a conventional pump) the end portions of the vanes are at direct radial contact against the inner surface 3 of the pump body 2. For this reason the described pump is capable of correctly operating even when the lubrication is scarce or entirely absent.

According to a feature of the invention, between the inner surface 3 of the pump body 2 and the annular member 11 there is left free a cavity 12, and this cavity is in some way, for example through a passageway 13, put in communication with the delivery duct extending from the delivery opening 9 to the delivery connection 10. In this manner, a portion of the pumped fluid flows into the cavity 12 by producing the effect of an air cushion, which contributes to reduce the slippings and the clearances, at the consequent benefit of the performances.

According to another feature of the invention, a freely rotatable disc 14 is interposed between the rotor 4 and the vanes 5, on one side, and an end wall of the pump body 2. A cavity 15 is left free between body 2 and disc 14, and this cavity is put in communication with the delivery duct for the fluid. Also in this case, a portion of the pumped fluid flows into the cavity 15 by
producing the effect of an air cushion, which contributes to reduce the slippings and the clearances, at the consequent benefit of the performances.

It is of advantage that the pump according to the invention is coupled with an electric motor 16 which operates the driving joint 6 of rotor 4. In this manner the pump is operated by its own electric motor and, when installed on a vehicle, it does not need a mechanical connection to the vehicle driving engine. Its installation is simplified and is free from restrictions. This has a particular importance for the application on a vehicle. In particular, such pump may be advantageously installed onto electric or hybrid vehicles, wherein it is not possible or suitable to couple the pump with a vehicle driving engine.

In this case it is easy to provide a control system intended to activate the pump only when suitable sensors reveal that the pump operation is needed. However, even when the pump is not coupled with an own electric motor, it is possible to provide a mechanism capable of stopping the pump when its operation is not needed.

The pump according to the invention is particularly suitable for forming a vacuum pump for use in the automotive field. It may be the only depression source, or it may be used as a support for a mechanical pump directly dragged by the vehicle driving motor, or even it may constitute an additional depression source in those installations which usually take the depression from the suction duct of the engine.

The main advantage offered by the invention resides in the possibility of providing a pump having a long duration and capable of operating in the absence of lubrication for intermittent working cycles, or with a very reduced quantity of lubricant for continual working cycles.

It is to be understood that the invention is not limited to the embodiment which has been described and shown as an example. Several possible modifications have been mentioned in the course of the description, and others are within the capacity of those skilled in the art. These modifications and others, as well any replacement with technically equivalent means may be applied to what has been described and shown without departing from the spirit of the invention and the scope of this patent as defined by the appended Claims.
CLAIMS

1. A rotary displacement pump with vanes, which comprises a body (2), a pumping chamber defined within said body (2) by a peripheral wall (3) having a cylindrical shape with a circular cross section, and a rotor (4) that carries vanes (5) and can be put in eccentric rotation within said pumping chamber, characterized in that a freely rotatable annular member (11) is installed inside said cylindrical peripheral wall (3) and defines a pump operating space (C) wherein rotates said vanes carrying rotor (4), the end portions of the vanes (5) being put in radial slipping contact against the inner surface of said rotatable annular member (11).

2. A displacement pump as set forth in Claim 1, characterized in that between the pumping chamber wall (3) of the pump and the outer surface of said freely rotatable annular member (11) there is left free a cavity (12), and this cavity (12) is put in communication with a delivery connection (10) of the pump.

3. A displacement pump as set forth in Claim 1, characterized in that a freely rotatable disc (14) is placed between at least one axial end of the vane carrying rotor (4) and the corresponding end wall of the pumping chamber, and a cavity (15) is left free between said rotatable disc (14) and said end wall of the pumping chamber, and is put in communication with a delivery connection (10) of the pump.

4. A displacement pump as set forth in Claim 1, characterized in that the pump is coupled with an own electric motor (16) for driving the same.

5. A displacement pump as set forth in Claim 4, characterized in that the pump is controlled by a system intended for operating the pump only when its operation is needed.

6. A displacement pump as set forth in Claim 1, characterized in that the pump is controlled by a mechanism intended for operating the pump only when its operation is needed.
7. A displacement pump as set forth in one or more of the foregoing Claims, characterized by its application to the pumping of air or gases, and in particular for the application in the automotive field as a vacuum pump intended to supply depression to a pneumatic servomotor for assistance to the braking, or to other apparatuses or pneumatic actuators which need to receive a depression.