# DIAPHRAGM PUMP

The present invention relates to a diaphragm pump comprising a pump housing and a pump cover, a diaphragm being clamped between the pump housing and the pump cover in a clamping region.

Such diaphragm pumps are generally known in a wide variety of variants and can be driven in different ways, for example mechanically, pneumatically, or hydraulically. Diaphragm pumps are also used in a wide variety of fields of application and for conveying different pumped media, ranging from gases and liquids to highly viscous fluids such as oils or butter. Furthermore, they can also be used as metering pumps.

For this purpose, the pump housing has a hydraulic chamber and the pump cover has a delivery chamber. The diaphragm is clamped between the pump housing and the pump cover in the clamping region in such a way that the hydraulic chamber is separated from the delivery chamber. Therefore, the diaphragm initially has the task of sealing off the delivery chamber from the hydraulic chamber, so that both the hydraulic chamber and the delivery chamber are protected against any harmful influences of the fluid to be conveyed or of the hydraulic fluid, respectively.

In addition, the diaphragm serves to drive the medium that is to be conveyed. For this purpose, the diaphragm can be designed as a flexible pressure diaphragm, so that, starting from its rest position, it can be deflected by pressure. It is pressurized for this purpose in the hydraulic chamber by a working medium. This can be achieved, for example, by means of a piston that is moved in the direction of the hydraulic chamber by a drive, such as a motor. To deflect the diaphragm back into the hydraulic chamber, the piston is moved in the other direction, so that the working medium is drawn in by the piston and a negative pressure is created in the hydraulic chamber. In other words, the negative pressure draws the diaphragm into the hydraulic chamber.

Typical materials from which such a diaphragm can be made include, for example, metals such as stainless steel sheets, but also plastics such as polytetrafluoroethylene (PTFE). However, the use of mixtures of different materials, such as composite materials, is also conceivable.

Since very high operating pressures are required when conveying highly viscous fluids, such as butter, metal diaphragms have generally been used here to date. These have proven particularly reliable, especially regarding tightness in the clamping region at very high pressures. This is due, among other things, to the fact that a diaphragm made of PTFE cannot be clamped with as much force and cannot be subjected to operating pressures as high as, for example, a diaphragm made of sheet steel.

This is because both the pump cover and the pump housing are repeatedly elastically deformed by the oscillating pressure fluctuations. The internal pressure in the delivery chamber as well as in the hydraulic chamber pushes the pump cover and the pump housing apart and each away from the diaphragm, resulting on the one hand in a gap between the pump cover and the diaphragm in the delivery chamber, and on the other hand in a gap between the pump housing and the diaphragm in the hydraulic chamber. Through the gap, the pressurized working medium and also the pumped medium can migrate under the clamping region. It has been shown that this leads to leaks along the diaphragm and widenings of the pump cover and of the pump housing in the clamping region. The higher the working pressure, the more pronounced this effect is. What is more, the oscillating deformation in the clamping region can also lead to material fatigue. Especially in conventional diaphragm pumps having polytetrafluoroethylene (PTFE) diaphragms, this limits the maximum operating pressure.

On the other hand, plastic diaphragms have certain cost advantages over metal diaphragms. It is therefore desirable that plastic diaphragms also be utilizable at

higher operating pressures than previously without compromising the tightness of the pump.

It is therefore the object of the present invention to provide a diaphragm pump that is improved with regard to sealing and to reduce manufacturing costs.

This object is achieved according to the invention with a diaphragm pump according to claim 1. Advantageous refinements of the invention follow from dependent claims 2 to 9.

The diaphragm pump according to the invention thus differs from a generic diaphragm pump in that the pump cover has, in the region of the center of the delivery chamber, an at least partially convex bulge into the delivery chamber.

The at least partially convex bulge of the pump cover offers special advantages. For instance, investigations by the applicant have shown that the shape of the pump cover in the region of the delivery chamber is of great importance. Conventional pump covers are planar in the region of the center of the delivery chamber, and the inlet and outlet to the delivery chamber are angled. High pressures can occur in the region of the angling, which pressures interact with the clamping region of the diaphragm and promote the pumped medium being forced into the gap. By virtue of the convex bulge according to the invention, the stiffness of the pump cover is increased, since the deformation is greatest particularly in the center of the pump cover. Granted, more material is required at this location for this purpose. However, this disadvantage is more than compensated for by the increased tightness in the clamping region of the diaphragm.

This is because a further advantageous effect of the bulge is the change in the direction of action of the pressure in the delivery chamber. Especially when the diaphragm is deflected into the delivery chamber in order to force the pumped medium

out of the delivery chamber, the internal pressure on the pump cover is increased. The bulge at the edges ensures that the pumped medium flows toward the clamping region approximately perpendicularly and presses against the same. The pressure there is thus deliberately increased in such a way that elastic movement in the clamping region of the diaphragm is reduced. As a result, a possible gap formation between the diaphragm and the pump cover in the clamping region is avoided, and thus also infiltration of the pumped medium through the gap. This in turn leads to greater tightness of the diaphragm in the clamping region. This design leads to an increase in the operating pressure when using PTFE diaphragms in diaphragm pumps, specifically with otherwise unchanged dimensions of the diaphragm pump. This results in cost advantages in manufacturing compared to diaphragm pumps having metal diaphragms.

In a refinement, the convex bulge of the pump cover is spherical at least in regions. "Spherical" is to be understood in particular as meaning that the radius of the three-dimensional bulge is constant. The curvature in the pump cover is thus directed more strongly radially outward. This provides a further improvement in the bending stiffness of the pump cover, in particular when the diaphragm is deflected into the delivery chamber in order to force the pumped medium out of the delivery chamber. Particularly the roundings of the bulge toward the outlet ensure better discharge of the pumped medium and a reduction in dynamic pressure on the pump cover.

Advantageously, the convex bulge of the pump cover is centered relative to the center of the delivery chamber. It is to be understood in this context that, in a plan view of the pump cover, the convex bulge of the pump cover is centered relative to the center of the delivery chamber. This advantageously provides an especially uniform distribution of the internal pressure over the circumference of the delivery chamber. Local pressure increases, which lead to local widenings or elastic movements of the pump cover in the clamping region, are reduced.

Preferably, the delivery chamber has a widening on the side of the clamping region of the diaphragm. The widening is directly connected to the inlet and outlet openings of the delivery chamber. Furthermore, the widening is tangentially connected to the convex bulge. The widening advantageously changes the internal pressure distribution on the clamping region in such a way that the prevailing internal pressure in the delivery chamber serves to assist the tightness of the diaphragm in the clamping region. This is achieved through a reduction of the elastic movement of the pump cover in the clamping region due to the internal pressure. This enables the use of PTFE diaphragms in diaphragm pumps at very high operating pressures.

In a refinement, the widening is formed circumferentially and centered relative to the center of the delivery chamber. It is to be understood in this context that, in a plan view of the pump cover, the widening is centered relative to the center of the delivery chamber. This advantageously results in an especially uniform pressure distribution across the circumference of the delivery chamber.

Preferably, the widening is configured such that a wall of the delivery chamber in the clamping region of the diaphragm extends perpendicular to the diaphragm in the undeformed state. Owing to the perpendicular design, the clamping region is made thicker and more solid. This leads to greater stability of the edge of the clamping region compared to a wall that tapers toward the diaphragm at an acute angle.

Advantageously, the widening is arranged relative to an inlet and/or outlet channel of the pump cover such that an inflowing and/or outflowing pumped medium flows at least partially perpendicular toward or away from the diaphragm. In this context, the expression “partially perpendicular” is to be understood as meaning that a portion of the pumped medium flows perpendicular toward or away from the diaphragm. This achieves an improved pressure distribution at the edges of the clamping region in the delivery chamber, which prevents local gap formation and thus infiltration of the pumped medium. This improves the tightness of the diaphragm in the clamping region.

Preferably, the delivery chamber has a diameter in the clamping region of the diaphragm which corresponds to the diameter of the hydraulic chamber in the clamping region of the diaphragm. As a result, uniform clamping of the diaphragm is advantageously achieved on both sides. Due to the identical diameters in the hydraulic chamber and in the delivery chamber, the deflected surface area of the diaphragm is identical in both directions, thereby avoiding excessive deformation of the diaphragm in one of the two directions. Furthermore, gap formation between the diaphragm and the pump cover or housing is also prevented, so that infiltration of the pumped medium or hydraulic medium and widening associated therewith is prevented.

Expediently, the diaphragm consists of a material which comprises at least one metal and/or a plastic, in particular a polytetrafluoroethylene (PTFE). If the diaphragm is made of a metallic material, higher pressures can be achieved with the diaphragm pump. If, on the other hand, the diaphragm is manufactured from a plastic material, the diameter of the hydraulic chamber can be smaller due to the higher deformability of the plastic material, which also reduces the external dimensions of the diaphragm pump.

The invention is explained in greater detail below with reference to an exemplary embodiment that is illustrated in the schematic drawings, in which:

FIG. 1 is a perspective view of a pump head of a diaphragm pump according to the invention;

FIG. 2 is a front view of the pump head of Fig. 1;

FIG. 3 is a cross-sectional view of the pump head of Fig. 2 along the sectional plane A-A;

FIG. 4 is a front view of a pump cover;

FIG. 5 is a cross-sectional view of the pump cover of Fig. 4 along the sectional plane B-B;

FIG. 6 is a rear perspective view of the pump cover of Fig. 4; and

FIG. 7 is a perspective cross-sectional view of the pump cover of FIG. 6.

Fig. 1 shows a perspective view of an exemplary embodiment of a pump head 1 of a diaphragm pump according to the invention. The pump head 1 has a pump housing 2 and a pump cover 3 fastened to the pump housing 2. The pump cover 3 has an inlet 4 and an outlet 5 to convey a pumped medium.

Fig. 2 shows a front view of the pump head 1 with a plan view of the pump cover 3. Indicated therein is a sectional plane A-A through the center of the pump head 1 and of the inlet and outlet 4, 5. The corresponding cross-sectional view of the pump head 1 along the sectional plane A-A is shown in Fig. 3.

As can be seen in particular from the sectional view in Fig. 3, the pump housing 2 has a hydraulic chamber 6 which, in the operating state, is filled with a working medium, such as a suitable hydraulic fluid. The pump cover 3 has a delivery chamber 7 in which, in the operating state, the pumped medium is conveyed from the inlet 4 to the outlet 5. The pump head 1 also has a diaphragm 8 which separates the hydraulic chamber 6 from the delivery chamber 7. The diaphragm 8 is positioned on the pump cover 3 with a pin 9 and fastened with fastening means 19 such that the diaphragm 8 is clamped between the pump housing 2 and the pump cover 3 in a clamping region 10. This will be explained in greater detail later.

The diaphragm 8 is configured such that it can be deflected back and forth into the delivery chamber 7 and into the hydraulic chamber 6. In order to force the pumped medium out of the delivery chamber 7, the diaphragm 8 is pressurized by the working medium, so that the diaphragm 8 is deflected into the delivery chamber 7 and, by the pressure on the pumped medium, the latter is pumped through the outlet 5. The pressurization of the working medium is effected by a piston 11 mounted in the pump housing 2 so as to be linearly movable transversely to the diaphragm 8. If the piston 11 is moved toward the diaphragm 8, the working medium is pressurized, so that the diaphragm 8 is deflected into the delivery chamber 7. If the piston 11 is moved away from the diaphragm 8, the working medium is drawn in by the piston 11, so that the diaphragm 8 is deflected into the hydraulic chamber 6. Due to the oscillating deflections of the diaphragm 8, the pumped medium is drawn into the delivery chamber 7 and forced out of the delivery chamber 7 again in the next working step.

The pump cover 3 is described in greater detail below. FIG. 4 shows a plan view of the pump cover 3. FIG. 5 shows the cross-sectional view along the sectional plane B-B, which extends through the center point of the pump cover 3, as can be seen from FIG. 4. For a better understanding of the design of the pump cover 3, the latter is shown in FIG. 5 without the diaphragm 8.

As can be seen from FIG. 5, the pump cover 3 has a convex bulge 12 in the region of the center of the delivery chamber 7. The bulge 12 is circular in plan view, as can be seen better in Fig. 7. It extends into the delivery chamber 7 and is centered relative to the center of the delivery chamber 7, so that the distance between the bulge 12 and the diaphragm 8 in the undeformed state is smallest in the center of the pump cover 3. Owing to the bulge 12 of the pump cover 3, the bending stiffness of the pump cover 3 is increased. This is because the oscillating deflection movements of the diaphragm 8 also result in pressure fluctuations in the delivery chamber, which lead to oscillating elastic movements of the pump cover 3. The bending stiffness of the pump cover 3, which is now increased compared to conventional pumps, leads to better tightness

overall and enables the use of PTFE as material for the diaphragm at significantly higher operating pressure than previously.

The inlet 4 has an inlet channel 13, and the outlet 5 has an outlet channel 14 in the pump cover 3. The inlet and outlet channels 13, 14 open respectively into the delivery chamber 7. The radius R of the bulge 12 is selected here such that the bulge 12 transitions tangentially into the inlet and outlet channels 13, 14, respectively. This improves the flow behavior of the conveyed medium in the inflow and outflow. In comparison to a variant in which the pumping chamber 7 has a planar surface parallel to the diaphragm 8, the bulge 12 and the tangential transition result in a better internal pressure distribution on the pump cover 3, since the pumped medium is able to flow out of the pumping chamber 7 better at the edges of the bulge 12.

As can also be seen from FIG. 5, the delivery chamber 7 has a widening 15 on the side of the clamping region 10 of the diaphragm 8, so that the distance between the bulge 12 and the clamping region 10 increases toward the diaphragm 8. The widening 15 is formed circumferentially between the bulge 12 and the clamping region 10 and centered relative to the center of the delivery chamber 7, as can be seen from Fig. 7. This advantageously achieves the most uniform possible internal pressure distribution in the circumferential direction. The widening 15 has the consequence that the inflowing or outflowing pumped medium increases the internal pressure on the clamping region 10. This reduces a widening of the clamping region 10 and the formation of a gap between the diaphragm 8 and the clamping region 10 in the pump cover 3. Owing to the greater internal pressure on the clamping region 10, elastic movements of the clamping region 10 are furthermore also reduced, which contributes to increasing the tightness and also the operating pressure of the pump.

It can be seen in FIG. 5 that the widening 15 is configured such that a wall 16 of the delivery chamber 7 in the clamping region 10 of the membrane 8 runs perpendicular to the membrane 8 in the undeformed state. The wall 16 is formed circumferentially

on the clamping region 10. The clamping region 10 also has a circumferential angled surface 17 which is situated opposite the bulge 12 and, together with the bulge 12, forms the widening 15.

The angle α is selected such that at least a portion of the pumped medium flowing through the inlet channel 13 into the delivery chamber 7 is deflected by the angle α and flows perpendicularly directly toward the diaphragm 8. Analogously to the inlet 4, at the outlet 5 the widening 15 is also arranged relative to the outlet channel 14 such that outflowing pumped medium flows at least partially perpendicularly away from the diaphragm 8. The wall 16, which projects perpendicularly to the membrane 8, makes the clamping region on the side of the pump cover 3 stiffer, thus advantageously reducing the elastic movements of the clamping region 10 and widenings between the membrane and the clamping region 10.

As can be seen in FIG. 5, the delivery chamber 7 has a diameter D1 in the clamping region 10 of the diaphragm 8, which diameter is formed by the circumferential wall 16. The hydraulic chamber 6 in the pump housing 2 likewise has a diameter D2 in the clamping region 10 of the diaphragm 8, as can be seen from FIG. 3. For a balanced pressure distribution in the clamping region between the pump cover 3 and the pump housing 2, and for an identical deformed area of the diaphragm 8 both into the delivery chamber 7 and into the hydraulic chamber 6, the diameter D1 corresponds to the diameter D2. Further advantages result from the fact that the clamping region 10 is loaded equally on both sides.

Fig. 6 shows a rear perspective view of the pump cover 3, i.e. the side which rests against the pump housing 2, and Fig. 7 shows a perspective cross-sectional view of the pump cover 3 cut through the inlet and outlet 4, 5.

In order to be able to better maintain the diaphragm 8 under pressure in the clamping region 10 of the pump cover 3 and of the pump housing 2, a serrated profile 18 is

provided on the clamping region 10 of the pump cover 3 and of the pump housing 2, respectively. By fastening the pump cover 3 to the pump housing 2, the diaphragm 8 is clamped and pressed in a positive-locking manner with the respective serrated profile 18 in order to prevent slipping of the diaphragm 8 in the clamping region 10 and to prevent ingress and infiltration of pumped medium and working medium into the clamping region 10.

In the present case, the diaphragm 8 consists of polytetrafluoroethylene (PTFE). Alternatively or additionally, however, it can consist of a metallic material in order to enable even greater operating pressures in the diaphragm pump to be achieved. Furthermore, the diaphragm 8 is embodied in the present case as a two-layer diaphragm in order to increase the leakage reliability and operational reliability of the diaphragm pump.

**REFERENCE SYMBOLS**

| | |
|---|---|
| 1 | pump head |
| 2 | pump housing |
| 3 | pump cover |
| 4 | inlet |
| 5 | outlet |
| 6 | hydraulic chamber |
| 7 | delivery chamber |
| 8 | diaphragm |
| 9 | pin |
| 10 | clamping region |
| 11 | piston |
| 12 | bulge |
| 13 | inlet channel |
| 14 | outlet channel |
| 15 | widening |
| 16 | wall |
| 17 | angled surface |
| 18 | serrated profile |
| 19 | fastening means |
| α | angle |
| D1 | diameter |
| D2 | diameter |
| R | radius |

## CLAIMS

1. A diaphragm pump comprising a pump housing (2) which has a hydraulic chamber (6), and a pump cover (3) which has a delivery chamber (7), wherein a diaphragm (8) is clamped between the pump housing (2) and the pump cover (3) in a clamping region (10) in such a way that the hydraulic chamber (6) and the delivery chamber (7) are separated from one another, **characterized in that** the pump cover (3) has, in the region of the center of the delivery chamber (7), an at least partially convex bulge (12) into the delivery chamber (7).

2. The diaphragm pump according to claim 1, **characterized in that** the convex bulge (12) of the pump cover (3) is spherical at least in regions.

3. The diaphragm pump according to claim 1 or 2, **characterized in that** the convex bulge (12) of the pump cover (3) is centered relative to the center of the delivery chamber (7).

4. The diaphragm pump according to any one of the preceding claims, **characterized in that** the delivery chamber (7) has a widening (15) on the side of the clamping region (10) of the diaphragm (8).

5. The diaphragm pump according to claim 4, **characterized in that** the widening (15) is formed circumferentially and centered relative to the center of the delivery chamber (7).

6. The diaphragm pump according to claim 4 or 5, **characterized in that** the widening (15) is configured such that a wall (16) of the delivery chamber (7) in the clamping region (10) of the diaphragm (8) extends perpendicular to the diaphragm (8) in the undeformed state.

7. The diaphragm pump according to any one of claims 4 to 6, **characterized in that** the widening (15) is arranged relative to an inlet channel and/or an outlet channel (13, 14) of the pump cover (3) such that inflowing and/or outflowing pumped medium flows at least partially perpendicular toward or away from the diaphragm (8).

8. The diaphragm pump according to any one of claims 4 to 7, **characterized in that** the delivery chamber (7) has a diameter (D1) in the clamping region (10) of the diaphragm (8) which corresponds to the diameter (D2) of the hydraulic chamber (6) in the clamping region (10) of the diaphragm (8).

9. The diaphragm pump according to any one of the preceding claims, **characterized in that** the diaphragm (8) consists of a material which comprises at least one metal and/or a plastic, in particular a polytetrafluoroethylene (PTFE).