

A Uni-axial Screw Pump

Field of The Invention

This invention relates to a uni-axial screw pump that conveys various liquids with different viscosities with a high pump efficiency and also to a motor with
5 large output.

Background of The Invention

In 300 B.C. an ancient Greek scientist Archimedes invented a so-called 'screw pump' with bamboo to pump water, having a helical blade mounted on a shaft, which rotates inside cylindrical hollow stem of bamboo.

10 A screw pump attracts concerns as a promising pump due to its simple structure, its mechanically strong rotor and its capability of operating in a wide range of flow and compression in comparison with other types of screw pumps.

Screw pumps whose entrance ends and discharge ends are bounded by the sealing lines are called enclosed screw pumps. And those without such sealing
15 line are called open screw pumps. Depending on the number of shafts carrying threaded rotor, the enclosed screw pumps are categorized into one-shaft screw pumps (or uni-axial screw pump), two-shaft screw pumps and three-shaft screw pumps.

An example of one-shaft screw pump is Moineau pump which comprises an
20 externally threaded rotor mounted in an internally threaded resilient casing, each carrying thread that winds in the opposite direction to be intermeshed each other. When the screw rotor rotates relative to the outer casing, the fluid trapped in the compartments formed in each pitch of screw is continuously conveyed in the axial direction. Thus, the Moineau pump is capable of quantitatively transferring
25 various viscous fluids with high pump efficiency. The intermeshing of external

thread of screw rotor and internal thread of outer casing is realized by two modes of movement of complicated motoring device; eccentric rotating and rocking movement which results in complication of motoring device and unfavorable vibration by dynamic load. Besides the outer casing should be made of resilient nonmetallic material with good endurance and for this purpose endurable synthetic rubber is generally used, but its service life is one month or less. Recent introduction of ceramic outer casing considerably increased service life, whereas the obtained pressure at the discharge end decreased to half that of synthetic rubber screw pump. Due to the unbalanced rotational movement of its motoring device that provides two movement modes of eccentric rotating and rocking, the speed of rotation should be limited, which makes mass transfer by Moineau pump impossible. Moreover, much mechanical friction loss is produced owing to the intermeshing of the threads that enables formation of seal and forced conveyance of the fluid to the outlet with high pump efficiency.

15 In an effort to overcome such frictional losses and limitation of rotation speed, screw pumps with two shafts were invented. A two-shaft screw pump comprises two parallel spaced shafts each carrying externally threaded rotors, the shafts being mounted in a pump body so that the threads of the rotors intermesh. Volumes of liquid trapped in each pitch between the threads of the rotors and the internal surface of casing are urged towards an outlet of the pump as the rotors rotate. During rotation, the threads intermesh, the gaps inevitably being formed at the points of intermeshing. By precisely differentiating the external diameters of the two screw rotors, it is theoretically possible to avoid the formation of gap, which enables operation of screw pump in high pressure. An ideal gap should be kept in the formation of seal and it is necessary to synchronize the rotating speed of the two rotors. Therefore, two-shaft and three-shaft screw pumps necessarily have the intermediary motoring device comprising a pair of synchronous gears.

And thus the production of these screw pumps raises various technical problems in the processing of intermeshing propellers. Moreover, enclosed two-shaft and three-shaft screw pumps are only capable of conveying lubricant fluids without foreign matters.

- 5 Open two-shaft screw pumps were developed to widen limited range of applicable fluids, improve conveying conditions of screw pumps and lower production cost.

As for open two-shaft screw pump, the sealing line is not formed even theoretically, which makes it possible to convey non-lubricant fluids in a wide
10 range of flow and conveying compression. However, the manufacturing process of these open screw pumps is still complicated and their weight is much heavier, since axial movement of fluid is realized necessarily by motoring device comprising a pair of synchronous gears.

Many studies have been carried out to avoid complexity in structure and
15 manufacturing problems caused by the intermediary motoring device and to realize the axially forced conveyance of fluid by means of a uni-axial screw pump.

As a screw rotor rotates in an outer cylinder with a linear central axis, the viscous fluid trapped in the groove of the screw, for its viscosity, rotates around the axis
20 of the screw and thus does not move in the axial direction as the screw rotor rotates. In structure of a screw pump for conveying powder material with high deformation resistance, the linear and grate-shaped grooves on the internal surface of the cylindrical casing restrain the material from moving in a direction around the axis and force it in an axial direction, wherein the material adjacent to
25 the inner surface of casing rather than that adjacent to the axis is more restrained against movement in a direction around its axis to thereby be urged in the axial direction.

To realize forced conveyance of fluid in the axial direction in a cylindrical casing with smooth inner surface, as realized in multi-axial screw pump, it is necessary to restrain the liquid's tendency to move in a direction around the axis of the screw rotor. It is based on the principle of bolt and nut; in order to ensure axial
5 movement of a nut, the nut should be restrained from moving around the axis when rotating the bolt.

Objects and Brief Description of The Invention

The first object of this invention is to provide a screw pump with high pump efficiency by inventing a new structure of uni-axial screw pump wherein by
10 restraining the liquid's tendency to rotate around the axis as the rotor rotates, the entire volume of conveyed fluid trapped between the helical blade and inner surface of cylindrical casing is forced in the axial direction towards the discharge end.

The second object of this invention is to provide a uni-axial screw pump, which
15 is simple in manufacturing structure, small in external dimension and capable of conveying fluids with various viscosities.

The third object of this invention is to provide a uni-axial screw pump having continuous motion mode, short conveyance channel and well-balanced state of rotation resulting in high speed of pumping.

20 The above objects could be achieved by the present invention that discloses a uni-axial screw pump mainly comprising: an outer cylindrical casing with entrance end and discharge end; a screw rotor mounted in the said casing which conveys the fluid from the entrance end to the discharge end as it rotates; a motor directly connected to the said rotor to drive it, characterized in that the thread
25 extended on the said rotor axis is disconnected perpendicularly to the axis to make a plurality of thread sections, a plurality of annular restraining devices

being inserted in the annular gaps formed between said disconnected thread sections, the said annular restraining devices having restraining elements and openings for the fluid to be conveyed through, inner cylindrical sections being axially disposed between the said inserted annular restraining devices to enclose
5 the screw rotor, as a result of which the fluid is restrained by the said restraining elements from moving in a direction around the axis as the axis rotates and is forced in the axial direction to the discharge end.

In a preferred embodiment of the present invention, the thread is disconnected at intervals of a screw pitch vertically to the axis to make a plurality of thread
10 sections, a plurality of ring shaped spaces being formed between thread sections. A plurality of restraining devices are inserted into the said spaces. The number of thread sections equals to that of the screw pitches in this embodiment.

According to the present invention, the said restraining devices are annular discs that fit the said annular gaps. The said annular discs comprise alternately
15 restraining elements and openings that the fluid may pass through in the axial direction. By the said restraining elements the fluid is restrained against the movement in a direction around the axis to thereby be forced in the axial direction.

In a preferred embodiment of the present invention, the said annular restraining
20 devices are diametrically halved for the convenience of fabrication and radially inserted into the annular spaces between the thread sections to be assembled as a unit.

According to the present invention, the internal diameter of the said annular restraining devices is smaller than that of the axis, whereby the devices are
25 plunged into the axis resulting in thorough sealing.

The part of disconnected surface of the thread at which the openings of restraining devices intersect with the thread is round shaped to thereby decrease resistance to the fluid.

If the said screw pumps are employed as extruders or molders, restraining
5 elements of the said restraining devices are bar shaped.

The axis of the said screw pump is tapering from the entrance end to the discharge end, the taper of which is $1/2 \sim 1/40$ towards the discharge end.

The outer cylindrical casing is in the form of jacket so that the said halved restraining devices and inner cylindrical sections can be conveniently and
10 accurately assembled.

The uni-axial screw pump according to the present invention further comprises liquid-cushion equalizer to equalize the thrust of the screw pump, wherein a rotating liquid-cushion equalizing disc is fixed to the axis of the screw rotor and a stationary liquid-cushion equalizing disc is mounted inside the covering of
15 medal. The two equalizing discs are contacted by means of the eccentric ring.

The uni-axial screw pump further comprises the structure of bearings wherein fibred non-metallic medals are inserted in 3-6 borings radially disposed in steel (or cast iron) bushing. The said structure makes it possible for the bearings to be safely immersed in the fluid and also for them to be closely located from each
20 other.

The external dimension of the uni-axial screw pump according to the present invention is less than one half that of the open two-shaft screw pump which has the same discharge capacity.

In comparison with the Moineau pump with identical diameter of the screw, the
25 flow of the screw pump of the present invention is increased by ten times, the external dimension is 40 %, the production cost is less than one seventh. Due to

its simple motoring device and no friction surface, its service life is increased by 20 times more than that of the Moineau pump and causes less vibration and sound during operation.

If the screw pump according to the present invention is employed as a hydraulic turbine, its efficiency, for its reaction rate of nearly 1, is higher than that of the existing hydraulic turbine by 10~15%. Its weight per horsepower is decreased to 1/8 ~1/10 that of existing hydraulic turbine with the same output and its service life is increased by 5 times as compared with that of the existing turbine.

Owing to the above advantages of the present invention, it can effectively serve for various purposes, for example, as hydraulic turbine, thermo motor, liquid motor, hydraulic coupling, extruder, food-processing machine.

The above objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of examples.

Brief Description of the Drawings

Figure 1 is a sectional view of the uni-axial screw pump according to a preferred embodiment of the present invention wherein a plurality of restraining devices are interposed between disconnected thread sections to restrain the fluid from moving around the axis and force all the fluid in the axial direction.

Figure 2 (a) is a sectional view of liquid-cushion equalizer according to a preferred embodiment of the present invention.

Figure 2 (b) is a sectional view of the said liquid-cushion equalizer that shows the contact surface wherein rotating disc and stationary disc are contacted by means of an eccentric ring.

Figure 3 (a) is a sectional view of nonmetallic medal of the bearing according to the present invention.

Figure 3 (b) is a sectional view that shows nonmetallic medal and its covering.

Description of The Preferred Embodiments

- 5 Referring now to the figure 1, the screw pump (1) made in accordance with the present invention is illustrated comprising an outer cylindrical casing (2) having an entrance end (1a) and a discharge end (1b).

The screw rotor (3) is a mould unit or welded unit is directly connected with the motor (4) and rotatably mounted in the said outer casing (2).

- 10 The thread (5) extended on the screw rotor (3) is disconnected at intervals of a pitch to make a plurality of thread sections (5) as many as screw pitches. The axis (6) of the screw is not disconnected, as a result of which a plurality of annular spaces is formed as the rotor (3) rotates between said disconnected thread sections (5).

- 15 A plurality of annular restraining devices (7) that fit the said annular spaces are inserted therein. The said devices (7) restrain the conveyed fluid from moving in a direction around the axis (6) as the screw rotor (3) rotates and urge it to axially move towards the discharge end (1b). An annular restraining device (7) is disposed at the start of the screw in order to restrain the conveyed fluid from the
20 beginning and thus the number of the annular restraining devices (7) is one more than that of the pitches of the screw.

As shown in figure 1, the annular restraining device comprises alternately restraining elements (9) and the trapezoid-shaped openings (8) for the fluid to pass through.

If the said screw pump is employed as extruder and molder, the restraining element is bar shaped.

The annular restraining devices (7) are diametrically divided into two, as shown in figure 1, for the convenience of fabrication. The screw rotor (3), inner
5 cylindrical sections (10), and the two-divided thread sections (7) are fabricated in proper sequence. The two-divided thread sections (7) are respectively inserted in the annular spaces in the radial direction to be assembled as a unit.

The internal diameter of the annular devices (7) is a little shorter than that of the axis (6) and thus a groove is formed on the axis (6) where the annular devices (7)
10 and the axis (6) intersect with each other. And the annular devices (7) are inserted therein. Therefore, the annular devices (7) are plunged into the axis (6) resulting in thorough sealing structure to prevent the leakage of the fluid in the gaps between the said devices (7) and the axis (6).

The axis (6) of the screw rotor (3) is tapering toward the discharge end (1b) to
15 increase the filling co-efficient in each thread sections (5), whose taper ranges from $1/2 \sim 1/40$ according to the kind of the conveyed fluid.

A plurality of inner cylindrical sections (10) are disposed between the said annular restraining devices (7) to encompass the screw rotor (3).

The part of the severed surface of the thread (5) at which the openings of
20 restraining devices (7) intersect with the severed surface of the thread is round shaped to thereby decrease resistance to the fluid.

The outer cylindrical casing (2) is in the form of jacket so that the said halved restraining devices (7) and inner cylindrical sections (10) can be conveniently and accurately assembled.

25 As shown in figure 2 (a) and (b), the device to equalize the thrust of the screw rotor (3) is disposed at discharge end (1b), which comprises stationary liquid

cushion disc (11) and rotating liquid cushion disc (12) contacted by means of eccentric ring (13b).

As shown in figure 3 (a) and (b), fibred non-metallic medals (16a) and (16b) in its coverings (15a) and (15b) are inserted in 3-6 borings radially disposed in steel
5 (or cast iron) bushing (14a) and (14b) which makes the bearing structure that can be safely immersed and lubricated in the fluid.

The operation of the above-mentioned screw pump (1) is described hereinafter in detail.

First of all, the operation of a screw pump with a connected thread is explained.

10 As the screw rotor rotates, the fluid around the screw rotor receives rotation moment and moment against rotation from the work surface of the thread and inner surface of cylinder. The fluid with viscosity has the tendency to rotate around the axis as the rotor rotates, while the inner surface of cylinder gives anti-rotating moment to the fluid and force it to move in the axial direction towards
15 the discharge end. Since most of the fluid trapped in the groove of the screw tends to move around the axis as the rotor rotates, the relative speed difference between the work surface of the thread and the fluid is nearly 0. Therefore, geometric flow and compression is not formed and the rotating fluid causes heat inside the cylinder.

20 The operation of the screw pump (1) with disconnected thread sections (5) and annular restraining devices (7) between them provided by the present invention is described hereinafter. As the rotor (3) rotates, the fluid trapped in the grooves of the screw receives energy by the restraining element that resists it from moving around the axis (6). As the resisted surface area increased, most of the
25 fluid is urged to flow horizontally in the axial direction towards the discharge end (1b). As a result, geometric flow is formed and the compression energy is obtained that is in proportion to the square of relative speed. The annular

restraining devices (7) have restraining elements (9) and alternately openings (8) that provide restraining effect and conveying effect at the same time, the mechanical energy and compression energy being continuously exchanged.

Therefore, the compression energy at the discharge end (1b) gets equal to
5 compression in one thread sections (5) multiplied by the number of the thread sections (5).

In the uni-axial screw pump (1) according to the present invention, axial thrust occurs by compression energy of the fluid. The figure 2 (a) and (b) shows liquid cushion equalizing device employed in an embodiment of the present invention
10 to equalize axial thrust of the screw pump (1) of the present invention. The operation of the said equalizer (11) is described in more detail hereinafter. The front surfaces of rotating cushion disc (12) and stationary disc (11) are influenced by the compressed fluid through the gap between the axis (6) and the bushing (14b) at the discharge end (1b), the two discs being fixed to the axis (6)
15 and prevented from axial movement. On the annular surface of the rotating cushion disc (12), pressure is given corresponding to its total area, which is equalized to the axial thrust by controlling the diameter of the said disc (11). As shown in figure 2 (a) and (b), the said rotating cushion disc (12) and stationary cushion disc (11) is ideally contacted each other at their sides by nonmetallic
20 ring (13b), which is eccentrically fixed to the stationary disc (11). The said nonmetallic ring (13b) involves rotating and rocking movement, as a result of which it is constantly lubricated and cooled to thereby increase its service life by 20 times that of concentric ring where heat is accumulated. In case that additional contacts may occur between the axis (6) at the entrance end and the
25 covering (15a) of the medal (16a) by the unbalanced thrust, nonmetallic contact ring (13b) is inserted at the side of the said covering (15a) to thereby decrease the friction.

Due to its axial parallel flow from the entrance end (1a) to the discharge end (1b), the uni-axial screw pump (1) with restraining devices (7) according to the present invention has short conveyance route and is not influenced by the radial load. The bearings of the said screw pump are mounted on both ends of the axis
5 wherein fibred non-metallic (wooden or plywood) medals are inserted in 3-6 borings radially disposed in steel (or cast iron) bushings (14). The said structure makes it possible for the bearings to be safely immersed and lubricated in the fluid and also for them to be closely located from each other. The vertical contact between steel and fabric nonmetal has low abrasion co-efficient resulting
10 in increased service life by 3-5 times that of metal ball bearing.

The present invention is not limited to the above-mentioned embodiments.

Claims

1. A uni-axial screw pump mainly comprising: an outer cylindrical casing with entrance end and discharge end; a screw rotor mounted in the said casing which conveys the fluid from the entrance end to the discharge end as it rotates; a motor directly connected to the said rotor to drive it, characterized in that the thread extended on the said rotor axis is disconnected perpendicularly to the axis to make a plurality of thread sections, a plurality of annular restraining devices being inserted in the annular gaps formed between said disconnected thread sections, the said annular restraining devices having restraining elements and openings for the fluid to be conveyed through, inner cylindrical sections being axially disposed between the said inserted annular restraining devices to enclose the screw rotor, as a result of which the fluid is restrained by the said restraining elements from moving in a direction around the axis as the axis rotates to thereby be forced in the axial direction to the discharge end.

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2. A uni-axial screw pump according to claim 1, wherein the thread is disconnected at intervals of a screw pitch vertically to the axis to make a plurality of thread sections, a plurality of annular devices being inserted in the gaps formed between the said thread sections.

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3. A uni-axial screw pump according to claim 1 or 2, wherein the said restraining devices are annular discs that fit the said annular spaces
4. A uni-axial screw pump according to claim 3, wherein the said annular restraining discs are diametrically halved and radially inserted into the said annular spaces.

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5. A uni-axial screw pump according to claim 3 or 4, wherein the internal diameter of the annular restraining discs is smaller than that of the axis, whereby the devices are plunged into the axis resulting in the sealing structure.
- 5 6. A uni-axial screw pump according to one of claim 1-5, wherein the disconnected surface of the thread at which the openings of restraining devices intersect with the thread is round shaped.
7. A uni-axial screw pump according to claim 1, wherein if employed as extruders or molders, restraining elements of the said restraining devices are bar shaped.
- 10 8. A uni-axial screw pump according to one of claim 1-7, wherein its axis is tapering from the entrance end to the discharge end, the taper of which is $1/2 \sim 1/40$ towards the discharge end.
9. A uni-axial screw pump according to one of claim 1-8, wherein the outer cylindrical casing is in the form of jacket so that the said halved restraining devices and inner cylindrical sections can be conveniently and accurately assembled.
- 15 10. A uni-axial screw pump according to claim 1 further comprising liquid-cushion equalizer to equalize the thrust of the screw pump, wherein a rotating liquid-cushion equalizing disc is fixed to the axis of the screw rotor and a stationary liquid-cushion equalizing disc is mounted inside the covering of medal whereby the two equalizing discs are contacted by means of the eccentric ring.
- 20 11. The uni-axial screw pump further comprising the structure of bearings wherein fibred non-metallic medals are inserted in 3-6 borings radially
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disposed in steel (or cast iron) bushing to enable the bearings to be safely immersed and lubricated by the fluid.