(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 269 981 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
**17.01.2018 Bulletin 2018/03**

(21) Application number: **15903690.4**

(22) Date of filing: **08.09.2015**

(51) Int Cl.:
***F04C 2/344*** *(2006.01)*

(86) International application number:
**PCT/RU2015/000568**

(87) International publication number:
**WO 2017/043993 (16.03.2017 Gazette 2017/11)**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**
Designated Validation States:
**MA**

(71) Applicant: **Mikheev, Alexandr Vasilievich**
**Moscow 119019 (RU)**

(72) Inventor: **Mikheev, Alexandr Vasilievich**
**Moscow 119019 (RU)**

(74) Representative: **Viering, Jentschura & Partner mbB**
**Patent- und Rechtsanwälte**
**Am Brauhaus 8**
**01099 Dresden (DE)**

# (54) ROTARY VANE PUMP STATOR

(57) The present invention relates to hydraulic machinery engineering, more specifically to stators of rotary vane-type pumps intended for pumping-over viscous, plastic masses and other fluids and multiphase mixtures lacking unctuous properties, but rich in mechanical impurities and/or having high viscosity, particularly such as stratum fluids of oil deposits, and may be applied in food-processing, chemical, petrochemical and other branches of industry.

A technical result to be achieved in implementation of the present invention lies in reduction of transfer area of a pumped fluid having high viscosity and high content of abrasive particles and gas, which leads to raising reliability of stator, increase of its service life, and enhancement of functional capabilities of the pump using such stator.

Said technical result is achieved by a stator of a rotary vane-type pump being configured as shells connected by bridges; wherein each of the shells comprises a hollow cylinder formed by two pairs of opposed concentric annular sectors, radii of curvature of each pair being different from each other, and four portions smoothly connecting said sectors; wherein said bridges are joined with the annular sectors of the shells, and have radii of curvature in cross-section corresponding to the radii of curvature of the annular sectors of the shells, and wherein the bridges have a width selected so as to minimize an area of a fluid transfer.

EP 3 269 981 A1

## Description

### Field of the invention

**[0001]** The present invention relates to hydraulic machinery engineering, more specifically to stators of rotary vane-type pumps intended for pumping-over viscous, plastic masses and other fluids and multiphase mixtures lacking unctuous properties, but rich in mechanical impurities and/or having high viscosity, particularly such as stratum fluids of oil deposits, and may be applied in food-processing, chemical, petrochemical and other branches of industry.

### Background and prior art

**[0002]** In the prior art there are known various solutions of stators of rotary vane-type pumps. In particular there is known a stator of a rotary vane-type crude-oil pump described in patent RU 2191926 published 27.10.2002, configured as a casing having a cavity with inlet and discharge ports. The cavity is configured as a cylindrical surface formed by two pairs of symmetrically positioned arcs of two different radii, and by smooth arc-like transitions from the arcs of large radius to the arcs of small radius, at that the arcs having same radii are disposed opposite one another.

**[0003]** A disadvantage of this solution is impossibility of pumping-over media with high content of mechanical particles, as a mere usage of specific materials for friction members does not exclude their abrasion wear when mechanical particles having higher hardness enter the gaps between rubbing parts, which leads to short life of the pump in these media. Presence of long and narrow passages in pump casing for suction of fluid creates a significant hydraulic resistance, and therefore possibility of cavitation in handling of viscos fluids, and fluid containing dissolved gas.

**[0004]** Also in the prior art there is known a stator of submersible rotary vane-type pump disclosed in patent RU 2296211 published 27.03.2007 configured with an inner cavity; at that on the walls of the stator opposite one another there are formed cutouts whose height corresponds to the height of the rotor vanes, and width equals to the length of arc that a vane describes from the beginning to the end of the vane exit out of its rotor slot.

**[0005]** This design, comprising appropriate cutouts in the stator, allows pumping-over high-viscosity fluids with high gas content, but it does not allow pumping-over fluids with mechanical impurities. When small abrasive particles along with high-viscosity fluid enter and pass between rubbing parts (vanes and stator, between rotor and disks, vanes and disks) abrasive wear of the pump is unavoidable, and as a result - reduction of pump service life.

**[0006]** Regarding a set of features, the closest to the present invention is the stator of rotor vane-type pump, described in patent application of RF No.2014100459 published 20.07.2015, comprising an inner cylindrical cavity formed by two pairs of symmetrically disposed arcs of two different radii, and by transition curves from arcs of one radius to the arcs of the other radius, at that the arcs having same radii are disposed opposite one another, and between the surfaces having constant radius of curvature there are cut two apertures for inlet and two apertures for discharge of fluid, with this the size of the latter is made comparable with size of discharge chamber.

**[0007]** Taking into consideration that size of discharge chamber depends on distance between adjacent vanes in rotor and height of rotor, in solution according to patent application No.2014100459 size of the discharge aperture comparable with discharge chamber is a variable associated with size of the pump, and it does not have a definite value or a formula to calculate such value. This design allows pumping-over high-viscosity fluids with high gas content and mechanical impurities due to presence of four apertures in stator. However, presence of apertures comparable with size of discharge chamber will lead to increased wear of vanes at locations of their permanent contact with stator, which results in non-uniform wear of work surface of the vanes and inevitable destruction of the stator and vanes at points of contact at flanks of the apertures, which leads to reduction of efficiency and pump failure.

### Summary of the invention

**[0008]** The object of the present invention is providing a design of a stator allowing pumping-over high-viscosity fluids, fluids with high content of abrasion particles and gas, while maintaining high efficiency and a long service life.

**[0009]** A technical result to be achieved in implementation of the present invention lies in reduction of transfer area of a pumped fluid having high viscosity and high content of abrasive particles and gas, which leads to raising reliability of stator, increase of its service life, and enhancement of functional capabilities of the pump using such stator.

**[0010]** Said technical result is achieved by a stator of a rotary vane-type pump being configured as shells connected by bridges; wherein each of the shells comprises a hollow cylinder formed by two pairs of opposed concentric annular sectors, radii of curvature of each pair being different from each other, and four portions smoothly connecting said sectors; wherein said bridges are joined with the annular sectors of the shells, and have radii of curvature in cross-section corresponding to the radii of curvature of the annular sectors of the shells, and wherein the bridges have a width selected so as to minimize an area of a fluid transfer.

**[0011]** The stator may be made either as a single part, or as a multipart stator, in the latter case parts of the stator (the shells and bridges) may be attached to each other by welding or adhesive connection.

**[0012]** Depending on application conditions the stator may be made of hard-alloy material, for example, tungsten carbide, or polymeric material.

Brief description of the drawings

**[0013]** Concept of the invention is clarified by the drawings where:

Fig. 1 shows a general axonometric view of stator,

Fig. 2 shows a sectional view along line A-A of fig. 1.

Detailed description of preferred embodiments of the invention

**[0014]** A stator comprises shells (1) and bridges (2) which form fluid discharge apertures (3) and fluid inlet apertures (4).

**[0015]** Each shell is a hollow cylinder formed by a first pair of oppositely disposed annular sectors (5) with radius R1 of curvature, a second pair of oppositely disposed annular sectors (6) with radius R2 of curvature, and four portions (7) providing smooth transition for said sectors. Annular sectors (5) and (6) are concentric.

**[0016]** Each of the bridges (2) is joined with the corresponding annular sector of the shell, and in cross-section it is made equal to the joint annular sector. At that, the width of the bridge is selected so as to minimize the area of transfer of fluid to be pumped over.

**[0017]** Length of the arc of the bridge should be minimal for fluid transferal in this cavity, but it must ensure seal between high pressure chamber and low pressure chamber. At a time, at least one vane should be pressed to inner surface of stator bridge. From there, minimal length of bridge arc equals to the length of arc between central lines of two adjacent vanes in constant stator curvature radii. In case when vane-to-stator contact surface (vane working end) is rounded according to bridge curvature radius, the bridge arc length may be increased by the width of the vane to ensure better seal between cavities with high and low pressures.

**[0018]** Minimal arc length for bridges with different curvature radius can be determined as follows:

$$\frac{2\pi R_1}{n} \leq L_1$$

$$\frac{2\pi R_2}{n} \leq L_2,$$

where:

n - the number of vanes,
L1 - the length of arc of inner surface of bridge with smaller radius of curvature,
L2 - the length of arc of inner surface of bridge with larger radius of curvature,
R1 - the minimum radius of curvature of stator inner surface,
R2 - the maximum radius of curvature of stator inner surface,

**[0019]** A minimal length of arc of stator bridge, necessary and sufficient to ensure seal of inlet and discharge cavities for fluid, allows pimping-over fluids with abrasive impurities, as there is no fluid transfer in closed space (chamber) without inlet or discharge. As a result, a chamber from fluid inlet cavity immediately transitions to discharge cavity, and absence of contact friction surfaces in these cavities allows carrying-out mechanical particles directly to discharge line without creating in said area abrasion wear of main working elements of the pump - vanes, which in turn allows avoiding leaks and drop of efficiency. Since, due to presence of apertures in stator between the bridges, there is almost no pressure drop at fluid inlet, then there is no fluid expansion, which eliminates cavitation during pumping-out gas-saturated fluid.

**[0020]** If necessary, the stator can be placed into a casing, and attached to the casing either by adhesive or by pressing-in. In this case, fluid discharge apertures and fluid inlet apertures should be made in the casing aligned with the respective apertures in the stator.

**[0021]** Stator may be made either as a single part (in this case the apertures are cut from a cylindrical work piece), or as an assembly, at that the elements of stator (shells and bridges) may be attached to one another either by welding or by adhesive.

**[0022]** Depending on application conditions, stator may be made of hard-alloy material, for example, tungsten carbide, or polymeric material.

**[0023]** Embodiment of the present invention may be illustrated by example of operation of rotary vane-type pump that comes down to fluid transfer from inlet to discharge line. If abrasive particles are present in fluid, their carrying-out along with the fluid does not always occur during transferal of a given volume directly into discharge chamber, and further into the line.

**[0024]** According to the present invention, to ensure seal between areas with high and low pressure, it is recommended to use a stator bridge only, and its shell - to limit protrusion of vanes from rotor slots.

**[0025]** Full opening of chambers for inlet and discharge of fluid, and accordingly absence of contact friction surfaces with stator throughout fluid inlet and outlet area makes impossible abrasion wear in said area of main working elements of the pump - vanes; and low hydrostatic resistance at inlet in pumping fluid allows pumping-over high-viscosity fluids, while absence of pressure drop at inlet prevents cavitation in pumping-over gas-saturated fluids.

**[0026]** In pump operation, the vanes are permanently forced against the stator but vane surface contact location varies and depends on at what portion of stator the

vane is. In vane motion between bridges within an aperture of fluid inlet, the trailing edge of vane surface contacts the shell; in passing an aperture of fluid discharge - the leading edge does. In approaching a bridge, angle between vane and stator is decreasing to zero, and vane, on finishing its motion along the aperture, complies with the bridge curvature, touching the bridge inner surface by all surface of its end. Contact of a vane with shells along the central line is impossible during vane passage between bridges, but it is inevitable during vane passage of bridges, that is why wear of vane along the central line will be uniform, which ensures seal of the chambers in fluid transfer from low pressure area to high pressure area, and prevents early failure of vanes and stator.

**[0027]** A rotary vane-type pump with a stator according to the present invention operates as follows.

**[0028]** In immersion of pump, fluid with gas and mechanical impurities fills open cavities of the pump through inlet apertures in casing aligned with the apertures in stator. The vanes within the apertures are fully in the fluid that surrounds the pump. In rotation of the rotor, the fluid following the vane moves into the transfer area, and further the fluid is moved by the working chamber of the pump into the discharge cavity. The fluid is compressed, and supplied into discharge line through the stator discharge apertures aligned with apertures in the casing.

**[0029]** As the vanes within the inlet aperture are situated directly in the fluid that surrounds the pump, the process of fluid transferal into the discharge chamber occurs without creating a low pressure area, without suction, which allows pumping-over gas-saturated fluid without cavitation, as well as a high-viscosity fluid.

**[0030]** In vane displacement within inlet aperture, large abrasive particles are kicked off due to flow fluid dynamics. A portion of small particles which entered the pump working chamber with fluid is transferred over bridge into discharge cavity. Under centrifugal force, particles are thrown off toward the stator, and upon entering the pump discharge cavity, they fully carried out through the discharge aperture.

**[0031]** Abrasive wear of parts is considerably reduced due to the fact that:

a) abrasive particles are thrown off by vanes on fluid entering through an open inlet aperture.

b) abrasive particles along with fluid and by centrifugal forces are carried out into an open discharge aperture, without further transferal along the stator, and without creating wear of surfaces of stator and vanes.

c) friction surfaces between vanes and stator are minimized, as the major portion of cylindrical stator surface is absent.

## Claims

1. A stator of a rotary vane-type pump, **characterized by** being configured as shells connected by bridges; wherein each of the shells comprises a hollow cylinder formed by two pairs of opposed concentric annular sectors, radii of curvature of each pair being different from each other, and four portions smoothly connecting said sectors; wherein said bridges are joined with the annular sectors of the shells and have radii of curvature in cross-section corresponding to the radii of curvature of the annular sectors of the shell; and wherein the bridges have a width selected so as to minimize an area of a fluid transfer.

2. The stator according to claim 1, wherein said stator is made as a single part.

3. The stator according to claim 2, wherein said stator is a multipart stator, wherein parts of the stator are attached to each other by welding or adhesive connection.

4. The stator according to claim 1, wherein said stator is made of hard-alloy material or polymeric material.

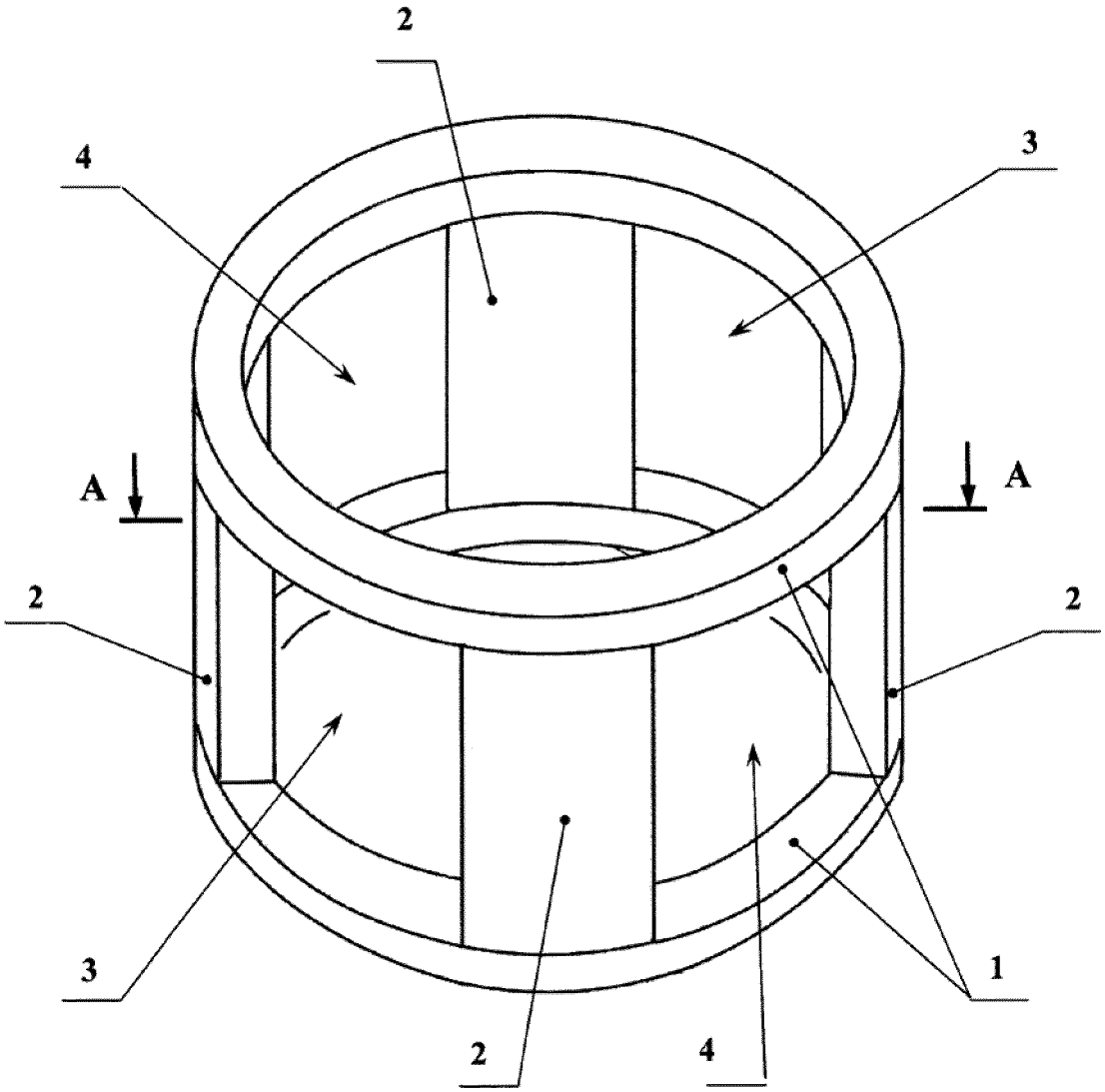


Fig. 1

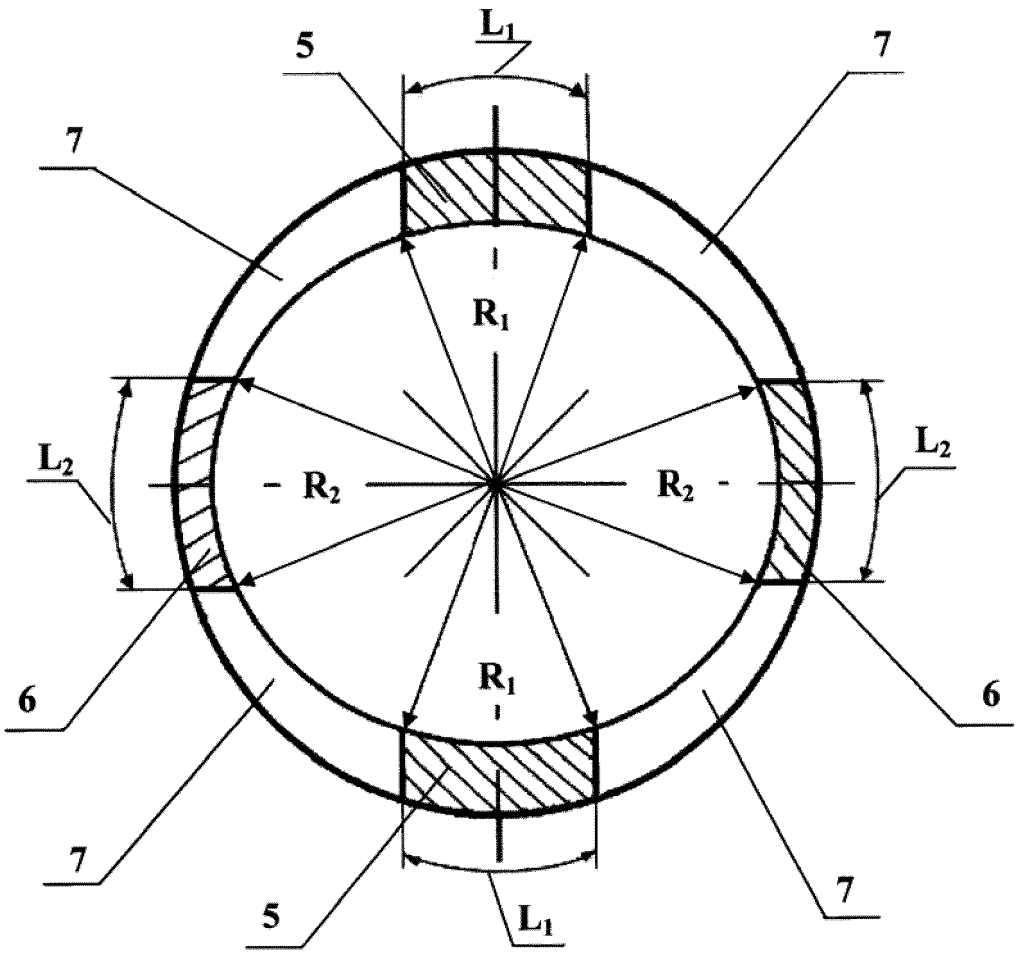


Fig. 2

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/RU 2015/000568

A. CLASSIFICATION OF SUBJECT MATTER

F04C 2/344 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01C 1/00, 1/30-1/46, 21/00, F02B 53/00-53/14, 55/00-55/16, F03C 2/30, F04C 2/00, 2/30-2/46, 15/00, 18/00, 18/344-18/46,

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A, D | RU 2014100459 A (MIKHEEV ALEKSANDR VASILEVICH) 20.07.2015 | 1-4 |
| A | US 5161962 A (VICENTE COMERCI) 10.11.1992 | 1-4 |
| A | US 45599057 A (VAN MULLECOM INNOVATION B.V.) 08.07.1986 | 1-4 |
| A | CN 201193615 Y (ZHEJIANG UNIVERSITY OF TECHNOLOGY) 11.02.2009 | 1-4 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 19 May 2016 (16.05.2016) | 19 May 2016 (19.05.2016) |
| Name and mailing address of the ISA/ RU | Authorized officer |
| Facsimile No. | Telephone No. |

Form PCT/ISA/210 (second sheet) (July 1998)

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- RU 2191926 **[0002]**
- RU 2296211 **[0004]**
- WO 2014100459 A **[0006] [0007]**