

(19)



(11)

EP 3 847 370 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

15.05.2024 Bulletin 2024/20

(51) International Patent Classification (IPC):

F04B 49/06 ^(2006.01) **F04B 49/20** ^(2006.01)
F04B 11/00 ^(2006.01)

(21) Application number: **19762781.3**

(52) Cooperative Patent Classification (CPC):

F04B 49/065; F04B 11/0058; F04B 49/20;

F04B 2201/0201; F04B 2203/0209; F04B 2205/05;
F04B 2205/09

(22) Date of filing: **03.09.2019**

(86) International application number:

PCT/EP2019/073404

(87) International publication number:

WO 2020/048947 (12.03.2020 Gazette 2020/11)

(54) **A METHOD FOR DETECTING LEAKAGE IN A POSITIVE DISPLACEMENT PUMP**

VERFAHREN ZUR ERKENNUNG VON LECKAGEN IN EINER VERDRÄNGERPUMPE

PROCÉDÉ DE DÉTECTION DE FUITE D'UNE POMPE À DÉPLACEMENT POSITIF

(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

(72) Inventor: **HELPERTZ, Markus**

44225 Dortmund (DE)

(30) Priority: **06.09.2018 DE 102018121760**

(74) Representative: **Ter Meer Steinmeister & Partner**

Patentanwälte mbB

Artur-Ladebeck-Strasse 51

33617 Bielefeld (DE)

(43) Date of publication of application:

14.07.2021 Bulletin 2021/28

(56) References cited:

EP-A2- 0 114 646 EP-B1- 0 264 148

US-A1- 2005 147 508 US-A1- 2013 283 773

US-A1- 2018 100 496 US-B2- 9 631 618

(73) Proprietor: **Brinkmann Pumpen**
K.H. Brinkmann GmbH & Co. KG
58791 Werdohl (DE)

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] The invention relates to a method of detecting internal leakage within a screw spindle pump and/or outer leakages out of a screw spindle pump.

[0002] In a screw spindle pump, the displacement bodies are formed by one or more screw spindles that are disposed to be rotatable in a casing and delimit, with one another and/or with the walls of the casing, one or more pump volumes. In the course of the rotation of the screw spindles, the positions where the screw-shaped displacement bodies and the walls of the casing form sealing gaps that enclose the pump volume move axially towards a high pressure side of the pump, so that the medium is displaced into the pressure line.

[0003] In positive displacement pumps, ideally, the volume flow rate is uniquely determined by the geometry of the displacement bodies and the speed thereof (linear velocity in case of a piston, rotary speed in case of a screw spindle pump), so that, when the speed is known, the volume flow rate can be calculated. In practice, it is not possible, however, to totally seal-off the contact points between the displacement bodies and the walls of the casing, so that gaps are formed that are sealed only more or less and at which an internal leakage can occur, i.e., a part of the medium that has been pumped flows back to the low pressure side. Moreover, depending upon the design of the pump, outer leakages may also occur, for example at seals at which a drive member for the displacement body or bodies enters into the casing.

[0004] For these reasons, the actual volume flow rate of the pump is in practice smaller than the value that should be expected theoretically. The quotient between these two quantities is designated as volumetric efficiency and should in general be within certain tolerance limits. However, the gap dimensions may become larger during operation of the pump due to wear, so that leakages may increase in the course of time and, accordingly, the volumetric efficiency decreases.

[0005] In many applications it is therefore necessary to check the wear condition of the pump from time to time by measuring the difference between the theoretical volume flow rate and the actual volume flow rate. However, a precise measurement of the actual volume flow rate is relatively cumbersome and requires the use of expensive volume flow meters.

[0006] US 2005147508 A1 and US 2018100496 A1 describe methods of detecting leakage in piston pumps.

[0007] It is an object of the invention to provide a method by which the wear condition of a screw spindle pump can be determined simply and reliably.

[0008] According to the invention, this object is achieved by a method with the following steps:

- providing a pressure line
- providing a screw spindle pump that has at least one displacement body for displacing a medium to be pumped into the pressure line,

- closing-off the pressure line,
- operating the pump with a known rotary speed of the displacement body, and
- measuring the pressure in the pressure line,
- successively driving the pump at different rotary speeds of the displacement body,
- measuring the pressure in the pressure line for each rotary speed of the displacement body,
- obtaining a curve that describes a relation between the pressure and the rotary speed of the displacement body; and
- examining the shape of this curve to assess possible causes for leakage,
- said possible causes being internal leakage where a part of the medium that has been pumped flows back to the low pressure side, and/or outer leakages, in particular at seals at which a drive member for the displacement body enters into the pump.

[0009] In the method according to the invention, the direct measurement of the volume flow rate is replaced by a pressure measurement which permits an indirect measurement of the leakage flow and, therewith, also the actual volume flow rate. This concept is based on the consideration that all leakage points of the pump, together, present a certain obstruction for the medium flowing out, and this obstruction determines the relation between the pressure drop and the leakage volume flow rate. If, when the pump is running, the pressure line is closed-off completely, the leakage volume flow rate is equal to the theoretical volume flow rate of the pump that would be obtained for the given speed of the displacement body, and the pressure drop at the leakage points is equal to the pressure that is measured in the pressure line. In this way, the flow resistance of the totality of all leakage points and, therewith, the leakage volume flow rate can be determined by measuring the pressure. The pressure measurement is performed at different speeds of the pump motor. The shape of the curve that describes the dependency of the pressure on the drive speed is determined, and more precise hints to possible causes of the occurring leakages can thereby be obtained.

[0010] An embodiment example will now be described in conjunction with the drawings, wherein:

Fig. 1 is a sketch of a positive displacement pump having a system for detecting leakages by means of a method according to the invention; and

Fig. 2 is an example of a relation between a rotary speed of a drive motor of the pump and the pressure in the pressure line during a measurement of the leakage flow.

[0011] As an example of a positive displacement pump, Fig. 1 shows a screw spindle pump 10 having displacement bodies 12 in the form of screw spindles.

The screw spindles are in sealing engagement with one another and with the walls of the pump casing and are driven by a motor 14 with equal rotary speeds, so that the volume spaces that are delimited by the screw spindles move axially from a low pressure side 16 of the pump towards a high pressure side 18, and a medium, e.g. a liquid, that is taken in at the low pressure side is displaced towards the high pressure side 18. The high pressure side of the pump is connected to a pressure line 20 through which the medium is supplied under high pressure to a consumer 22 (a spray nozzle in the example shown). The medium that has been discharged by the consumer is collected in a collection vessel 24 that is connected to the low pressure side of the pump, so that the medium may be recirculated.

[0012] The motor 14 is connected via a shaft 26 to a gear box, which has not been shown in detail, for driving the screw spindles, the shaft entering into the pump casing on the high pressure side 18. In order to reduce the pressure at the point where the shaft 26 penetrates the casing wall, a throttle 28 is provided in the casing of the pump 10 between the connection point of the pressure line 20 and the feedthrough for the shaft 28, the throttle having the function to reduce the pressure and to permit only a limited leakage flow which will exit from the casing through a leakage opening 30. Moreover, an internal leakage flow occurs inside of the pump 10 because a part of the medium that has been pumped flows back from the high pressure side 18 to the low pressure side 16 via gaps between the displacement bodies 12 and the casing.

[0013] A measurement kit 32 is provided for measuring the total amount of the several internal and external leakage flows of the pump and thereby to check whether the leakage is still within an admissible range. The measurement kit 32 comprises a lock valve 34 by which the pressure line 20 can be closed-off completely, a pressure sensor 36 connected to the pressure line 20 upstream of the lock valve 34 for measuring the pressure in the pressure line, and an electronic control and evaluation device 38 which controls the rotary speed of the motor 14 via a frequency converter 40 and processes a pressure signal that is provided by the pressure sensor 36. In the example shown, the control and evaluation device 38 is further connected to the lock valve 34 via a control line, so that the valve can be actuated electronically.

[0014] During normal operation of the pump 10, the lock valve 34 is open, and the rotary speed of the motor 14 is controlled or feedback-controlled such that the demand of the consumer 22 can be met.

[0015] Operational phases in which the consumer 22 is not active may be utilized for checking the wear condition of the pump 10 by means of the measurement kit 32. To that end, the lock valve 34 is closed and the motor 14 is driven with a rotary speed that may be smaller than the speed in normal operation. Then, a pressure that is detected by the pressure sensor builds up in the upstream part of the pressure line 20. The more this pres-

sure increases, the larger becomes the pressure drop at the leakage points of the pump, and the leakage volume flow rate at all these leakage points increases also, approximately in proportion to the pressure drop, with constant viscosity in case of a (Newtonian) liquid. The pressure measured by the pressure sensor 36 increases until an equilibrium has been reached between the leakage volume flow rate and the displacement volume flow rate of the pump 10. While the motor 14 is driven with unchanged rotary speed, the pressure sensor 36 will therefore measure, after a certain time, a constant pressure level which is indicative of the flow resistance of the leakage points. The larger the pressure level that is being reached, the larger is the leakage flow resistance.

[0016] In the equilibrium state, the leakage volume flow rate may be calculated on the basis of the rotary speed of the motor 14 because the leakage volume flow rate is equal to the theoretical displacement volume flow rate of the pump 10 that can be calculated for the given rotary speed on the basis of the known geometry of the pump 10.

[0017] On the basis of the known relation between the calculated leakage volume flow rate and the pressure measured by the pressure sensor 36, the flow resistance that opposes the leakage flow may be calculated. From this flow resistance, the leakage flow can also be calculated for the normal operating phases of the pump 10, i.e. the phases in which the motor driven is driven with a rotary speed as required by the consumer 22. From the leakage volume flow rate that is obtained in this way and from the theoretical displacement volume flow rate for the given rotary speed, the volumetric efficiency of the pump can be calculated, and it can be assessed how much this efficiency has decreased due to wear of the pump.

[0018] The measurement process described above is repeated for different rotary speeds of the motor 14.

[0019] Fig. 2 illustrates results of measurements that have been made at three different rotary speeds n_1 , n_2 and n_3 . A pressure P as measured by the pressure sensor 36 has been graphically shown here as a function of the rotary speed n . In the example shown, the three measurements at three measurement points confirm that a linear relation exists between the pressure and the rotary speed.

[0020] Depending upon the design and the condition of the pump and on the physical properties of the medium pumped, a non-linear relation, e.g. an exponential relation, may exist between the pressure and the rotary speed. Different causes for leakage in the pump will have different effects on the curve that describes the relation between pressure and rotary speed, and by examining the shape of this curve, it is possible to obtain hints on possible causes for the leakage.

[0021] The control and evaluation device 38 may also be programmed such that the leakage measurement is performed automatically in certain time intervals, wherein the exact timing of the measurement may be dependent

upon the demand of the consumer 32. The measurement results may be recorded automatically, printed and/or transmitted via a wireless link to a smartphone of an operator. Likewise, an alarm may be triggered automatically in cases in which the volumetric efficiency has become unacceptably low.

Claims

1. A method of detecting internal leakage within a screw spindle pump (10) and/or outer leakages out of a screw spindle pump (10), comprising the steps of:

- providing a pressure line (20),
- providing a screw spindle pump that has at least one displacement body (12) for displacing a medium to be pumped into the pressure line (20),
- closing-off the pressure line (20),
- operating the pump (10) with a known rotary speed of the displacement body (12), and
- measuring the pressure (P) in the pressure line (20),
- successively driving the pump (10) at different rotary speeds of the displacement body (12),
- measuring the pressure in the pressure line (20) for each rotary speed of the displacement body (12),
- obtaining a curve that describes a relation between the pressure and the rotary speed of the displacement body (12); and
- examining the shape of this curve to assess possible causes for leakage,
- said possible causes being internal leakage where a part of the medium that has been pumped flows back to the low pressure side, and/or outer leakages, in particular at seals at which a drive member for the displacement body (12) enters into the pump (10).

2. The method according to claim 1, comprising detecting an operating condition of a consumer (22) to which the medium is supplied by the pump (10), and closing-off the pressure line (20) in order to initiate a measurement process at a time when the consumer (22) does not need to be supplied with the medium.

Patentansprüche

1. Verfahren zur Feststellung von inneren Leckagen in einer Schraubenspindelpumpe (10) und/oder von äußeren Leckagen aus einer Schraubenspindelpumpe (10), mit **gekennzeichnet durch** den folgenden Schritten:

- bereitstellen einer Druckleitung (20),

- bereitstellen einer Schraubenspindelpumpe, die mindestens einen Verdrängerkörper (12) zum Verdrängen des zu pumpenden Mediums in die Druckleitung (20) aufweist,
- sperren der Druckleitung (20),
- betreiben der Pumpe (10) mit einer bekannten Drehgeschwindigkeit des Verdrängerkörpers (12),
- messen des Druckes (P) in der Druckleitung (20),
- sukzessives betreiben der Pumpe (10) mit unterschiedlichen Drehgeschwindigkeiten des Verdrängerkörpers (12),
- messen des Druckes (P) in der Druckleitung (20) für jede Drehgeschwindigkeit des Verdrängerkörpers (12),
- erstellen einer Kurve, die eine Beziehung zwischen dem Druck und der Drehgeschwindigkeit des Verdrängerkörpers (12) beschreibt, und
- untersuchen der Kurve auf mögliche Ursachen der Leckage,
- wobei diese möglichen Ursachen innere Leckagen, bei denen ein Teil des gepumpten Mediums zur Niederdruckseite zurückströmt, und/oder äußere Leckagen sind, insbesondere an Dichtungen an denen der Verdrängerkörper (12) in die Pumpe (10) eintritt.

2. Verfahren nach Anspruch 1, bei dem der Betriebszustand eines Verbrauchers (22) erfasst wird, der von der Pumpe (10) mit dem gepumpten Medium versorgt wird, und bei dem die Druckleitung (20) dann gesperrt wird, um einen Messvorgang auszulösen, wenn der Verbraucher (22) kein Medium benötigt.

Revendications

1. Procédé de détection d'une fuite interne à l'intérieur d'une pompe de broche à vis (10) et/ou de fuites extérieures à l'extérieur d'une pompe de broche à vis (10), comportant les étapes consistant à :

- fournir une ligne sous pression (20),
- fournir une pompe de broche à vis qui a au moins un corps de déplacement (12) pour déplacer un milieu à pomper dans la ligne sous pression (20),
- fermer la ligne sous pression (20),
- faire fonctionner la pompe (10) avec une vitesse de rotation connue du corps de déplacement (12), et
- mesurer la pression (P) dans la ligne sous pression (20),
- entraîner successivement la pompe (10) à différentes vitesses de rotation du corps de déplacement (12),

- mesurer la pression dans la ligne sous pression (20) pour chaque vitesse de rotation du corps de déplacement (12),
- obtenir une courbe qui décrit une relation entre la pression et la vitesse de rotation du corps de déplacement (12) ; et
- examiner la forme de cette courbe pour évaluer de possibles causes de fuite,
- lesdites causes possibles étant une fuite interne où une partie du milieu qui a été pompé reflue vers le côté basse pression, et/ou des fuites extérieures, en particulier sur des joints au niveau desquels un organe d'entraînement pour le corps de déplacement (12) pénètre dans la pompe (10).

5

10

15

2. Procédé selon la revendication 1, comportant la détection d'une condition de fonctionnement d'un consommateur (22) auquel le milieu est fourni par la pompe (10), et la fourniture de la ligne sous pression (20) afin d'initier un processus de mesure à un instant où le consommateur (22) n'a pas besoin d'être alimenté en milieu.

20

25

30

35

40

45

50

55

Fig. 1

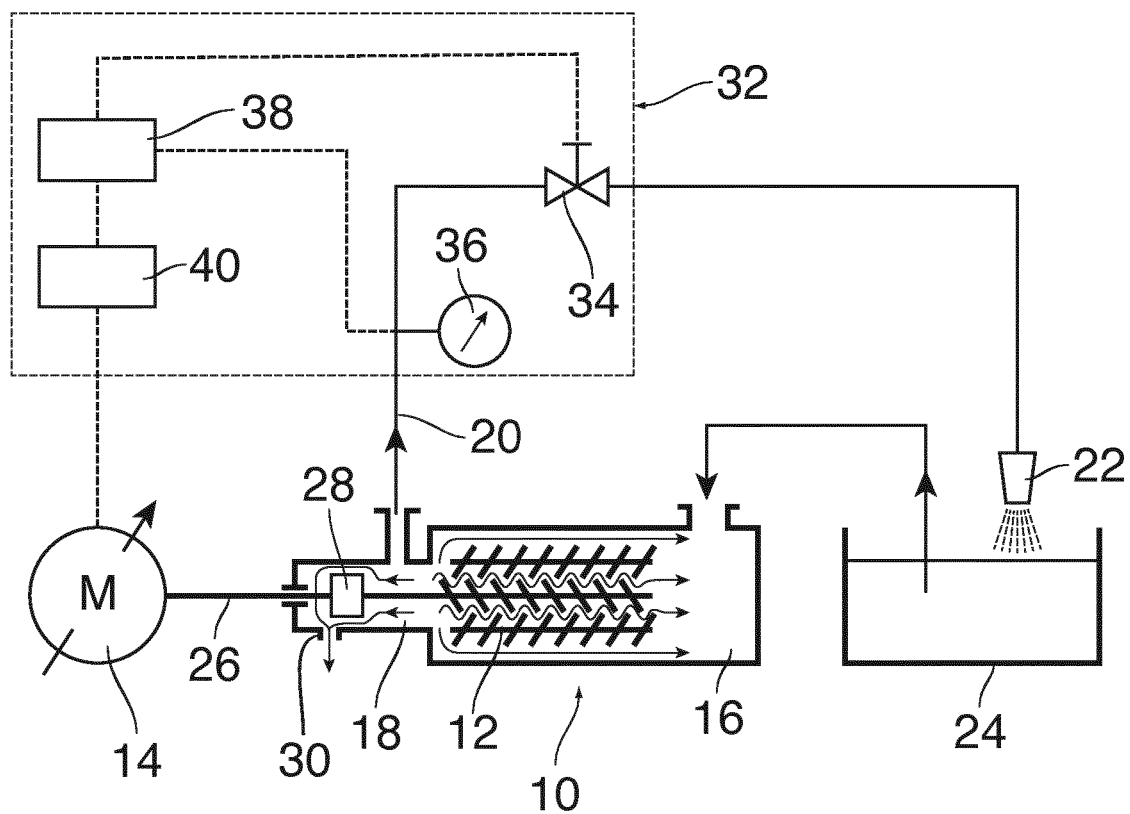
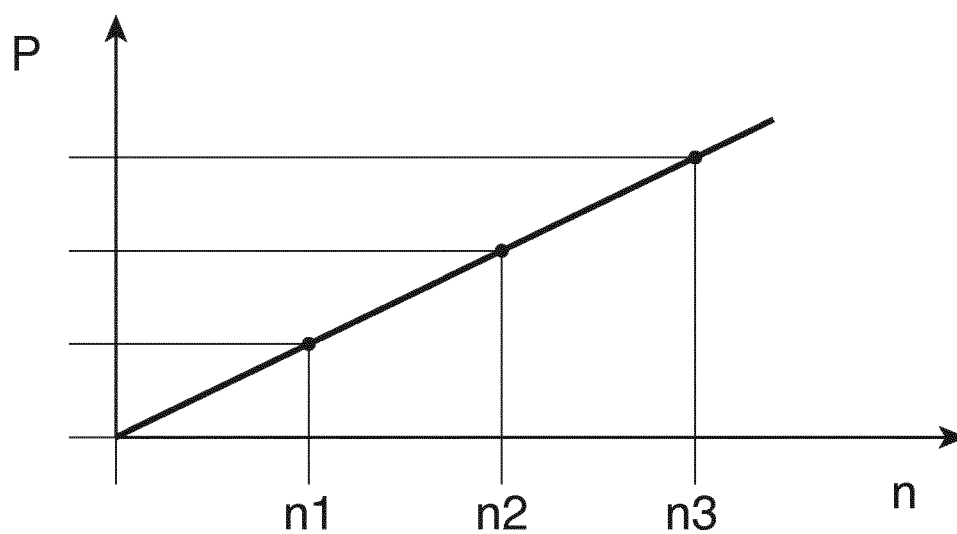


Fig. 2



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

- US 2005147508 A1 [0006]
- US 2018100496 A1 [0006]