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(54) **Method and equipment for controlling a multipoint fluid distribution system**

Verfahren und Vorrichtung zur Steuerung eines Mehrpunktsystems zur Verteilung von Flussigkeit

Procédé et équipement pour commander une système multipoint de distribution de fluide

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(56) References cited:

DE-A1- 4 243 118	**JP-A- 62 093 498**
US-A- 5 540 555	**US-A1- 2003 039 556**
US-B1- 6 234 759	**US-B2- 6 464 464**

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Description

Field of the Art

[0001] In a first aspect, the present invention relates to a method for controlling a multipoint fluid distribution system and particularly to a method which comprises controlling the fluid supply pressure for a plurality of consumption points which may require different supply pressures.

[0002] In a second aspect, the present invention comprises a piece of control equipment suitable for implementing the method of the first aspect of the present invention.

[0003] The invention provides an intelligent strategy which enables automatically adapting the operating conditions of a centrifugal pump and adjusting its performance to the various needs of different consumption points (variable demand), offering an adequate pressure at all times to said consumption point or points and further allowing an optimised use of water and energy resources.

Background of the Invention

[0004] The concern for water and energy saving is inspiring new household water pressurising and distributing systems in order to obtain a greater economic saving.

[0005] Some prior inventions disclose systems and/or methods for pressurising or controlling water pumps.

[0006] US2005095150A1 describes a centrifugal multi-stage pump including a microcontroller implementing a series of algorithms for controlling the pump operation by varying the rotating speed of its motor depending on the various parameters, such as the discharge height, the rotating speed of the motor of the pump, the supply pressure and the presence or absence of supply, temperature, etc.

[0007] US646446 B2 relates to a controller for controlling operating parameters, such as the flow, speed or pressure of a centrifugal pump including a memory where data indicative of one or more operating conditions are recorded, one or more sensors fixed to the pump for detecting an operating condition and generating a signal indicative of same and a processor running an algorithm using the recorded data and the signal generated by the sensor to in turn generate a control signal representative of a correction factor to be applied to the pump which is, for example, relative to a variation in the rotating speed of the motor of the pump.

[0008] EP1286240B1 describes a method for obtaining a curve of discharge height versus flow rate [Hinstalation(Q)] or electric consumption versus flow rate [Pinstalation(Q)] descriptive of the setpoint values of an installation for regulating the pumping capacity of a pump actuated by an electric motor the rotating speed of which is regulated, wherein a physical magnitude representative of the momentary pumping capacity of the pump is detected by means of a differential pressure sensor installed at the consumption point and a controller with an electric signal proportional to that physical magnitude is input as an actual value by means of which controller the rotating speed of the electric motor and thus the pumping capacity of the pump is regulated with the help of the curve descriptive of the setpoint values of the installation.

[0009] EP1286240B1 proposes obtaining the curve descriptive of the setpoint values which takes into consideration, at least by sections, the installation losses depending on the pumped flow rate by means of the opening of one or more consumption point every time, the detection of a functional service parameter of the consumption point, the momentary pump power variation until the consumer service parameter acquires a pre-set value and the obtainment of a pair of pump parameters which is representative of the momentary pumping capacity of the pump (such as H and Q or P and Q) at the time in which said pre-set value is acquired and the storage of those values. Finally, a function is calculated by means of a mathematical curve plotting method from the saved values of the pair of pump parameters and that function is stored as a [Hinstalation(Q)] curve descriptive of the setpoint values of the installation.

[0010] US 5540555 describes a multipoint fluid distribution system which at least includes a primary pump and a variable speed secondary pump by means of which the fluid supply pressure for a plurality of consumption points requiring different supply pressures taken as setpoint pressures for said control is controlled and which includes a plurality of pressure sensors arranged in part of or in all said consumption points for remotely measuring the supply pressure and varying the values of the setpoint pressures depending on the measured pressures, varying the speed of the secondary pump depending on said setpoint pressure values.

Summary of the Invention

[0011] The invention provides an alternative to the mentioned state of the art by means of an intelligent distribution system which allows adapting the operating condition and the performances offered by a centrifugal pump to the needs of demand at all times offering an suitable pressure according to the geometrical origin of the consumption point and allowing facilitating the user to modify (within pre-established margins) the supply conditions by selecting a specific performance level.

[0012] The objective of the invention is to achieve, by means of the method, a pumping control system and a centrifugal pump proposed to achieve a saving in pumped fluid and power when the centrifugal pump works in a minimum operating conditions suitable for providing sufficient pressure in the consumption points, thereby increasing the durability of the pumping installation.
[0013] To that end, a method for controlling a multipoint fluid distribution system which according to the prior art comprises:

setting the working conditions of the motor of a centrifugal pump of the distribution system by determining a fluid supply pressure for feeding a plurality of consumption points which may require different supply pressures taken as pump setpoint pressures, and
measuring the supply pressure in at least one point of said fluid distribution system and varying the values of said setpoint pressures depending on the measured pressure.

[0014] According to the principals of the invention, said point of the distribution system where the mentioned pressure measurement is performed is a point previous to said consumption points through which the pumped fluid directed towards said consumption points flows and it is a preferably a point inside the pump or contiguous thereto, for example located in a discharge conduit close to same.
[0015] The method of the invention comprises performing the following steps in sequence:

a) permanently acquiring a successive series of supply pressure values (Pi) measured in said previous point;
b) successively varying the pump rotating speed for compensating said pressure variation in response to a pressure variation detected in said previous point as a result of said measurements of step a);
c) detecting that at least two of said pressure values (P_{i1}), (P_{i2}), measured in said previous point increases or decreases in response to said variation of the pump rotating speed, and obtaining (in a diagram of flow discharge height) a curve of demand by calculating the coefficients of a known mathematical function descriptive of said curve of demand relating discharge height and flow rate of the pump, making said coefficient calculations from said measured pressure values (P_{i1}), (P_{i2}) and of corresponding calculated flow rate values;
d) determining a consumption point which is equal to the value of the discharge height obtained when applying a flow rate value equal to zero in said mathematical function descriptive of the curve of demand with calculated coefficients (intersection of said curve of demand with the y-axis reflecting the discharge height);
e) adopting a pump rotating speed providing a pump setpoint pressure depending on said consumption point determined in step d), and
f) restarting steps b) to e) in the event that another pressure variation is detected in said succession of values measured in step a) (which is performed at all times), indicative of an alteration in the demand.

[0016] Said variation of pump rotating speed of step b) will be an increase in speed if the measured pressure values (Pi) are below an initial setpoint pressure, or a decrease in said speed if said measured pressure values (Pi) are above said initial setpoint pressure.
[0017] On the other hand said mathematical function descriptive of a curve of demand includes an opening constant of the consumption point as one of the mentioned coefficients, and the mentioned curve of demand refers to at least one opening constant per consumption point.
[0018] The method envisages calculating each of said flow rate values of step c) from the corresponding measured pressure value (Pi) and from a characteristic pump curve selected from a plurality of known characteristic pump curves previously recorded in the system (stored for example in a non-volatile, accessible memory), one per rotating speed, relating discharge height with flow rate,.
[0019] The mentioned calculation of the corresponding flow rate values is based on the scaling laws which establish that the flow rate is proportional to the speed and the pressure is proportional to the square thereof.
[0020] Therefore, the following actions are performed for calculating the flow rate (Qc) from the actual pressure (P) and speed (v):

1 - Determining the closest characteristic curves of speed v1< v <v2.
2 - Calculating the pressures similar to the current one at speeds v1 and v2 (according to scaling laws):

$$P1=P*(v1/v)^2$$

$$P2=P*(v2/v)^2$$

3 -Finding the closest points within the curve

$$v1: \quad P1L < P1 < P1H$$

$$v2: \quad P2L < P2 < P2H$$

4 - Reading the flow rate in the four points found from the point matrix:

Q1L: flow rate at pressure P1L i speed v1.
Q1H: flow rate at pressure P1H i speed v1.
Q2L: flow rate at pressure P2L i speed v2.
Q2H: flow rate at pressure P2H i speed v2.

5 - Calculating the flow rates by interpolation (quadratic)

$$Q1=(Q1L^2+(Q1H^2-Q1L^2)*(P1-P1L)/(P1H-P1L))^{1/2}$$

$$Q2=(Q2L^2+(Q2H^2-Q2L^2)*(P2-P2L)/(P2H-P2L))^{1/2}$$

$$Qc=Q1+(v-v1)*(Q2-Q1)/(v2-v1)$$

[0021] For each of the pressure values of step c) (P_{i1}), (P_{i2}) (in which an increasing or decreasing trend can be seen), and with the aid of the rotating speeds and the characteristic pump curves, a corresponding flow rate is thus obtained, making obtaining a curve of demand possible by applying the mathematical function expressing the flow rate and pressure relationship.

[0022] To assure the precision of the calculated values, acquiring successive measurements of the pump suction pressure has also been envisaged, and applying a correction of the successive pressure measurements in said previous point, taking into account the value of the measured suction pressure.

[0023] According to a preferred aspect of the invention, a proposal is made to use several bundles or sets of characteristic pump curves corresponding to different working conditions of said pump, including at least the temperature of the drive motor of the pump and operating time of the pump recorded in the system (also stored in an accessible memory). More precise and reliable flow rate calculations are thus achieved since they correspond with the operating situation of the pump at all times during its entire operation.

[0024] The features of the centrifugal pump will thus be input by means of a set of characteristic curves at different speeds and at different temperatures of the pump acquired in a laboratory. The data can be input as a polynomial or as a point matrix. In the latter case linear or quadratic interpolations will be performed between the data to enable knowing any point of the curve.

[0025] The method comprises performing at least said steps a) to e) for locating two or more of said consumption points of the step d) in a different location.

[0026] According to the mentioned control method, if after determining said consumption point, or first consumption point, in said step d) a drop in the supply pressure in said common point is detected the method comprises determining that said drop in pressure has been caused by one of the following reasons:

i) because the flow rate of the consumption point has been modified (increase or decrease) adopting a second opening constant; or

ii) because at least one second consumption point has been added, in the latter case fluid being supplied to both consumption points through said common point,

discriminating one case from another based on detecting one and the same or a different consumption point when obtaining, as discussed, the new curve of demand.

[0027] According to the method which is being described, in the case of i), an associated resulting curve of demand combining the curves of demand of the same consumption point for first and second opening constants is obtained and used for varying the setpoint pressure of step e)

[0028] In contrast, if reason ii) occurs in step c) a new curve of demand is determined from the coefficients of at least the previous curve of demand and the difference of the flow rates calculated in the new situation, from the successive readings of the pressure values in said previous point. If there were already two previous curves of demand obtained from previous situations of applying the method, the coefficients of said previously known two curves of demand would be taken into consideration, in addition to the difference in the flow rates calculated in the new situation with respect to the immediate preceding situation.

[0029] It has been further envisaged that, once said consumption point has been identified, additional tasks for controlling and monitoring said consumption point locally or remotely in a customised manner and by actuating the pump and modifying the supply conditions thereof in a predetermined extension (limited variation range). A user can thus influence the system by setting its performance to achieve a determined comfort and he/she can also manage the water and energy saving of the installation.

[0030] Lastly, the method further envisages applying a correction to the location of the consumption point determined in step d), said correction comprising the consumption intensity measurement of the pump at all times and using known characteristic power curves of consumption /flow rate of the pump previously stored in the system.

[0031] In one embodiment, said correction is only applied when the calculated flow rate values are below a predetermined threshold value, i.e., for flow rate values less than 1500 l/h, for example.

[0032] The invention also provides a piece of control equipment for controlling a multipoint fluid distribution system which provides fluid to a plurality of consumption points requiring different supply pressures, the control system comprising, according to a known structure, the following elements:

- a pressure sensor arranged for measuring the supply pressure in at least one point of said fluid distribution system;
- control means in connection with said pressure sensor and with regulation means for regulating the speed of a centrifugal pump of said fluid distribution system, configured for controlling the fluid supply pressure for said plurality of consumption points, actuating on said regulation means, taking said different supply pressures as setpoint pressures for said control, and for varying the values of said setpoint pressures depending on the pressure measured by said pressure sensor.

[0033] The control equipment according to this invention is provided for implementing the proposed method described above and for such purpose the point of the distribution system where the pressure sensor is arranged is a point (advantageously inside the pump or contiguous thereto) previous to said consumption points through which the fluid directed to at least part of said consumption points flows, and the control system comprises at least one memory where the following are recorded:

- said known mathematical function descriptive of a curve of demand relating discharge height and flow rate of the pump, and
- a plurality of characteristic pump curves, one per rotating speed, relating discharge height with flow rate in different working conditions;

[0034] In turn, said control means include processing means, they have access to the values recorded in said memory and are configured for:

◦ controlling the pressure sensor for carrying out step a) of the method;
◦ controlling said regulation means for regulating the speed of the pump for performing step b) of the method;
◦ performing steps c) and d) of the method by means of said processing means using at least the values measured by the pressure sensor and those recorded in said at least one memory; and
◦ performing step e) of the method by means of said processing means depending on the location determined in step d).

<u>Brief Description of the Drawings</u>

[0035] The foregoing and other advantages and features will be better understood from the following detailed description of several embodiments referring to the attached drawings which must be interpreted in an illustrative and non-limiting manner, in which:

Figure 1 shows a diagram of flow rate, discharge height, the obtainment of a curve of demand 10 according to the principals of the method proposed by this invention only from acquiring a successive series of supply pressure measurements P_i at different rotating speeds of the centrifugal pump, detecting a variation in pressure (herein a drop), modifying the pump rotating speed to compensate said variation, detecting points P_{i1}, P_{i2} where an inflection or a trend change (in the case depicted, an increase) and calculating the corresponding flows rates using, to that end, a series of characteristic pump curves (11a, 11b,11c, 11d, 11e, 11f), one per rotating speed which are shown as a graph in the figure as explained above. The figure also shows how a consumption point 12 is obtained for the shown situation according to that detailed above.

Figure 2 illustrates a diagram of pressure (discharge height)/ flow rate of several curves of demand 13a, 13b, 13c, 13e is response to different requests of the fluid distribution system, three of said curves 13a, 13b, 13c having a common point of origin or height 14 (consumption point) and a fourth curve having a different consumption point 15. In the diagram one of the characteristic curves 11a of a centrifugal pump at a fixed frequency has also been depicted.

Figure 3 illustrates obtaining a curve of demand 18 by applying the proposed method when simultaneity situations arise between consumption points of different floors illustrated from corresponding curves of consumption 16, 17.

[0036] Lastly, Figure 4 is a graph illustrating, in a diagram, flow rate/ time in different characterised consumption points of a dwelling: 19 (sink: 20a hot water, 20b cold water); 21 (wash basin), 22 (shower), 23 (taps), (24) bidet, 25 (WC), observing the disparity of the supply conditions that they require.

Detailed Description of the Invention

[0037] A proposal is made to use a centrifugal pump with a brushless DC type synchronous motor (although it is possible to use an alternating current motor) for the purpose of knowing the speed accurately and preventing the sliding of the motor from affecting the calculations to be made by computational means (for example a microcontroller integrated in a card).

[0038] The pressure sensor used is a digital transducer calibrated at different temperatures and with a 14 bit analogue/digital converter, for the purpose of obtaining sufficient resolution.

[0039] The calculations have been made in a type of 32 bit floating point to enable covering very large ranges of numbers, taking into account that a sum of flow rates raised to the fourth magnitude is performed when calculating the height.

[0040] Tests have been carried out with a centrifugal pump with a check valve in the suction for facilitating precise pressure reading of the installation.

[0041] In a preferred embodiment, the proposed system is designed for a home pressure system of a single family dwelling and applied in a pump and frequency variator assembly for meeting the needs of such dwelling. However, this concept is completely applicable, and even more appealing economically speaking, if its application is considered in the pressure system of a building with many floors where the differences between the maximum pressure required for the top floor and that required for lower floors are greater.

[0042] The proposed control system is also applicable to any industrial distribution system with a frequency variator which requires operating at different objective pressures automatically without the need for additional auxiliary elements or a costly installation.

System Characterisation

[0043] Figure 2 shows the characteristic curve 11a of a centrifugal pump at a fixed frequency. This characteristic curve relates the flow rate (Q) and the pressure (H):

$$H(Q) = a1 \cdot Q^3 + b1 \cdot Q^2 + c1 \cdot Q + d1 \ [\text{mca}]$$

$$Q(H) = a2 \cdot H^3 + b2 \cdot H^2 + c2 \cdot H + d2 \ [m^3/h]$$

[0044] Wherein the values of a, b, c and d are pump-dependent coefficients.

[0045] The influence of the variation of the rotating speed (ω) of the pump in the resulting characteristic curve which are related according to the scaling laws must also be taken into account.

$$n = \frac{\omega_1}{\omega_0} \ldots \frac{actual}{maximum\ (50Hz)} \qquad Q_1 = a\left(\frac{H_1}{n^2}\right)^3 + b\left(\frac{H_1}{n^2}\right)^2 + c\left(\frac{H_1}{n^2}\right) + d$$

[0046] Similarly, the curve of demand (defining the consumption point) can be characterised in a similar manner, in which load losses (ΔH) are related with the flowing flow rate (Q) which is formally expressed as the following:

$$\Delta H = O + K \cdot Q^2$$

[0047] The influence of the point O (geometric origin of the consumption point) and the value of K (opening constant of the consumption point) can be seen in Figure 1.

<u>Detection of the origin</u>

[0048] It is necessary to know the value of O, independently of the value of the opening constant to enable providing the suitable pressure.

[0049] It is possible to determine the value of the origin 12 (see Figure 1) if the pressure and flow rate values in two points P_{i1}, P_{i2} of the curve of the system are provided, which are achieved by making the pump work at two different and close enough rotating speeds so that it is not noticed in the consumption point.

[0050] If the pressures (H) are measured and the flow rates are calculated through the relationships defined in the characterisation phase of the system the values of K and consequently O are obtained.

$$K = \frac{H_2 - H_1}{Q_2^2 - Q_1^2} \qquad O = H_1 - K \cdot Q_1^2$$

[0051] Once the geometric origin 12 of the consumption point is determined the new setpoint pressure can be calculated taking into account the pressure required by the BTC (building technical code) according to:

$$P_{PC} = O + P_{CTE}$$

[0052] With the control methods of a current constant pressure system, the system is able to work at the optimum pressure required according to the geometric origin 12 of the consumption point.

[0053] The origin detection method becomes complex when simultaneity situations arise between points of the same or different floors, which requires the definition of a more complex monitoring and control protocol, according to the method explained above and illustrated in Figure 3 for obtaining the curve 18 from curves of demand 16, 17 of two different consumption points.

[0054] With the possibility of detecting the consumption point 12 even in simultaneity situations, the system provides optimum performance in any possible demand situation.

[0055] Given that the performance in terms of flow rates required by the BTC are greater than the mean, being able to provide the system with automatic operating modes which allow reducing consumption is interesting. For that purpose, the following is proposed:

- Two or more operating modes at reduced pressure providing an added saving at water and energy level
- Acceptable comfort reduction in the service
- Easy mode activation/deactivation/change

[0056] In the different saving modes lower pressures which at the same time involve a reduction in electrical and flow rate consumption additional to those offered from the curve of demand obtained by applying the method of this invention are offered.

[0057] Likewise it is envisaged that the user can apply a correction coefficient to the desired pressure in the consumption point involving a positive or negative increase in said pressure, introducing for such purpose a correcting factor (within of a specified range) which will be taken into account in the future for calculating the subsequent curves of consumption.

Consumption point characterisation

[0058] Characterising a consumption point involves knowing its curve of demand, i.e., the flow rate provided for each pressure value.
[0059] To that end it is assumed that, according to that described above, the relationship H = O + K Q2 is complied with.
[0060] As a consequence of the dynamic nature of the electric/hydraulic system, much more information will be obtained if all the pressure and speed readings which can be obtained are used. In other words, instead of attempting a location on a specific curve, all the intermediate points will be taken, thus the variations of pressure are progressive, without gaps.
[0061] When variations exist, it is important that each pressure reading corresponds with the speed in the same instant. To that end, filtering the readings and correcting the delays so that the points are coherent is necessary. In this sense it is advisable that the changes in pressure and speed occur with the most constant acceleration possible.
[0062] On the other hand and as indicated above, the set of points can be taken both in ascending as descending direction. Therefore, when the pressure is below the setpoint the points will be taken in an ascending manner (from lower to higher speed and pressure) and when the pressure is above the setpoint they will be taken in a descending manner (from higher to lower speed and pressure).
[0063] The precision obtained will depend greatly on the number of points used. This depends both on the acceleration (the slower the variations the better) and on the range of variation of the points (the wider the better) having to adopt a compromise that assures comfort.

Calculation of the height and opening constant of each consumption point

[0064] The parameters will be obtained by means of a linear regression between the pressure and the square of the flow rate (Q^2), linked by the relationship $Q = (a+b^* H)^2$.
Then, the height will be O=a/b and the opening constant K=b
[0065] A proposal is made to use the relationship $Q^2= a+b^*H$, instead of $H= a+b^*Q^2$, because the regression is performed by means of the minimum square method, and in this case it is of interest to minimize the error of flow rate, mainly for low consumption.
[0066] Therefore:

$$O= (\sum(H)^* \sum(H^*Q^2) - \sum(H^2)^* \sum(Q^2)) / (n^*\sum(H^*Q^2) - \sum(H)^* \sum(Q^2))$$

$$k= (n^*\sum(H^*Q^2) - \sum(H)^* \sum(Q^2)) / (n^*\sum(H^2) - \sum(H)^2)$$

Detection of condition change of the system or simultaneity

[0067] The flow rate provided when there is a consumption point is Q_p wherein $(Q_p)^2= k^*(H-O)$, wherein k and O have been calculated by means of the mentioned method.
[0068] If the calculated flow rate is different from that provided (greater or lesser), it means that the consumption points have changed and performing a new regression is necessary, but taking the flow rate variation with respect to that provided (Q_c-Q_p) as data for the purpose of knowing the contribution of the new consumption point. If any consumption point (lower flow rate) has been closed, this variation will be negative, and the resulting negative k will be indicative of this decrease.
[0069] Once the new results have been obtained, decision must be made on how the consumption points are modified:

a) If an additional tap has been opened in a flat different from the previous ones, the value of k will be positive and the point O will be different from any previously calculated consumption point. In this case a new consumption point would be added.
b) If the additional tap which has been opened belongs to the same flat with an already operating previous tap, the value of k will be positive and the value of O will be similar to the previous consumption point. In this case the opening constant of said consumption point is modified. Optionally, if the heights are not identical, it is possible to perform a correction by calculating a weighted mean between the previous O and the new one.

c) If a tap is closed, be it partially or completely, the value of k will be negative. In this case the value of the opening constant of the consumption point closest in height is reduced, or the consumption point is eliminated, depending on the case.

[0070] With reference to Figure 4 illustrating the results of a study wherein different characterised consumption points are shown, it is indicated that taking the control system to a more optimal operation, providing higher savings, researching different aspects in addition to those proposed in the previous phases is feasible.

[0071] Performing the following is particularly contemplated

- Specific identification of the consumption point for maximum utilisation of hydraulic and energy resources according to demand.
- Leakage check
- Real time monitoring
- Remote control
- Communication of the control system with a home automation system.

Claims

1. A method for controlling a multipoint fluid distribution system which comprises:

setting the working conditions of the motor of a centrifugal pump of the distribution system by determining a fluid supply pressure for feeding a plurality of consumption points which may require different supply pressures taken as the pump setpoint pressures, and

measuring the supply pressure in at least one point of said fluid distribution system and varying the values of said setpoint pressures depending on the measured pressure,

wherein said point of the distribution system where said pressure measurement is performed is a point previous to said consumption points through which the pumped fluid flows, and wherein the method comprises performing the following steps in sequence:

a) permanently acquiring a successive series of supply pressure values (Pi) measured in said previous point; and

b) successively varying the pump rotating speed for compensating said pressure variation in response to a pressure variation detected in said previous point as a result of said measurements of step a);

the method being **characterised in that** it further comprises:

c) detecting that at least two of said pressure values (P_{i1}), (P_{i2}), measured in said previous point increases or decreases in response to said variation of the pump rotating speed, and obtaining a curve of demand (10) by calculating the coefficients of a known mathematical function descriptive of said curve of demand relating discharge height and flow rate of the pump, making said coefficient calculations from said measured pressure values (P_{i1}), (P_{i2}) and of corresponding calculated flow rate values;

d) determining a consumption point (12) which is equal to the value of the discharge height obtained when applying a flow rate value equal to zero in said mathematical function descriptive of the curve of demand with calculated coefficients;

e) adopting a pump rotating speed providing a pump setpoint pressure, depending on said consumption point determined in step d), and

f) restarting steps b) to e) in the event that another pressure variation is detected in said succession of values measured in step a) indicative of an alteration in the demand.

2. The method according to claim 1, **characterised in that** said variation of pump rotating speed of step b) is an increment if the measured pressure values (Pi) are below an initial setpoint pressure, or a decrease if said measured pressure values (Pi) are above said initial setpoint pressure.

3. The method according to claim 1, **characterised in that** it comprises calculating each of said flow rate values of step c) from the corresponding measured pressure value (Pi) and from a characteristic pump curve selected from a plurality of known characteristic pump curves (11a, 11b, 11c, 11d, 11e, 11f) previously recorded in the system, one per rotating speed, relating discharge height with flow rate.

4. The method according to claim 3, **characterised in that** it comprises using several bundles or sets of characteristic pump curves corresponding to different working conditions of the pump, including at least temperature of the drive motor of the pump and operating time of the pump, registered in the system.

5. The method according to any one of the preceding claims, **characterised in that** said mathematical function descriptive of a curve of demand includes an opening constant of the consumption point as one of said coefficients, and said curve of demand refers to at least one opening constant per consumption point.

6. The method according to any one of the preceding claims, **characterised in that** it comprises performing at least said steps a) to e) for at least locating two of said consumption points of step d) in a different location.

7. The method according to any one of the preceding claims, **characterised in that** it further comprises acquiring successive measurements of the pump suction pressure, and applying a correction of the successive pressure measurements in said previous point, taking into account the value of the measured suction pressure.

8. The method according to any one of claims 1 to 6, **characterised in that** if after determining said consumption point (12), or first consumption point, in said step d) a drop in the supply pressure in said common point is detected, the method comprises determining that said drop in pressure has been caused by one of the following reasons:

   i) because the flow rate of the consumption point has been modified adopting a second opening constant; or
   ii) because at least one second consumption point has been added, in the latter case fluid being supplied to both consumption points through said common point,
   discriminating one case from another based on detecting one and the same or a different consumption point in the new curve of demand.

9. The method according to claim 8, **characterised in that** in the case of i), an associated resulting curve of demand combining the curves of demand of the same consumption point for first and second opening constants is obtained and used for varying the setpoint pressure of step e).

10. The method according to claim 8, **characterised in that** if reason ii) occurs in step c) the new curve of demand is determined from the coefficients of at least the previous curve of demand and the difference of the flow rates calculated in the new situation, from the successive readings of the pressure values in said previous point.

11. The method according to any one of the preceding claims, **characterised in that** it comprises, once said consumption point has been identified, performing additional tasks for controlling and monitoring said consumption point locally or remotely in a customised manner and by actuating the pump and modifying the supply conditions thereof in a predetermined extension.

12. The method according to any one of the preceding claims, **characterised in that** said previous point of pressure measurement is a point inside the pump or contiguous thereto.

13. The method according to any one of the preceding claims, **characterised in that** by further applying a correction to the location determined in step d) said correction comprising the consumption intensity measurement of the pump at all times and using known characteristic power curves of consumption /flow rate of the pump previously stored in the system.

14. A piece of control equipment for controlling a multipoint fluid distribution system by pumping, wherein the distribution system provides fluid to a plurality of consumption points requiring different supply pressures, and said control equipment comprises:

   - at least one pressure sensor arranged for measuring the supply pressure in at least one point of said fluid distribution system;
   - control means in connection with said at least one pressure sensor and with regulation means for regulating the speed of a pump of said fluid distribution system, and configured for controlling the fluid supply pressure for said plurality of consumption points, actuating on said regulation means, taking said different supply pressures as setpoint pressures for said control, and for varying the values of said setpoint pressures depending on the pressure measured by said at least one pressure sensor
   the system being **characterised in that** it implements the proposed method according to any one of the preceding

claims, **in that** said point of the distribution system where said pressure sensor is arranged is a point previous to said consumption points through which the fluid directed to at least part of said consumption points flows, and **in that**:
- the control equipment comprises at least one memory where the following are recorded:

- at least said known mathematical function descriptive of a curve of demand (10) relating discharge height and flow rate of the pump, and
- a plurality of characteristic pump curves, one per rotating speed, relating discharge height with flow rate in different working conditions;

and **in that** said control means include processing means, they have access to the values recorded in said memory and are configured for:

◦ controlling the pressure sensor for carrying out step a) of the method;
◦ controlling said regulation means for regulating the speed of the pump for performing step b) of the method;
◦ performing steps c) and d) of the method by means of said processing means using at least the values measured by the pressure sensor and those recorded in said at least one memory; and
◦ performing step e) of the method by means of said processing means depending on the location determined in step d).

Patentansprüche

1. Verfahren zum Steuern eines Mehrstellen-Fluidverteilungssystems, aufweisend:

Einstellen der Betriebsbedingungen des Motors einer Zentrifugalpumpe des Verteilungssystems durch Ermitteln eines Fluid-Versorgungsdruckes zum Versorgen einer Vielzahl von Verbrauchsstellen, die unterschiedliche Versorgungsdrücke erfordern können, die als die Pumpen-Sollwertdrücke abgelesen werden, und
Messen des Versorgungsdruckes an wenigstens einer Stelle des Fluidverteilungssystems und Variieren der Sollwertdrücke in Abhängigkeit von dem gemessenen Druck,
wobei es sich bei der Stelle des Verteilungssystems, an der die Druckmessung durchgeführt wird, um eine Stelle vor den Verbrauchsstellen handelt, durch die das gepumpte Fluid fließt, und wobei das Verfahren Durchführen der folgenden sequenziellen Schritte aufweist:

a) permanentes Beziehen einer aufeinanderfolgenden Reihe von Versorgungsdruckwerten (Pi), die an der vorherigen Stelle gemessen wurden; und
b) aufeinanderfolgendes Variieren der Pumpendrehgeschwindigkeit zum Kompensieren der Druckänderung in Reaktion auf eine Druckänderung, die an der vorherigen Stelle als Ergebnis der Messung von Schritt a) erfasst wurde;

wobei das Verfahren **dadurch gekennzeichnet ist, dass** es des Weiteren aufweist:

c) Erfassen, dass sich wenigstens zwei der Druckwerte (P_{i1}), (P_{i2}), die an den vorherigen Stellen gemessen wurden, in Reaktion auf die Änderung der Pumpendrehgeschwindigkeit erhöhen oder verringern, und Beziehen einer Bedarfskurve (10) durch Berechnen der Koeffizienten einer bekannten mathematischen Funktion, die die Bedarfskurve in Bezug zu der Auslaufhöhe und der Durchflussrate der Pumpe beschreibt, wobei die Berechnungen der Koeffizienten anhand der gemessenen Druckwerte (P_{i1}), (P_{i2}) und anhand der entsprechenden berechneten Durchflussratenwerte durchgeführt werden;
d) Ermitteln einer Verbrauchsstelle (12), die dem Wert der Auslaufhöhe entspricht, der bezogen wird, wenn ein Durchflussratenwert angewendet wird, der dem Wert Null in der mathematischen Funktion entspricht, die die Bedarfskurve mit berechneten Koeffizienten beschreibt;
e) Annehmen einer Pumpendrehgeschwindigkeit, die einen Pumpen-Sollwertdruck in Abhängigkeit von der in Schritt d) ermittelten Verbrauchsstelle bereitstellt und
f) erneutes Beginnen der Schritte b) bis e) für den Fall, dass eine weitere Druckänderung in der Aufeinanderfolge von Werten erkannt wird, die in Schritt a) gemessen wurden, die eine Änderung des Bedarfes anzeigt.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** es sich bei der Änderung der Pumpendrehgeschwin-

digkeit von Schritt b) um eine Erhöhung handelt, wenn die gemessenen Druckwerte (P_i) unterhalb eines anfänglichen Sollwertdruckes liegen, oder um eine Verringerung handelt, wenn die gemessenen Druckwerte (P_i) oberhalb eines anfänglichen Sollwertdruckes liegen.

3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** es Berechnen jeder der Durchflussratenweiie von Schritt c) anhand des entsprechenden gemessenen Druckwertes (P_i) und anhand einer charakteristischen Pumpenkurve aufweist, die aus einer Vielzahl von bekannten charakteristischen Pumpenkurven (11a, 11b, 11c, 11d, 11e, 11f) ausgewählt wird, die vorab in dem System, eine pro Drehgeschwindigkeit, in Bezug auf die Auslaufhöhe mit der Durchflussrate aufgezeichnet wurden.

4. Verfahren nach Anspruch 3, **dadurch gekennzeichnet, dass** es Verwenden mehrerer Sätze oder Mengen an Pumpenkurven aufweist, die unterschiedlichen Betriebsbedingungen der Pumpe entsprechen, unter anderem wenigstens der Temperatur des Antriebsmotors der Pumpe und der Betriebszeit der Pumpe, die in dem System registriert sind.

5. Verfahren nach einem beliebigen der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** die mathematische Funktion, die eine Bedarfskurve beschreibt, einen Anfangsfestwert der Verbrauchsstelle als einen der Koeffizienten aufweist und sich die Bedarfskurve auf wenigstens einen Anfangsfestwert je Verbrauchsstelle bezieht.

6. Verfahren nach einem beliebigen der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** es Durchführen wenigstens der Schritte a) bis c) für wenigstens Lokalisieren der Verbrauchsstellen von Schritt d) an einem anderen Ort aufweist.

7. Verfahren nach einem beliebigen der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** es des Weiteren Beziehen aufeinanderfolgender Messungen des Pumpensaugdruckes und Anwenden einer Korrektur der aufeinanderfolgenden Pumpenmessungen an der vorherigen Stelle aufweist, wobei der Wert des gemessenen Saugdruckes berücksichtigt wird.

8. Verfahren nach einem beliebigen der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass**, wenn nach dem Ermitteln der Verbrauchsstelle (12) oder der ersten Verbrauchsstelle in Schritt d) ein Abfall des Versorgungsdruckes an der Verteilersammelstelle erfasst wird, das Verfahren Ermitteln aufweist, dass der Druckabfall durch eine der folgenden Ursachen ausgelöst worden ist:

i) weil die Durchflussrate der Verbrauchsstelle dahingehend modifiziert worden ist, dass sie einen zweiten Anfangsfestwert aufweist; oder

ii) weil wenigstens eine zweite Verbrauchsstelle hinzugefügt worden ist, wobei in dem letzten Fall beiden Verbrauchsstellen Fluid über die Verteilersammelstelle eingespeist wird, wobei zwischen beiden Fällen dadurch unterschieden wird, dass entweder dieselbe oder eine andere Verbrauchsstelle in der neuen Bedarfskurve erfasst wird.

9. Verfahren nach Anspruch 8, **dadurch gekennzeichnet, dass** im Fall von i) eine dazugehörige resultierende Bedarfskurve, die die Bedarfskurven derselben Verbrauchsstelle für den ersten und den zweiten Anfangsfestwert zusammenlegt, bezogen und zum Variieren des Sollwertdruckes von Schritt e) verwendet wird.

10. Verfahren nach Anspruch 8, **dadurch gekennzeichnet, dass**, wenn Ursache ii) in Schritt c) auftritt, die neue Bedarfskurve anhand der Koeffizienten von wenigstens der vorherigen Bedarfskurve und die Differenz der in der neuen Situation berechneten Durchflussraten anhand der aufeinanderfolgenden Ableseergebnisse der Druckwerte an der vorherigen Stelle ermittelt werden.

11. Verfahren nach einem beliebigen der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** es, sobald die Verbrauchsstelle identifiziert worden ist, Durchführen zusätzlicher Aufgaben zum Steuern und Überwachen der Verbrauchsstelle kundenspezifiziert lokal oder fern aufweist, sowie Betätigen der Pumpe und Modifizieren der Versorgungsbedingungen davon in einer vorab festgelegten Erweiterung aufweist.

12. Verfahren nach einem beliebigen der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** es sich bei der ersten Stelle der Druckmessung um eine Stelle innerhalb der Pumpe oder daran angeschlossen handelt.

13. Verfahren nach einem beliebigen der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** es des Weiteren

Anwenden einer Korrektur auf die in Schritt d) ermittelte Stelle aufweist, wobei die Korrektur die Messung der durchgängigen Verbrauchsintensität der Pumpe unter Verwendung der bekannten charakteristischen Stromverbrauchskurven/Durchflussraten der Pumpe, die vorab in dem System gespeichert wurden, aufweist.

14. Eine Steuergeräteeinheit zum Steuern eines Multipoint-Fluidverteilungssystems mittels Pumpen, wobei das Verteilungssystem einer Vielzahl von Verbrauchstellen, die unterschiedliche Versorgungsdrücke benötigen, Fluid bereitstellt und das Steuergerät aufweist:

- wenigstens einen Drucksensor, der so eingerichtet ist, dass er den Versorgungsdruck an wenigstens einer Stelle des Fluid-Verteilungssystems misst;
- Steuervorrichtung, die mit dem wenigstens einen Drucksensor und einer Reguliervorrichtung zum Regulieren der Pumpengeschwindigkeit in dem Fluid-Verteilungssystem verbunden ist und so konfiguriert ist, dass sie den Fluid-Versorgungsdruck für die Vielzahl von Verbrauchsstellen steuert, die Reguliervorrichtung ansteuert, verschiedene Versorgungsdrücke als Sollwertdrücke für die Steuerung abliest und die Werte der Sollwertdrücke in Abhängigkeit von dem durch den wenigstens einen Drucksensor gemessenen Druck variiert,

wobei das System **dadurch gekennzeichnet ist, dass** es das vorgeschlagene Verfahren nach einem beliebigen der vorstehenden Ansprüche implementiert, dadurch, dass es sich bei der Stelle des Verteilungssystems, an dem der Drucksensor eingerichtet ist, um eine Stelle vor den Verbrauchsstellen handelt, durch die das an wenigstens einen Teil der Verbrauchsstellen gerichtete Fluid fließt, und dadurch, dass:
- das Steuergerät wenigstens einen Speicher aufweist, in dem das Folgende gespeichert wird:

  - wenigstens eine bekannte mathematische Funktion, die eine Bedarfskurve (10) in Bezug auf die Auslaufhöhe und die Durchflussrate der Pumpe beschreibt, und
  - eine Vielzahl von charakteristischen Pumpenkurven, eine je Drehgeschwindigkeit, in Bezug auf die Auslaufhöhe mit der Durchflussrate bei verschiedenen Betriebsbedingungen;

  und dadurch, dass das Steuergerät Verarbeitungsvorrichtungen aufweist, die Zugriff auf die in dem Speicher aufgezeichneten Werte haben und so konfiguriert sind, dass sie:

  • den Drucksensor zum Durchführen von Schritt a) des Verfahrens steuern;
  • die Reguliervorrichtung zum Regulieren der Geschwindigkeit der Pumpe zum Durchführen von Schritt b) des Verfahrens steuern;
  • die Schritte c) und d) des Verfahrens mittels der Verarbeitungsvorrichtungen unter Verwendung von wenigstens den durch den Drucksensor gemessenen Werten und jenen Werten durchführen, die in dem wenigstens einen Speicher aufgezeichnet sind; und
  • Schritt e) des Verfahrens mittels der Verarbeitungsvoruchtungen in Abhängigkeit von dem in Schritt d) ermittelten Ort durchführen.

Revendications

1. Une méthode pour contrôler un système de distribution de fluide multipoint qui comprend :

le réglage des conditions de fonctionnement du moteur d'une pompe centrifuge du système de distribution en déterminant une pression de distribution de fluide pour approvisionner un grand nombre de points de consommation pouvant exiger différentes pressions de distribution prises en tant que pressions de consigne de pompage, et

la mesure de la pression de distribution, sur au moins un point dudit système de distribution de fluide et en variant les valeurs desdites pressions de consigne dépendant de la pression mesurée, où ledit point du système de distribution où ladite mesure de pression est réalisée est un point antérieur auxdits points de consommation à travers lesquels le fluide pompé s'écoule, et où la méthode comprend la réalisation des étapes suivantes en séquence:

a) obtenir en permanence une série successive de valeurs de pression d'approvisionnement (Pi) mesurée au point antérieur ; et
b) changer successivement la vitesse de rotation de la pompe pour compenser ladite variation de pression en réponse à la variation de la pression détectée au point antérieur suite auxdites mesures de l'étape a) ;

la méthode étant caractérisée parce qu'elle comprend en outre :

c) la détection qu'au moins deux desdites valeurs de pression (P_{i1}), (P_{i2}), mesurées au point antérieur augmentent ou diminuent en réponse à ladite variation de la vitesse de rotation de la pompe, et en obtenant une courbe de demande (10) en calculant les coefficients d'une fonction mathématique descriptive connue de ladite courbe de demande qui met en relation la hauteur de décharge et le débit d'écoulement de la pompe, en faisant lesdits calculs de coefficient à partir des valeurs de pression mesurées (P_{i1}), (P_{i2}) et des valeurs de débit calculées correspondantes ;
d) la détermination d'un point de consommation (12) égal à la valeur de la hauteur de décharge est obtenu lorsqu'on applique une valeur de débit égale à zéro dans ladite fonction mathématique descriptive de la courbe de demande avec les coefficients calculés ;
e) l'adoption d'une vitesse de rotation de la pompe qui fournit une pression de consigne de la pompe, dépendant dudit point de consommation déterminé à l'étape d), et
f) recommencer les étapes b) à e) au cas où une autre variation de la pression est détectée dans ladite succession de valeurs mesurée à l'étape a) révélatrice d'une altération de la demande.

2. La méthode, d'après la revendication 1, **caractérisée en ce que** ladite variation de la vitesse de rotation de la pompe à l'étape b) est une augmentation si les valeurs de pression mesurées (Pi) se trouvent en dessous de la pression de consigne initiale, ou une diminution si les valeurs de pression mesurées (Pi) se trouvent au dessus de la pression de consigne initiale.

3. La méthode, d'après la revendication 1, **caractérisée en ce qu'**elle comprend le calcul de chacune des valeurs dudit débit à l'étape c) à partir de la valeur de pression mesurée correspondante (Pi) et à partir d'une courbe de pompage caractéristique sélectionnée parmi un grand nombre de courbes de pompage caractéristiques connues (11a, 11b, 11c, 11d, 11e, 11f) précédemment enregistré dans le système, une par vitesse de rotation, mettant en relation la hauteur de décharge avec le débit d'écoulement.

4. La méthode, d'après la revendication 3, **caractérisée en ce qu'**elle comprend l'utilisation de plusieurs lots ou séries de courbes de pompage caractéristiques correspondantes aux différentes conditions de fonctionnement de la pompe, qui incluent au moins la température du moteur d'entraînement de la pompe et le temps de fonctionnement de la pompe, enregistrés dans le système.

5. La méthode, d'après l'une quelconque des revendications précédentes, **caractérisée en ce que** ladite fonction mathématique descriptive d'une courbe de demande inclue une constante d'ouverture du point de consommation comme un desdits coefficients, et ladite courbe de demande fait référence à au moins une constante d'ouverture par point de consommation.

6. La méthode, d'après l'une quelconque des revendications précédentes, **caractérisée en ce qu'**elle comprend la réalisation d'au moins une des étapes a) à e) pour au moins situer deux desdits points de consommation de l'étape d) dans un emplacement différent.

7. La méthode, d'après l'une quelconque des revendications précédentes, **caractérisée en ce qu'**elle comprend en outre l'obtention de mesures successives de la pression d'aspiration de pompage, et l'application d'une correction des mesures de pression successives dans ledit point antérieur, en prenant compte de la valeur de la pression d'aspiration successive.

8. La méthode, d'après l'une quelconque des revendications 1 à 6, **caractérisée en ce que** si après détermination dudit point de consommation (12), ou le premier point de consommation, une baisse de la pression d'approvisionnement dans ledit point commun est détectée dans ladite étape d), la méthode détermine que ladite baisse dans la pression est causée par l'une des raisons suivantes :

i) parce que le débit du point de consommation a été modifié en adoptant une deuxième constante d' ouverture ; ou
ii) parce qu'on a jouté au moins un deuxième point de consommation, dans ce dernier cas le fluide étant fourni aux deux points de consommation à travers ledit point commun, discriminant un cas d'un autre basé sur la détection d'un et le même ou un point de consommation différent dans la nouvelle courbe de demande.

9. La méthode, d'après la revendication 8, **caractérisée en ce que** dans le cas de i), on obtient une courbe de demande résultante relative qui combine les courbes de demande du même point de consommation pour la première et la deuxième constante d'ouverture et qui est utilisé pour changer la pression de consigne de l'étape e).

10. La méthode, d'après la revendication 8, **caractérisée en ce que** si ii) se produit à l'étape c) la nouvelle courbe de demande est déterminée à partir des coefficients, d'au moins, de la courbe de demande précédente et de la différence des débits calculés dans la nouvelle situation, à partir des lectures successives des valeurs de pression dans ledit point antérieur.

11. La méthode, d'après l'une quelconque des revendications précédentes, **caractérisée en ce qu'**elle comprend, une fois l'identification dudit point de consommation, la réalisation des tâches additionnelles pour contrôler et surveiller ledit point de consommation localement ou à distance de manière personnalisée et en actionnant la pompe et en modifiant les conditions d'approvisionnement de celle-ci d'après une extension prédéterminée.

12. La méthode, d'après l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit point antérieur de mesure de la pression est un point à l'intérieur de la pompe ou contigu à celle-ci.

13. La méthode, d'après l'une quelconque des revendications précédentes, **caractérisée en ce que** l'application additionnelle d'une correction à l'emplacement déterminé à l'étape d) comprend la mesure d'intensité de la consommation de la pompe à tout moment et l'utilisation de courbes de puissance caractéristiques connues de consommation/débit de la pompe précédemment stockée dans le système.

14. Une pièce d'équipement de commande pour contrôler un système de distribution de fluide multipoint en pompant, où le système de distribution fournit le fluide à un grand nombre de points de consommation exigeant différentes pressions d'approvisionnement. Cet équipement de commande comprend :

- au moins un capteur de pression disposé de manière à mesurer la pression d'approvisionnement dans au moins un point dudit système de distribution de fluide ;
- des moyens de commande connecté à, au moins, un capteur de pression et avec des moyens de régulation pour réguler la vitesse de la pompe dudit système de distribution de fluide, et configurés pour contrôler la pression d'approvisionnement de fluide pour ce grand nombre de points de consommation, en actionnant lesdits moyens de régulation, en prenant lesdites différentes pressions d'approvisionnement en tant que pressions de consigne pour ladite commande, et pour changer les valeurs desdites pressions de consigne dépendant de la pression mesurée par au moins un capteur de pression en question. Le système étant **caractérisé en ce qu'**il améliore la méthode proposée d'après l'une quelconques des revendications précédentes, **en ce que** ledit point du système de distribution où ledit capteur de pression est disposé est un point antérieur auxdits points de consommation à travers lesquels s'écoule le fluide dirigé vers au moins une partie desdits points de consommation, et parce que :
- l'équipement de commande comprend au moins une mémoire où est enregistré ce qui suit :
- au moins ladite fonction mathématique descriptive connue de la courbe de demande (10) qui met en relation la hauteur de décharge et le débit de la pompe, et
- un grand nombre de courbes de pompage caractéristiques, une par vitesse de rotation, qui met en relation la hauteur de décharge avec le débit dans différente conditions de fonctionnement ;

et **en ce que** lesdits moyens de commande incluent des moyens de traitement, ils ont accès aux valeurs enregistrées dans cette mémoire et sont configurés pour :

• contrôler le capteur de pression pour la réalisation de l'étape a) de la méthode ;
• contrôler lesdits moyens de régulation pour réguler la vitesse de la pompe pour réaliser l'étape b) de la méthode ;
• réaliser les étapes c) et d) de la méthode grâce auxdits moyens de traitement en utilisant au moins les valeurs mesurées par le capteur de pression et ceux enregistrés dans au moins une mémoire en question ; et
• réaliser l'étape e) de la méthode grâce auxdits moyens de traitement dépendant de l'emplacement déterminé à l'étape d).

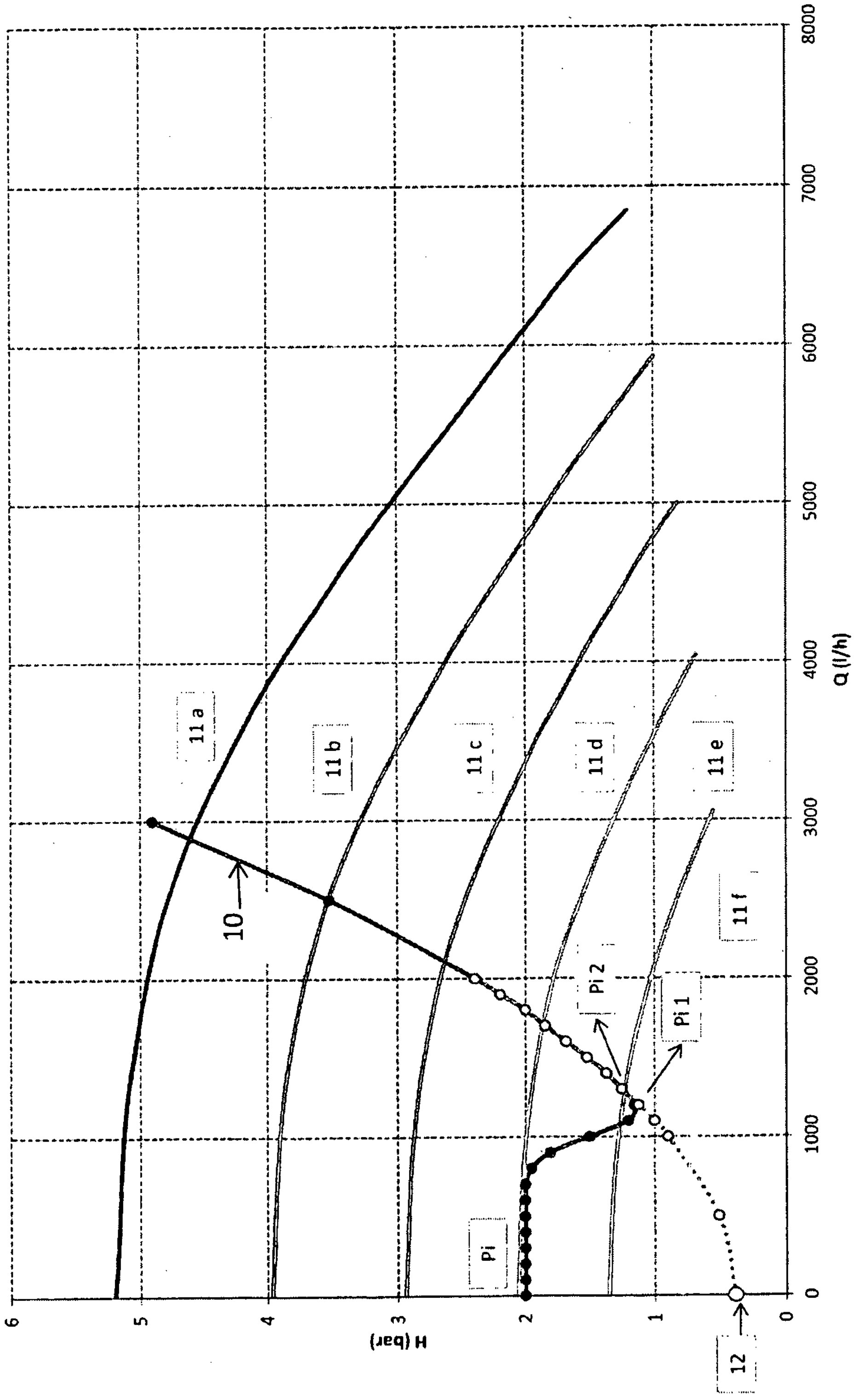
11 a
11 b
11 c
11 d
11 e
11 f
10
Pi
Pi 1
Pi 2
12
H (bar)
Q (l/h)
0
1
2
3
4
5
6
1000
2000
3000
4000
5000
6000
7000
8000

FIG. 1

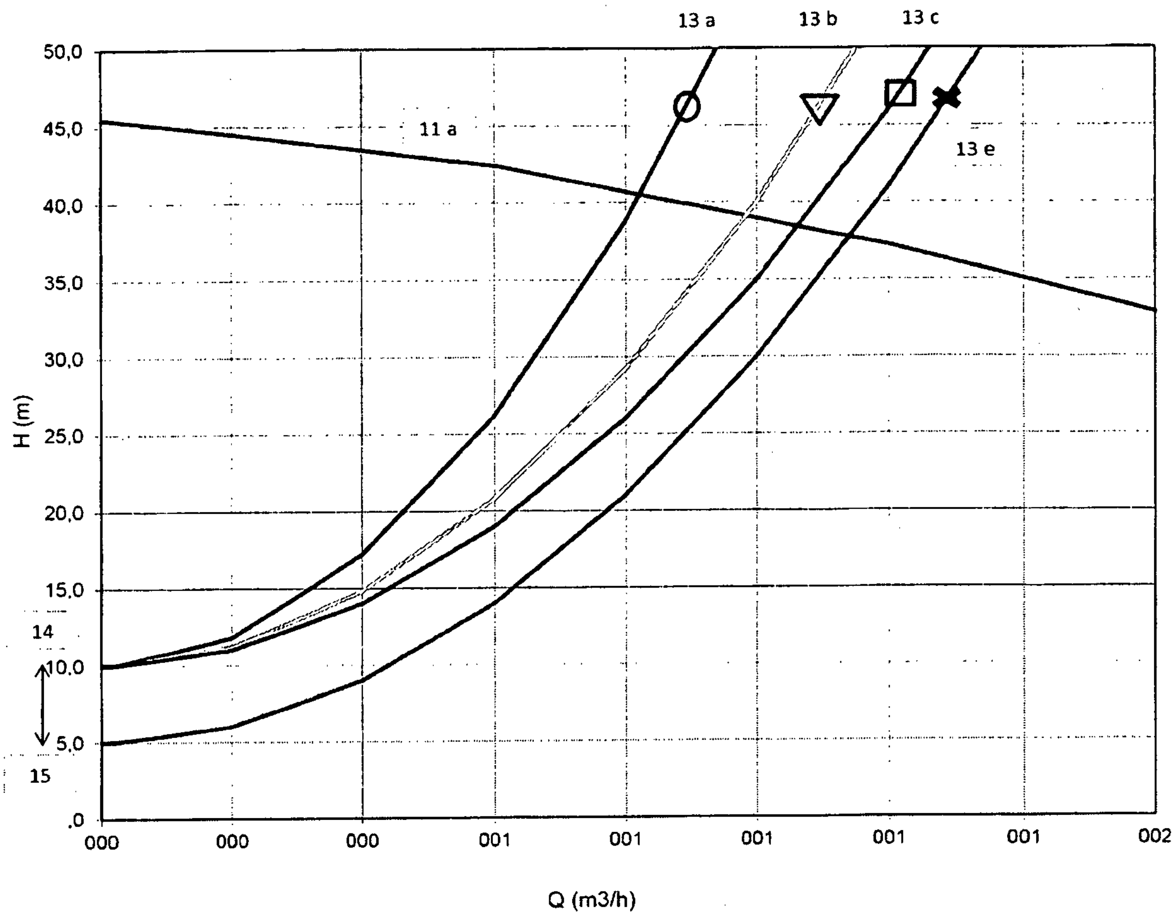
13 a
13 b
13 c
11 a
13 e
14
15
50,0
45,0
40,0
35,0
30,0
25,0
20,0
15,0
10,0
5,0
,0
H (m)
000
000
000
001
001
001
001
001
002
Q (m3/h)

FIG. 2

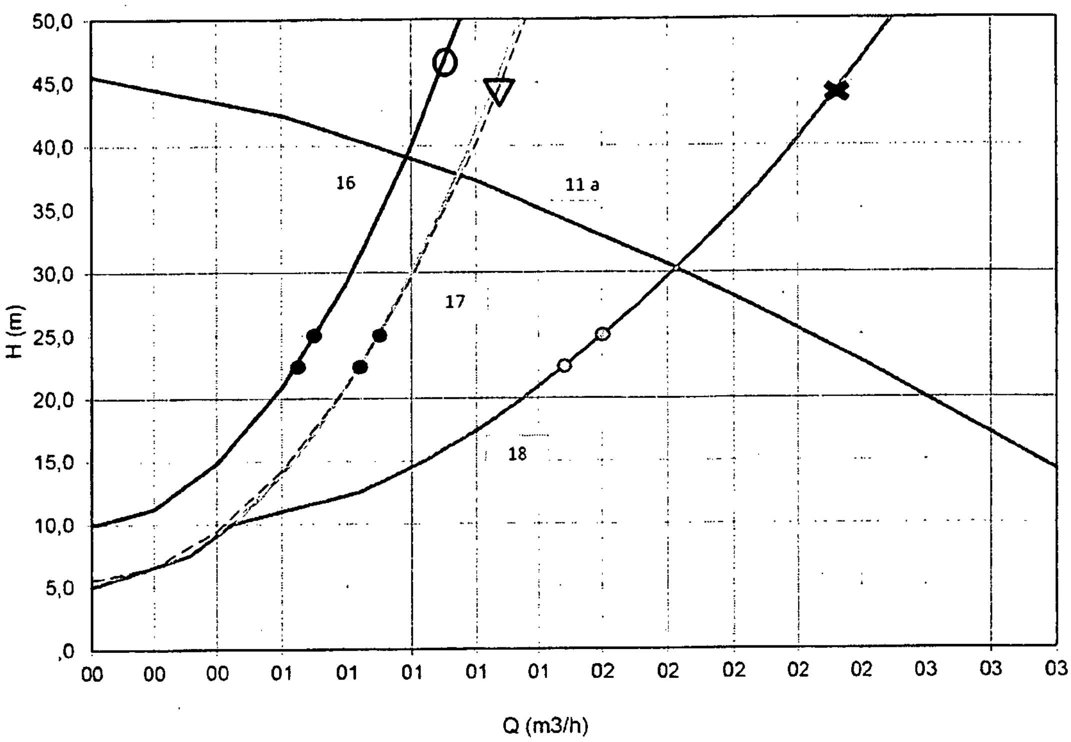
50,0
45,0
40,0
35,0
30,0
25,0
20,0
15,0
10,0
5,0
,0
H (m)
16
11 a
17
18
00
00
00
01
01
01
01
01
02
02
02
02
02
03
03
03
Q (m3/h)

FIG. 3

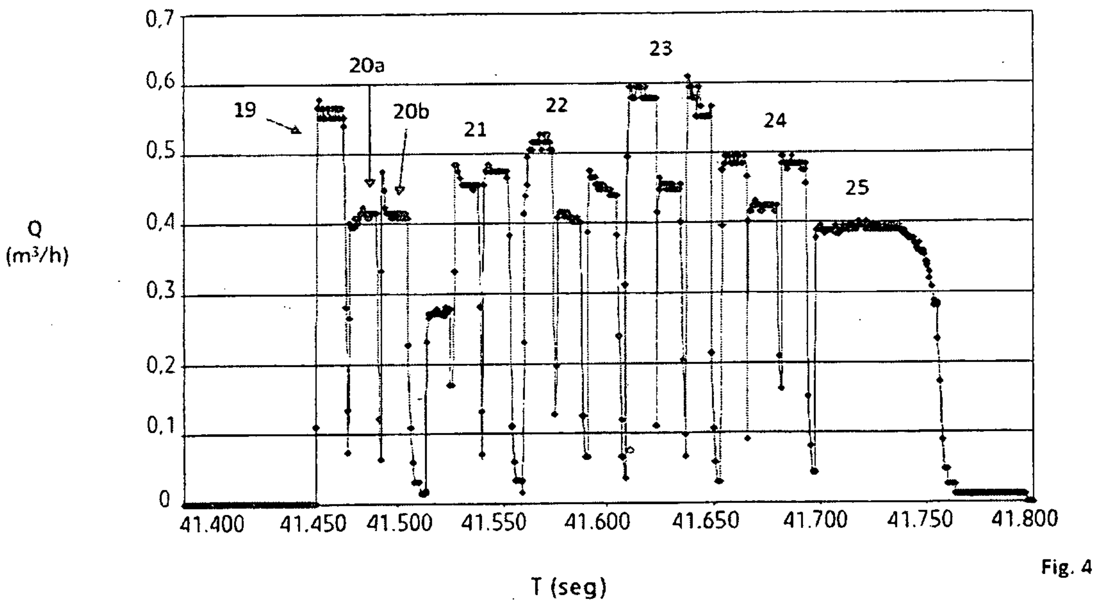
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Q
(m³/h)
19
20a
20b
21
22
23
24
25
41.400
41.450
41.500
41.550
41.600
41.650
41.700
41.750
41.800
T (seg)
Fig. 4

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2005095150 A1 **[0006]**
- US 646446 B2 **[0007]**
- EP 1286240 B1 **[0008] [0009]**
- US 5540555 A **[0010]**