

(19)



(11)

EP 4 567 285 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.06.2025 Bulletin 2025/24

(51) International Patent Classification (IPC):
F15B 19/00^(2006.01)

(21) Application number: **24216959.7**

(52) Cooperative Patent Classification (CPC):
F15B 19/005; F15B 2211/6309; F15B 2211/6313;
F15B 2211/6336; F15B 2211/634; F15B 2211/7053

(22) Date of filing: **02.12.2024**

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(72) Inventors:
• **TONDOLO, Flavio
Levate (BG) (IT)**
• **COFFETTI, Mirko
Levate (BG) (IT)**

(74) Representative: **Bruni, Giovanni
Laforgia, Bruni & Partners
Corso Duca degli Abruzzi, 2
10128 Torino (IT)**

(30) Priority: **06.12.2023 IT 202300026061**

(71) Applicant: **STI S.r.l.
24040 Levate (BG) (IT)**

(54) **ON-SERVICE DIAGNOSTICS OF AN INTELLIGENT POSITIONER FOR PNEUMATIC ACTUATORS**

(57) Method for implementing an on-service diagnostics of an intelligent positioner (3) for pneumatic actuators (2), the method being provided with the following steps:

a) identifying a sampling where a pressure difference (ΔP_p) measured in the positioner (3) is substantially equal to a pressure difference (ΔP_a) in the actuator (2) and then it assumes the sampling as valid under conditions of:

- low flow rate of the working fluid;

- low, constant or with negligible or almost zero acceleration speed of the actuator and the working fluid;
- reading received at a sufficiently time distance from accelerations and/or high speed and/or high flow rate,

b) correctly storing the pressure difference (ΔP_p) measured in the positioner,
c) processing the data received to report alarms/warnings and/or order decisions.

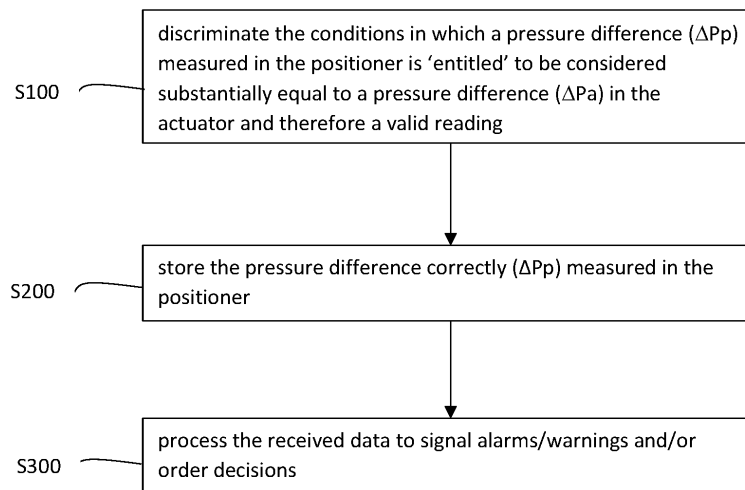


Fig. 2

EP 4 567 285 A1

DescriptionTechnical Sector of the Invention

5 **[0001]** The present invention relates to a method for implementing an "on-service" diagnostics of a "smart" positioned for pneumatic actuators.

Background art

10 **[0002]** As is known, a control valve regulates the flow of a fluid (for example: gas, steam, water or chemical compounds) that flows through a circuit of any industrial and civil system. Such fluid is typically called a process fluid. The regulation of such process fluid can occur by means of an actuator which, through the control fluid present in the actuator circuit, provides the driving force necessary for opening or closing the control valve.

15 **[0003]** In the following description, reference will be made to a double-acting actuator with linear movement, with two pressure chambers and without an elastic element. However, the description is also valid for angular movement and single-acting actuators and with an elastic element, where instead of a pressure difference (ΔP), the pressure of a chamber is read and, if necessary, the elastic force in the different positions of the elastic element is known or detected during the calibration).

20 **[0004]** It is also known that either a control valve positioner (or another positioning device) is a device mounted upon the actuator, which can manage the flow of the control fluid by means of a control strategy, processed by means of algorithms managed by a microprocessor. More recently, the control valve positioners have been greatly improved, also due to the use of digital devices, capable of monitoring the key variables and of implementing more complex control and data recording algorithms.

25 **[0005]** The positioners currently available are provided with internal devices, for example with sensors, in order to read the following quantities, with the least delay and with the greatest possible (real-time) frequency (the references are the same as those which will be further used in figure 1, and are coincident between respective quantity and respective sensor which measures it):

- 30 * requested position S of the actuator or set-point, the data being always available,
- * current position Z of the actuator, the reading being always present,
- * pressure P1 of connection to the first chamber of the actuator, the reading being present on the majority of positioners,
- * pressure P2 of connection to the second actuator chamber, if any, the reading being present on the majority of positioners,
- 35 * supply pressure Pa, the reading being present on various positioners,
- * sensor C which monitors the activation percentage of the device 4, which supplies or discharges a pneumatic flow to the actuator chambers, the reading being present on various positioners,
- * time interval between the readings (the reading being present on various positioners and in any case known through a fixed cycle of the electronics E).

40 **[0006]** By mathematically processing and combining the previous values, other dimensions can be deduced, such as speeds, accelerations, forces, position errors and so on.

[0007] The "smart" electronic positioners applied to the actuator have the ability to perform a self-calibration, by means of which they assign values of 0% and 100% to the physical limits of the adjustment stroke.

45 **[0008]** During the self-calibration, the positioners perform a "tuning" of P. (proportional) or P.I. (proportional-integrative) or P.I.D. (proportional-integrative-derivative) parameters, relating to the deviation between requested position (set point) and current position.

[0009] Furthermore, during the self-calibration or subsequently through a specific test, the positioners can perform a reading of the differential pressure ($\Delta P = P1 - P2$) in the two chambers of the actuator, towards the position and direction of movement. As the force of a pneumatic actuator is proportional to the pressure difference ($\Delta P = P1 - P2$), it is possible to get to a reading and a storage of the force necessary to move the organ to be positioned in the different positions and directions (the so-called "valve signature"). During the self-calibration (or another specific test), the valve must be moved in specific positions and speeds (normally generated by internal routines of the positioner) and therefore it cannot be operating. Therefore non-"on-service" tests are considered.

55 **[0010]** Even during the operation in operational control service, when the position requested to the valve comes from the control system, ΔP , position, time being known, it is possible to process (that is, to calculate and record) the force generated by the actuator, which was necessary to move the valve from point x1 to point x2, where 1 and 2 indicate all the positions which were traveled by the actuator-valve assembly. By means of the above reading and by evaluating how the detected

force data vary with respect to the initial data and how they vary over time, are the base used for evaluating the force opposing the movement in the different positions and therefore for evaluating the internal friction of the components in a relative motion between them. The friction and its variation is the most relevant indicator of the degradation of the components in relative motion and of the ability or not of the valve to move itself according to the design.

[0011] The evaluation of the current friction permits to have an evaluation of the current state of the valve, whereas its variation over time permits to perform analyses on the past and to make projections on the future state of the valve. It is important to underline that the analyses and projections can either easily be not truthful, or they are at most abundantly approximate, if the detected data are affected by influences not due to the friction but to other causes.

[0012] The state of the art described above inevitably involves the following problems that distort the findings and the consequent evaluations, especially in case of positioners operating in highly dynamic conditions. In fact:

1. The force or the pressure differential (ΔP) needed to overcome the friction, is not discriminated by the force used to accelerate the masses. This is a very important issue, as a positioning system is all the better the more it is able to bring the controlled organ to the required position without delay. It is therefore not desirable to have a low movement dynamics to reduce the accelerations. In common cases, ΔP measured in acceleration is several times greater than that due to the friction.

2. The friction force is not discriminated from the force generated by the controlled fluid passing through the valve. As such force is not knowable by the positioner, as it is mainly a function of the pressure upstream and downstream the valve and, therefore, it is variable over time, the positioners have no way of reading the forces generated by the fluid controlled by the valve. This value can also likely be very significant.

3. Phase delay between the reading of force (ΔP) and position. The pressure sensors are inside the positioned which is connected to the actuator chambers through pipes of variable length and section, depending on the various constructions, often spaced out by components such as on-off valves or flow amplifier valves (boosters). The pressures that determine the actuator force are those present inside the actuator chambers. During a variation phase, there is therefore an inevitable delay between the value read inside the positioner and the effective value within the actuator chambers. Such time lag must then be combined with the dynamics of the sensors and the electronic control methodology. Therefore, there is no certainty of the value-time attributed to the variable read. The analysis of non-contemporaneous data causes an unreal functional "image".

4. Incorrect pressure reading, due to the pressure drop between ΔP reading in the positioner and the actual value at the real point, at a certain distance from the positioner. As already mentioned, the presence of pipes and on-off valves and/or of flow amplifier valves means that a pressure drop must be generated for such components to function. The pressures that determine the force are those present inside the actuator chambers. The pressure drop in a pipe is approximately proportional to the square of the flow within the pipe itself. The pressure read when the flow rate delivered or discharged by the positioned is not negligible (non-negligible flow rate), is therefore distorted by the pressure drop in the ducts between the positioner and the actuator. From the experience and the test campaign carried out, the pressure detected inside the positioner and simultaneously within the actuator chambers, during the movement and with high flow rates, is significantly different.

[0013] There is therefore a need to define a method that overcomes the drawbacks described.

Summary of the Invention

[0014] A scope of the present invention is achieved by means of a method for implementing an "on-service" diagnostics of an intelligent positioner for pneumatic actuators.

[0015] In particular, the "on-service" diagnostics according to the present invention includes the following phases:

- a) discriminating the conditions under which a pressure difference (ΔP_p) measured in the positioned is 'entitled' to be considered as substantially equal to a pressure difference (ΔP_a) in the actuator and therefore a valid reading,
- b) archiving such data correctly
- c) processing the data received for reporting alarms/warnings and/or for ordering decisions.

[0016] These and other scopes and advantages are achieved, according to the invention, by a method for implementing an "on-service" diagnostics of an intelligent positioner for pneumatic actuators having the characteristics set forth in the attached independent method claim.

[0017] According to another scope, the method for implementing an "on-service" diagnostics may be realized by means of a computer program having the features set forth in the appended independent software claim.

[0018] Further preferred and/or particularly advantageous embodiments of the invention are described according to the characteristics set forth in the attached dependent claims.

Brief Description of the Drawings

[0019] The invention will now be described with reference to the attached drawings, which illustrate a non-limiting example of its implementation, in which:

- 5 - figure 1 is a diagram of the system which is the object of the implementation of an "on-service" diagnostics, according to an embodiment of the present invention, and
- figure 2 is a flow chart of a method for implementing the on-line diagnostics for the system in figure 1.

10 Detailed description

[0020] With reference to figure 1, according to an absolutely non-limiting embodiment of the present invention, a control system 10 is applied to a valve 1, for regulating a process fluid. The valve 1 is a component of a known type and comprises a shutter and a sealing seat. The system 10 comprises an actuator 2, a positioner 3, a plurality of sensors (for example, a pressure sensor P1, P2, Pa and/or a sensor C and/or a position sensor Z) and a controller 5, provided with an analysis software. The controller 5 can be a "stand alone" component, as well as it can be integrated into the positioner 3, as in the case here described. The positioner also comprises a flow rate/pressure distributor device 4, configured to move a working fluid to and from the actuator 2 and the sensor C monitors the activation percentage of the device 4.

[0021] The actuator 2, by an exemplary and not limiting way, is double-acting. As is known, this means that the actuator control stem, the organ which imparts a force to the valve shutter, is immersed between two chambers in which the relative pressures are balanced and a net force acts on the control stem, which is transmitted to the valve shutter. Naturally, with appropriate considerations on pressures and forces, the invention can also be implemented with single-acting actuators, having only one pressure chamber and where the balance of the forces occurs between a force related to the pressure present in the pressure chamber and a resistant force, for example an elastic force, just as the invention can also be extended to double-acting actuators, provided with an elastic reaction element. The invention is applicable both to actuators with linear motion and to actuators with rotary motion.

[0022] The positioner 3 is a component which determines the "behavior" of actuator 2 by regulating the pressure acting within the pressure chambers of the actuator 2 itself. The logical connection with the actuator 2 is achieved by means of feedback from the position sensor Z of the position of the actuator itself. Based on the feedback on the position of actuator 2, the positioner 3, by means of the device 4, is able to vary the pressure in the two chambers 21, 22 of the actuators 2 (pressure measured by respective pressure sensors P1, P2) in order to position the valve shutter 1 where it is required (required position S or set-point) . If the valve 1 is closed, therefore if the shutter is in contact with the seat, the positioner 3 can modulate the seat/shutter contact force by varying the pressure within the chambers of actuator 2.

[0023] In order to solve the above-mentioned problems and those related to the state of the art, according to the present invention the Applicant has processed the following observations, tests and methodological considerations.

1) A positioning system is better the more it is able to bring the controlled organ to the required position S, without any delay, and the speed of change of the required position is an external control. There is therefore a functional need for the positioner, downstream of each request, for changing its position from x1 to x2, so tending to generate the maximum acceleration (therefore, the maximum force and the maximum pressure difference ΔP) possible towards x2 (the so-called first phase or phase A). The only desired and managed limit of phase A is due to the system's ability to control the deceleration (decrease or inversion of the force and the pressure difference ΔP), once in the vicinity of x2, to correctly and progressively reach x2 (the so-called second phase or phase B). For the reasons mentioned above, the final part of phase B occurs without any significant acceleration. Therefore, the first phase (phase A), if the required movement is not minimal, generally results in insignificant readings, whereas the data detected in the final part of the second phase (phase B) are significant, which involves an approach to the final position x2 at low speed, progressively decreasing and/or interspersed with short pauses until reaching zero speed.

2) The fluid passing through the valve generates a force that depends on the valve position and on the pressure upstream and downstream of the valve. In fact, with the same valve position and pressure upstream and downstream of the valve, the force generated by the fluid in the valve can be considered constant. The positioner is constantly informed of the valve position but it has no information on the pressures. The fluid thrust can therefore be considered almost constant only for measurements made at positions very close to each other, both in the linear distance of position Z and in the time distance. In other words, the forces generated by the process fluid can be considered equal in two samplings therefore only if these are performed at a negligible time distance.

3) The pressure sensors read values inside the positioned at an undefined distance and in an undefined duct connected to the actuator chamber. The phase delay that can be reduced with high dynamic electronic detection systems cannot be eliminated in the case of significant dynamics of the pressure difference ΔP . The dynamics of pressure variation in the chambers depends on the combination of the volume variation and/or the injected/exhausted

flow rate. To have a credible reading of the value ΔP from which to derive the force exerted by the actuator, it is therefore necessary to consider the values read with rapid position movements (rapid volume variation at high speed) and rapid pressure variations (rapid force variations, high accelerations) as being insignificant.

4) For the same reason related to the positioning of the sensors, the pressure drop depends on the flow rate passing through the duct itself. The pressure drop in a duct tends to 0 as the flow rate tends to 0. To have a reading of the pressure difference that is credible with respect to the value present in the actuator chambers (the only position that is actually relevant for this type of analysis) and from which to derive the force exerted by the actuator, it is therefore necessary to consider significant only the values read with slow position movements and with sufficiently low flow rates supplied/discharged by the positioner.

[0024] The combination of considerations as in points 1)-4) leads to making credible and usable only those data obtained under the following conditions:

- low speed, either constant or with negligible accelerations or, better yet, almost equal to zero. These values are easily knowable and/or deducible since the position-time pairs are read continuously,
- low flow rate delivered/discharged by the positioner and low dynamics of pressure variation.

[0025] It is therefore advantageous (if not necessary) to have knowledge of the activation percentage of the device 4, which supplies or discharges a pneumatic flow to the actuator chambers, by means of the sensor C. Knowing the flow capacity of the device (CV) at any given moment and combining it with the pressures read upstream and downstream of the device (pressure P1, P2 in the first and second actuator chamber, supply pressure Pa) this gives an excellent approximation of the value of the flow rate passing between the positioner and the actuator chambers.

[0026] Therefore, in order to ensure the above considerations it is necessary to:

1) implement the value discrimination in the positioner. In fact, by delegating it to external devices this would result in a partial vision due to communication limitations with consequent reduced accuracy. The intent is to have a positioned that has diagnostic capabilities, without the need for additional instrumentation.

2) such feature requires a 'significant' calculation capacity in the positioner (which is usually a low-power device and cannot use powerful microprocessors) both for the mathematical calculations and for the frequency with which the data are detected and the calculations performed (loop time).

3) storing the data in the positioner's memory, in order to discriminate where (position), when (timestamp) and in what direction (UP movement, towards valve closing, or DOWN movement, towards valve opening), using the "historical" data.

[0027] The position must be read accurately both to ensure a correct attribution of 'where' and to quickly discriminate the movements.

[0028] The 'timestamp' is a fundamental element. It happens that the valve moves only in one direction allowing to store 'force' samples in various positions but only in a specific direction. Subsequently, it can happen that the valve moves in the opposite direction on the same positions. The evaluation of the correctness of the 'friction' sample (which in order to exclude the forces coming from the valve fluid must assume that the forces are unchanged and therefore they reasonably must assume a temporal correlation) requires that the UP and DOWN samples of a particular position are at a short time distance.

[0029] The direction serves to discriminate how the forces are to be taken into account (the friction as such always opposes the direction of movement, other forces are independent of it, for example, the weight of the masses to be moved).

[0030] 4) knowing the main quantity (ΔP between actuator chambers) and the quantities used to discriminate its reliability (speed of movement, flow in the pipes)

[0031] The measurement of ΔP , as already explained, can be 'falsified' by pressure losses on the pipes (or other intermediate elements such as boosters) and accelerations, consequently it is necessary to correlate it to the speed of movement (therefore excluding the accelerations) and to the quantity of air supplied (flow in the pipes and pressure losses).

[0032] With reference to figure 2, the method for implementing an on-line diagnostics of an intelligent positioned 3 for pneumatic actuators 2, and the algorithm, i.e. the computer program implementing the aforementioned online diagnostics methodology, are therefore based on the following phases:

- a) discriminating at S100 the conditions ("*detection*") in which a pressure difference ΔP_p measured in the positioner 3 is 'entitled' to be considered substantially equal to a pressure difference ΔP_a in the actuator 2 and therefore to a valid reading,
- b) storing at S200 correctly the pressure difference ΔP_p measured in the positioner 3,

c) processing at S300 the received data to signal alarms/warnings and/or order decisions.

[0033] The "detection" considers the pressure difference data ΔP_p valid in conditions of:

- 5 - low flow rate supplied/discharged by the device 4, therefore low speed of the driving fluid in the ducts between the device 4 and the chambers 21, 22 of the actuator 2. Knowing the action/position of the spool group 4 which supplies or discharges a pneumatic flow to the actuator chambers, instant by instant, the flow coefficient (CV) of the spool group is known and combining it with the pressures read upstream and downstream of the same (pressure P1, P2 in the first and second chamber of the actuator, supply pressure Pa), with excellent approximation the value of the flow rate of the
- 10 working fluid passing between the positioner 3 and the chambers 21, 22 of the actuator 2, is obtained,
- low speed of the actuator 2 - valve 1 assembly, either constant or with negligible accelerations or, even better, almost equal to zero. Such values can be easily known and/or deduced as the actuator position-time pairs are read continuously,
- 15 - sampling values received at a sufficiently distant time interval from accelerations and/or high speeds and/or high flow rates, in order to neutralize the possible error due to the dynamics/synchronism of reading/communication of the sensors.

[0034] Preferably, the time distance should be reduced between two successive samplings of a particular position in both UP (e.g., towards valve closing) and DOWN (e.g., towards valve opening) travel directions.

20 **[0035]** This last condition can be better understood by means of some mathematical steps. Let be defined:

- $F_a(x)$ the dynamic friction force at a point x,
- $F(x^+)$ the force required to move the actuator up to point x (first sampling) from a "smaller" position than x (for example, more open valve),
- 25 - $F(x^-)$ the force required to move the actuator up to point x (second sampling) from a position "greater" than x (for example, valve more closed),
- P_m pressure upstream of the valve
- P_v pressure downstream of the valve
- 30 - F_f force of the process fluid which depends on the pressures upstream P_m and downstream P_v of the valve, in particular F_f^+ is the force acting during the first sampling and F_f^- is the force acting during the second sampling.

[0036] For the equilibrium of the acting forces it results:

35
$$F(x^+) = F_a(x) + F_f^+ \text{ and } F(x^-) = - F_a(x) + F_f^-$$
 (a)

40 **[0037]** Combining the (1), we get:

$$2F_a(x) = F(x^+) - F_f^+ - F(x^-) + F_f^- \quad (b)$$

45 **[0038]** If the two samplings, i.e. the two passages through the point x, are carried out at a short time interval, it is possible to consider the pressures of the process fluid upstream P_m and downstream P_v of the valve, to be substantially constant and therefore the forces of the process fluid F_f^+ , F_f^- to be equal to each other and therefore we obtain:

$$F(x) = [F(x^+) - F(x^-)] / 2 \quad (c)$$

50 **[0039]** From the relation (c) it is possible to conclude that the dynamic friction force at a point x can be considered equal to half the difference of the force (i.e. of the pressure) necessary to pass at x in the two directions of travel, only if the other forces are substantially equal in the two samplings.

55 **[0040]** In addition to what is described above, a further evaluation of the functional state of the system can be made by analyzing the static and dynamic friction value. The knowledge of the static friction/dynamic friction ratio and how it varies over time allows for a functional analysis and forecasts to be performed, establishing any attention and/or alarm thresholds based on the value and/or its variation over time.

[0041] This data can be deduced with the methodology previously explained by knowing the force (ΔP) necessary to start the movement and the minimum force (ΔP) to continue the movement. The values are considered credible for the

conditions described above. In the conditions of very slow movement request, the motion occurs with a succession of movements interspersed with pauses. In this situation, it is easy for the positioner to detect the ΔP necessary to start the movement (force that overcomes the static friction resistance) and that immediately before the stop (force that overcomes the dynamic friction resistance).

[0042] From what has been described above, it is therefore possible to state that a sampling is considered valid if the reliability threshold values for the following parameters are respected:

1. low flow rate of fluid delivered/discharged from the device
2. low actuator speed
3. time interval (Δt_3) from high speeds and/or high flow rates and/or high accelerations
4. time interval (Δt_4) from passing through the same point in UP and in DOWN.

[0043] To select the reliability threshold values, one proceeds as follows. Given the very wide variety of physical characteristics and functional parameters of the actuator-valve assembly to which the positioner can be applied, the values from 1 to 3 must be individually configurable by a "self-tuning" and possibly modifiable by an expert. During the "self-tuning" the positioner can easily evaluate the flow rate it is supplying/discharging, it can know the actuator movement over time and therefore it can investigate which flow rate generates a negligible ΔP and which speeds are generated in these conditions by selecting the values 1 and 2. The value 3 is deduced by performing initially fast movements, which are then brought back to conditions 1 and 2, verifying the delay necessary to read "stable" values. The time interval Δt_3 must therefore be greater than or equal to this time. The value 4 is instead a function of the type of valve and the controlled process, it can be set manually by an expert and by default a short time interval Δt_4 will be selected, also suitable for highly dynamic processes.

[0044] In addition to the modes of implementation of the invention, as described above, it is to be understood that there are numerous further variations. It is also to be understood that said modes of implementation are only exemplary and do not limit either the scope of the invention, or its applications, or its possible configurations. On the contrary, although the above description makes it possible for a skilled person to implement the present invention at least according to an exemplary configuration thereof, it is to be understood that numerous variations of the described components are conceivable, without thereby departing from the object of the invention, as defined in the appended claims, interpreted literally and/or according to their legal equivalents.

Claims

1. Method for implementing an on-service diagnostic of an intelligent positioner (3) for a pneumatic actuator (2), the positioner (3) including a flow/pressure distributor device (4) configured to move a working fluid to and from the actuator (2), the method including the following steps:

a) identifying a sampling in which a pressure difference (ΔP_p) measured in the positioner (3) is substantially equal to a pressure difference (ΔP_a) in the actuator (2) and therefore it assumes the sampling as valid in conditions of:

- low flow rate of the working fluid;
- low speed, constant speed or speed with negligible or almost zero accelerations of the actuator and the working fluid;
- reading received at a time distance sufficiently distant from accelerations and/or high speed and/or high flow rate,

b) correctly archiving the pressure difference (ΔP_p) measured in the positioner (3),
 c) processing the data received to report alarms/warnings and/or to order decisions.

2. Method according to claim 1, in which phase a) considers the sampling as valid in conditions of reduced time distance between two successive samplings of a particular position of the pneumatic actuator (2) in both travel directions.

3. Method according to claim 2, in which, in case of a reduced time distance between two successive samplings, the dynamic friction force in a particular position of the pneumatic actuator (2) is equal to the half-difference of the forces necessary to pass through the particular position in the two travel directions.

4. Method according to any of the previous claims, in which the sampling is considered valid if reliability threshold values are respected for the following parameters:

EP 4 567 285 A1

- low flow rate of delivered/discharged fluid by the device (4),
- low actuator speed,
- first time interval (Δt_3) from high speeds and/or high flow rates and/or high accelerations,
- second time interval (Δt_4) from passing through the same point in both travel directions.

- 5
5. System (10) for controlling a valve (1) regulating the flow of a process fluid, the system (10) comprising an actuator (2), a positioner (3), a plurality of sensors (C, Z, P1, P2, Pa) and a controller (5) configured to carry out the method of anyone of the preceding claims.
- 10
6. System (10) according to claim 5, wherein the controller (5) is integrated into the positioner (3) .
7. System (10) according to claim 5 or 6, wherein the positioner (3) includes a flow/pressure distributor device (4) configured to move a working fluid to and from the actuator (2).
- 15
8. System (10) according to any of claims 5 to 7, wherein the actuator (2) is single-acting or double-acting.
9. System (10) according to claim 8, wherein the actuator has linear motion or rotary motion.
- 20
10. Computer program configured to implement the method according to any of claims 1 to 4.

20

25

30

35

40

45

50

55

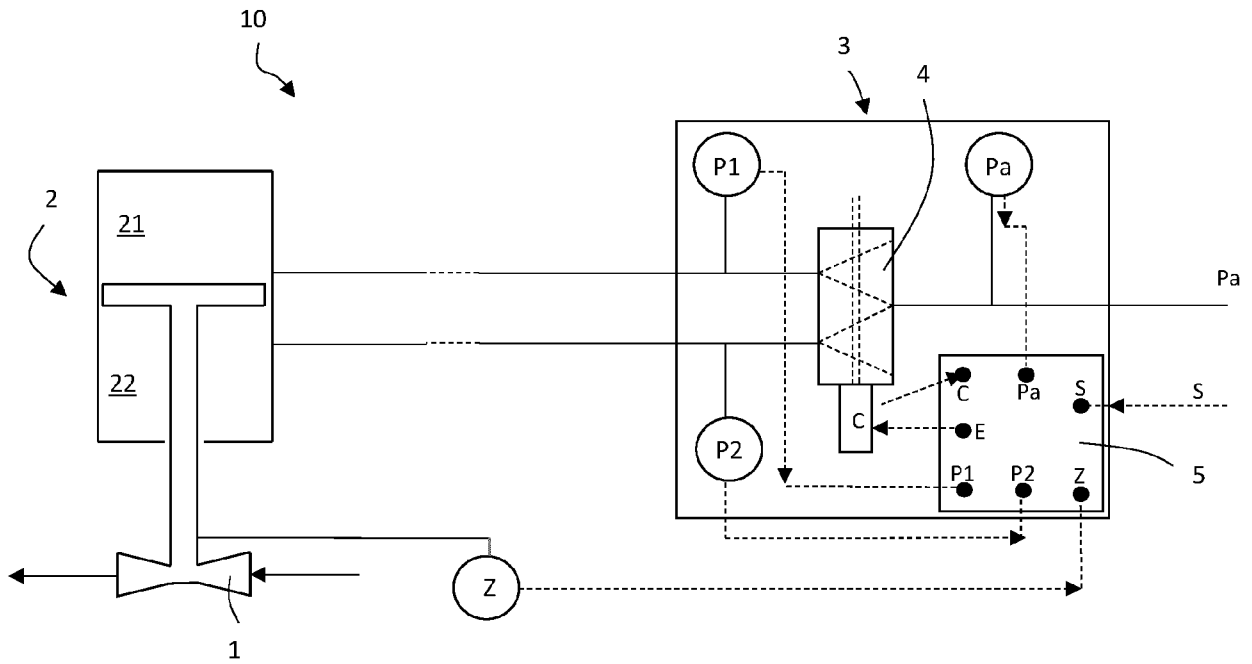


Fig. 1

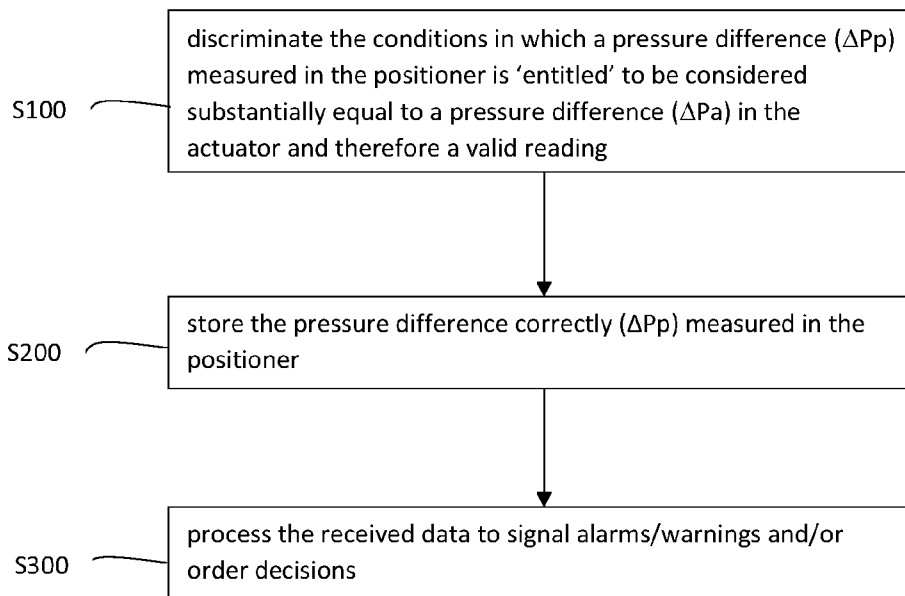


Fig. 2



EUROPEAN SEARCH REPORT

Application Number

EP 24 21 6959

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 6 131 609 A (METSO MIKA [FI] ET AL) 17 October 2000 (2000-10-17) * column 4, line 67 - column 7, line 25 * -----	1-10	INV. F15B19/00
A	US 2001/037159 A1 (BOGER HENRY [US] ET AL) 1 November 2001 (2001-11-01) * paragraphs [0122] - [0129] * -----	1,5,10	
			TECHNICAL FIELDS SEARCHED (IPC)
			F15B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 31 March 2025	Examiner Toffolo, Olivier
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03.82 (F04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 24 21 6959

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

31-03-2025

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
US 6131609 A	17-10-2000	DE 69707449 T2	14-11-2002	
		EP 0904573 A2	31-03-1999	
		ES 2168638 T3	16-06-2002	
		FI 962406 A	05-01-1998	
		JP 3885118 B2	21-02-2007	
		JP 2001522482 A	13-11-2001	
		US 6131609 A	17-10-2000	
US 2001037159 A1	01-11-2001	WO 9748026 A2	18-12-1997	

		AU 8413998 A	16-02-1999	
		DE 69833893 T2	23-11-2006	
		DE 69837412 T2	29-11-2007	
		EP 1058866 A2	13-12-2000	
		ES 2259163 T3	16-09-2006	
		ES 2285303 T3	16-11-2007	
		ES 2304565 T3	16-10-2008	
		US 6272401 B1	07-08-2001	
		US 6957127 B1	18-10-2005	
		US 2001032518 A1	25-10-2001	
		US 2001037159 A1	01-11-2001	
US 2001037670 A1	08-11-2001			
WO 9905576 A2	04-02-1999			

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82