

Description

The invention relates to a device comprising an electrical actuator, a current source, and an actuating unit, which actuator comprises a first actuator body having two diametrically opposed permanent-magnetic poles and a soft-magnetic second actuator body which is coaxial with the first actual body and which comprises at least three circumferentially equispaced teeth, each provided with an energizing coil arranged around the relevant tooth, the first actuator body and the second actuator body cooperating with each other via an air gap and being pivotable through an angle relative to one another about a pivotal axis, as set out in the precharacterising portion of claim 1

Such a device is known from US-A-4,447,793 (herewith incorporated by reference) and has an actuator comprising a circularly cylindrical stator surrounding a non-circularly cylindrical rotor having a north pole and a diametrically opposed south pole. The stator comprises a stator body having three stator teeth and three energizing coils. The stator teeth, which extend in radial directions relative to the rotor, form angles of 120° between them and have curved tooth surfaces, a narrow passage being formed between every two adjacent tooth surfaces. Together with the poles of the rotor, which is flattened at opposite sides of the poles, the tooth surfaces define an air gap.

The energizing coils arranged around the actuator teeth of the known device each comprise two bifilar windings and a single third winding. The energizing coils are coupled to a d.c. source via a change-over switch, to energize one of the bifilar windings and the non-bifilar winding at the same time. This energizing method results in two stable rotor positions.

The actuator of the known device has a torque-angle characteristic which is such that the rotor torque is maximal midway between the two stable positions and is minimal in the two stable positions. As a result of this, the known device is suitable for the actuation of a switch having two discrete positions, as is stated in said US Patent Specification, but the known device gives rise to problems if it is used in a control system in which a control member is to be set continuously and in a well-defined manner to any operating point situated between an initial position and an end position, as for example in the case of a control valve which is pivotable through an angle of for example 90° in a gas or liquid filled system.

Another drawback of the known actuator is that in order to combat detent torques, the tooth surfaces have tangential dimensions which are so large that arranging the coils around the teeth during manufacture of the actuator is complicated

as a result of the small amount of space available between the adjacent tooth surfaces. A further disadvantage is that the stator body is made up of various parts.

It is an object of the invention to provide a device of the type defined in the opening paragraph which enables a control member of a control system to be set to any position within its control range in an accurately defined manner. Moreover, the invention aims at constructing the actuator of the device in such a way that it is largely free from detent torques and can be of a simple and robust construction.

To this end the device in accordance with the invention is characterized in that the device comprises a control unit for dividing a limited operating range of the actuating unit into a plurality of sub-ranges and, depending on said sub-ranges, controllably feeding a current through one of the energizing coils, through at least two but not all the energizing coils, and through all the energizing coils, respectively, which control unit is electrically coupled between the actuating unit and the current source, during operation the control unit controlling the current source as function of said sub-ranges for positioning said actuating bodies relative to one another in positions of equilibrium within said angle.

An advantage of the device in accordance with the invention is that it enables the torque-angle characteristics of the actuator to be utilized for positioning a control member of a control system in such a way that the control member can be set unambiguously to all positions of its control range. If the load of the control member increases as a function of the displacement of the control member, the device in accordance with the invention also enables the torque to be increased as a function of the displacement, so that in an end position of the control member a comparatively large torque is available, enabling said end position to be reached with a minimal power.

In an embodiment of the device in accordance with the invention, in which the number of teeth and the number of energizing coils of the actuator is three, the number of sub-ranges is three. In this device the actuator has three distinctly different torque-angle characteristics. Since the control unit divides the operating range of the actuating unit into three sub-ranges an optimum use can be made of said characteristics when the appropriate current is successively fed through one energizing coil, two energizing coils and three energizing coils.

An embodiment of the device, in which the detent torque of the actuator is drastically minimized, is characterized in that the first actuator body of the actuator is at least substantially circularly cylindrical and is diametrically magnetized.

The sinusoidal variation of the magnet field around the first actuator body of this construction in conjunction with the rotational symmetry of the second actuator body assists in preventing detent torques.

Generally, the actuator will be a three-phase electromagnetic drive unit, in which for practical reasons the first actuator body of the actuator will preferably be a pivotable body. Obviously, the second actuator body then functions as a stator body.

It is to be noted that GB-A-1 50 376 discloses a actuator having a stator formed with a plurality of slots for receiving three 2-pole diametrically wound windings and a rotor including short-circuited windings. When one or two windings of the stator are energized the rotor moves to adopt a position in which the linkage of the short-circuited windings with the energized stator windings is minimized. Limit switches are provided for each stator winding, while a series of switches for controlling the energization of the stator windings is provided. A first cam plate is attached to the rotor shaft to operate the last mentioned switches and a second cam plate is provided to operate a limit switch. External switches are provided to operate two of the windings. All of the mentioned switches are missing in the device in accordance with the invention. Moreover the known actuator has not permanent magnets.

The invention further relates to a method for successful use of the device in accordance with the invention. The method in accordance with the invention for use of a device comprising an electrical actuator, a current source, and an actuating unit, which actuator comprises a first actuator body having two diametrically opposed permanent-magnetic poles and a soft-magnetic second actuator body which is coaxial with the first actuator body and which comprises at least three circumferentially equispaced teeth, each provided with a energizing coil arranged around the relevant tooth, the first actuator body and the second actuator body cooperating with each other via an air gap and being pivotable through an angle relative to one another about a pivotal axis, is characterized in that a control unit electrically coupled between the actuating unit and the current source is used for dividing a limited operating range of the actuating unit into a plurality of sub-ranges and, depending on said sub-ranges, for controllably feeding a current through one of the energizing coils, through at least two but not all the energizing coils, and through all the energizing coils, respectively, in order to position said actuating bodies relative to one another in positions of equilibrium within said angle.

An advantage of the method in accordance with the invention is that a optimum use is made of the torque-angle characteristics of the actuator, to traverse the entire operating range of a control

member driven by the actuator with a comparatively low average electric input power. This has the additional advantage of a minimal heat dissipation in the energizing coils, which is of particular importance for uses in high-temperature environments.

The invention further relates to a apparatus for the well-defined control of the flow rate of a gaseous or liquid medium, comprising a control unit which comprises a control member which is rotatable through a limited angle about an axis of rotation, and the device in accordance with the invention, the control member being mechanically coupled to an actuator shaft of the actuator. The control member may be coupled directly, for example mechanically, to the actuator shaft, the angle through which the actuator shaft is operative corresponding to the movement, for example a pivotal movement, of the control member. Preferably, the control member will be positioned in such a way relative to the actuator shaft that in the end position of the control member the actuator still produces a large torque.

The invention will now be described in more detail, by way of example, with reference to the accompanying drawings in which

Fig. 1 is a cross-sectional view of an embodiment of the actuator of the device in accordance with the invention,

Fig. 2 is a longitudinal sectional view, partly an elevational view, taken on the line II-II in Fig. 1,

Fig. 3 shows diagrammatically an embodiment of the system in accordance with the invention,

Fig. 4 is a graph representing the output signal of the actuating unit of the system shown in Fig. 3 as a function of the position in its operating range,

Fig. 5 is a graph representing the average current in each energizing coil of the actuator as a function of the position in the operating range of the actuating unit of the system shown in Fig. 3,

Fig. 6 is a vector diagram representing the torque which can be delivered by the actuator shown in Fig. 1 when one, two or three coils are energized respectively, and

Fig. 7 shows the three maximum torque-angle characteristics of the actuator and the torque-angle characteristic of a load.

The actuator 2 of the device in accordance with the invention shown in Fig. 1 comprises a first actuator body 1, a second actuator body 3 and a housing 4A and 4B. The first actuator body 1 comprises a cylindrical diametrically magnetized pivotable permanent-magnet body 5 having a north pole N and a south pole S. The pivotal body 5 is mounted on an actuator shaft 9 by means of a soft-magnetic sleeve 7, for example made of sintered iron, which shaft is supported in two bearings 11

and 13 and is pivotable relative to the second actuator body 3 about a pivotable axis 15. The second actuator body 3 comprises a stator body having three radially inwardly directed teeth 19, 20 and 21 of sintered iron which, in order to combat detent torques, are preferably identical to one another. If desired, the stator body 17 can also be manufactured in a different manner, for example by stacking laminations to form one lamination assembly.

The teeth 19, 20 and 21, hereinafter referred to as stator teeth, each have a curved tooth surface 19A, 20A and 21A respectively. The tooth surfaces are all situated on the same circularly cylindrical imaginary surface and define an air gap 23 relative to the pivotable body 5. The three stator teeth 19, 20 and 21 are of identical shape and dimensions and have central axes which are disposed at angles of 120° relative to each other, so that the stator body 17 may be regarded as an actuator part which is at least internally rotationally symmetrical. This inter alia enables the tangential passages 33 between the tooth surfaces 21A, 22A and 23A to be comparatively large. In the present example the tangential dimension of each of the tooth surfaces is approximately a quarter of the circumferential length of said cylindrical imaginary surface.

Each of the three stator teeth 19, 20 and 21 is provided with an energizing coil 29, 30 and 31 respectively. The coils 29, 30 and 31 comprise a plurality of turns arranged around the teeth 19, 20 and 21 and each have coil leads, not shown, which are electrically connected to a current source 35 (see Fig. 3). Since the passages 33 between the teeth are comparatively large the teeth 19, 20 and 21 can simply be provided with said coils.

The apparatus in accordance with the invention shown in Fig. 3 can be used, for example, in motor cars for controlling a throttle in a carburetor. The system comprises an actuating unit 37 having an actuating member, for example an accelerator pedal of a motor car, and a position sensor 39. The position sensor 39 may comprise, for example, a potentiometer whose output signal is a function of the position of the actuating member in its operating range. The system further comprises a control unit 41, for example a microprocessor, which is electrically coupled to the actuating unit 37 and which is electrically coupled to the current source 35. The current source 35 is electrically coupled to the energizing coils 29, 30 and 31 of the actuator 2. For this purpose the current source 35 comprises three independent outputs 43, 44 and 45, for separately applying a controllable current to each coil 29, 30 and 31. The actuator shaft 9 of the actuator 2 is mechanically coupled to a shaft 47 of a control unit 49. The shaft 47 carries a control member 51, for example a valve. In the present example the

shaft 47 carries a disc 53, which is connected to a tension spring 55. The tension spring 55 ensures inter alia that the control member 51 occupies a well-defined initial or rest position when the actuator 2 is not energized.

The operation of the apparatus in accordance with the invention will now be described hereinafter.

When the actuating member of the actuating unit 37 is actuated the control unit 41 receives a signal from the position sensor 39. The control unit is programmed in such a way that the operating range of the actuating unit is divided into three sub-ranges, for example as shown in the graph in Fig. 4, in which the sub-ranges are referenced I, II and III. The control unit 41 controls the current source 35 as a function of the three sub-ranges, for example as is illustrated in Fig. 5.

As is shown in Fig. 5 an energizing coil, for example the coil 29, is energized in the sub-range I, the current increasing proportionally to a maximum value at the transition from the first sub-range I to the second sub-range II. This current remains constant in the remainder of the operating range. In the sub-range II a second energizing coil, for example the coil 30, is energized proportionally to the same constant value at the transition from the sub-range II to the sub-range III, after which the current remains constant. In the sub-range III the energizing coil 31 is also energized proportionally.

The torque-angle characteristic for the maximum current strength, hereinafter referred to as the maximum torque-angle characteristic, of each energizing coil 29, 30 and 31 is represented by vectors 59, 60 and 61 respectively in Fig. 6. The lengths of the vectors correspond to the maximum torques in the torque-angle characteristics and the directions of the vectors correspond to the positions where the torque having a value zero is unstable. In Fig. 7 this position is indicated by the numeral 63 for the maximum torque-angle characteristic (59) of the coil 29.

By feeding the energizing current through the coils 29, 30 and 31 as already described with reference to Fig. 5 and by a suitable combination of the vectors, as is illustrated in Fig. 6, the three maximum torque-angle characteristics (59), (59 + 60) and (59 + 60 + 61) are obtained, which are phase-shifted relative to one another. In the present example the shift is up to 30° .

Fig. 7 also shows the torque-angle characteristic (65) of the load of the control unit 49. The torque-angle characteristics (59), (60 + 61) and (59 + 60 + 61) obtained by means of the device in accordance with the invention enable well-defined positions of equilibrium to be attained, which positions are situated between the initial position B and the end position E of the control member 51. In the

present example the control member 51 rotates through an angle of 90° between its initial position B and its end position E.

In order to guarantee that a control member of a control unit is correctly coupled to the actuator shaft of the actuator, the actuator may be provided with mechanical stops to limit the rotary movement of the rotary shaft.

In order to form a closed control circuit the apparatus in accordance with the invention may comprise an angular-position detector 67, which is, for example, mechanically coupled to the shaft 47 (see Fig. 3). The angular-position detector 67 supplies a signal which is a function of the position of the control member 51. The angular-position detector 67 is electrically coupled to the control unit 41, enabling small deviations from the desired valve position to be corrected.

Claims

1. A device comprising

- an electrical actuator (2),
- a current source (35), and
- an actuating unit (37),

which actuator comprises

- a first actuator body (1) having two diametrically opposed permanent-magnetic poles (N, S) and
- a soft-magnetic second actuator body (3) which is coaxial with the first actuator body and which comprises at least three circumferentially equispaced teeth (19, 20, 21), each provided with an energizing coil (29, 30, 31) arranged around the relevant tooth,

the first actuator body and the second actuator body cooperating with each other via an air gap and being pivotable through an angle relative to one another about a pivotal axis (15), characterized in that

- the device comprises a control unit (41) for dividing a limited operating range of the actuating unit (37) into a plurality of sub-ranges (I, II, III) and, depending on said sub-ranges, controllably feeding a current through one of the energizing coils, through at least two but not all the energizing coils, and through all the energizing coils (29, 30, 31), respectively, which control unit is electrically coupled between the actuating unit and the current source (35), during operation the control unit controlling the current source as function of said sub-ranges for positioning said actuating bodies relative to one another in positions of equilibrium within said angle.

2. A device as claimed in Claim 1, in which the number of teeth and the number of energizing coils of the actuator is three, characterized in that the number of sub-ranges is three, during operation the control unit feeding a current successively through one energizing coil, two energizing coils and three energizing coils.

3. A device as claimed in Claim 1 or 2, characterized in that the first actuator body of the actuator is at least substantially circularly cylindrical and is diametrically magnetized.

4. A device as claimed in any one of the Claim 1 to 3, characterized in that the actuating unit comprises a position sensor which is coupled to a movable actuating member of the actuating unit and which is electrically connected to the control unit.

5. A method for use of a device comprising an electrical actuator (2), a current source (35), and an actuating unit (37), which actuator comprises a first actuator body (1) having two diametrically opposed permanent-magnetic poles (N, S) and a soft-magnetic second actuator body (3) which is coaxial with the first actuator body and which comprises at least three circumferentially equispaced teeth (19, 20, 21), each provided with an energizing coil (29, 30, 31) arranged around the relevant tooth, the first actuator body and the second actuator body cooperating with each other via an air gap and being pivotable through an angle relative to one another about a pivotal axis (15), characterized in that a control unit (41) electrically coupled between the actuating unit and the current source (35) is used for dividing a limited operating range of the actuating unit (37) into a plurality of sub-ranges (I, II, III) and, depending on said sub-ranges, for controllably feeding a current through one of the energizing coils, through at least two but not all the energizing coils, and through all the energizing coils (29, 30, 31), respectively, in order to position said actuating bodies relative to one another in positions of equilibrium within said angle.

6. A method as claimed in Claim 5, characterized in that

- in a first sub-range the current to a first energizing coil of said coils increases proportionally to a maximum value at the transition from the first sub-range to a second sub-range, and remains constant in the remainder of the operating range,

present example the control member 51 rotates through an angle of 90° between its initial position B and its end position E.

In order to guarantee that a control member of a control unit is correctly coupled to the actuator shaft of the actuator, the actuator may be provided with mechanical stops to limit the rotary movement of the rotary shaft.

In order to form a closed control circuit the apparatus in accordance with the invention may comprise an angular-position detector 67, which is, for example, mechanically coupled to the shaft 47 (see Fig. 3). The angular-position detector 67 supplies a signal which is a function of the position of the control member 51. The angular-position detector 67 is electrically coupled to the control unit 41, enabling small deviations from the desired valve position to be corrected.

Claims

1. A device comprising

- an electrical actuator (2),
- a current source (35), and
- an actuating unit (37),

which actuator comprises

- a first actuator body (1) having two diametrically opposed permanent-magnetic poles (N, S) and
- a soft-magnetic second actuator body (3) which is coaxial with the first actuator body and which comprises at least three circumferentially equispaced teeth (19, 20, 21), each provided with an energizing coil (29, 30, 31) arranged around the relevant tooth,

the first actuator body and the second actuator body cooperating with each other via an air gap and being pivotable through an angle relative to one another about a pivotal axis (15), characterized in that

- the device comprises a control unit (41) for dividing a limited operating range of the actuating unit (37) into a plurality of sub-ranges (I, II, III) and, depending on said sub-ranges, controllably feeding a current through one of the energizing coils, through at least two but not all the energizing coils, and through all the energizing coils (29, 30, 31), respectively, which control unit is electrically coupled between the actuating unit and the current source (35), during operation the control unit controlling the current source as function of said sub-ranges for positioning said actuating bodies relative to one another in positions of equilibrium within said angle.

2. A device as claimed in Claim 1, in which the number of teeth and the number of energizing coils of the actuator is three, characterized in that the number of sub-ranges is three, during operation the control unit feeding a current successively through one energizing coil, two energizing coils and three energizing coils.

3. A device as claimed in Claim 1 or 2, characterized in that the first actuator body of the actuator is at least substantially circularly cylindrical and is diametrically magnetized.

4. A device as claimed in any one of the Claim 1 to 3, characterized in that the actuating unit comprises a position sensor which is coupled to a movable actuating member of the actuating unit and which is electrically connected to the control unit.

5. A method for use of a device comprising an electrical actuator (2), a current source (35), and an actuating unit (37), which actuator comprises a first actuator body (1) having two diametrically opposed permanent-magnetic poles (N, S) and a soft-magnetic second actuator body (3) which is coaxial with the first actuator body and which comprises at least three circumferentially equispaced teeth (19, 20, 21), each provided with an energizing coil (29, 30, 31) arranged around the relevant tooth, the first actuator body and the second actuator body cooperating with each other via an air gap and being pivotable through an angle relative to one another about a pivotal axis (15), characterized in that a control unit (41) electrically coupled between the actuating unit and the current source (35) is used for dividing a limited operating range of the actuating unit (37) into a plurality of sub-ranges (I, II, III) and, depending on said sub-ranges, for controllably feeding a current through one of the energizing coils, through at least two but not all the energizing coils, and through all the energizing coils (29, 30, 31), respectively, in order to position said actuating bodies relative to one another in positions of equilibrium within said angle.

6. A method as claimed in Claim 5, characterized in that

- in a first sub-range the current to a first energizing coil of said coils increases proportionally to a maximum value at the transition from the first sub-range to a second sub-range, and remains constant in the remainder of the operating range,



- in a second sub-range a second energizing coil is energized proportionally to a constant value at the transition from the second sub-range to a third sub-range, after which
- in a third sub-range a third energizing coil is energized proportionally.

7. An apparatus for a well-defined control of the flow rate of a gaseous or liquid medium, comprising

- a control unit (41) which comprises a control member (51) which is rotatable through a limited angle about an axis of rotation, and
- a device comprising an electrical actuator (2), a current source (35), and an actuating unit (37),

which actuator comprises

- a first actuator body (1) having two diametrically opposed permanent-magnetic poles (N, S) and
- a soft-magnetic second actuator body (3) which is coaxial with the first actuator body and which comprises at least three circumferentially equispaced teeth (19, 20, 21), each provided with an energizing coil (29, 30, 31) arranged around the relevant tooth,

the first actuator body and the second actuator body cooperating with each other via an air gap and being pivotable through an angle relative to one another about a pivotal axis (15), which device comprises the control unit (41) for dividing the limited operating range of the actuating unit (37) into a plurality of sub-ranges (I, II, III) and, depending on said sub-ranges, controllably feeding a current through one of the energizing coils, through at least two but not all the energizing coils, and through all the energizing coils (29, 30, 31), respectively, which control unit is electrically coupled between the actuating unit and the current source (35), during operation the said sub-ranges for positioning said actuating bodies relative to one another in each position within said angle, the control member being coupled to a pivotable output part of the actuator.

Patentansprüche

1. Vorrichtung mit

- einem elektrischen Betätiger (2),
- einer Stromquelle (35), und
- einer Betätigungseinheit (37),

wobei dieser Betätiger die folgenden Elemente aufweist

- einen ersten Betätigungskörper (1) mit zwei einander diametral gegenüber liegenden Dauermagnetpolen (N, S) und
- einen zu dem ersten Betätigungskörper coaxial liegenden weichmagnetischen zweiten Betätigungskörper (3), der mindestens drei in der Umfangsrichtung in regelmäßigen Abständen voneinander befindliche Zähne (19, 20, 21) aufweist, die mit je einer um den betreffenden Zahn vorgesehenen Erregungsspule (29, 30, 31) versehen sind,

wobei der erste Betätigungskörper und der zweite Betätigungskörper über einen Luftspalt miteinander zusammenarbeiten und um eine Schwenkachse (15) über einen Winkel gegenüber einander schwenkbar sind, dadurch gekennzeichnet, daß

- die Vorrichtung eine Regeleinheit (41) aufweist zur Unterteilung eines beschränkten Arbeitsbereiches der Betätigungseinheit (37) in eine Anzahl Teilbereiche (I, II, III) und, je nach diesen Teilbereichen, auf regelbare Weise durch eine der Erregungsspulen, durch wenigstens zwei aber nicht alle Erregungsspulen bzw. durch alle Erregungsspulen (29, 30, 31) einen Strom zuführt, wobei diese Regeleinheit zwischen der Betätigungseinheit und der Stromquelle (35) elektrisch gekoppelt ist, wobei die Regeleinheit im Betrieb die Stromquelle als Funktion der genannten Teilbereiche regelt zum jeweiligen Einstellen der genannten Betätigungskörper an Gleichgewichtsstellen innerhalb des genannten Winkels.

2. Vorrichtung nach Anspruch 1, wobei die Anzahl Zähne des Betätigers und die Anzahl Erregungsspulen drei beträgt, dadurch gekennzeichnet, daß die Anzahl Teilbereiche drei ist, daß im Betrieb die Regeleinheit durch eine Erregungsspule, durch zwei Erregungsspulen und durch drei Erregungsspulen einen Strom schickt.

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der erste Betätigungskörper des Betätigers wenigstens nahezu kreiszylindrisch ausgebildet und diametral magnetisiert ist.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Betätigungseinheit einen Lagensensor aufweist, der mit einem beweglichen Betätigungselement der Betätigungseinheit gekuppelt und mit der Regeleinheit elektrisch verbunden ist.



5. Verfahren zur Anwendung einer Vorrichtung mit einem elektrischen Betätiger (2), einer Stromquelle (35) und einer Betätigungseinheit (37), wobei dieser Betätiger einen ersten Betätigungskörper (1) mit zwei einander diametral gegenüber liegenden Dauermagnetpolen (N, S), und einen zu dem ersten Betätigungskörper koaxial liegenden weichmagnetischen zweiten Betätigungskörper (3) aufweist, der mindestens drei in der Umfangsrichtung in regelmäßigen Abständen voneinander befindliche Zähne (19, 20, 21) aufweist, die mit je einer um den betreffenden Zahn vorgesehenen Erregungsspule (29, 30, 31) versehen sind, wobei der erste Betätigungskörper und der zweite Betätigungskörper über einen Luftspalt miteinander zusammenarbeiten und um eine Schwenkachse (15) über einen Winkel gegenüber einander schwenkbar sind, dadurch gekennzeichnet, daß eine zwischen der Betätigungseinheit und der Stromquelle (35) elektrisch gekoppelte Regeleinheit (41) zur Aufteilung eines beschränkten Betätigungsbereiches der Betätigungseinheit (37) in eine Anzahl Teilbereiche (I, II, III) verwendet wird und, abhängig von den genannten Teilbereichen, zur steuerbaren Speisung eines Stromes durch nur eine der Erregungsspulen, durch mindestens zwei aber nicht alle Erregungsspulen bzw. durch alle Erregungsspulen (29, 30, 31) zum jeweiligen Einstellen der genannten Betätigungskörper an Gleichgewichtsstellen innerhalb des genannten Winkels.

6. Verfahren nach Anspruch 5, dadurch gekennzeichnet, daß

- der Strom zu einer ersten Erregungsspule in einem ersten Teilbereich zu einem Maximalwert beim Übergang von dem ersten Teilbereich I zu dem zweiten Teilbereich II proportional zunimmt und in dem restlichen Teil des Arbeitsbereiches weiterhin konstant bleibt,
- in einem zweiten Teilbereich eine zweite Erregungsspule zu einem konstanten Wert bei dem Übergang von dem zweiten Teilbereich zu dem dritten Teilbereich proportional erregt wird, wonach
- in einem dritten Teilbereich eine dritte Erregungsspule proportional erregt wird.

7. Gerät zur definierten Regelung des Durchsatzes eines gasförmigen oder flüssigen Mediums, mit

- einer Regeleinheit (49) mit einem um eine Drehungsachse über einen beschränkten Winkel drehbaren Regelelement (51), und

- einer Vorrichtung mit einem elektrischen Betätiger (2), einer Stromquelle (35), und einer Betätigungseinheit (37),

wobei dieser Betätiger die folgenden Elemente aufweist

- einen ersten Betätigungskörper (1) mit zwei einander diametral gegenüber liegenden Dauermagnetpolen (N, S) und
- einen zu dem ersten Betätigungskörper koaxial liegenden weichmagnetischen zweiten Betätigungskörper (3), der mindestens drei in der Umfangsrichtung in regelmäßigen Abständen voneinander befindliche Zähne (19, 20, 21) aufweist, die mit je einer um den betreffenden Zahn vorgesehenen Erregungsspule (29, 30, 31) versehen sind,

wobei der erste Betätigungskörper und der zweite Betätigungskörper über einen Luftspalt miteinander zusammenarbeiten und um eine Schwenkachse (15) über einen Winkel gegenüber einander schwenkbar sind, wobei diese Vorrichtung eine Regeleinheit (41) aufweist zur Unterteilung des beschränkten Arbeitsbereiches der Betätigungseinheit (37) in eine Anzahl Teilbereiche (I, II, III) und, je nach diesen Teilbereichen, auf regelbare Weise durch eine der Erregungsspulen, durch wenigstens zwei aber nicht alle Erregungsspulen bzw. durch alle Erregungsspulen (29, 30, 31) einen Strom zuführt, wobei diese Regeleinheit zwischen der Betätigungseinheit und der Stromquelle (35) elektrisch gekoppelt ist, und im Betrieb die Stromquelle als Funktion der genannten Teilbereiche regelt zum Einstellen der genannten Betätigungskörper gegenüber einander an jeder Stelle innerhalb des genannten Winkels, wobei das Regelelement mit einem schwenkbaren Ausgangsteil des Betätigers gekuppelt ist.

Revendications

1. Dispositif comportant

- un actionneur électrique (2),
- une source de courant (35) et
- une unité de manoeuvre (37),

actionneur qui comporte

- un premier corps d'actionneur (1) ayant deux pôles à aimantation permanente diamétralement opposés (N, S) et
- un second corps d'actionneur magnétique doux (3) coaxial avec le premier corps d'actionneur et présentant au moins trois dents (19, 20, 21) placées à écartement égal suivant le pourtour et entourées chacune d'une bobine d'excitation (29, 30, 31),



les premier et second corps d'actionneur coopérant l'un avec l'autre et pouvant pivoter d'un angle l'un par rapport à l'autre autour d'un axe de pivotement (15), caractérisé en ce qu'il comporte

- une unité de commande (41) pour diviser une gamme de fonctionnement limitée de l'unité de manoeuvre (37) en une pluralité de sous-gammes (I, II, III) et, selon ces sous-gammes, établir de façon réglable un courant respectivement à travers l'une des bobines d'excitation, à travers au moins deux bobines d'excitation, mais non toutes les bobines d'excitation, et à travers toutes les bobines d'excitation (29, 30, 31), unité de commande qui est couplée électriquement entre l'unité de manoeuvre et la source de courant (35), et qui, au cours du fonctionnement, commande la source de courant en fonction desdites sous-gammes pour positionner lesdits corps d'actionneur l'un par rapport à l'autre dans des positions d'équilibre, dans les limites dudit angle.

2. Dispositif selon la revendication 1, dans lequel le nombre de dents et le nombre de bobines d'excitation de l'actionneur sont égaux à trois, caractérisé en ce que le nombre de sous-gammes est égal à trois, l'unité de commande établissant au cours du fonctionnement un courant successivement à travers une seule bobine d'excitation, à travers deux bobines d'excitation et à travers trois bobines d'excitation.

3. Dispositif selon la revendication 1 ou 2, caractérisé en ce que le premier corps d'actionneur de l'actionneur est au moins sensiblement de forme cylindrique à base circulaire et présente une aimantation diamétrale.

4. Dispositif selon l'une quelconque des revendications 1 à 3, caractérisé en ce que l'unité de manoeuvre comporte un capteur de positions couplé à un organe de manoeuvre mobile de l'unité de manoeuvre et relié électriquement à l'unité de commande.

5. Procédé d'utilisation d'un dispositif comportant un actionneur électrique (2), une source de courant (35) et une unité de manoeuvre (37), actionneur qui comporte un premier corps d'actionneur (1) ayant deux pôles à aimantation permanente diamétralement opposés (N, S) et un second corps d'actionneur magnétique doux (3), coaxial avec le premier corps

d'actionneur et présentant au moins trois dents placées à écartement égal (19, 20, 21) suivant le pourtour et entourées chacune d'une bobine d'excitation (29, 30, 31), les premier et second corps d'actionneur coopérant l'un avec l'autre à travers un entrefer et pouvant pivoter d'un angle l'un par rapport à l'autre autour d'un axe de pivotement (15), caractérisé en ce qu'une unité de commande (41) couplée électriquement entre l'unité de manoeuvre et la source de courant (35) est utilisée pour diviser une gamme de fonctionnement limitée de l'unité de manoeuvre (37) en une pluralité de sous-gammes (I, II, III) et, selon lesdites sous-gammes, établir de façon réglable un courant respectivement à travers l'une des bobines d'excitation, à travers au moins deux bobines d'excitation, mais non toutes les bobines d'excitation, et à travers toutes les bobines d'excitation (29, 30, 31) afin de positionner lesdits corps d'actionneur l'un par rapport à l'autre dans des positions d'équilibre, dans les limites dudit angle.

6. Procédé selon la revendication 5, caractérisé en ce que

- dans une première sous-gamme, le courant circulant vers une première desdites bobines d'excitation augmente proportionnellement jusqu'à une valeur maximale à la transition de la première sous-gamme à une deuxième sous-gamme et reste constant dans le reste de la gamme de fonctionnement,
- dans une deuxième sous-gamme, une deuxième bobine d'excitation est excitée proportionnellement jusqu'à une valeur constante à la transition de la deuxième sous-gamme à une troisième sous-gamme, après quoi,
- dans une troisième sous-gamme, est excitée proportionnellement une troisième bobine d'excitation.

7. Appareil pour le réglage bien défini du débit d'un milieu gazeux ou liquide, comportant

- une unité de réglage (49) munie d'un organe de réglage (51) pouvant tourner d'un angle limité autour d'un axe de rotation et
- un dispositif comportant un actionneur électrique (2), une source de courant (35) et une unité de manoeuvre (37),

actionneur comportant

- un premier corps d'actionneur (1) ayant deux pôles à aimantation permanente diamétralement opposés (N, S) et
- un second corps d'actionneur magnétique doux (3), coaxial avec le premier



corps d'actionneur et présentant au moins trois dents (19, 20, 21) placées à écartement égal suivant la circonférence et munies chacune d'une bobine d'excitation (29, 30, 31) entourant la dent concernée,

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les premier et second corps d'actionneur coopérant l'un avec l'autre à travers un entrefer et pouvant pivoter d'un angle l'un par rapport à l'autre autour d'un axe de pivotement (15), dispositif qui comporte une unité de commande (41) pour diviser la gamme de fonctionnement limitée de l'unité de manoeuvre (37) en une pluralité de sous-gammes (I, II, III) et, selon lesdites sous-gammes, établir de façon réglable un courant, respectivement à travers l'une des bobines d'excitation, à travers au moins deux bobines d'excitation, mais non toutes les bobines d'excitation, et à travers toutes les bobines d'excitation (29, 30, 31), unité de commande qui est couplée électriquement entre l'unité de manoeuvre et la source de courant (35) et qui, au cours du fonctionnement, commande la source de courant en fonction desdites sous-gammes pour positionner lesdits corps d'actionneur l'un par rapport à l'autre dans chaque position dans les limites dudit angle, l'organe de réglage étant couplé à une partie de sortie pivotante de l'actionneur.

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