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(54) Title: ELECTRIC CONTROL VALVE FOR A COOLANT COMPRESSOR

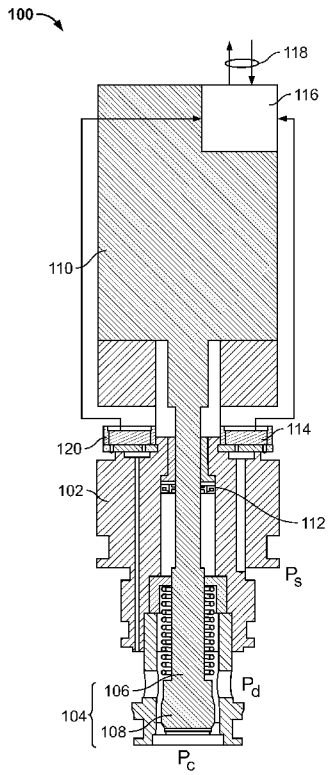


Fig. 1

(57) Abstract: The present invention relates to an electric control valve which controls a coolant flow. The control valve includes a valve housing, which has connectors for a suction-pressure region, a high-pressure region and a crankcase-chamber-pressure region, a valve body, which is arranged to be displaceable between two positions, the valve body either mutually connecting or separating the high-pressure region and the crankcase-chamber-pressure region depending on the position, an electric actuating drive, which displaces the valve body, a means for determining the position of the valve body, a first pressure sensor, which determines a value of the suction pressure in the suction-pressure region, an electric control means, which, as a function of the determined value of the suction pressure, controls the coolant flow by displacing the valve body using the electric actuating drive, in such a way that if the determined suction pressure falls below a predetermined threshold the valve body connects the high-pressure region to the crankcase-chamber-pressure region, and an electric interface, by way of which the value determined by the first pressure sensor can be read off, and by way of which the control valve can be connected to a power supply.

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Electric control valve for a coolant compressor

The invention relates to an electric control valve for use in a coolant compressor, in particular in a coolant compressor for a motor vehicle. The electric control valve controls the coolant flow from a high-pressure region into a crankcase-chamber-pressure region of the coolant compressor.

Both the construction and the mode of operation of a coolant compressor are known to the person skilled in the art, for example from DE 10 2011 117 354 A1.

In a crankcase of a coolant compressor, a plurality of pistons are arranged so as to pump coolant into a high-pressure chamber. The movement of the pistons is guided by a rotating wobble plate, as will be clear from the following description.

If the wobble plate, which is set in rotation for example by way of a belt drive, has a tilt angle other than zero, this leads to an axial stroke movement of the pistons during a rotation of the wobble plate about the axis of rotation thereof. Coolant is thus sucked up from the suction chamber of the coolant compressor and pumped into the pressure chamber.

The suction chamber is connected to the connector of the coolant compressor that is on the suction pressure side, and this connector is in turn connected, when mounted in the motor vehicle, to the suction-pressure region of the air-conditioning system, in other words in particular to the output of the evaporator. The pressure chamber is connected to the output of the coolant compressor that is on the high pressure side, and this output is in turn connected to the input of the evaporator by way of the high-pressure region of the air-conditioning system, in particular via a heat exchanger (condenser) and an expansion valve.

To adjust the delivery volume, in particular to control the coolant flow, it is already known to vary the tilt angle of the wobble plate in the coolant compressor. If for example the coolant compressor is pre-set for a maximum delivery volume, pivoting the wobble plate back brings about a decrease in the axial stroke movement of the pistons of the coolant compressor and thus a reduction in the delivery volume.

It is further known to undertake this type of control of the coolant flow using a control valve. In this case, the coolant flow between the high-pressure region and the crankcase-chamber-pressure region is controlled by way of the control valve.

The control valve is provided with three connectors in the valve housing, which are connected to the high-pressure region, the suction-pressure region and the crankcase-chamber-pressure region of the coolant compressor. The control valve controls the coolant flow between the high-pressure region and the crankcase-chamber-pressure region.

If for example in one position the control valve opens the connection between the high-pressure region and the crankcase-chamber-pressure region of the coolant compressor, coolant flows through the control valve from the high-pressure region into the crankcase-chamber-pressure region; this results in a rise in pressure in the crankcase-chamber-pressure region.

If in a further position the control valve closes the connection between the high-pressure region and the crankcase-chamber-pressure region of the coolant compressor, coolant flows through the permanently open passage provided in the coolant compressor from the crankcase-chamber-pressure region into the suction-pressure region; this results in a fall in pressure in the crankcase-chamber-pressure region.

As a result of the rise in pressure brought about by the control valve in the crankcase-chamber-pressure region, the wobble plate is caused to pivot back. This decreases the axial stroke movement of the pistons of the coolant compressor, and the delivery volume of the coolant compressor is reduced. As a result, the pressure in the high-pressure region of the air-conditioning system does not increase any further.

As a result of the fall in pressure brought about by the control valve in the crankcase-chamber-pressure region, the wobble plate is caused to pivot out (in other words to tilt). This increases the axial stroke movement of the pistons of the coolant compressor, and the delivery volume of the coolant compressor is increased. As a result, the pressure in the high-pressure region of the air-conditioning system increases further.

Usually, the wobble plate is held in a tilted initial position by spring tension, in such a way that, in the event of a subsequent fall in pressure in the crankcase-chamber-pressure region, the wobble plate pivots back into the initial position and ensures an initial setting for the delivery volume in the coolant compressor.

Conventionally, a protection mechanism is integrated into a coolant compressor and prevents the coolant evaporator from icing up, which would reduce or prevent the airflow into the passenger compartment. The coolant evaporator starts to ice up as soon as the suction pressure falls below a particular pressure.

An example implementation of a protection mechanism of this type includes a bellows, preferably made of metal, integrated into the control valve and arranged in the control valve in such a way that it can throttle the coolant compressor down. For this purpose, the bellows is filled with a gas mixture at a particular pressure.

If the pressure prevailing in the suction-pressure region of the control valve falls substantially below the fill pressure of the bellows, the volume of the gas mixture in the bellows increases in relative terms. As a result of the construction, the bellows then unfolds in a concertina shape and accordingly becomes longer.

Conversely, if the pressure prevailing in the suction-pressure region of the control valve substantially exceeds the fill pressure of the bellows, the volume of the gas mixture in the bellows decreases in relative terms. As a result of the construction, the bellows then folds up in a concertina shape and accordingly becomes shorter.

This construction-based mode of operation of the bellows is exploited by the safety mechanism for the control valve in that the bellows cooperates with the valve body in such a way that, if there is a fall below a critical pressure in the suction-pressure region, it mechanically transfers the valve body into the position in which the coolant compressor is throttled down.

During the construction of a control valve, the fill pressure and the type of gas mixture in the bellows are specifically selected in such a way that, if there is a fall below a minimum pressure in the suction-pressure region of the control valve, the bellows moves the valve body into the position in which the high-pressure region is connected to the crankcase-chamber-pressure region.

The rise in pressure in the crankcase-chamber-pressure region, brought about by the bellows, causes the wobble plate to pivot back. As a result, the axial stroke movement of the pistons of the coolant compressor and the delivery volume of the coolant compressor are reduced, and the coolant compressor is throttled down. As a result, the pressure in the suction region of the coolant compressor does not fall below the limit value, and the coolant evaporator is prevented from icing up.

However, a bellows of this type is a mechanically operating component, which is sluggish as a result of the construction and is also subject to ageing processes. Thus, for example, frequent unfolding in a concertina shape and subsequent folding up of the bellows results in material fatigue therein. Further, under some circumstances, it cannot be ensured that the bellows filled with a gas mixture will remain tight throughout its service life. There is therefore a further need for improvements.

The object of the underlying invention is to provide a control valve which has a safety mechanism which intervenes rapidly and precisely in the control of the coolant flow, and which brings the valve body into a reliable position in which the coolant flow ceases.

The object of the invention is further to make possible a simple, cost-effective adjustment of the safety mechanism for use with various coolant compressors and/or air-conditioning systems.

At least one of the aforementioned objects is achieved by the invention disclosed in the independent claim. Advantageous developments are set out in the dependent claims.

The underlying invention proposes an electric control valve, in particular for a coolant compressor, which controls a coolant flow through the control valve from a high-pressure region into a crankcase-chamber-pressure region.

The control valve includes a valve housing, which has connectors for a suction-pressure region, a high-pressure region and a crankcase-chamber-pressure region, and a valve body, which is arranged to be displaceable between two positions inside the valve housing, the valve body either mutually connecting or separating the high-pressure region and the crankcase-chamber-pressure region depending on the position.

An electric actuating drive, which displaces the valve body, a means for determining the position of the valve body, and a first pressure sensor, which determines a value of the suction pressure in the suction-pressure region, are additionally included.

An electric control means is further included, which, as a function of the value of the suction pressure determined in the suction-pressure region, controls the coolant flow from the high-pressure region into the crankcase-chamber-pressure region by displacing the valve body using the electric actuating drive, in such a way that if the determined suction pressure falls below a predetermined threshold the valve body connects the high-pressure region to the crankcase-chamber-pressure region.

An electric interface is also included, by way of which the value of the suction pressure in the suction-pressure region determined by the first pressure sensor can be read off, and by way of which the electric actuating drive, the first pressure sensor and the electric control means can be connected to a power supply.

Advantageously, by way of an electric control means of this type, a safety mechanism is implemented which intervenes rapidly and precisely in the control of the coolant flow and counteracts icing up in the coolant compressor. In this context, the coolant flow is controlled

using the value of the suction pressure in the suction-pressure region that is precisely determined by the suction pressure sensor, with the result that the rapid and precise intervention can be ensured if the suction pressure falls below a threshold.

It is additionally advantageous that the predetermined threshold is stored in the electric control system in advance and can be adjusted as a function of the coolant or the air-conditioning system. Thus, simple, cost-effective adjustment of the safety mechanism to different coolants and/or air-conditioning systems is possible.

For a better understanding of the present invention, it is described in greater detail by way of the embodiment shown in the following drawing. Like parts are provided with like reference numerals and like component names. Further, individual features or feature combinations from the shown and disclosed embodiments may also form independent inventive solutions or solutions according to the invention in their own right.

In the drawings:

Fig. 1 is a schematic drawing of a control valve according to the invention for a coolant compressor, for controlling a coolant flow from a high-pressure region into a crankcase-chamber-pressure region in accordance with an embodiment.

Hereinafter, with reference to Fig. 1, the general inventive principle of the electric control valve 100, in particular for a coolant compressor, for controlling a coolant flow from a high-pressure region into a crankcase-chamber-pressure region, will initially be explained in greater detail.

Fig. 1 shows a control valve according to the invention for a coolant compressor of a first embodiment; developments of the control valve and embodiments of the individual components of the control valve are described in greater detail in connection with the description. The control valve 100 controls the coolant flow from a high-pressure region into a crankcase-chamber-pressure region of a coolant compressor (not shown). For this purpose, the control valve 100 includes a valve housing 102 having a connector Pd for connection to the high-pressure region of a coolant compressor, having a connector Pc for connection to the crankcase-chamber-pressure region of the coolant compressor, and having a connector Ps for connection to the suction-pressure region of the coolant compressor.

The control valve 100 further includes a valve body 104, which is displaceable between two different positions inside the valve housing 102. These two positions thus each form an end position for the valve body 104 of the control valve 100 inside the valve housing 102.

In the first of the two different positions, the valve body 104 inside the valve housing 102 connects the high-pressure region to the crankcase-chamber-pressure region. In the second of the two different positions, the valve body 104 separates the high-pressure region from the crankcase-chamber-pressure region.

In an advantageous development of the control valve 100, the valve body 104 may also take up further positions, between the end positions, inside the valve housing 102. As a result, the valve body 104 takes up not only the two positions in which the high-pressure region and the crankcase-chamber-pressure region are mutually connected or separated, but also further positions in which the high-pressure region and the crankcase-chamber-pressure region are mutually connected but the flow rate is limited.

In one embodiment, the valve body 104 includes an actuation rod 106. Further, in this embodiment the valve body 104 includes a shut-off body (or sealing body) 108, which is formed in a plate shape, piston shape, cone shape or ball shape. A valve body 104 of this type is formed either in a single piece or in a plurality of pieces.

In an advantageous development of the control valve 100, the valve housing 102 is formed in such a way that it leads to the movement of the valve body 104 between the two end positions. For this purpose, a lateral guide, for example in the form of a guide rail or a thread, may be provided in the valve housing 102, and cooperates with a corresponding counterpart, for example in the form of a slide or a thread on the valve body 104, preferably on the actuation rod 106.

The control valve 100 is controlled, in connection with the invention, by the positioning of the valve body 104 in the two positions in which a passage from the high-pressure region into the crankcase-chamber-pressure region is open and closed respectively. The passage is determined by the position and shape of the valve body 104, and influences the flow rate of the coolant from the high-pressure region into the crankcase-chamber-pressure region.

An electric actuating drive 110, additionally included in the control valve 100 according to the invention, displaces the valve body 104 between the two positions inside the valve housing 102. Embodiments of the electric actuating drive 110 include a stepper motor, a DC motor, a servo motor and a piezoelectric drive.

The electric actuating drive 110 displaces the valve body 104 between the two positions by rotation or translation. A rotational movement of the electric actuating drive 110 is specifically advantageous because in this case the valve body 104 can be positioned with angular precision.

In an advantageous development of the control valve 100, the electric actuating drive 110 displaces the valve body continuously between the two different positions. Continuous control of the coolant flow through the control valve 100 from the high-pressure region into the crankcase-chamber-pressure region is thus possible.

The control valve 100 further includes a means 112 for determining the position of the valve body 104, displaced by the electric motor 110, inside the valve housing 102.

In an advantageous development, the means 112 is formed to determine the position of the valve body 104 using an electric position sensor. In this case, the position sensor directly detects the position of the valve body 104. Embodiments of a position sensor include a Hall effect sensor, a magnetoresistive sensor, an optical sensor, a capacitive sensor and an inductive sensor, each cooperating with a corresponding (reference signal) generator element.

In an alternative development, the electric control means 116 advantageously determines the position of the valve body 104 as a function of a control variable present at the electric actuating drive 110. The position of the valve body 104 is thus determined indirectly by the electric control means 116.

In one embodiment, a control variable or a variable dependent on a control variable, which makes it possible to determine a position of the valve body 104, is the predetermined number of steps (if the electric actuating drive is formed as a stepper motor), the voltage and/or current present (if the electric actuating drive is formed as a DC motor, servo motor or piezoelectric drive), or the power consumption dependent thereon.

In another alternative development, the electric control means 116 advantageously determines the position of the valve body 104 as a function of a reference position. In this case, the electric control means 116 detects whether or not the valve body 104 is in the reference position. For example, the position of the valve body 104 can be referenced using a mechanical stop or an electric switching device.

For example, in the above alternative development of the control valve 100, the position of the valve body 104 may be determined independently of valve play and valve wear by using referencing. The electric control means 116 acts on the electric actuating drive 110 at regular intervals, for example when the coolant compressor is set in operation, to displace the valve body 104 into a defined position (in other words into a reference position), for example into the position where the control valve is closed. This reference position is the new reference point (“zero setting”) for further operation.

The control valve 100 according to the invention further includes a suction-pressure sensor (or first sensor) 114, which determines a value of the suction pressure in the suction-pressure region. Embodiments of the suction-pressure sensor 114 include a piezoresistive, a capacitive, an electromagnetic and an optical pressure sensor.

For determining the suction pressure in this manner, the connector Ps is provided in the valve housing 102 for connection to the suction-pressure region of the coolant compressor. The suction-pressure sensor 114 determines the value of the suction pressure by way of this connector Ps in the valve housing 102.

In one embodiment, a blind hole is provided in the valve housing 102 as a connector to the suction-pressure region, and communicates with the suction-pressure sensor 114.

The control valve 100 according to the invention further includes an electric control means (or control system) 116, which controls the coolant flow through the control valve 100 from the high-pressure region into the crankcase-chamber-pressure region. This control takes place by way of the electric actuating drive 110, which in turn, as disclosed above, displaces the valve body 104 at least between the two positions. One embodiment of an electric control means 116 is an arithmetic-logic unit having appropriate electrical inputs and outputs.

As a result, the electric control means 116 controls the coolant flow through the control valve 100 by displacing the valve body 104. In this context, the valve body 104 takes up the one position, in which the high-pressure region and the crankcase-chamber-pressure region are mutually connected, or the other position, in which the high-pressure region and the crankcase-chamber-pressure region are separated.

In an advantageous development, the electric control means 116 for controlling the coolant flow through the control valve 100 is arranged outside the valve housing 102. Particularly advantageously, the control means 116 may be arranged spatially separated from the other components of the control valve 100, for example inside a control device connected to the control valve 100.

In connection with the invention, the safety mechanism, which is provided in the electric control means 116 and which rapidly and precisely intervenes in the control of the coolant flow and brings the valve body 104 into a safe position in which the coolant compressor is throttled down, will be discussed in greater detail in the following.

In this context, the coolant flow is controlled in the electric control means 116 by way of the value of the suction pressure in the suction-pressure region, which is precisely determined by

the suction-pressure sensor 114, with the result that rapid and precise intervention can be ensured if the suction pressure falls below a predetermined threshold.

As well as other control variables, the electric control means 116 initially reads in the value of the suction pressure determined by the suction-pressure sensor 114 as an input. Subsequently, the electric control means 116 checks whether the read-in value of the suction pressure is below a predetermined threshold (for example a minimum suction pressure).

If the electric control means 116 determines in this context that the value is below the predetermined threshold, the electric control means 116 thereupon controls the coolant flow in such a way that the valve body 104 connects the high-pressure region to the crankcase-chamber-pressure region. The coolant compressor is thus throttled down by the control valve 100.

In one embodiment, the predetermined threshold is stored in the electric control means 116 in advance, and can advantageously be adjusted as a function of the coolant or the air-conditioning system. This makes possible simple, cost-effective adjustment of the safety mechanism to different coolants and/or air-conditioning systems.

Because the electric control means 116 controls the coolant flow as a function of the precisely determined value of the suction pressure, rapid and precise intervention can be ensured if the suction pressure falls below the predetermined suction pressure. If the value falls below the predetermined threshold for the suction pressure, the electric control means 116 causes the valve body 104 to be displaced into the one of the two positions in which the high-pressure region and the crankcase-chamber-pressure region are mutually connected.

In other words, when the value of the suction pressure determined by the suction-pressure sensor 114 falls below the predetermined threshold, the electric control means 116 intervenes in the control of the coolant flow in such a way that the valve body 104 is displaced into a safe position in which the control valve 100 is open.

A controlling intervention of this type from the electric control means 116 causes a rise in pressure in the crankcase-chamber-pressure region, and this in turn causes the wobble plate in the coolant compressor to pivot back. This means that the axial stroke movement of the pistons of the coolant compressor is decreased, the delivery volume of the coolant compressor is reduced, and the suction pressure rises.

In connection with the invention, the control valve 100 further includes an electric interface 118 via which the value of the suction pressure determined by the suction-pressure sensor 114 can be read off. Embodiments of the electric interface 118 include a configuration which

makes it possible to read off the value of the suction pressure via a serial peripheral interface (SPI) data bus, via an inter-integrated circuit (I2C) data bus, via a local interconnect network (LIN) data bus, or via a controller area network (CAN) data bus.

The electric interface 118 of the control valve 100 further makes possible a power supply at least to the electric actuating drive 110, the suction-pressure sensor 114 and the electric control means 116. If the means 112 for determining the valve position is formed electrically, for example as a position sensor, it can also be connected to a power supply via the electric interface 118.

In another advantageous development, the electric control means 116 reads in the value of the suction pressure in the suction-pressure region determined by the suction-pressure sensor 114, processes the read-in value, and makes it possible to read off the processed value via the electric interface 118.

In an advantageous development of the control valve 100, the electric actuating drive 110 is arranged inside the valve housing 102 in the high-pressure region. In this case, the high-pressure region is hermetically sealed using a sealing device inside the electric interface 118, which together with the valve housing encloses the high-pressure region. An embodiment of a sealing device of this type is the housing of an electric plug.

In a modification to the above advantageous development of the control valve 100, the suction-pressure sensor 114 and the electric control means 116 are also arranged inside the valve housing 102 in the high-pressure region, as well as the electric actuating drive 110.

In an alternative development of the control valve 100, the electric actuating drive 110 is only arranged inside the valve housing 102 in the high-pressure region in part (specifically, the rotor). In this case, the high-pressure region is hermetically sealed using a capsule which is provided in the electric actuating drive and which encloses the high-pressure region. In one embodiment, the rotor of an actuating drive is encapsulated to separate it from the stator of said actuating drive.

In an alternative advantageous development of the control valve 100, the high-pressure region inside the valve housing 102 is hermetically sealed off from the outside using a bellows seal. In this case, one side of the bellows seal is fixed to the (movable) valve body 104 and the other side is fixed to the (stationary) valve housing 102. A bellows seal fixed in this manner compresses or extends together with the movement of the valve body 104.

In a further advantageous development, the control valve 100 additionally includes a high-pressure sensor (second pressure sensor) 120, which determines a value of the high

pressure in the high-pressure region. Thus, in the control valve 100, not only is the suction pressure in the suction-pressure region determined by a suction-pressure sensor, but the high pressure in the high-pressure region is also determined in parallel by a corresponding high-pressure sensor 120.

For determining the high pressure in this manner, a further stub line between the high-pressure region (for example at the connector Pd) and the high-pressure sensor is provided in the valve housing 102.

In addition or as an alternative to the above advantageous development, the control valve further includes a suction-pressure temperature sensor (first temperature sensor, not shown), which determines a value of the temperature in the suction-pressure region, and/or a high-pressure temperature sensor (second temperature sensor, not shown), which determines a value of the temperature in the high-pressure region.

For a measurement of this type of the suction-pressure or high-pressure temperature, the first and/or second temperature sensor must have preferably direct access to the coolant in the corresponding suction-pressure and/or high-pressure region.

For determining the temperature of the suction-pressure or high-pressure region, the following advantages may be noted. Using the suction temperature (as an alternative to the high-pressure temperature), the fill level of the coolant in the air-conditioning system can be monitored, since in the event of coolant loss the average temperature rises if the conditions are the same in the coolant circuit.

In a modification to the above advantageous development of the control valve 100, the high-pressure sensor 120, the suction-pressure temperature sensor and the high-pressure temperature sensor are also arranged inside the valve housing 102 in the high-pressure region.

In a further advantageous development of the control valve 100, additionally the value of the high pressure in the high-pressure region determined by the second pressure sensor 120 and/or additionally the value of the temperature in the suction-pressure region determined by the first temperature sensor and/or additionally the value of the temperature in the high-pressure region determined by the second temperature sensor can be read off by way of the electric interface 118.

In this above development too, embodiments of the electric interface 118 include a configuration which makes it possible to read off the corresponding values via a serial

peripheral interface (SPI) data bus, via an inter-integrated circuit (I2C) data bus, via a local interconnect network (LIN) data bus, or via a controller area network (CAN) data bus.

Advantageously, if all four values, specifically the value of the suction pressure, the value of the high pressure, the value of the temperature in the suction-pressure region and the value of the temperature in the high-pressure region, are determined by corresponding sensors, a control device connected to the control valve 100 can calculate the mass flow rate in the coolant circuit.

For this type of calculation of the mass flow rate, the following advantages may be cited. Using the mass flow rate, the torque of the air-conditioning compressor can be calculated. If the current or future torque of the air-conditioning compressor is known, the quantity injected in the motor vehicle can be tuned more precisely, and this leads to fuel savings and thus to reductions in CO_2.

Further, for controlled belt tensioners in the motor vehicle, the belt tension can be set as required for a known torque. This is advantageous because friction forces are reduced and the service life of the belt bearings is lengthened.

List of reference numerals:

Reference numeral	Description
100	Control valve
102	Valve housing
104	Valve body
106	Actuation rod
108	Shut-off body
110	Electric actuating drive
112	Means for determining the position of the valve body
114	Pressure sensor for the suction-pressure region
116	Electric control means
118	Electric interface
120	Pressure sensor for the high-pressure region

Claims

1. An electric control valve (100), in particular for a coolant compressor, which controls a coolant flow through the control valve from a high-pressure region into a crankcase-chamber-pressure region, including:

a valve housing (102), which has connectors for the suction-pressure region, the high-pressure region and the crankcase-chamber-pressure region;

a valve body (104), which is arranged to be displaceable between two positions inside the valve housing (102), the valve body (104) either mutually connecting or separating the high-pressure region and the crankcase-chamber-pressure region depending on the position;

an electric actuating drive (110), which displaces the valve body (104);

a means (112) for determining the position of the valve body (104);

a first pressure sensor (114), which determines a value of the suction pressure in the suction-pressure region;

an electric control means (116), which, as a function of the value of the suction pressure determined in the suction-pressure region, controls the coolant flow from the high-pressure region into the crankcase-chamber-pressure region by displacing the valve body (104) using the electric actuating drive (110), in such a way that if the determined suction pressure falls below a predetermined threshold the valve body (104) connects the high-pressure region to the crankcase-chamber-pressure region;

an electric interface (118), by way of which the value of the suction pressure in the suction-pressure region determined by the first pressure sensor (114) can be read off, and by way of which the electric actuating drive (110), the first pressure sensor (114) and the electric control means (116) can be connected to a power supply.

2. The control valve according to claim 1, wherein the position of the valve body (104) is determined using an electric position sensor.

3. The control valve according to claim 1, wherein the position of the valve body (104) is determined as a function of one or more control variables present at the electric actuating drive (110).

4. The control valve according to claim 1, wherein the position of the valve body (104) is determined independently of valve play and valve wear by using referencing.

5. The control valve according to any of claims 1 – 4, wherein the electric control means (116) for controlling the coolant flow is arranged outside the valve housing (102), in particular arranged spatially separated from the other components of the control valve (100).

6. The control valve according to any of claims 1 – 5, wherein the electric control means (116) reads in the value of the suction pressure in the suction-pressure region determined by the first pressure sensor (114), processes said value, and makes it possible to read off said value via the electric interface (118).

7. The control valve according to any of claims 1 – 6, wherein the electric actuating drive (110) is arranged inside the valve housing in the high-pressure region.

8. The control valve according to any of claims 1 – 7, wherein the pressure sensor (114) and the electric control means (116) are arranged inside the valve housing (102) in the high-pressure region.

9. The control valve according to any of claims 1 – 8, wherein the high-pressure region is hermetically sealed using:

   - a bellows seal and/or
   - an encapsulation provided in the electric actuating drive (110) and/or
   - a sealing device for the electric interface (118).

10. The control valve according to any of claims 1 – 9, wherein the electric actuating drive (110) displaces the valve body in the steps predetermined by the actuating drive.

11. The control valve according to any of claims 1 – 10, further including a second pressure sensor (120) which determines a value of the high pressure in the high-pressure region.

12. The control valve according to claim 11, further including a first temperature sensor which determines a value of the temperature in the suction-pressure region.

13. The control valve according to any of claims 11 – 12, further including a second temperature sensor which determines a value of the temperature in the high-pressure region.

14. The control valve according to any of claims 12 – 13, wherein the first pressure sensor and the first temperature sensor and/or the second pressure sensor and the second temperature sensor are formed as combined pressure and temperature sensors.

15. The control valve according to any of claims 11 – 14, wherein additionally

the value of the high pressure in the high-pressure region determined by the second pressure sensor (120), and/or additionally

the value of the temperature in the suction-pressure region determined by the first temperature sensor, and/or additionally

the value of the temperature in the high-pressure region determined by the second temperature sensor

can be read off via the electric interface (118).

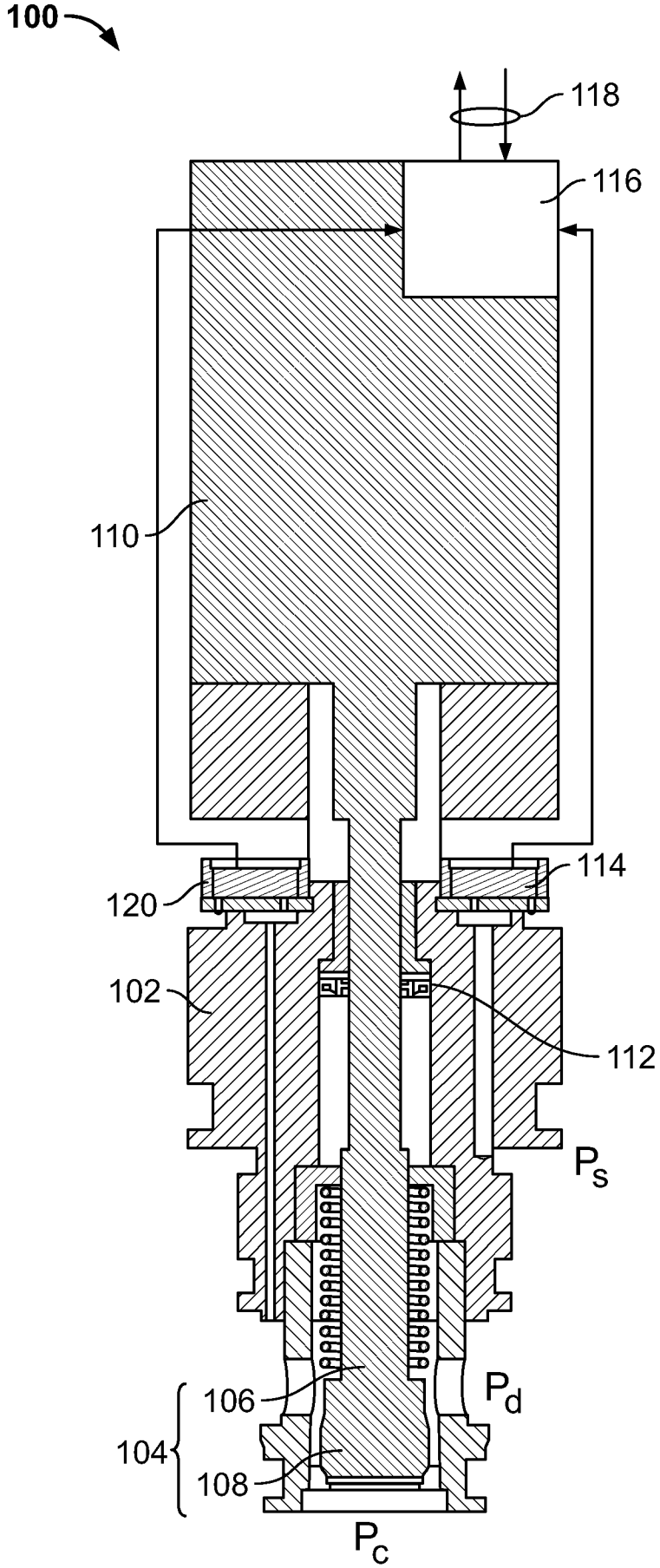


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/062089

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B27/18
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2011 117354 A1 (VOLKSWAGEN AG [DE]) 2 May 2013 (2013-05-02) cited in the application the whole document	1-15
A	DE 10 2007 028340 A1 (TGK CO LTD [JP]) 31 January 2008 (2008-01-31) claim 1; figure 9	1-15
A	US 2015/004010 A1 (SAEKI SHINJI [JP] ET AL) 1 January 2015 (2015-01-01) claim 1; figure 1	1-15
A	EP 1 375 918 A1 (DELPHI TECH INC [US]) 2 January 2004 (2004-01-02) claim 1; figure 1	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 July 2016	28/07/2016

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/062089

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