

Pump Body Heating Control System and Pump Body Heating Control Method

The present application claims the priority of the Chinese patent application filed on April 13, 2023 before the CNIPA, China National Intellectual Property Administration with the application number of 202310390646.4, which is incorporated herein in its entirety by reference.

Technical Field

The present application relates to the technical field of vacuum pumps, and more particularly relates to a pump body heating control system and a pump body heating control method.

Background Art

In the related art, in order to prevent condensation of a gas inside a vacuum pump from affecting the use of the vacuum pump, it is usually necessary to appropriately heat the vacuum pump during the operation of the vacuum pump. At present, heating control is generally performed according to a difference value between a pump body temperature measured in real time and a uniform preset temperature value. However, since the gas inside the vacuum pump may be doped with impurities, and states of the gas may be different, such a heating control mode cannot achieve a good effect of preventing the condensation of the gas.

Summary of the Invention

Technical problem

The present application provides a pump body heating control system and a pump body heating control method to solve the above technical problem.

Technical solution

The present application provides a pump body heating control system, including: a heating module; a temperature collection module configured to collect a temperature of a vacuum pump; an environmental information collection module configured to collect environmental information inside the vacuum pump; and a control module connected to the temperature collection module, the environmental information collection module and the heating module, and configured to control the heating module to heat a pump body of the vacuum pump based on the temperature collected by the temperature collection module and the environmental information collected by the environmental information collection module.

The present application further provides a pump body heating control method, including: acquiring current environmental information inside a vacuum pump and a current temperature of the vacuum pump, wherein the current environmental information includes at least one of a type

of a gas currently introduced into the vacuum pump, a current pressure value inside the vacuum pump, and a gas flow per unit time inside the vacuum pump; determining a target temperature corresponding to the current environmental information according to the current environmental information; and controlling pump body heating of the vacuum pump based on a difference value between the current temperature and the target temperature.

Beneficial effects

The present application has the following beneficial effects: in the present application, the environmental information collection module is additionally provided in the pump body heating control system, and the control module controls the heating module to heat the vacuum pump based on collection results of the temperature collection module and the environmental information collection module, so that the heating control can be more targeted, which is helpful in improving the effect of preventing condensation of the gas inside the vacuum pump.

Brief Description of the Drawings

FIG. 1 is a structural block diagram of a pump body heating control system provided in an example of the present application.

FIG. 2 is a structural block diagram of a heating module of FIG. 1.

FIG. 3 is a structural block diagram of a temperature collection module in the pump body heating control system of FIG. 1.

FIG. 4 is a circuit diagram of a constant current source unit provided in an example of the present application.

FIG. 5 is a circuit connection diagram of a pump body temperature sensor (or an exhaust temperature sensor), the constant current source unit and a signal conditioning unit in an example of the present application.

FIG. 6 is a structural block diagram of an analog signal collection module of FIG. 1.

FIG. 7 is a structural block diagram of an environmental information collection module of FIG. 1.

FIG. 8 is a circuit diagram of a signal adjustment unit provided in an example of the present application.

FIG. 9 is a flowchart of a pump body heating control method provided in an example of the present application.

Description of reference numerals:

pump body heating control system-10; heating module-11; temperature collection module-13; environmental information collection module-15; control module-17; heating plate-111; heating block-113; pump body temperature sensor-131; exhaust temperature sensor-132; constant current source unit-133; signal conditioning unit-134; analog signal collection module-12; analog signal

multiplexer-121; analog signal collector-122; signal adjustment unit-151; and human-computer interaction module-16.

Detailed Description of the Invention

Referring to FIG. 1, an example of the present application provides a pump body heating control system 10 configured to control a heating process of a pump body of a vacuum pump. The pump body heating control system 10 may include a heating module 11, a temperature collection module 13, an environmental information collection module 15, and a control module 17.

The heating module 11 is configured to be mounted on the pump body of the vacuum pump so as to heat the pump body of the vacuum pump. Referring to FIG. 2, the heating module 11 may include a heating plate 111 and a heating block 113. The number of the heating block 113 may be plural, and a plurality of heating blocks 113 may be all provided on the heating plate 111. After the heating module 11 is mounted on the pump body of the vacuum pump, the heating blocks 113 may be positioned between the heating plate and the pump body of the vacuum pump.

The temperature collection module 13 is configured to collect a temperature of the vacuum pump. Referring to FIG. 3, the temperature collection module 13 may include a plurality of pump body temperature sensors 131 and one exhaust temperature sensor 132. At this time, in order to enable data collected by the temperature collection module 13 to be recognized and utilized by the control module 17, the pump body heating control system 10 may further include an analog signal collection module 12. The analog signal collection module 12 may be connected between the pump body temperature sensors 131 and the exhaust temperature sensor 132 and the control module 17.

The plurality of pump body temperature sensors 131 may be dispersedly provided on the pump body of the vacuum pump, and the exhaust temperature sensor 132 may be provided on an exhaust pipe of the vacuum pump. A relatively accurate temperature of the vacuum pump may be collected by such configuration.

A temperature measurement range of the pump body temperature sensors 131 and the exhaust temperature sensor 132 may be within 0 °C to 175 °C, and temperature measurement accuracy is within ± 1 °C. As a result, the temperature measurement requirement of the vacuum pump may be met.

Thermal resistance temperature sensors may be adopted as both the pump body temperature sensors 131 and the exhaust temperature sensor 132. Since in thermal resistors, a platinum resistor has the features of high precision, reliable performance, good stability, and the like, and the linear characteristic of a relationship curve between a resistance relative change rate of the platinum resistor and a temperature is relatively obvious, in order to ensure the accuracy of temperature

measurement, the platinum resistor may be selected as a sensitive element of the pump body temperature sensors 131 and the exhaust temperature sensor 132.

Illustratively, PT100 or PT1000 temperature sensors may be adopted as both the pump body temperature sensors 131 and the exhaust temperature sensor 132.

Further, considering that resistive self-heating has a negative influence on the temperature measurement, in order to reduce this influence, the PT100 temperature sensors may be adopted as both the pump body temperature sensors 131 and the exhaust temperature sensor 132.

In the related art, when the thermal resistor is connected to a temperature measurement circuit, there are various connection methods, wherein a three-wire connection method is more common. However, after the thermal resistor is connected to the temperature measurement circuit by adopting the three-wire connection method, contact resistance of an adjustable resistor may be caused to be connected with resistance of a bridge arm, which may further lead to an unstable zero point of a bridge. In order to avoid this problem, in the example of the present application, the thermal resistor is connected to the temperature measurement circuit by adopting a four-wire connection method.

In one example, the temperature collection module 13 may further include constant current source units 133. The constant current source units 133 correspond to the pump body temperature sensors 131 and the exhaust temperature sensor 132 on a one-to-one basis, and each of the constant current source units 133 is connected between the pump body temperature sensor 131 or the exhaust temperature sensor 132 corresponding to the constant current source unit 133 and the analog signal collection module 12.

Since the self-heating effect of the thermal resistor has a negative influence on the temperature measurement, in order to reduce this influence, it is necessary to ensure that a current flowing through the thermal resistor is as small as possible. However, if the current is too small, the temperature measurement is vulnerable to noise interference, and in order to avoid the above problem, in the present application, an output current of the constant current source unit 133 is between 0.5 mA and 2 mA, for example, 1 mA.

Illustratively, the constant current source unit 133 may be a constant current source formed by converting a constant voltage source chip TL431 utilizing current negative feedback, and a circuit diagram thereof may be as shown in FIG. 4. The accuracy of the constant current source unit 133 is about 0.4%. An operational amplifier U4 in the constant current source unit 133 is configured to improve the load-driving capability of the current source. Resistors having accuracy of 0.1% may be selected as all the resistors R2, R3, R9 and R10 in the constant current source unit 133.

In one example, the temperature collection module 13 may further include signal conditioning units 134. The signal conditioning units 134 correspond to the constant current source units 133 on

a one-to-one basis, and each of the signal conditioning units 134 is connected between the constant current source unit 133 corresponding to the signal conditioning unit 134 and the analog signal collection module 12.

Referring to FIG. 5, illustratively, a subtraction circuit may be constructed by utilizing outputs of two constant current source units 133 (reference numerals of various elements of the two constant current source units 133 are distinguished in the drawings, and circuit structures of the two constant current source units 133 are substantially the same) as differential inputs of an instrumentation amplifier of the signal conditioning unit 134, so as to take out a voltage of the pump body temperature sensor 131 (or the exhaust temperature sensor 132) during changes within a range of 0 °C to 175 °C. FIG. 5 shows a connection relationship of the pump body temperature sensor 131 (or the exhaust temperature sensor 132) with the constant current source unit 133 and the signal conditioning unit 134.

Referring to FIG. 6, in one example, the analog signal collection module 12 includes an analog signal multiplexer 121 and an analog signal collector 122. The analog signal multiplexer 121 is connected between the signal conditioning unit 134 and the analog signal collector 122, and the analog signal collector 122 is further connected to the control module 17.

The environmental information collection module 15 is configured to collect environmental information inside the vacuum pump.

The environmental information collection module 15 may be provided in the vacuum pump.

The environmental information collection module 15 may include at least one of a gas type sensor, a gas flow sensor, and a pressure sensor. As a result, when pump body heating control is performed, at least a gas composition, a gas flow, or a gas pressure inside the vacuum pump are taken into consideration, so that the heating control can be more targeted to a certain extent, which improves the effect of preventing condensation of the gas inside the vacuum pump.

Compared with a voltage type sensor with an output signal being a voltage, a current type sensor with an output signal being a current has higher anti-interference capability in the process of signal transmission, so that both the gas flow sensor and the pressure sensor may be the current type sensors. Further, the current type sensors with output currents of 4 mA to 20 mA may be selected as the gas flow sensor and the pressure sensor.

Referring to FIG. 7, in one example, the environmental information collection module 15 may include the gas type sensor, the gas flow sensor, and the pressure sensor simultaneously. The analog signal collection module 12 may further be connected between the pressure sensor and the gas flow sensor and the control module 17. Specifically, the analog signal multiplexer 121 is connected between the pressure sensor and the gas flow sensor and the analog signal collector 122. The gas type sensor is connected to the control module 17. Illustratively, the gas type sensor may

transfer the detected various types of gases to the control module 17 through an I2C bus interface. The control module 17 recognizes the types of the gases according to a pre-agreed communication protocol.

Further, the environmental information collection module 15 may further include signal adjustment units 151. The signal adjustment units 151 are provided in one-to-one correspondence with the pressure sensor and the gas flow sensor, and are connected between the sensors corresponding to the signal adjustment units 151 and the analog signal multiplexer 121 of the analog signal collection module 12. Illustratively, a circuit structure of the signal adjustment unit 151 may be as shown in FIG. 8, wherein an output signal of the pressure sensor (or the gas flow sensor) is input into the signal adjustment unit 151 via an ANA IN port, and the signal adjustment unit 151 outputs the adjusted signal via an ANA OUT port.

The control module 17 is connected to the temperature collection module 13, the environmental information collection module 15 and the heating module 11, and is configured to control the heating module 11 to heat a pump body of the vacuum pump based on the temperature collected by the temperature collection module 13 and the environmental information collected by the environmental information collection module 15.

Referring again to FIG. 1, it should be understood that the pump body heating control system 10 may further include a human-computer interaction module 16. The human-computer interaction module 16 is connected to the control module 17. The human-computer interaction module 16 may include a display unit and an input unit. A user may learn the temperature information collected by the temperature collection module 13 and the environmental information collected by the environmental information collection module through the display unit of the human-computer interaction module 16, and may set upper temperature limits of various temperature sensors in the temperature collection module 13 and other information through the input unit of the human-computer interaction module 16.

In the present application, the environmental information collection module is additionally provided in the pump body heating control system, and the control module controls the heating module to heat the vacuum pump based on collection results of the temperature collection module and the environmental information collection module, so that the heating control can be more targeted, which is helpful in improving the effect of preventing condensation of the gas inside the vacuum pump.

Referring to FIG. 9, based on the same inventive concept, an example of the present application further provides a pump body heating control method. The method may be configured as the control module 17 in the pump body heating control system 10 described above.

In one example, the method may include the following steps.

Step S11, acquiring current environmental information inside a vacuum pump and a current temperature of the vacuum pump, wherein the current environmental information includes at least one of a type of a gas currently introduced into the vacuum pump, a current pressure value inside the vacuum pump, and a gas flow per unit time inside the vacuum pump.

Specifically, the control module 17 may acquire the current environmental information inside the vacuum pump from the environmental information collection module 15, and acquire the current temperature of the vacuum pump from the temperature collection module 13.

Step S12, determining a target temperature corresponding to the current environmental information according to the current environmental information.

In one example, step S12 may include: searching for the target temperature corresponding to the current environmental information from a preset corresponding relationship table according to the current environmental information. It should be noted that the preset corresponding relationship table may record corresponding relationships between various environmental information and regulated temperatures, for example, record a corresponding relationship between the type of the gas inside the vacuum pump and the regulated temperature, a corresponding relationship between a pressure and the regulated temperature, and a corresponding relationship between a gas flow and the regulated temperature; or record a corresponding relationship between both the type of the gas and the pressure inside the vacuum pump and the regulated temperature, a corresponding relationship between both the type of the gas and the gas flow inside the vacuum pump and the regulated temperature, and a corresponding relationship between both the pressure and the gas flow inside the vacuum pump and the regulated temperature; or record a corresponding relationship between three of the type of the gas, the pressure and the gas flow inside the vacuum pump and the regulated temperature; or record all of the corresponding relationships listed above. The regulated temperature corresponding to each kind of environmental information refers to the temperature required to obtain the best effect of preventing condensation of the gas in an environment corresponding to the environmental information.

Step S13, controlling pump body heating of the vacuum pump based on a difference value between the current temperature and the target temperature.

In one example, step S13 may include: when the current temperature is lower than the target temperature, starting pump body heating; and when the temperature reaches the target temperature, stopping pump body heating. Specifically, when the current temperature is lower than the target temperature, the heating module 11 is started to heat the pump body of the vacuum pump; and when the temperature reaches the target temperature, the heating module 11 is controlled to stop pump body heating of the vacuum pump.

Claims

1. A pump body heating control system, comprising:
a heating module;
a temperature collection module configured to collect a temperature of a vacuum pump;
an environmental information collection module configured to collect environmental information inside the vacuum pump; and
a control module connected to the temperature collection module, the environmental information collection module and the heating module, and configured to control the heating module to heat a pump body of the vacuum pump based on the temperature collected by the temperature collection module and the environmental information collected by the environmental information collection module.
2. The pump body heating control system of claim 1, wherein the environmental information collection module comprises at least one of a gas type sensor, a gas flow sensor, and a pressure sensor.
3. The pump body heating control system of claim 2, wherein the environmental information collection module comprises the gas type sensor, the gas flow sensor and the pressure sensor, the pump body heating control system further comprises an analog signal collection module, the analog signal collection module is connected between the pressure sensor, the gas flow sensor and the temperature collection module and the control module, and the gas type sensor is connected to the control module.
4. The pump body heating control system of claim 3, wherein the temperature collection module comprises a plurality of pump body temperature sensors and one exhaust temperature sensor, the pump body temperature sensors are configured to be dispersedly provided on the pump body of the vacuum pump and each connected to the analog signal collection module, and the exhaust temperature sensor is configured to be provided on an exhaust pipe of the vacuum pump and connected to the analog signal collection module.
5. The pump body heating control system of claim 4, wherein both the pump body temperature sensors and the exhaust temperature sensor are PT100 temperature sensors.
6. The pump body heating control system of claim 4, wherein the temperature collection module further comprises constant current source units, the constant current source units correspond to the pump body temperature sensors and the exhaust temperature sensor on a one-to-one basis, and each of the constant current source units is connected between the pump body temperature sensor or the exhaust temperature sensor corresponding to the constant current source unit and the analog signal collection module.
7. The pump body heating control system of claim 6, wherein an output current of the constant

current source unit is between 0.5 mA and 2 mA.

8. The pump body heating control system of claim 6, wherein the temperature collection module further comprises signal conditioning units, the signal conditioning units correspond to the constant current source units on a one-to-one basis, and each of the signal conditioning units is connected between the constant current source unit corresponding to the signal conditioning unit and the analog signal collection module.

9. The pump body heating control system of claim 8, wherein the analog signal collection module comprises an analog signal multiplexer and an analog signal collector, the analog signal multiplexer is connected between the signal conditioning unit and the analog signal collector, and the analog signal collector is further connected to the control module.

10. A pump body heating control method, comprising:

acquiring current environmental information inside a vacuum pump and a current temperature of the vacuum pump, wherein the current environmental information comprises at least one of a type of a gas currently introduced into the vacuum pump, a current pressure value inside the vacuum pump, and a gas flow per unit time inside the vacuum pump;

determining a target temperature corresponding to the current environmental information according to the current environmental information; and

controlling pump body heating of the vacuum pump based on a difference value between the current temperature and the target temperature.