CLAIMS

[Claim 1] A flow rate control system comprising:

a first valve provided downstream of a flow rate controller;

a flow rate measurement device provided downstream of the first valve, the flow rate measurement device having a pressure sensor, a temperature sensor, and a second valve provided downstream of both sensors: and

a control unit for controlling an opening/closing operation of the first valve and the second valve,

wherein the control unit includes:

a recording unit for recording the measured values of the pressure sensor and the temperature sensor;

a storage unit for storing a volume value from the first valve to the second valve corresponding to the measured value of the pressure sensor, and

an arithmetic unit for calculating a flow rate based on:

a first pressure value and a first temperature value measured after opening the first valve and the second valve to flow gas and closing the first valve and the second valve simultaneously in a state where the gas is flowing;

a second pressure value and a second temperature value measured after opening the first valve and the second valve to flow the gas, closing the second valve in a state where the gas is flowing, and then closing the first valve after a predetermined time period has elapsed; and

a volume value from the first valve to the second valve corresponding to the second pressure value obtained from the storage unit.

[Claim 2] The flow rate control system according to claim 1 further comprising a third valve provided between the first valve and the second valve, wherein the arithmetic unit calculates the flow rate by adding a third pressure value, a third temperature value, a fourth pressure value, and a fourth temperature value into consideration,

the third pressure value and the third temperature value are measured after measuring the second pressure value and the second temperature value, and after closing the third

valve simultaneously with or immediately before opening the second valve in which the second valve is opened for a shorter time than the predetermined time period and then closed in a state where the first valve is closed, the third pressure value and the third temperature value being measured in a state where the second valve and the third valve are closed; and

the fourth pressure value and the fourth temperature value are measured after measuring the third pressure value and the third temperature value, and after opening the third valve in a state where the first valve and the second valve are closed.

[Claim 3] A flow rate measurement method performed in a flow rate control system comprising: a first valve provided downstream of a flow rate controller; a flow rate measurement device provided downstream of the first valve, the flow rate measurement device having a pressure sensor, a temperature sensor, and a second valve provided downstream of both sensors; and a control unit for controlling the opening/closing operation of the first valve and the second valve,

the flow rate measurement method comprising:

a first step of opening the first valve and the second valve to flow a gas, then closing the first and second valves simultaneously in a state where the gas is flowing, and measuring a pressure and a temperature thereafter;

a second step of opening the first valve and the second valve to flow a gas, then closing the second valve in a state where the gas is flowing, then closing the first valve after a predetermined time period has elapsed, and measuring a pressure and a temperature thereafter; and

a third step of calculating a flow rate on the basis of the pressure and temperature measured in the first step, the pressure and temperature measured in the second step, and a build-up volume that varies corresponding to the pressure measured in the second step.

[Claim 4] The flow rate measurement method according to claim 3, wherein the flow rate control system further comprises a third valve provided downstream of the flow rate controller and the first valve, but upstream of the pressure sensor and the temperature sensor, the third valve being opened while performing the first step and the

second step, and

wherein after pressure measurement and temperature measurement of the second step, a pressure measured after opening and then closing the second valve in a short time while closing the third valve and a pressure further measured after opening the third valve in a state where the second valve is closed are used for the flow rate calculation of the third step.

CLAIMS

1. A flow rate control system comprising:

a downstream flow path of a flow rate controller;

a first valve provided to the downstream flow path of the flow rate controller;

a downstream flow path of the first valve;

a flow rate measurement device provided to the downstream flow path of the first valve, the flow rate measurement device having a pressure sensor, a temperature sensor, and a second valve provided to a downstream flow path of both sensors; and

a control unit for controlling an opening/closing operation of the first valve and the second valve,

wherein the control unit includes:

a recording unit for recording the measured values of the pressure sensor and the temperature sensor;

a storage unit for storing a volume value of a fluid between the first valve and the second valve corresponding to the measured value of the pressure sensor; and

an arithmetic unit for calculating a flow rate, and

wherein the arithmetic unit is configured to calculate the flow rate based on:

a first pressure value and a first temperature value measured after opening the first valve and the second valve to flow gas from the flow rate controller to a downstream flow path of the flow rate measurement device and then closing the first valve and the second valve simultaneously in a state where the gas is flowing;

a second pressure value and a second temperature value measured after opening the first valve and the second valve to flow the gas, closing the second valve in a state where the gas is flowing, and then closing the first valve after a predetermined time period has elapsed; and

the volume value of the fluid between the first valve and the second valve corresponding to the measured second pressure value obtained from the storage unit.

2. The flow rate control system according to claim 1 further comprising a third valve provided to a flow path between the first valve and the second valve,

wherein the arithmetic unit is configured to calculate the flow rate based on a third pressure value, a third temperature value, a fourth pressure value, and a fourth temperature value in addition to the first pressure value, the first temperature value, the second pressure value, and the second temperature value,

wherein the third pressure value and the third temperature value are measured after measuring the second pressure value and the second temperature value while the first valve and the second valve are closed and the third valve is open, and then closing the third valve simultaneously with or immediately before opening the second valve in which the second valve is opened for a shorter time than the predetermined time period and then closed while the first valve is kept closed, and

wherein the fourth pressure value and the fourth temperature value are measured after measuring the third pressure value and the third temperature value, and then opening the third valve while the first valve and the second valve are kept closed.

3. A flow rate measurement method performed in a flow rate control system comprising: a downstream flow path of a flow rate controller, a first valve provided to the downstream flow path of the flow rate controller, a downstream flow path of the first valve, a flow rate measurement device provided to the downstream flow path of the first valve, the flow rate measurement device having a pressure sensor, a temperature sensor, and a second valve provided to a downstream flow path of both sensors; and a control unit for controlling the opening/closing operation of the first valve and the second valve,

the flow rate measurement method comprising:

a first step of opening the first valve and the second valve to flow a gas from the flow rate controller to a downstream flow path of the flow rate measurement device, then closing the first and second valves simultaneously in a state where the gas is flowing, and measuring a pressure and a temperature thereafter;

a second step of opening the first valve and the second valve to flow a gas from the flow rate controller to a downstream flow path of the flow rate measurement device, then closing the second valve in a state where the gas is flowing, then closing the first valve after a predetermined time period has elapsed, and measuring a pressure and a temperature thereafter; and

a third step of calculating a flow rate on the basis of the pressure and temperature measured in the first step, the pressure and temperature measured in the second step, and a volume value of a fluid between the first valve and the second valve that varies corresponding to the pressure measured in the second step.

4. The flow rate measurement method according to claim 3,

wherein the flow rate control system further comprises a third valve provided downstream of the flow rate controller and the first valve, but upstream of the pressure sensor and the temperature sensor, the first step and the second step being merely performed while the third valve is open, and

wherein after pressure measurement and temperature measurement of the second step, a pressure measured after opening and then closing the second valve in a short time while closing the third valve and a pressure further measured after opening the third valve in a state where the second valve is kept closed are used for the flow rate calculation of the third step.

5. The flow rate control system according to claim 1, wherein the arithmetic unit is configured to calculate the flow rate according to the equation that Q=22.4*V*(P2/T2-P1/T1)/(760*R**Δt), where Q is a flow rate, V is the volume value of the fluid between the first valve and the second valve corresponding to the measured second pressure value, P1 is the first pressure value, T1 is the first temperature value, P2 is the second pressure value, T2 is the second temperature value, R is a gas constant, and Δt is the predetermined time period.

6. The flow rate control system according to claim 2, wherein the arithmetic unit is configured to calculate the flow rate according to the equation that Q=22.4*((P2- P1)/(760*R* Δt))*(Vb/Tb*(P2-P3)/(P2-P4)+Vst/Tst), where Q is a flow rate, P1 is the first pressure value, P2 is the second pressure value, P3 is the third pressure value, P4 is the fourth pressure value, R is a gas constant, and Δt is the predetermined time period, Vb is a volume value of the fluid between the third valve and the second valve, Vst is a volume value of the fluid between the flow rate controller and the first valve, and Tb and Tst are temperature values corresponding to the third temperature value or the fourth temperature value.

7. The flow rate measurement method according to claim 3, wherein the third step of calculating the flow rate comprises a step of calculating the flow rate according to the equation that Q=22.4*V*(P2/T2-P1/T1)/(760*R*Δt), where Q is a flow rate, V is the volume value of the fluid between the first valve and the second valve, P1 is a pressure value measured in the first step, T1 is a temperature value measured in the first step, P2 is a pressure value measured in the second step, T2 is a temperature value measured in the second step, R is a gas constant, and Δt is the predetermined time period in the second step.

8. The flow rate measurement method according to claim 4, wherein the third step of calculating the flow rate comprises a step of calculating the flow rate according to the equation that $Q=22.4*((P2-P1)/(760*R*\Delta t))*(Vb/Tb*(P2-P3)/(P2-P4)+Vst/Tst)$, where Q is a flow rate, P1 is a pressure value measured in the first step, P2 is a pressure value measured in the second step, P3 is a pressure value measured after opening and then closing the second valve in a short time while closing the third valve after the second step, P4 is a pressure value measured after opening the third valve in a state where the second valve is kept closed after the second step, R is a gas constant, and Δt is the predetermined time period in the second step, Vb is a volume value of the fluid between the third valve and the second valve, Vst is a volume value of the fluid between the flow rate controller and the first valve, and Tb and Tst are temperature values measured after opening and then closing the second valve in a short time while closing the third valve after the second step.