

Title:

VAV AIR CONDITIONING SYSTEM AND AIR CONDITIONING CONTROL METHOD

BACKGROUND

5 Technical Field

[0001] The invention relates to a VAV air conditioning system adjusting cooling and heating ability by changing an air blow-off volume in accordance with variation of a thermal load of an indoor space.

Description of Related Art

10 **[0002]** Conventionally, in a variable air volume (VAV) air conditioning system, a variable air volume adjustment unit (VAV unit) is provided for each controlled area, and a supplied air blow-off volume from the VAV unit is controlled by a VAV controller in accordance with a load condition of the controlled area (see Patent Document 1).

[0003] In the variable air volume control in the VAV air conditioning system, an inverter-type
15 air conditioner capable of controlling the air volume (fan rotation speed) in accordance with the required air volume of each VAV unit is used. The fan rotation speed is proportional to the frequency of the inverter.

[0004] A fan rotation speed F of the air conditioner is obtained from a total required air volume Σv_i summing up required air volumes v_i of respective VAV units according to the
20 following formulae (FIG. 15).

$$F=a \times \Sigma v_i + b \text{ (where } V_{\min} \leq \Sigma v_i \leq V_{\max} \text{)} \quad \cdots (1)$$

$$F=F_{\min} (\Sigma v_i < V_{\min}) \quad \cdots (2)$$

$$F=F_{\max} (\Sigma v_i > V_{\max}) \quad \cdots (3)$$

[0005] In Formula (1), a and b are predetermined constant numbers. Formula (2) indicates
25 that, in the case where the total required air volume Σv_i is less than a lower limit value $V_{\min}$, the fan rotation speed F is limited to a lower limit value $F_{\min}$. Formula (3) indicates that, in the case where the total required air volume Σv_i is greater than an upper limit value $V_{\max}$, the fan rotation speed F is limited to an upper limit value $F_{\max}$.

[0006] Also, in the VAV air conditioning system, total static pressure excess/insufficiency
30 information is generated based on static pressure excess/insufficiency information transmitted from the VAV controllers controlling the respective VAV units, and the fan rotation speed F is corrected to increase/decrease based on the total static pressure excess/insufficiency information.

[0007] In accordance with the damper opening degree of each controlled VAV unit, each VAV controller outputs the static pressure excess/insufficiency information of one of "insufficient static pressure", "appropriate", "excessive static pressure". An air conditioning control device sets the total static pressure excess/insufficiency information as "insufficient static pressure" when any of the static pressure excess/insufficiency information transmitted from the respective VAV controllers is "insufficient static pressure". The air conditioning control device sets the total static pressure excess/insufficiency information as "appropriate" when "appropriate" and "excessive static pressure" are mixed in the static pressure excess/insufficiency information transmitted from the respective VAV controllers. The air conditioning control device sets the total static pressure excess/insufficiency information as "excessive static pressure" when all of the static pressure excess/insufficiency information transmitted from the respective VAV controllers indicates "excessive static pressure".

[0008] When the total static pressure excess/insufficiency information is "insufficient static pressure", the air conditioning control device corrects the fan rotation speed F of the air conditioner by increasing $\alpha\%$, α being a predetermined value. When the total static pressure excess/insufficiency information is "appropriate", the air conditioning control device maintains the fan rotation speed F in the current state. When the total static pressure excess/insufficiency information is "excessive static pressure", the air conditioning control device corrects the fan rotation speed F by decreasing $\alpha\%$.

[0009] In the following, issues arising from the conventional technology are described.

[0010] [First issue]

Based on the room temperature and the room temperature setting value, each VAV controller obtains the required air volume as shown in FIG. 16. In the example of FIG. 16, at the time of cooling, when the room temperature is higher than the cooling room temperature setting value, the required air volume increases in accordance with the characteristic of FIG. 16, and when the room temperature is equal to or lower than the cooling room temperature setting value, the required air volume is the minimum air volume. In addition, at the time of heating, when the room temperature is lower than the heating room temperature setting value, the required air volume increases in accordance with the characteristic of FIG. 16, and when the room temperature is equal to or higher than the heating room temperature setting value, the required air volume is the minimum air volume.

[0011] The VAV controller controls the opening degree of the damper inside the VAV unit to

ensure the required air volume as determined. Specifically, the VAV controller receives a feedback of a measured air volume measured by an air volume sensor inside the VAV unit, and controls the damper opening degree so that the required air volume is equal to the measured air volume.

5 **[0012]** Although each VAV controller outputs the static pressure excess/insufficiency information of one of "insufficient static pressure", "appropriate", and "excessive static pressure" in accordance with the damper opening degree of the VAV unit, even when the static pressure excess/insufficiency information is "insufficient static pressure", the room temperature may still be favorable (i.e., the absolute value of the difference between the room temperature setting
10 value and the room temperature is within $\Delta^{\circ}\text{C}$). FIG. 17 shows an example when the room temperature is PV. Although FIG. 17 shows an example at the time of cooling, the phenomenon that the static pressure is insufficient even though the room temperature is still favorable also occurs at the time of heating. Since the control direction (heating, cooling) of the room temperature changes, the absolute value of the difference between the room temperature
15 setting value and the room temperature is used in the determination on whether the room temperature is favorable.

[0013] The issue that the static pressure is insufficient even though the room temperature is favorable (the absolute value of the difference between the room temperature setting value and the room temperature is within $\Delta^{\circ}\text{C}$) arises because even though the room temperature is
20 favorable, that is, the required air volume is small, the measured air volume does not satisfy the required air volume. The reasons why the measured air volume does not satisfy the required air volume include, for example, that the fan rotation speed is insufficient, or that the air volume to the target VAV unit is insufficient because the required air volume of another VAV unit is large, etc. As a result, even though the room temperature is favorable, the total static pressure
25 excess/insufficiency information indicates "insufficient static pressure", and the fan rotation speed is corrected to increase, which leads to increased energy, increased cost, etc.

[0014] [Second issue]

In addition, it is common to excessively set the temperature (e.g., the room temperature setting value at 20°C) with respect to a comfortable temperature (e.g., 25°C to 27°C during summer).
30 In such case, the required air volume of the VAV unit is constantly at the maximum air volume (FIG. 18). At this time, the issue that the static pressure excess/insufficiency information of "insufficient static pressure" keeps being output and the fan rotation speed keeps being corrected

to increase arises.

[Prior Art Document]

[Patent Document]

[0015]

5 [Patent Document 1] Japanese Patent No. 3334069

SUMMARY

10 **[0016]** The invention has been made to solve the above issues, and an objective thereof is to provide a VAV air conditioning system and an air conditioning control method capable of reducing the number of times that the fan rotation speed is corrected to increase, saving energy, and reducing cost.

[Means for Solving Problems]

15 **[0017]** A variable air volume (VAV) air conditioning system according to the invention includes: an air conditioner; a VAV unit, provided for each controlled area; a first control part, configured to control, for each of the controlled area, an opening degree of a damper of the VAV unit in accordance with a required air volume determined in accordance with a load condition of the controlled area; a status notification part, configured to transmit, for each of the VAV unit, static pressure excess/insufficiency information based on the opening degree of the damper; a fan rotation speed determination part, configured to determine a fan rotation speed of the air
20 conditioner based on a total required air volume summing up a value of the required air volume of each of the VAV unit; a fan rotation speed correction part, configured to correct the fan rotation speed of the air conditioner based on total static pressure excess/insufficiency information integrating the static pressure excess/insufficiency information of each of the VAV unit; a second control part, configured to control a fan of the air conditioner, so as to arrive at the
25 fan rotation speed determined by the fan rotation speed determination part and corrected by the fan rotation speed correction part; a re-determination part, configured to perform re-determination on the static pressure excess/insufficiency information based on a room temperature or a room CO₂ concentration of the controlled area before the static pressure excess/insufficiency information of each of the VAV unit is integrated; and a static pressure
30 excess/insufficiency information change part, configured to change the static pressure excess/insufficiency information of each of the VAV unit based on a determination result of the re-determination part before the static pressure excess/insufficiency information of each of the

VAV unit is integrated.

[0018] In addition, in a configuration example of the VAV air conditioning system according to the invention, in a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within an allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

In a configuration example of the VAV air conditioning system according to the invention, the allowable temperature range includes: a first allowable temperature range, which is a range in which a difference between the room temperature and a room temperature setting value of the controlled area is from negative infinity to a positive first predetermined temperature when cooling and a range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when heating; and a second allowable temperature range, which is a range in which the room temperature of the controlled area is from negative infinity to a positive second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating. In a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the VAV air conditioning system according to the invention, in a case where a difference between the room CO₂ concentration and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

[0019] In addition, a configuration example of the VAV air conditioning system according to the invention further includes a room temperature prediction part configured to predict the room temperature of each of the controlled area in a future moment. In a case where at least one of the room temperature and a room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a

static pressure as insufficient falls within an allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the VAV air conditioning system according to the invention, the allowable temperature range includes: a first allowable temperature range, which is

5 a range in which a difference between the room temperature and a room temperature setting value of the controlled area is from negative infinity to a positive first predetermined temperature when cooling and a range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when heating; and a second allowable temperature range, which is a range
10 in which the room temperature of the controlled area is from negative infinity to a positive second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating. In a case where at least one of the room temperature and the room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency
15 information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the VAV air conditioning system according to the invention, in a case where the room temperature prediction value of the controlled area
20 corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as appropriate is out of the allowable temperature range, the re-determination part determines that the static pressure is to be changed from appropriate to insufficient.

[0020] In addition, a configuration example of the VAV air conditioning system according to the invention further includes a room CO₂ concentration prediction part configured to predict the
25 room CO₂ concentration of each of the controlled area in a future moment. In a case where a difference between the room CO₂ concentration or a room CO₂ concentration prediction value and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, the
30 re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the VAV air conditioning system according to the

invention, in a case where a difference between the room CO₂ concentration prediction value and the room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as appropriate is out of the range from negative infinity to the positive predetermined concentration, the re-determination part determines that the static pressure is to be changed from appropriate to insufficient.

[0021] In addition, an air conditioning control method according to the invention includes: a first step of controlling, for each controlled area, an opening degree of a damper of a variable air volume (VAV) unit in accordance with a required air volume determined in accordance with a load condition of the controlled area; a second step of transmitting, for each of the VAV unit, static pressure excess/insufficiency information based on the opening degree of the damper; a third step of determining a fan rotation speed of an air conditioner supplying air to the VAV unit based on a total required air volume summing up a value of the required air volume of each of the VAV unit; a fourth step of correcting the fan rotation speed of the air conditioner based on total static pressure excess/insufficiency information integrating the static pressure excess/insufficiency information of each of the VAV unit; a fifth step of controlling a fan of the air conditioner, so as to arrive at the fan rotation speed determined in the third step and corrected in the fourth step; a sixth step of performing re-determination on the static pressure excess/insufficiency information based on a room temperature or a room CO₂ concentration of the controlled area before the static pressure excess/insufficiency information of each of the VAV unit is integrated; and a seventh step of changing the static pressure excess/insufficiency information of each of the VAV unit based on a determination result of Step 6 before the static pressure excess/insufficiency information of each of the VAV unit is integrated.

[0022] In addition, in a configuration example of the air conditioning control method according to the invention, the sixth step includes a step of, in a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within an allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the air conditioning control method according to the invention, the allowable temperature range includes: a first allowable temperature range, which is a range in which a difference between the room temperature and a room temperature setting value of the controlled area is from negative infinity to a positive first predetermined temperature

when cooling and a range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when heating; and a second allowable temperature range, which is a range in which the room temperature of the controlled area is from negative infinity to a positive second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating, The sixth step includes a step of, in a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the air conditioning control method according to the invention, the sixth step includes a step of, in a case where a difference between the room CO₂ concentration and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, determining that the static pressure is to be changed from insufficient to appropriate.

[0023] In addition, a configuration example of the air conditioning control method according to the invention further includes an eighth step of predicting the room temperature of each of the controlled area in a future moment. The sixth step includes a step of, in a case where at least one of the room temperature and a room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within an allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the air conditioning control method according to the invention, the allowable temperature range includes: a first allowable temperature range, which is a range in which a difference between the room temperature and a room temperature setting value of the controlled area is from negative infinity to a positive first predetermined temperature when cooling and a range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when heating; and a second allowable temperature range, which is a range in which the room temperature of the controlled area is from negative infinity to a positive

second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating, The sixth step includes a step of, in a case where at least one of the room temperature and the room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the air conditioning control method according to the invention, the sixth step includes a step of, in a case where a room prediction temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as appropriate is out of the allowable temperature range, determining that the static pressure is to be changed from appropriate to insufficient.

[0024] A configuration example of the air conditioning control method according to the invention further includes an eighth step of predicting the room CO₂ concentration of each of the controlled area in a future moment. The sixth step includes a step of, in a case where a difference between the room CO₂ concentration or a room CO₂ concentration prediction value and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, determining that the static pressure is to be changed from insufficient to appropriate.

In addition, in a configuration example of the air conditioning control method according to the invention, the sixth step includes a step of, in a case where a difference between the room CO₂ concentration prediction value and the room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient is out of the range from negative infinity to the positive predetermined concentration, determining that the static pressure is to be changed from appropriate to insufficient.

[Inventive Effects]

[0025] According to the invention, by providing a re-determination part and a static pressure excess/insufficiency information change part, the static pressure excess/insufficiency information indicating that the static pressure is insufficient can be reduced. Accordingly, the number of times that the fan rotation speed is corrected to increase can be reduced, the energy can be saved,

and the cost can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

5 FIG. 1 is a diagram illustrating an allowable temperature range at the time of cooling according to the invention.

 FIG. 2 is a diagram illustrating an allowable temperature range at the time of heating according to the invention.

10 FIG. 3 is a diagram illustrating an example of re-determination on static pressure excess/insufficiency information according to the invention.

 FIG. 4 is a diagram illustrating another example of re-determination on static pressure excess/insufficiency information according to the invention.

 FIG. 5 is a block diagram illustrating a configuration of a VAV air conditioning system according to a first embodiment of the invention.

15 FIG. 6 is a block diagram illustrating a configuration of a VAV controller of the VAV air conditioning system according to the first embodiment of the invention.

 FIG. 7 is a block diagram illustrating a configuration of a VAV air conditioner according to the first embodiment of the invention.

20 FIG. 8 is a block diagram illustrating a configuration of an air conditioner controller of the VAV air conditioning system according to the first embodiment of the invention.

 FIG. 9 is a flowchart illustrating an operation of the VAV controller of the VAV air conditioning system according to the first embodiment of the invention.

 FIG. 10 is a flowchart illustrating an operation of the air conditioner controller of the VAV air conditioning system according to the first embodiment of the invention.

25 FIG. 11 is a flowchart illustrating an operation of an analysis device of the VAV air conditioning system according to the first embodiment of the invention.

 FIG. 12 is a block diagram illustrating a configuration of a VAV air conditioning system according to a second embodiment of the invention.

30 FIG. 13 is a flowchart illustrating an operation of an analysis device of the VAV air conditioning system according to the second embodiment of the invention.

 FIG. 14 is a block diagram illustrating a configuration example of a computer realizing the VAV air conditioning system according to the first and second embodiments of the

invention.

FIG. 15 is a diagram illustrating a relationship between a fan rotation speed of an air conditioner and a total required air volume of VAV units.

FIG. 16 is diagram illustrating a method for determining a required air volume based on a room temperature and a room temperature setting value.

FIG. 17 is a diagram illustrating an example in which a static pressure is insufficient even though the room temperature is favorable.

FIG. 18 is a diagram illustrating an example in which a static pressure is insufficient due to an excessive temperature setting.

DESCRIPTION OF THE EMBODIMENTS

[0027] [General Principle of Invention]

In the invention, re-determination is performed in the formed that, based on temperature (actually measurement value or prediction value) information, static pressure excess/insufficiency information is changed from "insufficient static pressure" to "appropriate" or from "appropriate" to "insufficient static pressure". More specifically, even for a VAV unit determined as "insufficient static pressure", the VAV unit is determined as "appropriate" if the actually measurement value of the room temperature is within an allowable temperature range. In addition, even for a VAV unit determined as "appropriate", the VAV unit is determined as "insufficient static pressure" if the prediction value of the room temperature is out of the allowable temperature range.

[0028] Here, in the invention, two types of allowable temperature range, i.e., a first allowable temperature range A1 and a second allowable temperature range A2, are set to be the allowable temperature range. The first allowable temperature range A1 is a temperature range in which a difference PV-SP between a room temperature PV and a room temperature setting value SP is from negative infinity to $\Delta^{\circ}\text{C}$ (positive first predetermined temperature) at the time of cooling and a temperature range in which the difference PV-SP between the room temperature PV and the room temperature setting value SP is from $-\Delta^{\circ}\text{C}$ (negative first predetermined temperature) to infinity at the time of heating. The first allowable temperature range A1 serves to solve the first issue.

[0029] The second allowable temperature range A2 is a range on a side in which the consumed energy of the predetermined temperature (the optimized room temperature upper limit at the time

of cooling or the optimized room temperature lower limit at the time of heating) set within a room temperature zone (e.g., 25°C to 27°C during summer, 20°C to 24°C during winter) generally considered as comfortable increases. The second allowable temperature range A2 serves to solve the second issue. FIG. 1 shows the allowable temperature ranges A1 and A2 at the time of cooling, and FIG. 2 shows the allowable temperature ranges A1 and A2 at the time of heating.

[0030] The range on a side in which the consumed energy decreases (a side where the room temperature setting value increases at the time of cooling, a side where the room temperature setting value decreases at the time of heating) is not set as the second allowable temperature range A2 even in a range outside the temperature zone generally considered as comfortable. That is, the second allowable temperature range A2 at the time of cooling is a temperature range from negative infinity until the optimized room temperature upper limit (positive second predetermined temperature) at the time of cooling, and the second allowable temperature range A2 at the time of heating is a temperature range from the optimized room temperature lower limit (positive third predetermined temperature) at the time of heating to infinity.

[0031] In the invention, an example of re-determination from "insufficient static pressure" to "appropriate" at the time cooling is described with reference to FIG. 3. t_1 to t_8 in FIG. 3 are moments at which measurement values of the room temperature are obtained. In addition, for the ease of description, FIG. 3 illustrates only the case where the allowable temperature range A1 is used.

[0032] At the moments t_1 and t_2 , since the room temperature is out of the allowable temperature range A1, the static pressure excess/insufficiency information is not changed from "insufficient static pressure" to "appropriate". At the moments t_3 to t_7 , since the room temperature falls within the allowable temperature range A1, the static pressure excess/insufficiency information is changed from "insufficient static pressure" to "appropriate". At the moment t_8 , since the room temperature is out of the allowable temperature range A1, the result of re-determination is "insufficient static pressure".

Accordingly, in the invention, since the number of VAV units determined as "insufficient static pressure" is reduced through re-determination, the chance that the fan rotation speed is corrected to increase is also reduced.

[0033] By using a prediction value of the room temperature one step ahead, in addition to the current value, as the room temperature, the static pressure excess/insufficiency information can

be re-determined by taking into consideration the tendency of temperature change. In such case, if at least one of the measurement value of the room temperature and the prediction value of the room temperature one step ahead falls within the allowable temperature range, the static pressure excess/insufficiency information is re-determined as "appropriate".

5 **[0034]** In the invention, an example of re-determination from "insufficient static pressure" to "appropriate" at the time cooling is described with reference to FIG. 4. t1 to t8 in FIG. 4 are moments at which measurement values of the room temperature are obtained. The symbol "○" indicates a measurement value of the room temperature, and the symbol "□" indicates a prediction value of the room temperature. In addition, for the ease of description, FIG. 4
10 illustrates only the case where the allowable temperature range A1 is used.

[0035] At the moment t1, since the measurement value of the room temperature is out of the allowable temperature range A1, the static pressure excess/insufficiency information is not changed from "insufficient static pressure" to "appropriate". At the moment t2, although the measurement value of the room temperature is out of the allowable temperature range A1, the
15 prediction value is within the allowable temperature range A1. Therefore, the static pressure excess/insufficiency information is changed from "insufficient static pressure" to "appropriate". At the moments t3 to t6, since the measurement value and the prediction value of the room temperature both fall within the allowable temperature range A1, the static pressure excess/insufficiency information is changed from "insufficient static pressure" to "appropriate".
20 At the moment t7, although the prediction value is out of the allowable temperature range A1, the measurement value is within the allowable temperature range A1. Therefore, the static pressure excess/insufficiency information is changed from "insufficient static pressure" to "appropriate". At the moment t8, since both the measurement value and the prediction value are out of the allowable temperature range A1, the result of re-determination is "insufficient static pressure".

25 **[0036]** The advantage of using the prediction value of the indoor temperature is that, even if the measurement value of the room temperature is out of the allowable temperature range, like the moment t2, the determination of "appropriate" is made at the time when the prediction value falls within the allowable temperature range. By doing so, the fan rotation speed can be corrected to decrease one step head, and the energy as well as the cost can be saved.

30 **[0037]** [First Embodiment]

In the following, the embodiments of the invention will be described with reference to the accompanying drawings. FIG. 5 is a block diagram illustrating a configuration of a VAV air

conditioning system according to a first embodiment of the invention. The VAV air conditioning system is configured by: a VAV unit 1, which is a variable supplied air volume adjustment unit provided for each controlled area (air conditioning zone) and controlling the volume of air supplied to the controlled area for each controlled area; a VAV controller 2 provided for each VAV unit 1 and controlling the corresponding VAV unit 1; an air conditioner 3; a supplied air duct 4 supplying the air supplied from the air conditioner 3 to each VAV unit 1; and an air conditioner controller 5 controlling the air conditioner 3; and an analysis device 6 provided in a central system 7.

[0038] FIG. 6 is a block diagram illustrating a configuration of the VAV controller 2. Each VAV controller 2 includes: a required air volume calculation part 20 calculating a required air volume of the VAV unit 1 based on a deviation between the room temperature of the corresponding controlled area and a room temperature setting value set by the resident of the controlled area or the manager of the air conditioning system; an air volume control part 21 (first control part) controlling the damper opening degree adjusting the supplied air blow-off volume of the VAV unit 1 to ensure the required air volume calculated by the required air volume calculation part 20; a required air volume notification part 22 notifying the air conditioner controller 5 of the value of the required air volume; a status notification part 23 transmitting the static pressure excess/insufficiency information of each controlled area to the air conditioner controller 5; and a room temperature notification part 24, notifying the air conditioner controller 5 of the room temperature of the corresponding controlled area.

[0039] FIG. 7 is a block diagram illustrating a configuration of the air conditioner 3. The air conditioner 3 includes a cooling coil 30, a heating coil 31, and a fan 32. Besides, the configuration shown in FIG. 7 is merely an example, and the configuration may also be one other than FIG. 7.

[0040] FIG. 8 is a block diagram illustrating a configuration of the air conditioner controller 5. The air conditioner controller 5 includes: an operation volume output part 50 outputting an operation volume for controlling the air conditioner 3 based on the deviation between a supplied air temperature and a supplied air temperature setting value; an air volume calculation part 51, calculating the value of a total required air volume of the entire system from the value of the required air volume notified from each VAV controller 2; a fan rotation speed determination part 52 determining a fan rotation speed of the air conditioner 3 based on the value of the total required air volume that is calculated; an air volume control part 53 (second control part)

controlling the fan 32 of the air conditioner 3; an information generation part 54 generating total static pressure excess/insufficiency information based on the static pressure excess/insufficiency information notified from each VAV controller 2; and a fan rotation speed correction part 55 correcting the fan rotation speed of the air conditioner 3 based on the total static pressure excess/insufficiency information.

[0041] As shown in FIG. 5, the analysis device 6 includes: a data accumulation part 60 accumulating data of the room temperature, the static pressure excess/insufficiency information, and the room temperature setting value of each controlled area; a re-determination part 61 performing re-determination on the static pressure excess/insufficiency information based on the room temperature of the controlled area before the static pressure excess/insufficiency information of the respective VAV units 1 is integrated; and a static pressure excess/insufficiency information change part 62 changing the static pressure excess/insufficiency information of the respective VAV units 1 based on the determination result of the re-determination part 61 before the static pressure excess/insufficiency information of the respective VAV units 1 is integrated.

[0042] The VAV unit 1 and the VAV controller 2 are provided in each controlled area. The air (supplied air) cooled off or heated by the air conditioner 3 is supplied to the VAV unit 1 of each controlled area via the supplied air duct 4, and passes through the VAV unit 1 to be supplied to each controlled area. A damper not shown herein is provided inside the VAV unit 1 to be able to adjust the volume of the supplied air passing through the VAV unit 1.

[0043] In the following, an operation of the embodiment is described. FIG. 9 is a flowchart illustrating an operation of the VAV controller 2, and FIG. 10 is a flowchart illustrating an operation of the air conditioner controller 5.

[0044] The room temperature notification part 24 of the VAV controller 2 notifies the air conditioner controller 5 of the values of a room temperature PV measured by a room temperature sensor and a room temperature setting value SP of the corresponding controlled area (Step S100 of FIG. 9). In the case where the room temperature setting value SP is set by the manager of the air conditioning system and notified from the air conditioner controller 5 to each VAV controller 2, it is not necessary to notify the room temperature setting value SP from each VAV controller 2 to the air conditioner controller 5.

[0045] The required air volume calculation part 20 of the VAV controller 2 calculates a required air volume v_i of the VAV unit 1 of the control target in accordance with a thermal load condition of the corresponding controlled area (Step S101 of FIG. 9). Specifically, the required

air volume calculation part 20 calculates the required air volume v_i of the VAV unit 1 so that the room temperature PV of the corresponding controlled area is consistent with the room temperature setting value SP set by the resident of the controlled area or the manager of the air conditioning system.

5 **[0046]** The required air volume notification part 22 of the VAV controller 2 notifies the air conditioner controller 5 of the value of the required air volume v_i calculated by the required air volume part 20 (Step S102 of FIG. 9).

The air volume control part 21 of the VAV controller 2 controls an opening degree of the damper (not shown) in the VAV unit 1 of the control target so as to ensure the required air volume
10 calculated by the required air volume calculation part 20 (S103 of FIG. 9).

[0047] The status notification part 23 of the VAV controller 2 transmits, to the air conditioner controller 5, the static pressure excess/insufficiency information indicating a current cooling/heating control state of the corresponding controlled area (S104 of FIG. 9). The status notification part 23, for example, generates the static pressure excess/insufficiency information of
15 one of "insufficient static pressure", "appropriate", "excessive static pressure", based on the damper opening degree of the VAV unit 1.

[0048] Specifically, if the damper opening degree of the VAV unit 1 is fully open, the status notification part 23 sets the static pressure excess/insufficiency information as "insufficient static pressure". If the damper opening degree of the VAV unit is not fully open, but is equal to or
20 greater than a predetermined opening degree (e.g., 85%), the status notification part 23 sets the static pressure excess/insufficiency information as "appropriate". If the damper opening degree of the VAV unit 1 is less than the predetermined opening degree, the status notification part 23 sets the static pressure excess/insufficiency information as "excessive static pressure".

[0049] The combination of the VAV controller 2 and the VAV unit 1 performs the process of
25 Steps S100 to S104 as described above at a prescribed time interval until the air conditioning is stopped (YES in Step S105 of FIG. 9).

[0050] Meanwhile, the operation volume output part 50 of the air conditioner controller 5 calculates, and outputs to the air conditioner 3, an operation amount according to a predetermined control computing algorithm (e.g., PID), so that the supplied air temperature is
30 consistent with the supplied air setting value (Step S200 of FIG. 10). By doing so, the amount of a thermal medium (cold or hot water) supplied to the cooling coil 30 or the heating coil 31 of the air conditioner 3 is adjusted in accordance with the operation amount, and the supplied air

temperature is thus controlled.

[0051] The air volume calculation part 51 of the air conditioner controller 5 calculates a total required air volume Σv_i summing up the values of the required air volumes v_i notified from the respective VAV controllers 2 (Step S201 of FIG. 10).

5 The fan rotation speed determination part 52 of the air conditioner controller 5 determines a fan rotation speed F of the air conditioner 3 based on the value of the total required air volume Σv_i (Step S202 of FIG. 10). The fan rotation speed determination part 52 determines the fan rotation speed F corresponding to the total required air volume Σv_i based on the relations shown in Formulae (1) to (3) above.

10 **[0052]** The information generation part 54 of the air conditioner controller 5 generates the total static pressure excess/insufficiency information based on the static pressure excess/insufficiency information notified from the respective VAV controllers 2, but verifies whether the analysis device 6 changes the static pressure excess/insufficiency information as described in the following (Step S203 of FIG. 10).

15 **[0053]** In the case where the static pressure excess/insufficiency information is not changed by the analysis device 6, the information generation part 54 keeps using the static pressure excess/insufficiency information notified from the respective VAV controllers 2 to generate the total static pressure excess/insufficiency information (S204 of FIG. 10). Similar to the conventional art, in the case where any of the static pressure excess/insufficiency information
20 transmitted from the respective VAV controllers 2 indicates "insufficient static pressure", the information generation part 54 sets the total static pressure excess/insufficiency information as "insufficient static pressure". The information generation part 54 sets the total static pressure excess/insufficiency information as "appropriate" in the case where "appropriate" and "excessive static pressure" are mixed in the static pressure excess/insufficiency information transmitted from
25 the respective VAV controllers 2. The information generation part 54 sets the total static pressure excess/insufficiency information as "excessive static pressure" in the case where all of the static pressure excess/insufficiency information transmitted from the respective VAV controllers 2 indicates "excessive static pressure".

[0054] In the case where the static pressure excess/insufficiency information is changed by the
30 analysis device 6, the information generation part 54 uses the changed static pressure excess/insufficiency information and the static pressure excess/insufficiency information not changed by the analysis device 6 among the static pressure excess/insufficiency information

notified from the respective VAV controllers 2 to generate the total static pressure excess/insufficiency information (Step S205 of FIG. 10). In the case where any of the changed static pressure excess/insufficiency information and the unchanged static pressure excess/insufficiency information is "insufficient static pressure", the information generation part 54 sets the total static pressure excess/insufficiency information as "insufficient static pressure". In the case where "appropriate" and "excessive static pressure" are mixed in the changed static pressure excess/insufficiency information and the unchanged static pressure excess/insufficiency information, the information generation part 54 sets the total static pressure excess/insufficiency information as "appropriate". In the case where all the changed static pressure excess/insufficiency information and the unchanged static pressure excess/insufficiency information are "excessive static pressure", the information generation part 54 sets the total static pressure excess/insufficiency information as "excessive static pressure".

[0055] The fan rotation speed correction part 55 of the air conditioner controller 5 corrects the fan rotation speed F of the air conditioner 3 based on the total static pressure excess/insufficiency information (Step S206 of FIG. 10). Similar to the conventional art, in the case where the total static pressure excess/insufficiency information indicates "insufficient static pressure", the fan rotation speed correction part 55 corrects the fan rotation speed F determined by the fan rotation speed determination part 52 by increasing $\alpha\%$, α being a predetermined positive real number. In the case where the total static pressure excess/insufficiency information indicates "appropriate", the fan rotation speed correction part 55 maintains the current state of the fan rotation speed F determined by the fan rotation determination part 52. In the case where the total static pressure excess/insufficiency information indicates "excessive static pressure", the fan rotation speed correction part 55 corrects the fan rotation speed F determined by the fan rotation determination part 52 by decreasing $\alpha\%$.

[0056] The air volume control part 53 of the air conditioner controller 5 controls the fan 32 of the air conditioner 3 so as to arrive at the fan rotation speed F determined by the fan rotation speed determination part 52 and corrected as necessary by the fan rotation speed correction part 55 (Step S207 of FIG. 10). By doing so, the air volume of the supplied air transmitted from the air conditioner 3 is controlled.

The air conditioner controller 5 performs the process of Step S200 to S207 as described above at a prescribed time interval until the air conditioning is stopped (YES in Step S208 of FIG. 10). In addition, each air conditioner controller 5 performs the process of FIG. 10 for each

corresponding air conditioner 3. Therefore, each air conditioner controller 5 performs the process of FIG. 10 for the VAV units 1 and the VAV controllers 2 belonging to the same air conditioning system (the same air conditioner 3).

[0057] FIG. 11 is a flowchart illustrating an operation of the analysis device 6. The data accumulation part 60 of the analysis device 6 constantly collects and accumulates, from the air conditioner controller 5, the room temperature PV and the static pressure excess/insufficiency information notified from each VAV controller 2, and the room temperature setting value SP in an air conditioning operation (Step S300 of FIG. 11).

[0058] The re-determination part 61 of the analysis device 6 performs re-determination on the latest static pressure excess/insufficiency information notified from the respective VAV controllers 2. Specifically, the re-determination part 61 obtains the latest data accumulated in the data accumulation part 60 (Step S301 of FIG. 11). In addition, the re-determination part 61 extracts the static pressure excess/insufficiency information of "insufficient static pressure" from the latest static pressure excess/insufficiency information obtained in Step S301 (Step S302 of FIG. 11).

[0059] Then, the re-determination part 61 performs re-determination on the static pressure excess/insufficiency information of "insufficient static pressure" extracted in Step S302. Here, for the clarity of description, the VAV unit whose latest static pressure excess/insufficiency information is "insufficient static pressure" is set as 1-i, the latest room temperature of the controlled area corresponding to the VAV unit 1-i is set as PV_i , the room temperature setting value is set as SP_i , the first allowable temperature range of the controlled area corresponding to the VAV unit 1-i is set as $A1_i$, and the second allowable temperature range is set as $A2_i$.

[0060] Regarding the VAV unit 1-i whose static pressure excess/insufficiency information is "insufficient static pressure", the re-determination part 61 sets the first allowable temperature range $A1_i$ and the second allowable temperature range $A2_i$ based on the room temperature setting value SP_i , the optimized room temperature upper limit when cooling, and the optimized room temperature lower limit when heating. Then, if the room temperature PV_i falls within at least one of the first allowable temperature range $A1_i$ and the second allowable temperature range $A2_i$, the re-determination part 61 determines that the static pressure excess/insufficiency information of "insufficient static pressure" is to be changed to "appropriate". In addition, if the room temperature PV_i is out of the first allowable temperature range $A1_i$ and the second allowable temperature range $A2_i$, the re-determination part 61 determines that the static pressure

excess/insufficiency information of "insufficient static pressure" is not to be changed. The re-determination part 61 performs the above re-determination on the static pressure excess/insufficiency information for each VAV unit 1 of "insufficient static pressure" (for each controlled area).

5 **[0061]** In the case where the static pressure excess/insufficiency information of "insufficient static pressure" is determined to be changed to "appropriate" by the re-determination part 61 (YES in Step S304 of FIG. 11), the static pressure excess/insufficiency information change part 62 of the analysis device 6 changes such information held by the air conditioner controller 5 to "appropriate" (Step S305 of FIG. 11). In addition, in the case where no static pressure
10 excess/insufficiency information is determined to be changed to "appropriate" (NO in Step S304), the static pressure excess/insufficiency information change part 62 notifies the air conditioner controller 5 that there is no change to the static pressure excess/insufficiency information (Step S306 of FIG. 11).

[0062] As described above, in the case where there is no change to the static pressure
15 excess/insufficiency information, the information generation part 54 of the air conditioner controller 5 keeps using the static pressure excess/insufficiency information notified from the respective VAV controllers 2 to generate the total static pressure excess/insufficiency information (S204). In addition, in the case where the static pressure excess/insufficiency information is changed, the information generation part 54 uses the changed static pressure
20 excess/insufficiency information and the static pressure excess/insufficiency information that is not changed by the analysis device 6 among the static pressure excess/insufficiency information notified from the respective VAV controllers 2 to generate the total static pressure excess/insufficiency information (Step S205).

[0063] The analysis device 6 performs the process of Step S300 to S306 as described above at
25 a prescribed time interval until the air conditioning is stopped (YES in Step S307 of FIG. 11). In addition, the analysis device 6 performs the process of FIG. 11 for each air conditioner controller 5 (for each air conditioner 3).

[0064] By doing so, in the embodiment, the static pressure excess/insufficiency information of "insufficient static pressure" can be reduced. Therefore, the number of times that the fan
30 rotation speed is corrected to increase can be reduced, the energy can be saved, and the cost can be reduced.

[0065] [Second Embodiment]

In the following, a second embodiment of the invention is described. FIG. 12 is a block diagram illustrating a configuration of a VAV air conditioning system according to a second embodiment of the invention. The VAV air conditioning system of the embodiment is formed by the VAV unit 1, the VAV controller 2, the air conditioner 3, the supplied gas duct 4, the air conditioner controller 5, and an analysis device 6a provided in the central system 7.

[0066] The VAV unit 1, the VAV controller 2, the air conditioner 3, and the air conditioner controller 5 have the same configuration as that of the first embodiment.

As shown in FIG. 12, the analysis device 6a includes the data accumulation part 60, a re-determination part 61a, the static pressure excess/insufficiency information change part 62, and a room temperature prediction part 63 predicting the room temperature of each controlled area at a future moment.

[0067] FIG. 13 is a flowchart illustrating an operation of the analysis device 6a. The data accumulation part 60 of the analysis device 6a constantly collects and accumulates, from the air conditioner controller 5, the room temperature PV and the static pressure excess/insufficiency information notified from each VAV controller 2, the room temperature setting value SP, the required air volume v_i notified from each VAV controller 2, and the data of a supplied air temperature APV in an air conditioning operation (Step S300a of FIG. 13).

[0068] The re-determination part 61a of the analysis device 6a obtains the latest data accumulated in the data accumulation part 60 (Step S301a of FIG. 13). The re-determination part 61a extracts the static pressure excess/insufficiency information of "insufficient static pressure" and the static pressure excess/insufficiency information of "appropriate" from the latest static pressure excess/insufficiency information obtained in Step S301a (Step S302a of FIG. 13).

[0069] Meanwhile, the room temperature prediction part 63 predicts a room temperature PV' of the controlled area one step ahead (after a predetermined time) for each controlled area (Step S308 of FIG. 13). The room temperature PV' one step ahead is the room temperature PV after a re-determination period passes from the current moment, and is the room temperature PV at the time of the next re-determination.

[0070] The room temperature prediction part 63 predicts, through a neural network, for example, the room temperature PV' of the controlled area based on a latest outside air temperature TO measured by an outside air temperature sensor not shown herein, a latest outside air humidity HO measured by an outside air humidity sensor not shown herein, the latest required air volume v_i obtained in Step S301a, the latest room temperature PV of the controlled area

obtained in Step S301a, and the latest supplied air temperature APV obtained in Step S301a.

[0071] In the room temperature prediction part 63, a neural network modeling the relationship among the outside air temperature TO, the outside air humidity HO, the required air volume v_i , the supplied air temperature APV, the room temperature PV, and the room temperature PV' one step ahead for each controlled area is built in advance. The neural network sets time-series data of the outside air temperature TO, time-series data of the outside air humidity HO, time-series data of the required air volume v_i , time-series data of the supplied air temperature APV, and time-series data of the room temperature PV, among the the time-series data recorded in a past data recording period, as input variables of the neural network, sets time-series data of the room temperature PV' one step ahead as an output variable of the neural network with respect to the input variables, and performs learning in advance to obtain a desired output variable. Regarding the prediction method of the room temperature PV', a method other than the embodiment may also be used.

[0072] Then, the re-determination part 61a performs re-determination on the static pressure excess/insufficiency information of "insufficient static pressure" and the static pressure excess/insufficiency information of "appropriate" extracted in Step S302a (Step S303a of FIG. 13). Here, for the clarity of description, the VAV unit whose latest static pressure excess/insufficiency information is "insufficient static pressure" is set as 1-i, the latest room temperature of the controlled area corresponding to the VAV unit 1-i is set as PV_i , the room temperature setting value is set as SP_i , the first allowable temperature range of the controlled area corresponding to the VAV unit 1 is set as $A1_i$, the second allowable temperature range is set as $A2_i$, and the prediction value of the room temperature predicted by the room temperature prediction part 63 for the controlled area corresponding to the VAV unit 1-i is set as PV_i' . In addition, the VAV unit whose latest static pressure excess/insufficiency information is "appropriate" is set as 1-j, the latest room temperature of the controlled area corresponding to the VAV unit 1-j is set as PV_j , the room temperature setting value is set as SP_j , the first allowable temperature range of the controlled area corresponding to the VAV unit 1-j is set as $A1_j$, the second allowable temperature range is set as $A2_j$, and the prediction value of the room temperature predicted by the room temperature prediction part 63 for the controlled area corresponding to the VAV unit 1-j is set as PV_j' .

[0073] Regarding the VAV unit 1-i whose static pressure excess/insufficiency information is "insufficient static pressure", the re-determination part 61a sets the first allowable temperature

range A1i and the second allowable temperature range A2i based on the room temperature setting value SPi, the optimized room temperature upper limit when cooling, and the optimized room temperature lower limit when heating. Then, if at least one of the room temperature PVi and the prediction value PVi' one step ahead falls within at least one of the first allowable temperature range A1i and the second allowable temperature range A2i, the re-determination part 61a determines that the static pressure excess/insufficiency information of "insufficient static pressure" is to be changed to "appropriate". In addition, if the room temperature PVi and the prediction value PVi' one step ahead are out of the first allowable temperature range A1i and the second allowable temperature range A2i, the re-determination part 61a determines that the static pressure excess/insufficiency information of "insufficient static pressure" is not to be changed.

[0074] Besides, regarding the VAV unit 1-j whose static pressure excess/insufficiency information is "appropriate", the re-determination part 61a sets the first allowable temperature range A1j and the second allowable temperature range A2j based on the room temperature setting value SPj, the optimized room temperature upper limit when cooling, and the optimized room temperature lower limit when heating. Then, if the room temperature prediction value PVj' one step ahead is out of the first allowable temperature range A1j and the second allowable temperature range A2j, the re-determination part 61a determines that the static pressure excess/insufficiency information of "appropriate" is to be changed to "insufficient static pressure". Moreover, if the room temperature prediction value PVj' one step ahead falls within at least one of the first allowable temperature range A1j and the second allowable temperature range A2j, the re-determination part 61a determines that the static pressure excess/insufficiency information of "appropriate" is not to be changed. The re-determination part 61a performs the above re-determination on the static pressure excess/insufficiency information for each VAV unit 1 of "insufficient static pressure" and each VAV unit 1 of "appropriate".

[0075] The processes of Steps S304 to S306 of FIG. 13 are as described in the first embodiment. The analysis device 6a performs the process of Steps S300a to S302a, S308, S303a, and S304 to S306 as described above at a prescribed time interval until the air conditioning is stopped (YES in Step S307 of FIG. 13). In addition, the analysis device 6a performs the process of FIG. 13 for each air conditioner controller 5 (for each air conditioner 3).

[0076] In the first and second embodiments, each VAV controller 2 calculates the required air volume of the VAV unit 1, so that the room temperature of the corresponding controlled area is consistent with the room temperature setting value, and controls the opening degree of the

damper of the VAV unit 1 to ensure the required air volume. Comparatively, each VAV controller 2 may also calculate the required air volume of the VAV unit 1 so that a room CO₂ concentration of the corresponding controlled area measured by a CO₂ sensor is consistent with a CO₂ concentration setting value, and control the opening degree of the damper of the VAV unit 1 to ensure the required air volume.

[0077] In the case where such CO₂ concentration control is performed, only an allowable CO₂ concentration range A1 is used as an allowed CO₂ concentration range. The allowable CO₂ concentration range A1 is a range in which a difference between a room CO₂ concentration and a room CO₂ concentration setting value is from negative infinity to Δ ppm (positive predetermined concentration). Regarding the VAV unit 1-i whose static pressure excess/insufficiency information is "insufficient static pressure", if the room CO₂ concentration PVi falls within the allowable CO₂ concentration range A1i, the re-determination part 61 of the first embodiment determines that the static pressure excess/insufficiency information of "insufficient static pressure" is to be changed to "appropriate". In addition, if the room CO₂ concentration PVi is out of the allowable CO₂ concentration range A1i, the re-determination part 61 may determine that the static pressure excess/insufficiency information of "insufficient static pressure" is not to be changed (Step S303 of FIG. 11).

[0078] In addition, in the case where CO₂ concentration control is performed, in place of the room temperature prediction part 63 of the second embodiment, a room CO₂ concentration prediction part predicting the room CO₂ concentration of each controlled area at a future moment may also be provided. Regarding the prediction of CO₂ concentration, an auto-regressive model, a neural network, etc., may be used.

[0079] Regarding the VAV unit 1-i whose static pressure excess/insufficiency information is "insufficient static pressure", if at least one of the room CO₂ concentration PVi and a room CO₂ concentration prediction value PVi' one step ahead falls within the allowable CO₂ concentration range A1i, the re-determination part 61a of the second embodiment determines that the static pressure excess/insufficiency information of "insufficient static pressure" is to be changed to "appropriate". In addition, if the room CO₂ concentration PVi and the room CO₂ concentration prediction value PVi' one step ahead are out of the allowable CO₂ concentration range A1i, the re-determination part 61a may determine that the static pressure excess/insufficiency information of "insufficient static pressure" is not to be changed (Step S303a of FIG. 13).

[0080] In addition, regarding the VAV unit 1-j whose static pressure excess/insufficiency

information is "appropriate", if the room CO₂ concentration prediction value PVi' one step ahead is out of the allowable CO₂ concentration range A1j, the re-determination part 61 determines that the static pressure excess/insufficiency information of "appropriate" is to be changed to "insufficient static pressure". Moreover, if the room CO₂ concentration prediction value PVi' one step ahead falls within the allowable CO₂ concentration range A1j, the re-determination part 61a may determine that the static pressure excess/insufficiency information of "appropriate" is not to be changed (Step S303a of FIG. 13).

[0081] Each of the VAV controller 2, the air conditioner controller 5, and the analysis device 6, 6a of the first and second embodiments can be realized by a computer including a central processing unit (CPU), a storage device and an interface with the outside and a program controlling such hardware resources. A configuration example of such computer is shown in FIG. 14. The computer includes a CPU 300, a storage device 301, and an interface device (I/F) 302.

[0082] In the case of the VAV controller 2, the VAV unit 1, the air conditioner controller 5, and the temperature sensor of the controlled area, etc., are connected to the I/F 302. In the case of the air conditioner controller 5, the air conditioner 3, the VAV controller 2, and the analysis device 6, 6a, etc., are connected to the I/F 302. In the case of the analysis device 6, 6a, the air conditioner controller 5, etc., is connected to the I/F 302. A program for realizing the air conditioning control method of the invention is stored in the storage device 301. The CPU 300 of each device executes the processes described in the first and second embodiments according to the program stored in the storage device 301.

[Industrial Applicability]

[0083] The invention can be used in a VAV air conditioning system.

[Reference Signs List]

[0084] 1: VAV unit; 2: VAV controller; 3: Air conditioner; 4: Supplied air duct; 5: Air conditioner controller; 6, 6a: Analysis device; 7: Central system; 20: Required air volume calculation part; 21: Air volume control part; 22: Required air volume notification part; 23: Status notification part; 24: Room temperature notification part; 30: Cooling coil; 31: Heating coil; 32: Fan; 50: Operation amount output part; 51: Air volume calculation part; 52: Fan rotation speed determination part; 53: Air volume control part; 54: Information generation part; 55: Fan rotation speed correction part; 60: Data accumulation part; 61, 61a: Re-determination part; 62: Static pressure excess/insufficiency information change part; 63: Room temperature prediction

part.

Claims:

[Claim 1] A variable air volume (VAV) air conditioning system, comprising:

an air conditioner;

a VAV unit, provided for each controlled area;

5 a first control part, configured to control, for each of the controlled area, an opening degree of a damper of the VAV unit in accordance with a required air volume determined in accordance with a load condition of the controlled area;

a status notification part, configured to transmit, for each of the VAV unit, static pressure excess/insufficiency information based on the opening degree of the damper;

10 a fan rotation speed determination part, configured to determine a fan rotation speed of the air conditioner based on a total required air volume summing up a value of the required air volume of each of the VAV unit;

a fan rotation speed correction part, configured to correct the fan rotation speed of the air conditioner based on total static pressure excess/insufficiency information integrating the static pressure excess/insufficiency information of each of the VAV unit; a second control part, configured to control a fan of the air conditioner, so as to arrive at the fan rotation speed determined by the fan rotation speed determination part and corrected by the fan rotation speed correction part;

15 a re-determination part, configured to perform re-determination on the static pressure excess/insufficiency information based on a room temperature or a room CO₂ concentration of the controlled area before the static pressure excess/insufficiency information of each of the VAV unit is integrated; and

20 a static pressure excess/insufficiency information change part, configured to change the static pressure excess/insufficiency information of each of the VAV unit based on a determination result of the re-determination part before the static pressure excess/insufficiency information of each of the VAV unit is integrated.

25 [Claim 2] The VAV air conditioning system as claimed in claim 1, wherein in a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within an allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

[Claim 3] The VAV air conditioning system as claimed in claim 2, wherein the allowable

temperature range comprises: a first allowable temperature range, which is a range in which a difference between the room temperature and a room temperature setting value of the controlled area is from negative infinity to a positive first predetermined temperature when cooling and a range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when heating; and a second allowable temperature range, which is a range in which the room temperature of the controlled area is from negative infinity to a positive second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating,

in a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

[Claim 4] The VAV air conditioning system as claimed in claim 1, wherein in a case where a difference between the room CO₂ concentration and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

[Claim 5] The VAV air conditioning system as claimed in claim 1, further comprising a room temperature prediction part configured to predict the room temperature of each of the controlled area in a future moment,

wherein in a case where at least one of the room temperature and a room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within an allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

[Claim 6] The VAV air conditioning system as claimed in claim 5, wherein the allowable temperature range comprises: a first allowable temperature range, which is a range in which a difference between the room temperature and a room temperature setting value of the controlled area is from negative infinity to a positive first predetermined temperature when cooling and a

range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when heating; and a second allowable temperature range, which is a range in which the room temperature of the controlled area is from negative infinity to a positive second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating,

in a case where at least one of the room temperature and the room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

[Claim 7] The VAV air conditioning system as claimed in claim 5 or 6, wherein in a case where the room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as appropriate is out of the allowable temperature range, the re-determination part determines that the static pressure is to be changed from appropriate to insufficient.

[Claim 8] The VAV air conditioning system as claimed in claim 1, further comprising a room CO₂ concentration prediction part configured to predict the room CO₂ concentration of each of the controlled area in a future moment,

wherein in a case where a difference between the room CO₂ concentration or a room CO₂ concentration prediction value and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, the re-determination part determines that the static pressure is to be changed from insufficient to appropriate.

[Claim 9] The VAV air conditioning system as claimed in claim 8, wherein in a case where a difference between the room CO₂ concentration prediction value and the room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as appropriate is out of the range from negative infinity to the positive predetermined concentration, the re-determination part determines that the static pressure is to be changed from appropriate to insufficient.

[Claim 10] An air conditioning control method, comprising:

a first step of controlling, for each controlled area, an opening degree of a damper of a variable air volume (VAV) unit in accordance with a required air volume determined in accordance with a load condition of the controlled area;

5 a second step of transmitting, for each of the VAV unit, static pressure excess/insufficiency information based on the opening degree of the damper;

a third step of determining a fan rotation speed of an air conditioner supplying air to the VAV unit based on a total required air volume summing up a value of the required air volume of each of the VAV unit;

10 a fourth step of correcting the fan rotation speed of the air conditioner based on total static pressure excess/insufficiency information integrating the static pressure excess/insufficiency information of each of the VAV unit;

a fifth step of controlling a fan of the air conditioner, so as to arrive at the fan rotation speed determined in the third step and corrected in the fourth step;

15 a sixth step of performing re-determination on the static pressure excess/insufficiency information based on a room temperature or a room CO₂ concentration of the controlled area before the static pressure excess/insufficiency information of each of the VAV unit is integrated; and

a seventh step of changing the static pressure excess/insufficiency information of each of the VAV unit based on a determination result of the sixth step before the static pressure excess/insufficiency information of each of the VAV unit is integrated.

[Claim 11] The air conditioning method as claimed in claim 10, wherein the sixth step comprises a step of, in a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as
25 insufficient falls within an allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

[Claim 12] The air conditioning method as claimed in claim 11, wherein the allowable temperature range comprises: a first allowable temperature range, which is a range in which a difference between the room temperature and a room temperature setting value of the controlled
30 area is from negative infinity to a positive first predetermined temperature when cooling and a range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when

heating; and a second allowable temperature range, which is a range in which the room temperature of the controlled area is from negative infinity to a positive second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating,

5 wherein the sixth step comprises a step of, in a case where the room temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

10 [Claim 13] The air conditioning method as claimed in claim 10, wherein the sixth step comprises a step of, in a case where a difference between the room CO₂ concentration and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, determining
15 that the static pressure is to be changed from insufficient to appropriate.

[Claim 14] The air conditioning method as claimed in claim 10, further comprising an eighth step of predicting the room temperature of each of the controlled area in a future moment,

 wherein the sixth step comprises a step of, in a case where at least one of the room temperature and a room temperature prediction value of the controlled area corresponding to the
20 VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within an allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

[Claim 15] The air conditioning method as claimed in claim 14, wherein the allowable temperature range comprises: a first allowable temperature range, which is a range in which a
25 difference between the room temperature and a room temperature setting value of the controlled area is from negative infinity to a positive first predetermined temperature when cooling and a range in which the difference between the room temperature and the room temperature setting value of the controlled area is from a negative first predetermined temperature to infinity when heating; and a second allowable temperature range, which is a range in which the room
30 temperature of the controlled area is from negative infinity to a positive second predetermined temperature when cooling and a range in which the room temperature of the controlled area is from a positive third predetermined temperature to infinity when heating,

wherein the sixth step comprises a step of, in a case where at least one of the room temperature and the room temperature prediction value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient falls within at least one of the first allowable temperature range and the second allowable temperature range, determining that the static pressure is to be changed from insufficient to appropriate.

[Claim 16] The air conditioning method as claimed in claim 14 or 15, wherein the sixth step comprises a step of, in a case where a room prediction temperature of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as appropriate is out of the allowable temperature range, determining that the static pressure is to be changed from appropriate to insufficient.

[Claim 17] The air conditioning method as claimed in claim 10, further comprising an eighth step of predicting the room CO₂ concentration of each of the controlled area in a future moment,

wherein the sixth step comprises a step of, in a case where a difference between the room CO₂ concentration or a room CO₂ concentration prediction value and a room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates a static pressure as insufficient falls within a range from negative infinity to a positive predetermined concentration, determining that the static pressure is to be changed from insufficient to appropriate.

[Claim 18] The air conditioning method as claimed in claim 17, wherein the sixth step comprises a step of, in a case where a difference between the room CO₂ concentration prediction value and the room CO₂ concentration setting value of the controlled area corresponding to the VAV unit whose static pressure excess/insufficiency information indicates the static pressure as insufficient is out of the range from negative infinity to the positive predetermined concentration, determining that the static pressure is to be changed from appropriate to insufficient.