TITLE

# AIR-CONDITIONING CONTROL METHOD AND AIR-CONDITIONING SYSTEM

## TECHNICAL FIELD

[0001] The present disclosure relates to an air-conditioning control method and an air-conditioning system.

## BACKGROUND

[0002] Japanese Patent No. 5284528 discloses an air-conditioning control device, an air-conditioning system, an air-conditioning control method, and an air-conditioning control program. The air-conditioning control system controls air-conditioning in a building of an air-conditioning target. The air-conditioning control system has a plurality of air conditioners, a plurality of temperature sensors, a plurality of humidity sensors, a central cooling/heating plant, and an air-conditioning cooperation controller.

[0003] The air conditioner has an outdoor air-cooling coil, a return air-cooling coil, and a fan. Each air conditioner transmits measured values acquired from the temperature sensor and the humidity sensor to the air-conditioning cooperation controller. The central cooling/heating plant has a chiller generating chilled water, a cooling tower cooling the cooling water, and a pump circulating the chilled water. The air-conditioning cooperation controller acquires measured values of the temperature sensor and the humidity sensor transmitted from each air conditioner and calculates a room temperature setpoint and a humidity setpoint so that energy consumption of a cooling tower, a chiller, a water pump, an outdoor air-cooling coil, return air-cooling coil, and a fan is minimized

within a range of comfort index set in advance.

[0004] Japanese Unexamined Patent Publication No. 2020-30010 discloses a ventilation system. A ventilation system includes a cough detection device detecting occurrence of cough or sneeze in a room, a ventilation device discharging air to an outside of the room, and a controller controlling the ventilation device. The controller acquires a degree of diffusion indicating likelihood that a substance released into the room due to the occurrence of the cough or sneeze will diffuse throughout a space within the room. The controller calculates a waiting time from the time when the cough or sneeze occurs until the ventilation device is activated, based on the obtained degree of diffusion. Then, the controller waits for the waiting time from the time when the cough detection device detects the occurrence of the cough or sneeze, and then activates the ventilation device.

[0005] By the way, for example, when air-conditioning is used in the summer, there is a problem that much energy is consumed when an indoor thermal environment is controlled only by temperature of the air. In addition, it is considered that, in order to reduce an infection risk with viruses or bacteria, the amount of outdoor air intake is increased. However, in order to increase the amount of outdoor air intake, in a case of a new construction, there is a possibility that the equipment capacity is increased, or in a case of an existing construction, there is a possibility that the equipment is required to be renewed, so that the cost increases. Furthermore, there is a possibility that the increase in the amount of outdoor air intake may lead to the increase in air-conditioning energy consumption. Therefore, there is room for improvement in terms of

energy saving as well.

SUMMARY

[0006] An object of the present disclosure is to provide an air-conditioning control method and an air-conditioning control system that capable of implementing energy saving and reducing an infection risk with viruses or the like.

[0007] An air-conditioning control method according to one aspect of the present disclosure is an air-conditioning control method controlling a temperature control device for cooling by controlling temperature in a room and an air movement control device controlling an air movement in the room. The air-conditioning control method includes a step of computing or storing a thermal comfort range indicating a relationship between the temperature and the air movement at which a person existing in the room feels comfortable; a step of computing or storing a first airspeed threshold, which is a minimum value of an airspeed being able to reduce an infection risk with bacteria or viruses in the room; a step of calculating a maximum temperature, which is a maximum value of the temperature within the thermal comfort range; a step of calculating a second airspeed threshold, which is an airspeed corresponding to the maximum temperature within the thermal comfort range; a step of controlling the temperature control device so that the maximum temperature is set to a temperature setpoint; and a step of controlling the air movement control device so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to an airspeed setpoint.

[0008] The air-conditioning system according to the present disclosure

includes: a temperature control device controlling temperature in a room for cooling; an air movement control device controlling an air movement in the room; a storage device computing and storing a thermal comfort range indicating a relationship between the temperature and the air movement at which a person existing in the room feels comfortable; and a control unit controlling the temperature control device and the air movement control device. The storage device computes or stores a first airspeed threshold, which is a minimum airspeed threshold being able to reduce an infection risk with bacteria or viruses in the room. The control unit calculates a maximum temperature, which is a maximum value of the temperature within the thermal comfort range, calculates a second airspeed threshold, which is an airspeed corresponding to the maximum temperature within the thermal comfort range, and controls the temperature control device so that the maximum temperature is set to a temperature setpoint, and controls the air movement control device so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to an airspeed setpoint.

[0009] In this air-conditioning control method and the air-conditioning system, the temperature control device performs cooling. Then, the thermal comfort range, which is the relationship between the temperature and the air movement at which the person existing in the room feels comfortable, is computed or stored, and the first airspeed threshold, which is the minimum airspeed threshold being able to reduce the infection risk, is computed or stored. By computing or storing the first airspeed threshold, the infection risk can be reduced by the air movement control device. In this air-conditioning control method, the maximum

temperature within the thermal comfort range is calculated, and a second airspeed threshold, which is an airspeed corresponding to the maximum temperature within the thermal comfort range, is calculated. Then, the temperature control device is controlled so that the maximum temperature is set to the temperature setpoint, and the air movement control device is controlled so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set. Therefore, during the cooling, the maximum temperature is set to the temperature setpoint, and the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set, so that the energy saving effect can be improved by raising the temperature during the cooling.

[0010] The air-conditioning control method may include, before the step of controlling the temperature control device, a step of, when the first airspeed threshold is higher than the second airspeed threshold, correcting the maximum temperature so that the temperature corresponds to the first airspeed threshold. In this case, when the first airspeed threshold is higher than the second airspeed threshold, the maximum temperature is corrected so that the temperature corresponds to the first airspeed threshold. Therefore, the energy saving effect and comfort can be further improved.

[0011] The interior of the room may be divided into the plurality of areas, and the air movement control device may be provided to each of the plurality of areas. In the step of computing or storing the thermal comfort range, in the step of computing or storing the thermal comfort range for each area and calculating the maximum temperature, the lowest value among the maximum temperatures of the plurality of thermal

comfort ranges in the plurality of areas may be calculated. In the step of calculating the second airspeed threshold, the second airspeed threshold, which is the minimum airspeed corresponding to the lowest value in each of the plurality of thermal comfort ranges, may be calculated for each area. In the step of controlling the temperature control device, the temperature control device is controlled so that the lowest value is set to the temperature setpoint, and in the step of controlling the air movement control device, the air movement control device may be controlled for each area so as to set the higher airspeed of the first airspeed threshold and the second airspeed threshold to the airspeed setpoint. In this case, the air movement control device is provided for each of the plurality of areas in the room, and the thermal comfort range is computed or stored for each area. Then, the second airspeed threshold, which is the minimum airspeed corresponding to the lowest value in each of the plurality of thermal comfort ranges, is calculated for each area, and the air movement control device is controlled for each area so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to the airspeed setpoint. Therefore, by controlling the air movement control device for each area, it is possible to more finely control the air movement for each of the plurality of areas. As a result, the energy saving effect can be improved and the comfort can be improved.

[0012] An air-conditioning control method according to another aspect of the present disclosure is an air-conditioning control method controlling a temperature control device for heating by controlling temperature in a room and an air movement control device controlling an air movement in

the room. The air-conditioning control method includes: computing or storing a thermal comfort range indicating a relationship between the temperature and the air movement at which a person existing in the room feels comfortable; computing or storing a first airspeed threshold, which is a minimum value of the airspeed being able to reduce an infection risk with bacteria or viruses in the room; calculating a minimum temperature, which is a minimum value of the temperature within the thermal comfort range; calculating a second airspeed threshold, which is an airspeed corresponding to the minimum temperature within the thermal comfort range; controlling the temperature control device so that the minimum temperature is set to a temperature setpoint; and controlling the air movement control device so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to an airspeed setpoint.

[0013] In this air-conditioning control method, the temperature control device performs heating. Then, similarly to the case of cooling, the thermal comfort range and a first airspeed threshold, which is a minimum value of the airspeed being able to reduce the infection risk, are computed or stored. Therefore, the infection risk can be reduced by the air movement control device. In this air-conditioning control method, the minimum temperature within the thermal comfort range is calculated, and a second airspeed threshold, which is an airspeed corresponding to the minimum temperature within the thermal comfort range, is calculated. Therefore, during the heating, the minimum temperature is set to the temperature setpoint, and the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set, so that the energy

saving effect can be increased by lowering the temperature during the heating.

[0014] In the air-conditioning control method described above, in controlling the air movement control device, the air movement control device may be controlled so that an upward air movement is generated from the air movement control device. In this case, the air movement control device generates the upward air movement during the heating. Since the upward air movement is generated, the air movement can be blown onto the ceiling, so that heat build-up on the ceiling can be mitigated. More specifically, it is possible to eliminate the vertical temperature distribution due to the difference in air density and avoid uncomfortable conditions.

[0015] According to the present disclosure, it is possible to implement energy saving and reduce an infection risk with viruses or the like.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a plan view illustrating an air-conditioning system according to an embodiment.

FIG. 2 is a diagram illustrating an example of a thermal comfort range.

FIG. 3 is a flowchart illustrating an example of steps of an air-conditioning control method according to a first embodiment.

FIG. 4 is a flowchart illustrating an example of steps of an air-conditioning control method according to a second embodiment.

FIG. 5 is a side view schematically illustrating an air movement control device.

## DETAILED DESCRIPTION

[0017] Hereinafter, embodiments of the air-conditioning control method and the air-conditioning control system according to the present disclosure will be described with reference to the drawings. In the description of the drawings, the same or corresponding elements are denoted by the same reference numerals, and redundant descriptions are omitted as appropriate. In addition, the drawings may be partially simplified or exaggerated for easy understanding, and the dimensional ratios and the like are not limited to those described in the drawings.

[0018] (First Embodiment)

In an air-conditioning control method and an air-conditioning control system 1 according to this embodiment, two control variables of temperature and air movement (for example, an airspeed) are optimized based on three objective functions of energy saving, improving of thermal comfort of occupants, and reducing the infection risk with viruses or bacteria. Thermal comfort is defined as a state of mind indicating satisfaction with a surrounding thermal environment. Six thermal environment elements (air temperature, radiant temperature, humidity, air movement, clothing, and metabolic rate) affect the physical heat exchange between the human body and the environment. However, since the clothing and the metabolic rate are personal factors, the air temperature, the radiant temperature, the humidity, and the air movement can be control targets. As comprehensive thermal environment indices that combine the above-described six thermal environment elements, PMV (predicted mean vote), PPD (predicted percentage of dissatisfied), SET* (standard new effective temperature), and the like are exemplified. Therefore, when grasping the thermal comfort of the individual under a

certain thermal environment, there is a way of finding a relationship between the above-described six thermal environment elements and the thermal comfort, or a way of finding a relationship between the thermal comfort and a comprehensive index such as PMV.

[0019] In addition, the elements constituting the indoor thermal environment include the air temperature, the radiant temperature, the humidity, and the air movement. The radiant temperature is a concept for considering the heat energy received by the human body due to infrared radiation from indoor surfaces such as walls and ceilings. As an example, mean radiant temperature corresponds to a weighted average value of the radiant temperature of each indoor surface using a shape factor. In the air-conditioning control method and the air-conditioning control system according to this embodiment, the energy required for air cooling can be reduced by raising a setpoint of the air temperature by using the air movement when using, for example, the air-conditioning for cooling in summer.

[0020] FIG. 1 is a diagram schematically illustrating a plan view of a building S to which an air-conditioning control method and an air-conditioning control system 1 according to this embodiment are adopted. As illustrated in FIG. 1, the air-conditioning control system 1 according to this embodiment is installed in a building S. For example, the building S is a building where users are fixed to some extent, such as an office building or a school.

[0021] As an example, the building S is a newly constructed building, and the air-conditioning control system 1 is introduced when constructing the building S. However, the building S may be an existing building,

and the air-conditioning control system 1 may be introduced into the existing building S. The building S has a room H, and the room H is defined by a ceiling and walls W.

[0022] The air-conditioning control system 1 has a temperature control device 2 controlling the temperature inside the room H (indoor) and an air movement control device 3 controlling the air movement inside the room. In the first embodiment, an example in which the temperature control device 2 performs cooling will be described. The temperature control device 2 supplies conditioned air K into the room. The temperature control device 2 is, for example, a VAV (variable air volume) unit. In this case, the temperature control device 2 has an airflow modulating mechanism. The air movement control device 3 is, for example, a ceiling fan.

[0023] For example, a plurality of areas A are provided to the room, and the plurality of areas A include a first area A1, a second area A2, a third area A3, and a fourth area A4. For example, a plurality (for example, four) of desks D are installed in each of the first area A1, the second area A2, the third area A3, and the fourth area A4. As an example, the room H is a room for 16 persons, one temperature control device 2 supplies air K to the room H, and one air movement control device 3 is installed for each four persons.

[0024] In this embodiment, the room H is provided with one temperature control device 2, and a plurality of (for example, four) air movement control devices 3. Therefore, a floor area of the room H handled by one temperature control device 2 is larger than a floor area of the room H handled by one air movement control device 3.

[0025] Therefore, the control of the air movement in the room H by the air movement control device 3 can be executed more finely than the control of the temperature of the room H by the temperature control device 2. That is, while the temperature control device 2 is capable of controlling each room H, the air movement control device 3 is capable of controlling each area A. The air movement generated by the air movement control device 3 has locality compared to the indoor temperature controlled by the temperature control device 2. Therefore, by controlling each of the plurality of air movement control devices 3, independent air movement control for each area A is possible.

[0026] With respect to reducing the infection risk with viruses, bacteria, or the like, by allowing the air movement to be strong (by increasing the airspeed), the contaminants scattered from the speaker are promoted to dilute, which can reduce the infection risk. On the other hand, thermal comfort is greatly affected by both the temperature and the air movement. In thermal comfort, temperature being comfortable and strength of the comfortable air movement exist for each a person (for example, an occupant of room H).

[0027] The energy saving is more affected by the temperature than by the strength of the air movement. As a specific example, during the cooling, energy consumption is greater when the temperature is lowered than when the air movement is strengthened. Therefore, during the cooling, by increasing the airspeed and increasing the temperature, the energy saving can be implemented while maintaining thermal comfort.

[0028] The thermal condition in which persons feel thermally comfortable (thermal preference) differs from person to person, and is

represented by, for example, the thermal comfort range B as illustrated in FIG. 2. In the example of FIG. 2, the portion with the darkest color is indicated as the thermal comfort range B. The thermal comfort range B indicates the relationship between the temperature and the air movement at which the person existing in the room feels comfortable. FIG. 2 illustrates the number of comfortable persons MAP for each area A. The vertical axis in FIG. 2 indicates the strength of the air movement (airspeed), and the horizontal axis in FIG. 2 indicates the temperature. In the thermal comfort range B in FIG. 2, in the case of cooling, the higher the temperature or the weaker the air movement (the airspeed is low), the higher the energy saving efficiency, and the stronger the air movement, the higher the reduction effect of the infection risk.

[0029]The thermal comfort range B (the number of comfortable persons) is generated, for example, from the results of conducting the questionnaire to the plurality of persons. In the example of FIG. 2, dark-colored areas indicate temperatures and air movement strengths that more persons answered were comfortable, and light-colored areas indicate temperatures and air movement strengths that fewer persons said they were comfortable. That is, the dark-colored area in FIG. 2 becomes the comfortable area for many persons (for example, four persons) belonging to the area A.

[0030] The thermal comfort range B is generated, for example, for each area A. In addition, the thermal comfort range B can be generated by a method other than the above-described questionnaire. For example, the thermal comfort range B may be generated as a MAP for each area A by generating the model for each individual and synthesizing the outputs of

the models. In addition, the thermal comfort range B may be generated as one sub-zone model or MAP after integrating the results of the above-described questionnaire for each area A.

[0031] As illustrated in FIGS. 1 and 2, the air-conditioning control system 1 includes, for example, an air movement temperature control device 10 controlling the indoor temperature and air movement. The air movement temperature control device 10 includes, for example, a processor (for example, CPU) executing an operating system and software (applications), a main storage unit configured with a ROM and a RAM, an auxiliary storage unit configured with a flash memory or the like, a communication control unit configured by a wireless communication module or the like, an input device, and an output device such as a display. However, the configuration of the air movement temperature control device 10 is not limited to the above-described one and can be changed as appropriate.

[0032] Each functional element of the air movement temperature control device 10 is implemented, for example, by reading predetermined software into the processor or the storage unit (for example, the main storage unit or auxiliary storage unit described above) and executing the software. The processor may allow the above-described communication control unit, input device, or output device to operate according to the software to read and write the data in the storage unit. The data or database used for the processing of the air movement temperature control device 10 may be stored in the storage unit.

[0033] The air movement temperature control device 10 includes a control unit 11 controlling the temperature control device 2 and the air

movement control device 3 and a storage device 12 computing and storing the thermal comfort range B. For example, the air movement temperature control device 10 further includes a sensor 13 detecting at least one of the indoor temperature and air movement. Moreover, the sensor 13 may be a sensor detecting the concentration of bacteria or viruses (hereinafter sometimes referred to as contaminants) in the room.

[0034] For example, the control unit 11 calculates a maximum temperature T1, which is a maximum value of the temperature within the thermal comfort range B. As an example, the control unit 11 calculates a lowest value V1 among the maximum temperatures T1 of the plurality of thermal comfort ranges B of the plurality of areas A. The storage device 12 computes or stores a first airspeed threshold F1, which is the minimum value of the airspeed being able to reduce the infection risk with bacteria or viruses in the room.

[0035] The first airspeed threshold F1 is, for example, the airspeed threshold value (lower limit) determined based on the measured value (or estimated value) of the contaminant concentration. This lower limit is determined based on experimental data obtained in advance from experiments or simulation results. Further, the storage device 12 may calculate the first airspeed threshold F1 by using the predetermined relational expression from the concentration of contaminants detected by the sensor 13 and may store the first airspeed threshold F1 obtained by the calculation. The predetermined relational expression is, for example, a linear expression representing the relationship between the concentration of contaminants (or the numerical value representing the amount of conversation such as noise) and the required airspeed from the

viewpoint of diluting the contaminants. For example, the storage device 12 computes and stores the first airspeed threshold F1 for each area A.

[0036] For example, the control unit 11 calculates a second airspeed threshold F2, which is an airspeed corresponding to the maximum temperature T1 within the thermal comfort range B. As an example, the control unit 11 calculates the second airspeed threshold F2, which is the minimum airspeed corresponding to the lowest value V1 in each of the plurality of thermal comfort ranges B of the plurality of areas A, for each area A.

[0037] Furthermore, the control unit 11 controls the temperature control device 2 so that the maximum temperature T1 is set to the temperature setpoint. Then, the control unit 11 controls the air movement control device 3 so that the higher airspeed out of the first airspeed threshold F1 and the second airspeed threshold F2 is set to the airspeed setpoint. The air movement control device 3 is controlled by this control unit 11 for each area A.

[0038] Next, the steps of the air-conditioning control method according to this embodiment will be described with reference to FIG. 3. FIG. 3 is a flowchart illustrating an example of the steps of the air-conditioning control method according to this embodiment. First, the storage device 12 computes or stores the thermal comfort range B (step of computing or storing the thermal comfort range, step S11). At this time, the thermal comfort range B is stored for each area A, for example, as illustrated in FIG. 2. The thermal comfort range B may be stored in advance by the storage device 12, or the thermal comfort range B computed by the storage device 12 from the values detected by the sensor 13 may be

temporarily stored in a short-term memory.

[0039] Next, the storage device 12 computes or stores the first airspeed threshold F1 (step of computing or storing the first airspeed threshold, step S12). For example, the storage device 12 computes and stores the lowest airspeed threshold being able to reduce the infection risk as the first airspeed threshold F1. As an example, the storage device 12 may compute the first airspeed threshold F1 from the amount of conversation detected by the sensor 13.

[0040] Subsequently, the control unit 11 calculates the maximum temperature T1, which is the maximum temperature within the thermal comfort range B (the step of calculating the maximum temperature, step S13). For example, the control unit 11 calculates the lowest value V1 among the maximum temperatures T1 of the plurality of thermal comfort ranges B in the plurality of areas A.

[0041] Then, the control unit 11 calculates the second airspeed threshold F2, which is an airspeed corresponding to the maximum temperature T1 within the thermal comfort range B (step of calculating the second airspeed threshold, step S14). More specifically, the control unit 11 calculates the second airspeed threshold F2, which is the minimum airspeed corresponding to the lowest value V1 among each of the plurality of thermal comfort ranges B for each area A.

[0042] After that, the control unit 11 determines the temperature setpoint to control the temperature control device 2 and determines the airspeed setpoint to control the air movement control device 3 (step S15). Specifically, the control unit 11 controls the temperature control device 2 so that the maximum temperature T1 is set to the temperature setpoint

(step of controlling the temperature control device).

[0043] The control unit 11 controls the air movement control device 3 so that the higher airspeed out of the first airspeed threshold F1 and the second airspeed threshold F2 is set to the airspeed setpoint (step of controlling the air movement control device). The control unit 11 controls the air movement control device 3 described above for each area A. As described above, the control unit 11 controls the temperature control device 2 and each air movement control device 3, the air K is supplied from the temperature control device 2, and each air movement control device 3 generates the air movement at the airspeed setpoint, and a series of steps are completed.

[0044] Next, functions and effects obtained from the air-conditioning control system 1 and the air movement control method according to this embodiment will be described. In the air-conditioning control system 1 and the air-conditioning control method according to this embodiment, the temperature control device 2 performs cooling. Then, the thermal comfort range B, which is the relationship between the temperature and the air movement at which the person existing in the room feels comfortable, is computed or stored, and the first airspeed threshold F1, which is the minimum value of the airspeed being able to reduce the infection risk, is computed or stored. By computing or storing the first airspeed threshold F1, the air movement control device 3 can reduce the infection risk. Furthermore, the thermal comfort range B, which is the relationship between the temperature and the air movement at which the person feels comfortable, is computed or stored, and the airspeed and the temperature setpoint are determined from the thermal comfort range B,

so that comfort can be improved.

[0045] In this air-conditioning control method and the air-conditioning control system 1, the maximum temperature T1 within the thermal comfort range B is calculated, and the second airspeed threshold F2, which is an airspeed corresponding to the maximum temperature T1 within the thermal comfort range B, is calculated. Then, the temperature control device 2 is controlled so that the maximum temperature T1 is set to the temperature setpoint, and the air movement control device 3 is controlled so that the airspeed is set to the higher airspeed out of the first airspeed threshold F1 and the second airspeed threshold F2. Therefore, during the cooling, the maximum temperature T1 is set to the temperature setpoint, and the higher airspeed out of the first airspeed threshold F1 and the second airspeed threshold F2 is set, so that the energy saving effect can be improved by setting the maximum temperature T1 during the cooling and the infection risk can be reliably reduced by increasing the airspeed.

[0046] In the air-conditioning control method, before the step of controlling the temperature control device 2, when the first airspeed threshold F1 is higher than the second airspeed threshold F2, a step of correcting the maximum temperature T1 so that the temperature corresponding to the first airspeed threshold F1 is obtained may be provided. The maximum temperature T1 may be corrected to the higher value so that the temperature corresponds to the first airspeed threshold F1. In this case, when the first airspeed threshold F1 is higher than the second airspeed threshold F2, the maximum temperature T1 is corrected so that the temperature corresponds to the first airspeed threshold F1.

Therefore, since the temperature of the temperature control device 2 can be set higher during the cooling, the energy saving effect and the comfort can be further improved.

[0047] In this embodiment, the interior of the room is divided into a plurality of areas A, and the air movement control device 3 is provided to each of the plurality of areas A. In the step of computing or storing the thermal comfort range B, the thermal comfort range B is computed or stored for each area A, and in the step of calculating the maximum temperature T1, the lowest value V1 among the maximum temperatures T1 of the plurality of thermal comfort ranges B in the plurality of areas A is calculated. In the step of calculating the second airspeed threshold F2, the second airspeed threshold F2, which is the minimum airspeed corresponding to the lowest value V1 in each of the plurality of thermal comfort ranges B, is calculated for each area A. In the step of controlling the temperature control device 2, the temperature control device 2 is controlled so as to set the lowest value V1 as the temperature setpoint. In the step of controlling the air movement control device 3, the air movement control device 3 is controlled for each area so that the higher airspeed out of the first airspeed threshold F1 and the second airspeed threshold F2 is set to the airspeed setpoint.

[0048] Therefore, the air movement control device 3 is provided to each of the plurality of areas A in the room, and the thermal comfort range B is computed or stored for each area A. Then, the second airspeed threshold F2, which is the minimum airspeed corresponding to the lowest value V1 in each of the plurality of thermal comfort ranges B, is calculated for each area A, and the air movement control device 3 is

controlled for each area A so that the higher airspeed out of the first airspeed threshold F1 and the second airspeed threshold F2 is set to the airspeed setpoint. Therefore, by controlling the air movement control device 3 for each area A, the air movement for each of the plurality of areas A can be more finely controlled.

[0049] Furthermore, in the air-conditioning control method and the air-conditioning control system 1 according to this embodiment, the appropriate airspeed threshold and temperature are calculated from the qualitative relationship among the MAP (thermal comfort range B), the control variables (temperature and air movement), and the objective functions (energy saving, improving of human thermal comfort, and reducing of the infection risk with viruses, bacteria, or the like), so that the appropriate temperature and airspeed can be calculated by a simple process.

[0050] (Second Embodiment)

Next, an air-conditioning control method according to a second embodiment will be described. An air-conditioning control system used in the air-conditioning control method according to the second embodiment is the same as, for example, the air-conditioning control system 1 used in the air-conditioning control method according to the first embodiment. The second embodiment differs from the first embodiment in that the air-conditioning control system 1 performs heating. In the following, description overlapping with the description of the first embodiment are denoted by the same reference numerals and omitted as appropriate.

[0051] FIG. 4 is a flowchart illustrating an example of steps of the air-

conditioning control method according to the second embodiment. First, the storage device 12 computes or stores the thermal comfort range B (a step of computing or storing the thermal comfort range, step S21), and the storage device 12 computes or stores the first airspeed threshold F1 (a step of computing or storing the first airspeed threshold, step S22). For example, each process of step S21 and step S22 is the same as each process of step S11 and step S12 which were mentioned above.

[0052] Next, the control unit 11 calculates the minimum temperature, which is a minimum value of the temperature within the thermal comfort range B (step of calculating the minimum temperature, step S23). For example, the control unit 11 calculates the highest value among the minimum temperatures of the plurality of thermal comfort ranges B in the plurality of areas A.

[0053] In the second embodiment, for example, the energy required for heating the air can be reduced by lowering the set value of the air temperature during the using of the heating in winter. That is, during the heating, by lowering the temperature, the energy saving can be implemented while maintaining the thermal comfort. In the thermal comfort range B in FIG. 2, in the case of heating, the lower the temperature or the weaker the air movement (the lower the airspeed), the higher the energy saving efficiency, and the stronger the air movement, the higher the reduction effect of the infection risk.

[0054] Then, the control unit 11 calculates the second airspeed threshold being the airspeed corresponding to the minimum temperature within the thermal comfort range B (step of calculating the second airspeed threshold, step S24). More specifically, the control unit 11 calculates

the second airspeed threshold, which is the minimum airspeed corresponding to the highest value described above in each of the plurality of thermal comfort ranges B, for each area A.

[0055] After that, the control unit 11 controls the temperature control device 2 so that the minimum temperature is set to the temperature setpoint (step of controlling the temperature control device, step S25) and controls each air movement control device 3 so that the higher airspeed is set to the airspeed setpoint out of the first airspeed threshold F1 and the second airspeed threshold (step of controlling the air movement control device, step S25).

[0056] As illustrated in FIG. 5, the control unit 11 may control the air movement control device 3 so that an upward air movement X is generated from the air movement control device 3. As a specific example, when the air movement control device 3 is a ceiling fan, the control unit 11 rotates the shaft of the air movement control device 3 in the direction opposite to that during the cooling, so that the upward air movement X is caused to be generated from the air movement control device 3. After the air K is supplied from the temperature control device 2 and each air movement control device 3 generates the air movement at the airspeed setpoint, a series of steps is completed.

[0057] Next, functions and effects obtained from the air-conditioning control method according to the second embodiment will be described. In the air-conditioning control method according to the second embodiment, the temperature control device 2 performs heating. Then, similarly to the case of cooling, the thermal comfort range B and the first airspeed threshold F1, which is the minimum value of the airspeed being

able to reduce the infection risk, are stored. Therefore, the air movement control device 3 can reduce the infection risk and implement energy saving.

[0058] In the air-conditioning control method according to the second embodiment, the minimum temperature within the thermal comfort range B is calculated, and a second airspeed threshold, which is an airspeed corresponding to the minimum temperature within the thermal comfort range B, is calculated. Therefore, during the heating, the minimum temperature is set to the temperature setpoint, and the higher airspeed out of the first airspeed threshold F1 and the second airspeed threshold is set, so that the energy saving effect can be increased by setting the maximum temperature T1 during the heating, and the airspeed can be increased to more reliably reduce the infection risk. Furthermore, even during the heating, when the first airspeed threshold F1 is higher than the second airspeed threshold F2 before the step of controlling the temperature control device 2, the air-conditioning control method may include the step of correcting the maximum temperature T1 so as to be the temperature corresponding to the first airspeed threshold F1. In this case, when the first airspeed threshold F1 is higher than the second airspeed threshold F2, the maximum temperature T1 is corrected so that the temperature corresponds to the first airspeed threshold F1. Therefore, even during the heating, the energy saving effect and the comfort can be further improved.

[0059] In the air-conditioning control method according to the second embodiment, in the step of controlling the air movement control device 3, the air movement control device 3 may be controlled so that the upward

air movement X is generated from the air movement control device 3. In this case, during the heating, the air movement control device 3 generates the upward air movement. In this case, the upward air movement X is generated, and thus, the air movement X can be blown onto the ceiling, so that by suppressing the heat build-up on the ceiling, the ceiling heat can be circulated down the room H. Therefore, during the heating, warm air can more effectively flow downward in the room H.

[0060] More specifically, by generating the upward air movement X from the air movement control device 3 during the heating, the air in the room can be gently mixed while suppressing a low airspeed in the living area of the room H. As a result, it is possible to reduce the infection risk and eliminate the vertical temperature distribution, so that the situation where the ceiling temperature is high and the foot temperature is low can be eliminated. That is, the situation in which the temperature of the ceiling is high and the temperature of the feet is low is an uncomfortable situation in terms of thermal comfort of person, but in the second embodiment, such the uncomfortable situation can be resolved.

[0061] Various embodiments of the air-conditioning control method and the air-conditioning control system according to the present disclosure have been described above. However, the present disclosure is not limited to the above-described embodiments, and can be modified as appropriate within the scope of the claims. That is, the function, configuration, shape, size, number, material and arrangement of each component of the air-conditioning control system according to the present disclosure, and the contents and order of the steps of the air-conditioning

control method can be changed as appropriate within the above-described scope.

[0062] For example, in the above-described embodiments, the temperature control device 2, which is a VAV unit, and the air movement control device 3, which is a ceiling fan, have been described. However, the type of temperature control device and the type of air movement control device are not limited to the above-described embodiments. For example, the temperature control device may be a CAV (constant air volume) system or a multi-package air-conditioning system. The air movement control device may be a floor fan or may be a desk fan.

[0063] In the above-described embodiment, the thermal comfort range B, which is the number of thermal comfort persons MAP illustrated for each area A, has been described. However, the thermal comfort range need not be a MAP such as the number of thermal comfort persons MAP, and may be tabular data. The thermal comfort range need not be data that can be displayed in such as the form of the MAP, but may be internal data or numerical data stored in the storage device. Further, the thermal comfort range may be a mathematical model such as a polynomial approximation model or a machine learning model, or the like. Thus, the data format of the thermal comfort range is not particularly limited.

[0064] In the embodiment described above, the first airspeed threshold F1 is set for each area A by the storage device 12. For example, the storage device 12 may determine which area A has a large amount of conversation (whether the infection risk is high) from the detection value of the sensor 13, which is a noise sensor. Then, as a result of the determination, the storage device 12 may set the first airspeed threshold

F1 high only in the area A where the amount of conversation is large. In this case, the higher first airspeed threshold F1 is set for the area A where the amount of conversation is large, which contributes to further reduction of the infection risk.

[0065] Furthermore, the storage device 12 may change the first airspeed threshold F1 in consideration of the history of noise data detected by the sensor 13. For example, the storage device 12 may set the first airspeed threshold F1 from an integrated value of noise data for the past N minutes (N is a natural number of, for example, N=10).

[0066] In the above-described embodiments, the air-conditioning control method and the air-conditioning control system 1 optimizing the two control variables of temperature and air movement (for example, airspeed) have been described. At least one of the radiant temperature and the humidity may be added to this control variable. Further, to add both the air temperature and the radiant temperature, the combined working temperature of the air temperature and the radiant temperature may be added to the control variables.

[0067] For example, instead of the thermal comfort range B in FIG. 2, the thermal comfort range, indicating the relationship between the working temperature and the air movement at which the person existing in the room feels comfortable, may be used. In this case, the appropriate working temperature set value can be obtained by the same method to that of the above-described embodiment. Furthermore, SET* (total temperature index) may be added to control variables to take at least one of the amount of clothing and the amount of metabolism into consideration. Also in this case, the optimum SET* setting value can

be obtained by the same method as in the above-described embodiment.

[0068] In the above-described embodiment, the example in which one temperature control device 2 is provided and the plurality of air movement control devices 3 are provided to the room H has been described. However, the number of temperature control devices 2 and the number of air movement control devices 3 provided to the room can be changed as appropriate. For example, the room H may be provided with one temperature control device 2 and one air movement control device 3. In addition, the room H may be provided with a plurality of temperature control devices 2 and one air movement control device 3.

[0069] In the above-described embodiment, the air-conditioning control method and the air-conditioning control system 1 that are adopted to the building S, which is a building such as an office building or a school, where the number of users is fixed to some extent, have been described. This type of building is suitable for capturing and reflecting comfort preferences of the persons. However, the type of building to which the air-conditioning control method and the air-conditioning control system according to the present disclosure are adopted is not particularly limited.

REFERENCE SIGNS LIST

[0070] 1: air-conditioning control system, 2: temperature control device, 3: air movement control device, 10: air movement temperature control device, 11: control unit, 12: storage device, 13: sensor, A: area, A1: first area, A2: second area, A3: third area, A4: fourth area, B: thermal comfort range, D: desk, F1: first airspeed threshold, F2: second airspeed threshold, H: room, K: air, S: building, T1: maximum temperature, V1: lowest value, W: wall, X: air movement.

WHAT IS CLAIMED IS:

1. An air-conditioning control method controlling a temperature control device for cooling by controlling temperature in a room and an air movement control device controlling an air movement in the room, the air-conditioning control method comprising:

computing or storing a thermal comfort range indicating a relationship between the temperature and the air movement at which a person existing in the room feels comfortable;

computing or storing a first airspeed threshold, which is a minimum value of an airspeed being able to reduce an infection risk with bacteria or viruses in the room;

calculating a maximum temperature, which is a maximum value of the temperature within the thermal comfort range;

calculating a second airspeed threshold, which is an airspeed corresponding to the maximum temperature within the thermal comfort range;

controlling the temperature control device so that the maximum temperature is set to a temperature setpoint; and

controlling the air movement control device so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to an airspeed setpoint.

2. The air-conditioning control method according to claim 1, wherein before the controlling the temperature control device, when the

first airspeed threshold is higher than the second airspeed threshold, correcting the maximum temperature so as to be temperature corresponding to the first airspeed threshold.

3. The air-conditioning control method according to claim 1 or 2,

wherein an interior of the room is divided into a plurality of areas,

wherein the air movement control device is provided to each of the plurality of areas,

wherein the computing or storing of the thermal comfort range includes computing or storing the thermal comfort range for each of the areas;

wherein the calculating of the maximum temperature includes calculating the lowest value among the maximum temperatures of the plurality of thermal comfort ranges in the plurality of areas;

wherein the calculating of the second airspeed threshold includes calculating the second airspeed threshold, which is the minimum airspeed corresponding to the lowest value in each of the plurality of thermal comfort ranges, for each of the areas;

wherein the controlling of the temperature control device includes controlling the temperature control device so that the lowest value is set to a temperature setpoint; and

wherein the controlling of the air movement control device includes controlling the air movement control device for each area so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to an airspeed setpoint.

4. An air-conditioning control method controlling a temperature control device for heating by controlling temperature in a room and an air movement control device controlling an air movement in the room, the air-conditioning control method comprising:

computing or storing a thermal comfort range indicating a relationship between the temperature and the air movement at which a person existing in the room feels comfortable;

computing or storing a first airspeed threshold, which is a minimum value of the airspeed being able to reduce an infection risk with bacteria or viruses in the room;

calculating a minimum temperature, which is a minimum value of the temperature within the thermal comfort range;

calculating a second airspeed threshold, which is an airspeed corresponding to the minimum temperature within the thermal comfort range;

controlling the temperature control device so that the minimum temperature is set to a temperature setpoint; and

controlling the air movement control device so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to an airspeed setpoint.

5. The air-conditioning control method according to claim 4, wherein, in controlling the air movement control device, the air movement control device is controlled so that an upward air movement is generated from the air movement control device.

6. An air-conditioning system comprising:

a temperature control device controlling temperature in a room for cooling;

an air movement control device controlling an air movement in the room;

a storage device computing and storing a thermal comfort range indicating a relationship between the temperature and the air movement at which a person existing in the room feels comfortable; and

a control unit controlling the temperature control device and the air movement control device,

wherein the storage device computes or stores a first airspeed threshold, which is a minimum airspeed threshold being able to reduce an infection risk with bacteria or viruses in the room, and

wherein the control unit:

calculates a maximum temperature, which is a maximum value of the temperature within the thermal comfort range,

calculates a second airspeed threshold, which is an airspeed corresponding to the maximum temperature within the thermal comfort range, and

controls the temperature control device so that the maximum temperature is set to a temperature setpoint, and controls the air movement control device so that the higher airspeed out of the first airspeed threshold and the second airspeed threshold is set to an airspeed setpoint.