

Air conditioning unit

Field of the invention

[0001] The present invention relates to an air conditioning device, and a method
5 for air conditioning a confined space.

Background of the invention

[0002] Air conditioning devices integrated into the ceiling of confined spaces are well known. Among these devices, a first type relates to static-type cold beams, in which
10 the air passes through a cooled exchanger, the air flow being created by simple convection.

[0003] A second type of cold beam relates to dynamic-type cold beams in which a flow of fresh air coming from outside the confined space is mixed with secondary air coming from the room to be air conditioned. In this type of device, the primary air is
15 injected at high pressure into nozzles, causing suction of secondary air by means of the Venturi effect. This type of device has many advantages. The first advantage is that the injection of fresh air makes it possible to refresh the air in the confined space. The primary fresh air may further be dried so as to avoid condensation phenomena. Lastly, the secondary air passes into a cooled heat exchanger before mixing, which increases
20 the cooling capacity of the whole device.

[0004] However, these dynamic cold beams have other drawbacks that the present invention will seek to reduce. For instance, this type of device is generally noisy. In fact, for optimal operation, the ratio between the intake of primary fresh air and the recirculation of secondary air should be approximately 1:7. However, to obtain such a
25 ratio purely by means of the Venturi effect, the pressure of the primary air and its speed in the nozzles cause noise that is difficult to bear continuously. Furthermore, these dynamic beams generally work with a suboptimal primary air/secondary air ratio, generally comprised between 1:2 and 1:6. This low ratio involves an air renewal in the medium exceeding what is necessary, involving higher energy consumption than what is
30 strictly necessary.

[0005] European patent application EP 1,319,901 discloses a device comprising two Venturi-type devices positioned in series making it possible to mix so-called primary fresh air with so-called secondary recirculated air. Nevertheless, the inlet pressure of the second Venturi of the device is greatly insufficient, and does not make it possible to achieve a sufficient secondary air suction, and the ratio between secondary air and primary air is still insufficient.

Aim of the invention

[0006] The present invention aims to propose a dynamic cold beam air conditioning device, having reduced noise while offering an improved primary air/secondary (recirculated) air ratio.

[0007] According to certain preferred embodiments of the invention, it also aims to improve the thermal comfort related to the use of the device according to the invention.

Summary of the invention

[0008] The present invention relates to an air conditioning device comprising a primary air intake pipe (chamber) connected to the inlet of a first Venturi-type device (induction unit) whereof the suction communicates with a first secondary air intake pipe (chamber), the outlet of the first Venturi-type device communicating with the inlet of a second Venturi-type device (induction unit) whereof the suction is connected to a second secondary air intake pipe (chamber) comprising a main heat exchanger.

[0009] The outlet of this device communicates directly or indirectly with the room to be air conditioned.

[0010] Preferably, the first Venturi-type device comprises a primary air inlet nozzle comprising a diameter restriction at its free end, said free end emerging in a suction chamber communicating with the first secondary air intake pipe, said suction chamber comprising an outlet orifice across from the outlet of said inlet nozzle, said outlet orifice communicating with the inlet of the second Venturi-type device.

[0011] Advantageously, the second Venturi-type device comprises an intake (or mixing) chamber, the intake chamber having a section at least twice as large as the outlet orifice of the suction chamber of the first Venturi-type device.

[0012] Advantageously, the second Venturi-type device comprises a plate pierced with orifices, said plate separating the intake chamber communicating with the outlet of the first mixing device and a mixing chamber communicating with the second secondary air intake pipe, said orifices producing, during use, a Venturi effect suctioning the secondary air from the secondary air intake pipe.

[0013] Preferably, the device according to the invention comprises an adjustable gate or valve making it possible to inject primary air directly at the inlet of the second Venturi-type device, downstream from the first Venturi-type device, so as to be able to regulate the total mixture ratio between the primary air and the secondary air.

[0014] Advantageously, the first secondary air intake pipe comprises a second heat exchanger making it possible to cool the secondary air during use.

[0015] Preferably, the heat exchanger(s) comprise vertical fins, and a device discharging condensation at the bottom thereof.

[0016] A second aspect of the invention relate to a façade, a façade element or an element allowing access to the façade of a building comprising an air conditioning device according to any one of the preceding claims.

[0017] Advantageously, the façade according to the invention comprises two walls separated by a ventilation space, the first and second secondary air intake pipes communicating with said ventilation space.

[0018] The second wall may be of the curtain or helioscreen type, or preferably, the façade will be of the active façade type.

[0019] A third aspect of the invention relates to a method for air conditioning a confined space comprising the following steps:

a. drawing in outside air, called primary air, and bringing it to a predetermined pressure;

b. injecting said primary air into a Venturi-type device, suctioning and mixing air from the confined space, called secondary air, with the primary air, the

secondary air passing, before mixing, into a first heat exchanger regulated to a setpoint temperature thus obtaining a first air mixture;

c. injecting the first air mixture into a second Venturi-type device, suctioning and mixing secondary air with said first air mixture, the secondary air passing, before mixing, into a second heat exchanger regulated to a setpoint temperature;

d. reinjecting the obtained air mixture into the confined space.

[0020] According to preferred embodiments of the invention, the air conditioning method according to the invention further comprises one or a suitable combination of several of the following features:

- the first air mixture is compressed in a mixing chamber communicating with the outlet orifice of the suction chamber, said intake chamber having a section at least twice as large as the outlet orifice of the suction chamber, so as to cause compression of the first air mixture;

- said predetermined pressure is comprised between 100 and 1,000 Pa, preferably between 300 and 500 Pa;

- the ratio between the intake of primary air and secondary air in the first mixing device is comprised between 0.7 and 2.5, preferably between 0.9 and 2.5, advantageously greater than 1.6;

- the flow ratio between the intake of the first air mixture and secondary air in the second mixing device is comprised between 2 and 4;

- the pressure of the first air mixture at the inlet of the second Venturi device is comprised between 50 and 200 Pa, preferably between 70 and 150 Pa;

- the secondary air flows in a ventilated space between two walls of an active façade before being taken into the first and second mixing chambers;

- the primary air withdrawn in step (a) is brought to a predetermined temperature before being injected into said first Venturi-type device.

Brief description of the figures

[0021] Figure 1 shows a stripped down view of an exemplary air conditioning device according to the invention.

[0022] Figure 2 shows a side sectional view along plane AA" of figure 1.

[0023] Figure 3 shows a side sectional view along plane BB' of figure 1.

5 **[0024]** Figure 4 shows a sectional side view along plane BB' of figure 1, the device comprising a bypass in the open position.

Detailed description of the invention

10 **[0025]** The present invention relates to an air conditioning device 10 of the dynamic cold beam type comprising a double induction module for secondary air, making it possible, during use, to increase the ratio between the flow rate of outside primary air 18, 22 injected into the room to be air conditioned and the flow rate of secondary recirculated air 16, 17. The use of two Venturi-type induction modules, arranged in series, makes it possible to reduce noise, without increasing the necessary
15 primary air pressure, while making it possible to increase the secondary air flow rate for a given primary air flow rate.

[0026] A Venturi-type device, or induction device, refers to any type of device in which a first flow of air is accelerated by a section restriction of the fluid path causing suctioning of a second air flow by means of the Venturi effect. It typically involves a
20 device of the ejector or eductor type, in the form of nozzles or diaphragms, or more complex devices comprising an inlet nozzle, a suction chamber and an outlet nozzle. A Venturi device inlet refers to the inlet for the first flow of air.

[0027] Preferably, the first Venturi device, into which the air conditioned air 18 coming from an external air conditioning battery is injected, comprises an injection
25 nozzle 3 comprising a restriction at its free end. This nozzle opens into a suction chamber 2 communicating with a secondary air pipe 9 (coming from the room to be air conditioned). The suction chamber 2 also comprises an outlet orifice 15 across from the outlet of the injection nozzle 3. This orifice 15 will advantageously be extended by a profiled ejection nozzle, so as to reduce the turbulence and the noise generated by that
30 turbulence.

[0028] Preferably, the first Venturi device is dimensioned such that the flow ratio between the primary air 18 and the air 17 induced by the first Venturi device is comprised between 0.7 and 1.5.

[0029] Advantageously, the second Venturi-type device comprises an intake chamber, the intake chamber having a section that is at least twice as large as the outlet orifice of the suction chamber. The increased section of the intake chamber allows the compression of the first air mixture, which considerably improves the air induction by the second Venturi-type device.

[0030] The temperature of the primary air 18 will preferably be comprised between 14 and 18°C as a function of the required cooling power. This primary air 18 will further have a controlled humidity level so as to reduce the relative humidity of the room, in order to prevent any condensation phenomenon. Lastly, the pressure of the primary air 18 will preferably be comprised between 300 and 500 Pa, ideally approximately 400 Pa.

[0031] The pressures used in this description are of course relative pressures with respect to the ambient atmospheric pressure (pressure difference relative to the atmosphere).

[0032] The second induction device will preferably assume the form of a wall (plate) separating the intake or mixing chamber 4, into which opens the outlet 15 of the first Venturi device, from a second mixing chamber 6, into which opens a second secondary air intake pipe 11. This second intake pipe comprises a main heat exchanger 8 making it possible to effectively cool the secondary air flow 16 induced by the second Venturi device.

[0033] The wall 14 will comprise orifices 5 communicating between the first mixing chamber 4 and the second mixing chamber 6. These orifices 5 will either assume the form of simple diaphragms, or of nozzles causing an increase in the speed of the air, and thus a Venturi effect suctioning the secondary air 16 through the primary heat exchanger 8.

[0034] The pressure in the first mixing chamber 4 is preferably comprised between 50 and 100 Pa, so as to reduce the noise generated by the device.

[0035] The flow ratio between the intake of secondary air 16 of the second Venturi device and the outlet 19 of the first induction device is preferably comprised between 2 and 4, bringing the total ratio between primary air and air induced by the two Venturi devices to a value greater than approximately 4, preferably greater than 6, and even advantageously greater than 7.

[0036] Advantageously, a bypass valve 20, 21 between a primary air distribution pipe 12 and the first mixing chamber 4, so as to be able to increase the primary air injection 22 (primary air/secondary air ratio), for example when an unusual number of occupants are in the room. Figure 4 shows the operation of the device when the valve 21 is in the open position. In that case, a primary air flow 22 is admitted directly into the inlet chamber 4. In that case, preferably, the first secondary air intake pipe will include a non-return device (not shown), for example in the form of a gate preventing a reverse flow of primary air.

[0037] A secondary heat exchanger 7 can advantageously be placed on the fluid path of the secondary air flow 17 upstream from the suction of the first Venturi-type device. This secondary heat exchanger 7 makes it possible on the one hand to increase the total power of the device, and on the other hand to regulate the humidity of the mixture in the first chamber 4.

[0038] Preferably, the setpoint temperature of the heat exchangers 7, 8 will be a temperature comprised between 14 and 20°C, so as to avoid condensation while offering sufficient cooling power. This setpoint temperature will be adapted as a function of the necessary power and the relative humidity of the secondary air.

[0039] Preferably, the air conditioning module (device) of the invention is integrated into the façade, above the windows, so as to induce a secondary air flow in front of the hot zone caused by the window of the building. This hot zone may advantageously be optimized by using devices simulating an active façade, such as curtains or helioscreens.

[0040] Advantageously, the air conditioning module according to the invention is integrated into an active façade comprising a ventilated empty space comprised between two walls, the intake pipes 9, 11 for secondary air being connected to said ventilated empty space. In that case, the air conditioned secondary air circulation

between the two walls makes it possible to cool the inner wall, and thus to improve the comfort of the air conditioned room, the walls of the room having a lower temperature, which improves comfort.

[0041] The arrangement in the façade makes it possible to use vertical exchangers, which allows an easy collection and discharge of any condensation on the fins of those exchangers.

[0042] The integration of the air conditioning module of the invention into the façade also makes it possible to reduce the bulk, the primary air and cold water channels easily being able to be integrated into said facade, avoiding having to integrate the beams into the ceiling, which poses installation and maintenance difficulties.

[0043] The device according to the invention may advantageously incorporate one or more charcoal filters. Furthermore, the inner surfaces of the mixing chambers and Venturi devices may be covered with catalytic paint comprising Ag ions or photocatalytic titanium oxide paint making it possible, through the use of UV light sources, to reduce the volatile organic compounds present in the room.

[0044] The primary fresh air can also be taken directly from the façade using a fan, the humidity regulation then being done directly along the heat exchangers, using a condensate tub placed below the heat exchangers.

Example

[0045] One exemplary embodiment of a device 10 according to the invention is shown in figures 1 to 4. This device is integrated into an active façade in which the air is heated by the action of the sun in a ventilated empty space comprised between two windows. The air in the ventilated empty space communicates with the room to be air conditioned by the bottom of the active window, so as to increase the natural convection through the device, thereby further improving the secondary air flow rate.

[0046] In this device, a distribution pipe 12 placed on the façade brings in the conditioned primary air. The air in this pipe is kept at a pressure of 410 Pa and a temperature of approximately 14°C. The humidity of this primary air is approximately 90%. This air is conditioned using a first centralized battery for the entire building. The

energy consumption of this first battery, per air conditioning module, is approximately 283 W for an outside temperature of 32°C and a relative humidity of 50%.

[0047] This air conditioned primary air 18 is brought in through a distribution chamber 1 to a nozzle 3 opening into the first suction chamber 2. The flow rate of air conditioned primary air in each façade module is 25 m³/h.

[0048] The air conditioned primary air flow rate at the outlet of the nozzle 3 suctions secondary air 17 through an orifice 13. This secondary air coming from the intake pipe 9 passes in a heat exchanger 7 before being mixed with the primary air 18 in the suction chamber 2. The temperature of the cooling water in this exchanger is 12°C at the inlet and 14°C at the outlet. The power consumed by this battery is approximately 146 W. The flow rate of secondary air 17 comes from an active façade, and enters the heat exchanger at a temperature of 34°C and 36% relative humidity. The flow rate of secondary air 17 in this first heat exchanger 7, induced by the primary air flow, is 25 m³/h.

[0049] The mixture 19 of primary air 18 and secondary air 17 induced by the first Venturi device is injected into a chamber 4 delimited by a wall 14 pierced with orifices 5 opening into a second suction chamber 6. Secondary air 16 enters that second suction chamber 6 through a second heat exchanger 8. The secondary air suctioned by the pipe 11 once again comes from the active façade and has the same inlet characteristics as the air admitted by the pipe 9. The flow rate of secondary air induced in this second Venturi device is approximately 150 m³/h.

[0050] One therefore obtains an air flow rate at the outlet of the device of 200 m³/h, for a primary air flow rate of 25 m³/h, i.e., a multiplicative factor of 8 (or a 1:7 ratio). The outlet air in this example is at 18°C, for an ambient temperature of 26°C. This conditioned air is ejected via the orifice 23.

[0051] A gate 20, 21 makes it possible, as needed, to bypass the first induction unit (Venturi device), so as to increase the reduce the multiplicative factor of the device. During operation with the gate 21 opened, the primary air flow rate goes to 50 m³/h, while the flow rate of secondary air induced in the second induction unit remains constant at 150 m³/h, going from a multiplicative factor of 8 to 4.

[0052] Injecting the secondary air in a forced manner into the ventilated empty space of the active façade makes it possible to avoid an exaggerated increase in the temperature of the inner walls of the premises, which increases the feeling of comfort for occupants.

5 **[0053]** The two heat exchangers 7, 8 being adjacent, in practice, it is possible to use a single exchanger with a wall separating the two pipes. Nevertheless, it may be interesting to adjust these two heat exchangers differently, so as to avoid any condensation in the first mixing chamber.

10 **[0054]** The dimensions of the module of the example are compatible with the dimensions of windows typically used in the building, in the case at hand, in this example, the width of the second heat exchanger is 1 m, and 25 cm for the first exchanger. The height of the first and second heat exchangers is 29 cm, while the total height of the module (including the distribution pipe 12 for the primary air) is 60 cm.

CLAIMS

1. An air conditioning device (10) comprising a primary air intake pipe (1)
5 connected to the inlet of a first Venturi-type device whereof the suction communicates with a first secondary air intake pipe (9), the outlet of the first Venturi-type device communicating with the inlet of a second Venturi-type device whereof the suction is connected to a second secondary air intake pipe (11) comprising a main heat exchanger (8), the first Venturi-type device comprising a primary air inlet nozzle (3) comprising a
10 diameter restriction at its free end, said free end emerging in a suction chamber (2) communicating with the first secondary air intake pipe (9), said suction chamber (2) comprising an outlet orifice (15) across from the outlet of said inlet nozzle, said outlet orifice (15) communicating with the inlet of the second Venturi-type device, characterized in that the second Venturi-type device comprises an intake chamber (4),
15 said intake chamber (4) having a section at least twice as large as the outlet orifice (15) of the suction chamber (2).
2. The air conditioning device (10) according to claim 1, wherein the second Venturi-type device comprises a plate (14) pierced with orifices (5), said plate separating the intake chamber (4) communicating with the outlet (15) of the first mixing device and
20 a mixing chamber (6) communicating with the second secondary air intake pipe (11), said orifices (5) producing, during use, a Venturi effect suctioning the secondary air.
3. The air conditioning device (10) according to either one of the preceding claims, wherein the first secondary air intake pipe (9) comprises a secondary heat exchanger (7).
- 25 4. The air conditioning device (10) according to any one of the preceding claims, wherein the heat exchanger(s) comprise vertical fins, and a device discharging condensation at the bottom thereof.
5. The air conditioning device (10) according to any one of the preceding claims, wherein an adjustable gate makes it possible to inject primary air directly at the
30 inlet of the second Venturi-type device, downstream from the first Venturi-type device,

so as to be able to regulate the total mixture ratio between the primary air and the secondary air.

6. A façade comprising an air conditioning device (10) according to any one of the preceding claims.

5 7. The façade according to claim 6, comprising two walls separated by a ventilation space, the first and second secondary air intake pipes being connected to said ventilation space.

8. A method for air conditioning a confined space comprising the following steps:

10 a. drawing in outside air (18), called primary air, and bringing it to a predetermined pressure;

b. injecting said primary air (18) into a Venturi-type device, suctioning from a suction chamber (2) and mixing air from the confined space, called secondary air (17), with the primary air, the secondary air passing, before
15 mixing, into a first heat exchanger (7) regulated to a setpoint temperature thus obtaining a first air mixture (19);

c. injecting the first air mixture (19) into a second Venturi-type device, suctioning and mixing secondary air (16) with said first air mixture (19), the secondary air passing, before mixing, into a second heat exchanger (8)
20 regulated to a setpoint temperature;

d. reinjecting the obtained air mixture into the confined space;
characterized in that the first air mixture (19) is compressed in a mixing chamber (4) communicating with the outlet orifice (15) of the suction chamber (2), said intake chamber (4) having a section at least twice as large as the outlet orifice (15) of the
25 suction chamber (2), so as to cause compression of the first air mixture (19).

9. The method according to claim 8, wherein said predetermined pressure is comprised between 100 and 1,000 Pa.

10. The method according to either one of claims 8 and 9, wherein the ratio
30 between the intake of primary air and secondary air in the first mixing device is comprised between 0.7 and 2.5.

11. The method according to any one of claims 8 to 10, wherein the flow ratio between the intake of the first air mixture and secondary air in the second mixing device is comprised between 2 and 4.
12. The method according to any one of claims 8 to 11, wherein the pressure
5 of the first air mixture at the inlet of the second Venturi device is comprised between 50 and 100 Pa.
13. The method according to any one of claims 8 to 12, wherein the secondary air flows in a ventilated space between two walls of an active façade before being suctioned through the heat exchangers (7, 8).
- 10 14. The method according to any one of claims 8 to 13, wherein the primary air drawn in in step (a) is brought to a predetermined temperature before being injected into said first Venturi-type device.