A SYSTEM FOR FRESH AIR PRE-TREATMENT

TECHNICAL FIELD

The present invention relates to a humidity control system for buildings. More particularly, the present invention relates to a fresh air pre-treatment system to remove moisture from air stream prior to delivery to an air-conditioning unit.

BACKGROUND ART

In conventional systems, a common way to control the humidity of a room is the 'Over-cooled and Re-heat' System. In a normal air conditioning system, the cooling coil of the air handling unit will cool the air stream to around 16°C before throwing the air-conditioned air into the room. The cooling coil will be controlled by the room temperature. In the case of 'Over-cooled and Re-heat' system, the cooling coil will be controlled by the room relative humidity (RH). This is because the cooling coil is now used for moisture removal instead of temperature control. When the air stream is cooled, the moisture in the air stream will be condensed out and thus, the air becomes drier. This temperature is usually around 12°C. This is the 'over-cool' part of the system.

However, at this temperature, the air cannot be directly thrown out into the room as it is too cold to be delivered into the room. As such, the air stream needs to be heated up again to the required temperature. This heater is controlled by the room temperature.

This system has got 2 major problems. Firstly, the cooling coil and heating elements works in a dynamic balance. If someone decides to change the room temperature or the room humidity, the system will take some time to regain its balance. Secondly and more importantly, this system is a very energy consuming system. Firstly, the system will need to spend energy to over-cool the entire air stream and then it has to spend energy to re-heat the air stream again. The common heating power required is between 20 - 30 kW. This means that if the building has 50 air handling units, they will require 1MW of extra power. For new building owners the electricity bill will be very high and for existing buildings, this method is not even usable as the existing building will not have much extra power to be used by this system.

Another available system in the market is the de-humidifier. In this system, the air stream runs through a dehumidifier. Within the de-humidifier, there is another air stream known as reactive air stream. This reactive air stream is first heated up with heaters. This allows the reactive air to be able to absorb more moisture from the air stream. From there, both the air stream and the reactive air will go through a desiccant where the reactive air will absorb moisture from the air stream. This will dry the air stream. The amount of moisture that can be transferred into the reactive air stream is controlled by the heaters. The air stream coming from the de-humidifier will therefore be dry but hot. The heating to the air stream is due to the heat being transferred from the hot reactive air to the air stream. The usual temperature of the air stream coming out from the dehumidifier is 50°C.

After the de-humidifier, the air stream will then go through an air handling unit (AHU) to reduce the temperature of the air stream to around 16°C which is then delivered to the room. The cooling coil of the AHU will be controlled by the room temperature. Usually, the designer will design a bypass into the system to reduce the energy needed for the AHU. Due to the complexity of the of the system, a schematic drawing of the de-humidifier system is illustrated in Figure 1.

Due to the presence of the electric heaters, the system uses a large amount of electrical power as well. Furthermore, the AHU will also be required to cool the temperature to about 16°C again which requires power as well.

In general, all the existing methods uses a tremendous amount of energy. Furthermore, the existing building cannot even install this as they will not have the required amount of excess energy. As a result, many existing buildings in the tropical climate zone suffers from the effects of high humidity. Some of the effects includes moulds, bacterial growth, condensation, asthma and allergies.

SUMMARY OF THE INVENTION

The present invention relates to a humidity control system for buildings. More particularly, the present invention relates to a fresh air pre-treatment system to remove moisture from air stream before the air stream is delivered to an air-conditioning unit.

One aspect of the present invention provides a fresh air pre-treatment system for controlling humidity in a building, comprising a fresh air pre-treatment unit and a fan configured to deliver the treated fresh air from the moisture removal section to the air handling unit and maintain positive pressure in the building relative to outdoor pressure to prevent moisture infiltration. The fresh air pre-treatment unit further comprises a moisture removal section positioned in a fresh air intake line upstream of an air handling unit, the moisture removal section including a heat pipe pre-cool section configured to pre-cool incoming outdoor air and reclaim heat therefrom, a cooling coil positioned downstream of the heat pipe pre-cool section and configured to remove moisture from the pre-cooled outdoor air by condensing water vapor to produce treated fresh air, a heat pipe re-heat section positioned downstream of the cooling coil and configured to reheat the treated fresh air using the heat reclaimed by the heat pipe pre-cool section, and a mixing chamber positioned downstream of the heat pipe re-heat section and configured to mix the treated fresh air with return air to be delivered to an air handling unit, AHU.

Still another aspect of the present invention provides that the cooling coil uses chilled water as a cooling medium.

Yet another aspect of the present invention provides that the cooling coil uses refrigerant as a cooling medium.

Another aspect of the present invention provides that the cooling coil is configured to cool the pre-cooled outdoor air to approximately 12°C.

Still another aspect of the present invention provides that the fan is an EC fan.

Yet another aspect of the present invention provides that the fan is a VSD controlled fan.

Another aspect of the present invention provides that the system further comprises a pressure differential sensor positioned between indoor and outdoor environments, wherein the fan is controlled by the pressure differential sensor to maintain the positive pressure at approximately 5 Pa above outdoor pressure.

Still another aspect of the present invention provides that the system further comprises a humidity sensor configured to control the cooling coil, wherein the humidity sensor is positioned in a room or a return duct.

Yet another aspect of the present invention provides that the system further comprises a loopback component configured to divert a portion of return air to an outdoor intake to increase fresh air flow through the fresh air pre-treatment unit.

Another aspect of the present invention provides that the loopback component is configured to reduce temperature of air intake while maintaining energy consumption of the fresh air pre-treatment unit.

The present invention consists of features and a combination of parts hereinafter fully described and illustrated in the accompanying drawings, it being understood that various changes in the details may be made without departing from the scope of the invention or sacrificing any of the advantages of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention relates to a humidity control system for buildings. More particularly, the present invention relates to a fresh air pre-treatment system to remove moisture from air stream before the air stream is delivered to an air-conditioning unit.

Hereinafter, this specification will describe the present invention according to the preferred embodiments. It is to be understood that limiting the description to the preferred embodiments of the invention is merely to facilitate discussion of the present invention and it is envisioned without departing from the scope of the appended claims.

According to the present invention, the moisture removal should not be done in the air handling unit (AHU). In fact, moisture should be removed from the system before it touches the air condition. The concept comes from “where does the water come from”. It comes from two sources - the fresh air intake and infiltration of outdoor air into the room via windows and other openings. The present invention will remove the moisture at the fresh air intake and then create a positive pressure in the room to prevent moisture infiltration from the outdoors. The new concept here is that if there is no moisture coming into the system, there is no humidity problem.

According to the present invention, a fresh air pre-treatment unit is installed into the fresh air intake to remove the moisture before it reaches the air conditioning system. The fresh air pre-treatment unit is the main component in the Fresh Air Pre-treatment System. The fresh air pre-treatment unit consists of a moisture removal section and a fan to create a positive pressure in the room. This dry air will then be supplied to the existing AHU as its fresh air intake.

In an embodiment of the invention, the outdoor air will first go into the fresh air pre-treatment unit. Within the fresh air pre-treatment unit, the fresh air will go through a heat pipe pre-cool section. This pre-cool coil will reclaim some of the heat from the outdoor air and thus pre-cooling the fresh air. From the heat pipe pre-cool section, the fresh air will then go through the cooling coil to condense the moisture out from the fresh air. This cooling coil will use either chilled water or refrigerant as a medium. The temperature of the fresh air will drop with the moisture removal process to around 12 °C. The cooled fresh air will then pass through the heat

pipe re-heat section. The heat medium used here is the heat reclaimed from the pre-cool section of the heat pipe. This treated fresh air will then be cool and dry. From the fresh air pre-treatment unit, the fresh air is then sent into the air conditioning system. This will ensure that the fresh air coming into the building is dry.

In an embodiment of the invention, there is also a fan in the fresh air pre-treatment unit. The main purpose of this fan is to control the amount of fresh air going into the room. This fan will be designed to deliver more fresh air than the total exhaust system in the room and therefore, will keep the room in a positive pressure compared to the external. This positive pressure will prevent the moisture coming into the room from the outdoors.

By ensuring that only dry air is introduced into the building, the system can effectively control the room humidity.

Reference is now made to Figure 2 that shows the main component which is the fresh air pre-treatment unit is actually located in the fresh air line and not directly in the air conditioning system. The main function of the fresh air pre-treatment unit is to remove moisture from the fresh air stream. Therefore, it is important to know how much of moisture needs to be removed. In order to determine this, it is noted to refer to the heat load calculation. The heat load calculation will calculate the heat load capacity and will also calculate the supply air temperature. The supply air temperature is the design objective of the system. Based on a real-life condition in a hospital Psychiatric Clinics, in order to get a room condition of 23 °C / 55% RH (Humidity ratio of 9.93 g/kg of dry air), the supply air condition required is 16°C / 83.53% RH. From this supply air condition and the psychrometric chart, it is noted that the supply air humidity ratio is 9.64 g/kg. With this in mind, the design and size of the fresh air pre-treatment unit can be made.

The Fresh Air Pre-treatment System is a precision engineered system. This means that the exact process is calculated through which the fresh air stream passes and as a result, the exact transformation of the fresh air stream is calculated.

Outdoor Air Intake: The outdoor air intake is basically the condition of the outdoor air which is 33 / 27°C in Malaysia. For nighttime, the worst-case scenario is 27 / 25.6 °C. They both carry and humidity ratio of above 20 g/kg dry air.

Process 1 - Heat Pipe Pre-cooled Coil (1): This process main objective is to reclaim the heat from the outdoor air. It will also act to cool the fresh air stream from 33 / 27°C to 25 / 24.92 °C. In this process, it will be able to re-claim 5.94 kW of cooling. The humidity ratio at this point is 20.50 g/kg of dry air.

Process 2 - Cooling Coil (2): This is the main de-humidification process. From the above and the heat load calculations, the following is noted:

a) Supply air humidity ratio (HR) : 9.64 g/kg

b) Supply air flow : 4,150 cfm

c) Mixed air HR (Process 4) : 9.64 g/kg (This is because Process 5 only process the sensible load and does not affect the moisture content) [refer to Process 4 & 5 to comprehend the 2 processes]

d) Return air flow : 3,010 cfm

e) Return air humidity ratio : 9.93 g/kg (Room condition)

f) Treated fresh air flow : 1,140 cfm

From the above, it can be calculated that the treated fresh air requires a humidity ratio of 8.89 g/kg of dry air. Since the re-heat component does not increase the humidity ratio, the off-coil humidity ratio from the cooling coil will be 8.89 g/kg. This means that the cooling coil must be designed to be able to remove 11.61 g/kg of moisture from the fresh air. The cooling coil is controlled by a relative humidity sensor (RH sensor) or the off-cooling coil temperature. The humidity sensor can be located in the room or the return duct. The fresh air condition after the cooling coil is as follows:

a) Fresh air flow : 1,140 cfm

b) Air temperature : 12 °C

c) Humidity ratio : 8.89 g/kg of dry air

Process 3 - Heat Pipe Re-heat Coil (3): The temperature coming out from the cooling coil is 12°C which is very low. As such, the heat reclaimed in Process 1 is used to heat up the fresh air coming out from the cooling coil. After the heating process, the condition of the fresh air is

a) Fresh air flow : 1,140 cfm

b) Air dry bulb temperature : 20 °C

c) Air relative humidity : 59.97%

d) Humidity ratio : 8.89 g/kg of dry air (there is no increase in humidity ratio as this is only heating).

This process will also remove the need for heaters and as such, save a tremendous amount of energy consumption.

Process 4 - Air Mixing (4): Process 4 is also one the most important section. This is the section where the treated fresh air is mixed with the return air. In this process, the treated fresh air is used to absorb the humidity coming in from the return air. After the mixing, as stated in Process 2, the air stream condition will be as follows:

a) Fresh air flow : 4,150 cfm

b) Air dry bulb temperature : 22.18 °C

c) Air relative humidity : 56.71%

d) Humidity ratio : 9.64 g/kg of dry air (same as the required supply air humidity ratio).

Process 5 - Final cooling (5): At Process 4, the humidity ratio has been achieved and the system has already removed the total moisture content of 11.61 g/kg. This final cooling at the air conditioning system only controls the temperature. In this case, it will cool the air stream temperature of 22.18°C to 16°C. This process is controlled by a temperature sensor at the room or the return duct. After the cooling coil, the supply air condition will be as follows:

a) Fresh air flow : 4,150 cfm

b) Air dry bulb temperature : 16 °C

c) Air relative humidity : 83.53%

d) Humidity ratio : 9.64 g/kg of dry air.

As a result, the room temperature can now be stable at 23°C/55% RH.

Process 6 - Control of pressure between the room and atmosphere: The fresh air pre-treatment unit comes with a fan which is either an EC fan or a VSD controlled fan (6). This fan (6) is controlled by a pressure differential sensor located between the indoor and outdoor. The main purpose of this control is to make sure that the pressure in the room is just slightly above the outdoors. If the room pressure is below the outdoors, the room will become negative pressured, and the moisture will come into the room. However, if the pressure is too high, there will be a lot of wasted energy because the air-conditioned air will be lost to the outdoor. As such, the room positive pressure is kept to around 5 Pa.

Reference is now made to Figure 4, where a loopback process is illustrated.

Embodiment 2 - Loopback: In the preferred embodiment, there is a point where it will not be effective. This is when the fresh air required is too low. Process 4 is where the good and dry fresh air is mixed into the system to remove the excess moisture coming in from the moisture gain in the room. If the treated fresh air is not enough, the drying process of the return air will not be effective. Therefore, the overall system will not work. Therefore, in order to control the humidity in the room, the air flow through the fresh air pre-treatment unit has to be increased to get a good mixture in Process 4. However, this will increase the electricity consumption. In this embodiment, it is noted that a “loopback” component is created where some return air is diverted to the outdoor intake. This will increase the fresh air flow while reducing the temperature of the air intake. As a result, the air mixture in Process 4 will be good while the fresh air pre-treatment unit capacity will be maintained and thus, maintaining the energy consumption. This embodiment is shown in Figure 3 and labelled as Loopback RAD.

CLAIMS

1. A fresh air pre-treatment system for controlling humidity in a building, comprising:

a fresh air pre-treatment unit, the fresh air pre-treatment unit further comprises:

a moisture removal section positioned in a fresh air intake line upstream of an air handling unit, the moisture removal section including:

a heat pipe pre-cool section configured to pre-cool incoming outdoor air and reclaim heat therefrom;

a cooling coil positioned downstream of the heat pipe pre-cool section and configured to remove moisture from the pre-cooled outdoor air by condensing moisture to produce treated fresh air;

a heat pipe re-heat section positioned downstream of the cooling coil and configured to reheat the treated fresh air using the heat reclaimed by the heat pipe pre-cool section; and

a mixing chamber positioned downstream of the heat pipe re-heat section and configured to mix the treated fresh air with return air to be delivered to an air handling unit, AHU; and

a fan configured to deliver the treated fresh air from the moisture removal section to the air handling unit and maintain positive pressure in the building relative to outdoor pressure to prevent moisture infiltration.

2. The system of claim 1, wherein the cooling coil uses chilled water as a cooling medium.

3. The system of claim 1, wherein the cooling coil uses refrigerant as a cooling medium.

4. The system of claim 1, wherein the cooling coil is configured to cool the pre-cooled outdoor air to approximately 12°C.

5. The system of claim 1, wherein the fan is an EC fan.

6. The system of claim 1, wherein the fan is a VSD controlled fan.

7. The system of claim 1, further comprising a pressure differential sensor positioned between indoor and outdoor environments, wherein the fan is controlled by the pressure differential sensor to maintain the positive pressure at approximately 5 Pa above outdoor pressure.

8. The system of claim 1, further comprising a relative humidity sensor configured to control the cooling coil, wherein the humidity sensor is positioned in a room or a return duct.

9. The system of claim 1, further comprising a loopback component configured to divert a portion of return air to an outdoor intake to increase fresh air flow through the fresh air pre-treatment unit.

10. The system of claim 9, wherein the loopback component is configured to reduce temperature of air intake while maintaining energy consumption of the fresh air pre-treatment unit.