

# **Radiation Heat Exchanging Air Conditioning System and Radiation Heat-exchanging Ceiling thereof**

## **Technical Field**

The present application relates to a direct-cooling air conditioning system.

- 5 More specifically, the present application relates to a direct-cooling air conditioning system equipped with radiation heat-exchanging ceiling.

## **Technical Background**

The heat pump system in prior ceiling air conditioning system is not designed to make directly radiation heat-exchanging ceiling cool, but cold  
10 water from water-circulation system is used to make it cool. If the heat pump system is used to make it cool directly, the bottom surface of radiation heat-exchanging ceiling will dew heavily due to the lower temperature, and when the dew condenses to a certain extent it will drop from the ceiling and thus form so-called “artificial rain” in room. The prior ceiling conditioning  
15 system with water circulation system can be used in the relatively dry areas such as Northern Europe because the humidity of these areas is relatively low and radiation heat-exchanging ceiling will not dew even if at a relatively lower temperature.

However, there exists serious dewing problem when prior ceiling air  
20 conditioning system is used in relatively more humid areas such as Southern China or Southeast Asia. Heavy dewing occurred in the prior ceiling air conditioning systems installed in Macau, Shenzhen, etc, which resulted in

frequent “artificial rain” from a room ceiling. For the prior air conditioning systems with dew point sensor they would automatically stop working frequently because the sensor detected heavy dewing.

After a long-term observation and study, the inventor of the present  
5 application found out that the main reasons why the prior radiation heat-exchanging ceiling are easy to dew in more humid environments are as follows:

1. The humidity in moist areas is about 70-80%, and the vapor content in the air is close to saturation. Its dew point temperature is only few lower than  
10 the ambient temperature. Therefore it is easy for vapor to contact objects of which their temperature is lower than the dew point and thus dew will form on these objects.

2. The prior radiation heat-exchanging ceiling includes metal ceiling plate and heat-exchanging coil. The heat-exchanging coil is installed into the  
15 grooves on top of the metal ceiling plate and contacts with the metal ceiling plate directly. Therefore the temperature on the area in which the heat-exchanging coil contacts with the metal ceiling is often lower than the dew point temperature.

In hot and moist areas the circulating water of a ceiling conditioning system  
20 would be set at a temperature as low as possible for effective cooling. Because its heat-exchanging coil contacts directly with its metal ceiling plate the circulating water at low temperature will readily make the temperature at the contacting area of the bottom surface of the metal ceiling

plate lower than the dew point temperature. And this will inevitably cause dewing problems.

Therefore, it is necessary to provide a direct-cooling air conditioning system in which a radiation heat-exchanging ceiling is installed to avoid dewing.

## 5 **Summary of the Invention**

The purpose of the present invention is to provide a direct-cooling air conditioning system or so-called ceiling conditioning system which employs a radiation heat-exchanging ceiling plate difficult to dew and which can overcome heavy dewing problems occurred on both prior radiation  
10 heat-exchanging ceiling and prior ceiling conditioning system.

As one aspect, the present invention is to provide a direct-cooling air conditioning system which includes a heat pump system and a water circulation system wherein the water circulation system includes a water circulation loop which further includes a circulating pump, an air  
15 heat-exchanging device and a water heat-exchanging device. The air heat-exchanging device exchanges heat with outside air and the water heat-exchanging device exchanges heat with the heat pump system. In the direct-cooling air conditioning system according to the present invention, the water circulation system includes a plurality of radiation heat-exchanging  
20 ceiling plates which comprise metal ceiling plates and heat-exchanging coils. The heat-exchanging coils are fixed on the top of the metal ceiling plates in such a way that the heat-exchanging coils are adjacent to but do not contact with the metal ceiling plates, and there is a layer of thermal insulation

material on the top of the heat-exchanging coils. The heat-exchanging coils are connected to the circulation loop of the water circulation system.

In the above direct-cooling air conditioning system because the heat-exchanging coils do not directly contact with the metal ceiling plates  
5 there is not any area on the metal ceiling plates with its temperature being lower than the dew point temperature. And thus it is difficult to dew on such an air conditioning system.

In addition, in the above direct-cooling air conditioning system the radiation heat-exchanging ceiling plates in a same room can be connected with each  
10 other in series or in parallel or in a combination of both in series and in parallel.

Preferably, in the direct-cooling air conditioning system one or more layers of metal foil can be further placed on the bottom of the thermal insulation material. That is, the metal foil can be placed between the heat-exchanging  
15 coils and the layer of thermal insulation material. In such a design the metal foil increases the heat-exchanging area for the heat-exchanging coils and thus improves heat-exchanging efficiency.

As a specific embodiment of the present invention, in the above direct-cooling air conditioning system coil brackets for supporting the  
20 heat-exchanging coils can be installed on the top surface of the metal ceiling plates wherein the coil brackets can be made from poor thermal conducting material such as plastics. The heat-exchanging coils can be mounted on the coil brackets. In such a design a correct positioning between the

heat-exchanging coils and the metal ceiling plates can be so maintained that they neither contact each other nor be in an excessive distance.

As another specific embodiment of the present invention, in the above direct-cooling air conditioning system a sealing layer can be further placed  
5 on the top of the layer of thermal insulation material. The sealing layer covers over the layer of thermal insulation material so as to isolate it from the outside air. In such a design the outside air is prevented from entering into the layer of thermal insulation material, and therefore the heat-exchanging coils will not dew. The thermal insulation material can be  
10 kept dry to reach a better insulation effect.

As still another specific embodiment of the present invention, in the above direct-cooling air conditioning system an aluminum foil can be used as the metal foil and glass wool or mineral wool can be used as the thermal insulation material. The aluminum foil, the glass wool and the sealing layer  
15 can be stacked up or laminated to form a layer of aluminum foil/glass wool insulation material. In such a design the aluminum foil/glass wool insulation materials can be available from the market and it can be easily and conveniently closed over the heat-exchanging coils when assembling.

As yet another specific embodiment of the present invention, the above  
20 direct-cooling air conditioning system further includes a fresh flue (i.e. a passage for fresh air) with which a fan is equipped. The inlet of the fresh flue is in communication with the outdoor air, and its outlet is in communication with the indoor air. A heat-exchanging coil for fresh air is

mounted within the fresh flue, which is connected between the circulating pump of the water circulation system and the heat-exchanging coils of the radiation heat-exchanging ceiling plates. In such a design, the fresh flue can provide dry and cold fresh air when the system is refrigerating, which will  
5 not only reduce the duty load of the radiation heat-exchanging ceiling but also prevent the temperature of the circulating water from being lower than the dew point temperature through preheating by the fresh air before entering into the heat-exchanging coils of the radiation heat-exchanging ceiling plates. Therefore dewing will be avoided.

10 As another specific embodiment of the direct-cooling air conditioning system of the present invention the water circulation loop further includes a water tank for thermal buffering which is positioned between the circulation pump and the heat-exchanging coil for fresh air. In such a design circulating water has a small fluctuation on its temperature and the compressor need not  
15 to turn on and off frequently.

As another specific embodiment of the direct-cooling air conditioning system of the present invention, the fresh flue is equipped with a solenoid valve. A solenoid valve is also placed between the circulating pump of the water circulation loop and the heat-exchanging coils of the radiation  
20 heat-exchanging ceiling. Such a design has the advantages of being easily adjusted and suitable for central air conditioning.

As another aspect the present invention is to provide a radiation heat-exchanging ceiling plate used in an air-conditioning system,

particularly in a direct-cooling air conditioning system such as a ceiling conditioning system. The radiation heat-exchanging ceiling plate includes a metal ceiling plate and a heat-exchanging coil. The heat-exchanging coil is fixed on the top of the metal ceiling plate in such a way that the  
5 heat-exchanging coil is adjacent to but does not contact with the metal ceiling plate, and there is a layer of thermal insulation material on the top of the heat-exchanging coil.

Preferably in the above radiation heat-exchanging ceiling plate a layer of metal foil can be further placed on the bottom of the thermal insulation  
10 material. That is, the metal foil can be placed between the heat-exchanging coil and the layer of thermal insulation material.

Preferably in the above radiation heat-exchanging ceiling plate coil brackets for supporting the heat-exchanging coil can be installed on the top surface of the metal ceiling plate wherein the coil brackets can be made from poor  
15 thermal conducting material such as plastics. In such a design a correct positioning between the heat-exchanging coil and the metal ceiling plate can be so maintained that they neither contact each other nor be in an excessive distance.

Preferably in the above radiation heat-exchanging ceiling plate a sealing  
20 layer can be further placed on the top of the layer of thermal insulation material. The sealing layer covers over the layer of thermal insulation material so as to isolate it from the outside air.

Preferably in the above radiation heat-exchanging ceiling plate an aluminum

foil can be used as the metal foil and glass wool or mineral wool can be used as the thermal insulation material. The aluminum foil, the glass wool and the sealing layer can be stacked up or laminated to form a layer of aluminum foil/glass wool insulation material.

- 5 The direct-cooling air conditioning system of the present invention (i.e. the ceiling conditioning system with radiation heat-exchanging ceiling) is not easy to dew when in operation. It belongs to a real quite air conditioning system without any noise because both its compressor and pumps can be placed outside and there is no fan inside. Due to large heat-exchanging area  
10 of the ceiling conditioning system the inlet temperature of the coolant can be 5 °C higher than that of an ordinary air conditioning system, and the indoor temperature can be 3 °C higher than that of an ordinary air conditioning system with same comfort level. Therefore compared with an prior air conditioning system the direct-cooling air conditioning system of the present  
15 invention has a higher energy efficiency and will save energy in about more than 30%. Thus the direct-cooling air conditioning system of the present invention has a good prospect in the market.

The direct-cooling air conditioning system of the present invention (i.e. the ceiling conditioning system with radiation heat-exchanging ceiling) and the  
20 radiation heat-exchanging ceiling plate thereof will be further understood through the following illustrative and non-limitative description of preferred embodiments with reference to the appended drawings.

## **Brief Descriptions for the Drawings**

Figure 1 is an explosive view of the radiation heat-exchanging ceiling according to one embodiment of the present invention;

Figure 2 is a diagrammatic sketch showing the structure of the radiation  
5 heat-exchanging ceiling according to one embodiment of the present invention;

Figure 3 is a schematic flowchart of the direct-cooling air conditioning system according to one embodiment of the present invention.

The numerals in the drawing represent respectively: 1 metal ceiling plate, 2  
10 heat-exchanging coil, 3 glass wool layer, 4 coil brackets, 5 aluminum foil, 6 sealing layer, 7 heat pump system, 8 water-circulation system, 9 pump, 10 air heat-exchanging device, 11 water heat-exchanging device, 12 fresh flue, 13 fan, 14 inlet, 15 outlet, 16 heat-exchanging coil for fresh air, 17 heat pump, 18 throttling elements (such as capillary or expansion valve), 19  
15 sealing strips, and 20 a plurality of radiation heat-exchanging ceiling plates in each room.

## **Detailed Description of Preferred Embodiments**

One of embodiments of the radiation heat-exchanging ceiling plate of the present invention is shown in Figure 1 and Figure 2, including a metal  
20 ceiling plate 1 and a radiation heat-exchanging coil 2 in which the heat-exchanging coil 2 is placed on the top of the metal ceiling plate 1. The heat-exchanging coil 2 is adjacent to but does not contact with the metal ceiling plate 1. A layer of glass wool 3 covers on the top of the

heat-exchanging coil 2. The upper surface of the metal ceiling plate 1 is equipped with coil brackets 4. The coil brackets 4 are made from poor thermal conducting material, and the heat-exchanging coil 2 is installed on the coil brackets 4.

5 A layer of aluminum foil 5 locates under the layer of glass wool 3. The aluminum foil 5 is positioned between the heat-exchanging coil 2 and the layer of glass wool 3. There is also a sealing layer 6 on the top of the layer of glass wool 3. The sealing layer 6 covers on the layer of glass wool 3 so as to insolate it from the outside air. The aluminum foil 5 can also be replaced  
10 by a copper foil, and the layer of glass wool 3 replaced by another insulation material.

One of embodiments of the direct-cooling air conditioning system of the present invention is shown in Figure 3, in which a radiation heat-exchanging ceiling is used. The direct-cooling air conditioning system includes a heat  
15 pump system 7 and a water circulation system 8 in which the water circulation system 8 further includes a water circulation loop comprising a circulation pump 9, an air heat-exchanging device 10, and a water heat-exchanging device 11. The air heat-exchanging device 10 exchanges heat with the outside air, and the water heat-exchanging device 11  
20 exchanges heat with the heat pump system. The water circulation system 8 comprises a plurality of radiation heat-exchanging ceiling plates as shown in Figure 1 with their heat-exchanging coils 2 being connected into the circulation loop of the water circulation system 8.

The above direct-cooling air conditioning system can further comprise a fresh flue 12 which is equipped with a fan 13. The inlet 14 of the fresh flue 12 is in communication with the outdoor air, and its outlet 15 is in communication with the indoor air. A heat-exchanging coil 16 for fresh air is placed within the fresh flue 12, and it is connected between the pump 9 and the heat-exchanging coils 2 of the radiation heat-exchanging ceiling plates. The water heat-exchanging device 11 can be a water tank for thermal buffering which is positioned between the pump 9 and the heat-exchanging coil 16 for fresh air. The evaporator coils of the heat pump system 7 are installed in the water tank for thermal buffering.

A solenoid valve can be equipped in the fresh flue 12, and a solenoid valve can also be placed between the pump 9 of the water circulation loop and the heat-exchanging coils 2 of the radiation heat-exchanging ceiling plates (not shown in the figures).

As another embodiment of the direct-cooling air conditioning system of the present invention the water circulation loop can have an additional water tank for thermal buffering.

## Claims

1. A direct-cooling air conditioning system comprising a heat pump system and a water circulation system, wherein said water circulation system comprises a water circulation loop which further comprises a  
5 circulating pump, an air heat-exchanging device and a water heat-exchanging device in which said air heat-exchanging device exchanges heat with the outside air and said water heat-exchanging device exchanges heat with said heat pump system,

wherein said water circulation system comprises a plurality of radiation  
10 heat-exchanging ceiling plates which further comprises metal ceiling plates and heat-exchanging coils in which said heat-exchanging coils are fixed on the top of said metal ceiling plates in such a way that said heat-exchanging coils are adjacent to but do not contact with said metal ceiling plates, and there is a layer of thermal insulation material on the top of said  
15 heat-exchanging coils,

wherein said heat-exchanging coils are connected to said water circulation loop of said water circulation system, and

wherein coil brackets for supporting said heat-exchanging coils are installed on the top surface of said metal ceiling plates, said coil brackets are  
20 made from poor thermal conducting material, and said heat-exchanging coils are mounted on said coil brackets.

2. The direct-cooling air conditioning system of claim 1, wherein one

or more layers of metal foil are placed on the bottom of said thermal insulation material and positioned between said heat-exchanging coils and said layer of thermal insulation material.

5        3. The direct-cooling air conditioning system of claim 1, wherein a sealing layer is installed on the top of said layer of thermal insulation material, and said sealing layer covers over said layer of thermal insulation material so as to isolate it from the outside air.

10       4. The direct-cooling air conditioning system of claim 3, wherein said metal foil is aluminium foil, said thermal insulation material is glass wool, and wherein said aluminum foil, said glass wool and said sealing layer are stacked up to form a layer of aluminum foil/glass wool insulation material.

15       5. The direct-cooling air conditioning system of claim1 further comprising a fresh flue, wherein said fresh flue is equipped with a fan, the inlet of said fresh flue is in communication with the outdoor air, the outlet of said fresh flue is in communication with the indoor air, a heat-exchanging coil for fresh air is mounted within said fresh flue, and said heat-exchanging  
20 coil for fresh air is connected between said circulating pump of said water circulation system and said heat-exchanging coils of said radiation heat-exchanging ceiling plates.

6. The direct-cooling air conditioning system of claim 5, wherein said water circulation loop further comprises a water tank for thermal buffering which is positioned between said circulation pump and said heat-exchanging  
5 coil for fresh air.

7. A radiation heat-exchanging ceiling plate used for an air conditioning system comprising a metal ceiling plate and a heat-exchanging coil, wherein said heat-exchanging coil is fixed on the top of said metal  
10 ceiling plate in such a way that said heat-exchanging coil is adjacent to but does not contact with said metal ceiling plate, and there is a layer of thermal insulation material on the top of said heat-exchanging coil, and

wherein coil brackets for supporting said heat-exchanging coil are installed on the top surface of said metal ceiling plate, said coil brackets are  
15 made from poor thermal conducting material, and said heat-exchanging coil is mounted on said coil brackets.

8. The radiation heat-exchanging ceiling plate of claim 7, wherein a layer of metal foil is placed on the bottom of said thermal insulation material  
20 and positioned between said heat-exchanging coil and said layer of thermal insulation material.

9. The radiation heat-exchanging ceiling plate of claim 7, wherein a sealing layer is installed on the top of said layer of thermal insulation material, and said sealing layer covers over said layer of thermal insulation material so as to isolate it from the outside air.

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10. The radiation heat-exchanging ceiling plate of claim 9, wherein said metal foil is aluminium foil, said thermal insulation material is glass wool, and wherein said aluminum foil, said glass wool and said sealing layer are stacked up to form a layer of aluminum foil/glass wool insulation material.

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