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Floor Radiation Cooling and Air Supply System based on Thermal Comfort

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Abstract

With the increasing demand for comfort, energy conservation, and environmental protection, floor radiation cooling and air supply systems have received more attention. Floor radiation cooling and air supply systems are a type of system that utilizes the principle of floor radiation heat transfer to achieve cooling effects. Maintaining thermal comfort is crucial for the design and operation of floor radiation cooling systems. Reasonable cooling capacity and temperature control strategies can be used to optimize air supply methods Increasing the radiation area and using auxiliary equipment to improve user thermal comfort, floor radiation cooling systems have many advantages and broad application prospects in different scenarios, such as commercial buildings, residential areas, and offices. This article focuses on analyzing the components and working principles of the floor radiation cooling and air supply system, exploring the impact of thermal comfort on the floor radiation cooling and air supply system, and methods to improve thermal comfort. It also looks forward to the future application advantages and prospects of the floor radiation cooling and air supply system with thermal comfort.

Keywords

Thermal Comfort; Floor Radiation; Cooling and Air Supply System.

1. Introduction

The floor radiation cooling and air supply system is a system that utilizes the principle of floor radiation heat transfer to achieve cooling effects. Its working principle is to transport coolant or cold air to the interior of the room through the cooling pipeline installed under the floor, and absorb heat from the human body or object surface through radiation. Compared with traditional air conditioning systems, floor radiation cooling systems can effectively reduce indoor temperature and provide a more comfortable environment. During the cooling process, thermal comfort is always a crucial factor. Thermal comfort refers to the degree of comfort felt by the human body in the thermal environment, which is influenced by multiple parameters such as indoor temperature, relative humidity, and air flow rate [1]. For floor radiation cooling systems, maintaining appropriate thermal comfort can not only enhance the user experience, but also improve work efficiency and quality of life. Therefore, when designing and operating a floor radiation cooling system, it is necessary to consider how to improve thermal comfort.

2. The Components and Working Principle of the Floor Radiation Cooling and Air Supply System

2.1 The Components of the Floor Radiation Cooling and Air Supply System

The components of the floor radiation cooling and air supply system include the following main components [2]: (a) floor radiation cooling and air supply duct, which is located under the floor and

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is responsible for conveying coolant or air supply. It can be a pipe made of plastic, aluminum alloy, or steel, with good thermal conductivity and strength. (b) Coolants or air supply units, these devices are used to generate coolant (such as water) or air supply, and transport it to the floor through pipelines. Coolants can be provided by chillers or ground source heat pumps, while air supply can be provided by air conditioning units or fans. (c) The temperature control system is used to monitor and adjust the temperature of the floor radiation cooling and air supply system. It can include temperature sensors, temperature control valves, controllers, and automation equipment to ensure indoor comfort and energy-saving effects. (d) Floor radiation cooling and air supply panels, which are located above the floor and in contact with the ground, are used for cooling or air supply through thermal conductivity. They are usually made of thermal conductive materials (such as aluminum alloy) and have the characteristics of radiative heat dissipation, which can evenly transfer the temperature of the coolant to the indoor environment. (e) Leakage detection system (optional) can be installed to ensure the normal operation and safety of the system. It is used to monitor the leakage of pipelines and equipment. Once a leak is detected, the system can issue an alarm and take necessary measures to repair the problem. It should be noted that the specific components of the floor radiation cooling and air supply system may vary depending on the application environment and requirements. Before installing and using the system, comprehensive design and selection should be carried out according to the specific situation.

2.2 Working Principle of Floor Radiation Cooling and Air Supply System

The floor radiation cooling and air supply system is an air conditioning system that dissipates heat or supplies air through the floor. Its working principle is as follows: Firstly, the floor radiation cooling system transfers heat to the floor by installing heat pipes or fins on the ground. Generally speaking, the system circulates cold water or coolant in the heat pipes to absorb the heat in the room and transfer it to the floor, achieving the effect of heat dissipation. When the floor dissipates heat, the surrounding air is heated and rises, forming natural convection, Reduce indoor temperature. Secondly, the floor radiation cooling system can also supply air through the floor. The system sends cold air into the cavity below the floor, and then into the room through small pores or openings in the floor. The cold air sent into the room exchanges heat through radiation and convection, reducing the indoor temperature.

Both in terms of heat dissipation and air supply, the floor radiation cooling system can achieve rapid cooling of the air in the room. Compared with traditional air conditioning systems, the advantage of floor radiation cooling systems is that they can provide more uniform and comfortable cooling effects, reduce noise and particle propagation caused by air flow, and achieve personalized comfort control by adjusting the floor temperature. It should be noted that the floor radiation cooling and air supply system needs to be used in conjunction with other air conditioning equipment (such as chillers, fans, etc.) to achieve circulation and distribution of hot and cold media. In addition, the design and installation of the system also need to comply with relevant technical standards and specifications to ensure the normal operation and safety of the system [3]. It is recommended to consult a professional air conditioning designer or engineer for more detailed and personalized information and advice.

3. The Impact of Thermal Comfort on Floor Radiation Cooling and Air Supply Systems

3.1 Definition and Parameters of Thermal Comfort Analysis

The floor radiation cooling system is a cooling method that utilizes the floor for heat exchange. It reduces the surface temperature of the floor by transmitting cooling energy to the lower part of the floor, thereby achieving the cooling effect of the indoor space. Thermal comfort refers to the degree of comfort that the human body feels in a specific environment. For floor radiation cooling systems, the following are definitions and parameters related to thermal comfort: surface temperature, floor surface temperature is an important factor affecting human thermal sensation. In the floor radiation cooling system, the surface temperature of the floor needs to be maintained within a comfortable

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range, that is, not too low or too high, to ensure that the heat transfer between the human body and the floor reaches an appropriate level; The air temperature and floor radiation cooling system not only cool the indoor space, but also have an impact on the air temperature. The indoor air temperature should be coordinated with the surface temperature of the floor to provide an overall sense of comfort; Relative humidity also has a significant impact on thermal comfort. In a floor radiation cooling system, relative humidity needs to be maintained within a comfortable range to avoid the discomfort caused by excessively dry or humid air on the human body; The air flow rate also affects thermal comfort. The floor radiation cooling system usually cools the floor through refrigerant or cold water, so the ventilation requirements are relatively low. An appropriate air flow rate can help dissipate heat and enhance the heat exchange effect between the human body and the environment [4].

In summary, the thermal comfort of a floor radiation cooling system depends on the reasonable adjustment and maintenance of parameters such as floor surface temperature, indoor air temperature, relative humidity, and air flow rate. These parameters need to be appropriately designed and adjusted according to specific usage scenarios and needs to provide a comfortable thermal environment.

3.2 The Relationship between Thermal Comfort and Floor Radiation Cooling and Air Supply Systems

There is a certain relationship between thermal comfort and floor radiation cooling and air supply systems. Floor radiation cooling and air supply systems are systems that dissipate heat or provide cooling through the floor, providing uniform temperature distribution and a comfortable indoor environment. In winter, floor radiation heating can directly transfer heat from the floor to the human body, making people feel warm and comfortable. This form of heating eliminates discomfort caused by air convection and provides floor warmth, increasing indoor air quality. In summer, floor radiation cooling systems can dissipate heat through the floor, provide a low-temperature surface, and lower indoor temperature. Compared to traditional air conditioning systems, floor radiation cooling systems reduce air convection and uneven temperature, providing a more comfortable indoor environment. In short, the floor radiation cooling and air supply system can provide a comfortable thermal environment. It achieves indoor cooling and heating through the thermal radiation of the floor, avoiding discomfort caused by air convection and improving thermal comfort.

4. Methods to Improve the Thermal Comfort of Floor Radiation Cooling and Air Supply Systems

4.1 Reasonably Control Temperature and Humidity

Firstly, by adjusting the temperature of the floor radiation cooling and air supply system, it can provide a comfortable indoor temperature, which can be achieved using devices such as thermostats and temperature sensors. Secondly, the floor radiation cooling and air supply system may cause an increase in indoor humidity during the cooling process. Properly controlling indoor humidity can improve thermal comfort within a comfortable range.

4.2 Optimize the Air Supply Method

Firstly, technicians can adopt a uniform air supply method to avoid the situation of cold air blowing directly into the human body. This can be achieved by designing a reasonable position, angle, and layout of the air supply outlet. Secondly, maintaining indoor air circulation can help reduce local temperature differences and improve thermal comfort. Reasonable ventilation through doors and windows, or the use of fans and other equipment can be considered to increase air circulation.

4.3 Increase Radiation Area

The increase in radiation area can improve the heat dissipation effect of the floor radiation cooling and air supply system [5]. It can be considered to install radiation panels in more areas or increase their size. In this process, it is necessary to consider adding multiple temperature sensors in the floor

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radiation cooling and air supply system, and distributing them reasonably in different positions to ensure a more uniform temperature throughout the room and avoid obvious hot and cold areas.

4.4 Comprehensive Use of Other Auxiliary Equipment

Firstly, technicians can use other auxiliary equipment in combination with actual situations, such as using electric fans or mobile air conditioners, to increase air convection in the room and improve overall thermal comfort. Secondly, the reasonable use of shading facilities, such as blinds, curtains, shading films, etc., can control the indoor sunlight intensity and heat input, and improve thermal comfort.

5. The Advantages and Application Prospects of Floor Radiation Cooling and Air Supply Systems based on Thermal Comfort

5.1 Advantages of Floor Radiation Cooling and Air Supply System based on Thermal Comfort

The floor radiation cooling and air supply system with thermal comfort has the following advantages: providing uniform thermal comfort. The floor radiation cooling and air supply system can provide a uniform and long-lasting comfortable temperature in the room. By directly transferring heat or cold air to the floor, the system can provide a uniform temperature distribution over a large range, eliminating temperature differences generated in traditional heating systems; To improve indoor air quality, compared to traditional air convection heating or cooling systems, floor radiation cooling and air supply systems do not generate convection in the air, thus reducing the chances of dust, pollen, and other pollutants suspended in the air. This helps to improve indoor air quality and reduce the spread of allergens and odors; To save energy and reduce operating costs, the floor radiation cooling and air supply system utilizes radiation heat transfer, which can more effectively transfer heat or cold air compared to traditional air convection systems, thereby improving energy utilization. In addition, the system does not have filters and fans that need to be replaced frequently, resulting in lower operating costs; Increasing indoor space utilization, the floor radiation cooling and air supply system does not require the installation of radiators or air conditioners, which can save indoor space and improve room efficiency, which is particularly beneficial for buildings with limited space; No noise and no visible equipment, floor radiation cooling and air supply systems are usually noiseless, unlike traditional air conditioning systems that produce fan noise [6]. In addition, the equipment of floor radiation cooling and air supply systems is usually buried under the floor and will not have a visible impact on indoor decoration.

5.2 Application Prospects of Floor Radiation Cooling and Air Supply Systems based on Thermal Comfort

The floor radiation cooling and air supply system with thermal comfort has broad application prospects in the future, mainly reflected in the following aspects [7]: (a) Sustainable energy utilization. With the increasing attention to environmental protection and sustainable development, the floor radiation cooling and air supply system with thermal comfort, as an efficient energy utilization method, will receive more attention and application. By combining renewable energy sources such as solar and geothermal energy, efficient utilization of energy can be achieved, reducing reliance on traditional energy and reducing environmental impact. (b) With the continuous development of intelligent building technology, the floor radiation cooling and air supply system for thermal comfort will also move towards intelligence and automation control. Through sensors and automatic adjustment systems, precise control and adjustment of indoor temperature can be achieved, improving system energy efficiency and comfort. At the same time, it can also be combined with home intelligent control systems to achieve remote monitoring and control, improving user convenience and comfort. (c) Artificial intelligence and big data analysis, with the help of AI and big data analysis technology, can achieve more intelligent control and optimization of floor radiation cooling and air supply systems for thermal comfort. By collecting and analyzing a large amount of data, the system can learn

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user preferences and behavioral habits, automatically adjust temperature and humidity, provide personalized comfort experience. At the same time, by analyzing data, problems during system operation can be discovered and solved, improving system reliability and stability. (d) Expansion of application areas. Currently, the floor radiation cooling and air supply system for thermal comfort is mainly applied in residential buildings. In the future, with the advancement of technology and the reduction of costs, it will be extended to more areas of buildings, such as commercial office buildings, medical institutions, hotels, schools, etc [8]. These areas have a high demand for comfort, Moreover, more efficient energy and space utilization can be achieved through the floor radiation cooling and air supply system.

6. Conclusion

In summary, the floor radiation cooling and air supply system with thermal comfort provides a uniform and comfortable temperature distribution, improves indoor air quality, saves energy and operating costs, and increases indoor space utilization. The floor radiation cooling and air supply system with thermal comfort has broad application prospects in the future. It will continuously develop and innovate in environmental protection, intelligent control, artificial intelligence, and big data analysis, providing users with a more comfortable, energy-saving, and intelligent indoor environment.

References

[1] Tianjin Urban Construction University, Tianjin Tiandiyuan Technology Development Co., Ltd Floor radiation cooling and air supply system based on thermal comfort: CN201711436730.6 [P]. 2018-05-08.

[2] Wang Jingjing Research on Construction Technology of Low Temperature Hot Water Floor Radiation Heating Engineering [J] Development Orientation of Building Materials (Part 1), 2023,21 (2): 106-108.

[3] Fang Yulong, Zhang Xiaosong, Liu Chang Experimental study on a dry floor radiation non fully covered thermal conductive plate end heating system [J] Journal of Southeast University (Natural Science Edition), 2022, 52 (6): 1104-1113.

[4] Zhao Wang, Kang Yanming, Zhong Ke The impact of adjacent room temperature on energy consumption in air-conditioned and floor radiant heating rooms [J] Cleanliness and Air Conditioning Technology, 2023 (1): 5-8.

[5] Wang Huiping Analysis of Low Temperature Hot Water Floor Radiation Heating [J] Development Orientation of Building Materials (Part 1), 2021,19 (6): 18-19.

[6] Liu Yan, Li Chen, Zhang Chen, etc Research on zoning of floor radiation system for air source heat pumps in China [J] HVAC, 2021, 51 (1): 114-120.

[7] Kong Xiangqiang, Yan Xunzheng, Zhang Peng, etc Design of experimental platform for direct expansion solar heat pump floor radiation heating [J] Laboratory Research and Exploration, 2022, 41 (3): 75-78105.

[8] Chen Jinhua, Wang Wenqian, Jiang Dong, etc Research on improving indoor thermal environment with floor radiation cooling [J] HVAC, 2020,50 (5): 42-48.